# Lecture Notes in Medical Informatics

Edited by D. A. B. Lindberg and P. L. Reichertz

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# The Computer and Blood Banking

(EDP Applications in Transfusion Medicine)
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Proceedings

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Editor's Preface

In the autumn of 1980, the decision was made by the responsible bodies of the German Society for Medical Documentation, Informatics and Statistics (Deutsche Gesellschaft für Medizinische Dokumentation, Informatik und Statistik e.V.) to make the application of computers in blood banking and blood transfusion one of the topics to be treated at the 8th spring conference of this Society, which was then arranged to take place in Tübingen from April 9-11, 1981. The goal of the conference was to unite application specialists and methodologists in order to assess current achievements and identify fields needing further improvement.
We were fortunate to obtain the interest of the German Society for Blood Transfusion and Immunohaematology Dr. Roos, the head of the EDP Work study group of the Section 1 of this Society did substantially influence the programme. Many of the papers actually reflect accomplishments of his research and of the work study group. We also consider ourselves fortunate to win Prof. C. Mueller-Eckhardt, current president of this Society, to give an introductory address.

The programme committee identified the topics to be covered and agreed to invite papers on these topics. At the same time the conferenc was opened to voluntary contributions by setting up a poster session. The programme committee did also agree to our suggestion that the proceedings of the conference be published in English despite the fact that the conference would be held overwhelmingly in German. This decision was made assuming that the topics discussed would be of international interest.

We are well aware that this kind of decision is a criterial one, especially with the short term response required by the tight schedule characterizing preparation of the conference. The decision is critical because what is gained in understandability by conversion from a less common language to a more common one, might be lost in intelligibility if the papers have to be prepared in another language than the mother tongue by the majority of authors. This especially if in addition a tight schedule has to be observed. We are grateful to our collegues to comply with these unusual demands.

In compiling this volume we assigned the highest priority to issuing the proceedings as timely as possible. The editing task concentrated on making the English text readable, rather than on improving on the style of the authors. Usually the figures are left in the appearance in that they were provided by the authors.

However we are not quite sure whether some problems of basic terminology have been solved adequately. One of these problems includes the English title of the conference. The English term "Blood Banking" does not encompass all aspects of the applications covered in this conference - e.g. decision support in transfusion therapy. On the other hand the term "Transfusion Medicine" is not in common usage in the Anglo Saxon language community. As Prof. Mueller-Eckhardt pointed out in his introduction, there are reasons to use this term. An example of another language problem is the use in German of the term "supra-regional" service when referring to a blood collection service organized e.g. at the level of an entire federal state, where colleagues from English speaking countries would speak of a "regional" system. We tried to adopt to the English terminology in such cases. However we cannot be entirely sure that the problems of this kind have been solved and submit the proceedings to the public with the hope that the material will be considered of interest despite persistent deficiencies.

Finally we would like to thank all those, who made the conference and this volume possible. The conference drew its substance from the experience and dedication of our colleagues in the programme committee. But it would not have come about without the diligent work of the organizing staff. B. Pietsch, Ch. Maucher, I. Hengstler-Häfner and H. Rosnik devoted much of their work hours and many hours of overtime to the organization of this conference under the very able guidance through H. Juranek, Akad.Direktor, Div. of Medical Documentation and Statistics, Univ. of Tübingen. Whatever readability was achieved in many of the English versions of the papers prepared by our colleagues from not English speaking countries is due to Mrs. L. Blumenthal, our experienced lecturer. All the corrected papers had to be retyped, for which we are endebted to Mrs. S. Kraus.

Finally all this work would not have been possible without the sub-support from the subsidizing companies who also took care that the speakers from overseas were able to attend the conference.

J.R. Möhr
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# Structure and Goals of Transfusion Medicine

C. Mueller-Eckhardt

Institute for Clinical Immunology and Transfusion Medicine, University of Gießen, FRG.

As an introduction to the problems of documentation and data processing, which will be covered in subsequent papers at this conference, I consider it my duty to address some of the more fundamental problems of transfusion medicine. Such a consideration will by necessity be a personal testimony, marked by proper experience.

The subject will be subdivided into the discussion of the following aspects

1 Why transfusion medicine?
2 Can transfusion medicine meet its objectives in its current structure?
3 Goals of transfusion medicine,
4 Scientific perspective.

When the term "Transfusion Medicine" was coined a few years ago, it gained quick acceptance in the German speaking community. Not only has it been accepted as an auxiliary specification of a medical specialty by the German Medical Association (Deutscher Ärztetag), but the term is also part of the designation of several pertinent institutions. In my view this is an advantage we dispose of in comparison with our colleagues of the Anglo Saxon community who know such terms as "Nuclear Medicine", but hardly "Transfusion Medicine". The English terms used are still "Immuno Hematology" and "Blood Banking".

Why then "transfusion medicine"? At a time of centrifugal subspecialization of medicine, every new discipline has to pose itself the question of its delimitation to other areas and of their economic implications, if it intends to document its autonomy not only in the medical but also the structural and legal sense. Only if it meets this requirement in the competition with adjacent fields, will it sustain itself in the long run.

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Condensed and translated version prepared by J.R. Möhr on the basis of the original paper given in German.

Trying to define "transfusion medicine" I would designate it as the set of medical knowledge, measures and problems related directly or indirectly to the disposition, storage, conservation and transmission of blood and blood constituents. The tasks of transfusion medicine which I will summarize under the following five headings derive from this definition:

1 Blood may be obtained only from healthy human beings. It has to be the supreme goal (perhaps particularly in the age of phereses) to protect the health of the person consenting to blood donations.

2 Qualitative and quantitative deficiencies of the organ complex blood have to be offset totally or partially in accordance with the particular requirements of differential hemotherapy.

3 Preparation of blood derivatives is only medically and economically feasible in specially equipped institutions (blood fractionation, blood banking).

4 The protection of treated recipients requires special methods in order to discover disturbances prior to, during and after blood transfusion (immuno hematology, hemostaseology).

5 Education, training and scientific investigation.

Is transfusion medicine able to meet the respective demands in its present structure? A view back at the recent history of our discipline may help to better distinguish the strong and weakpoints of its present structure.

In this country, the beginning of transfusion medicine has to be dated back to the time after the Second World War, while properly working transfusion teams were active on the side of the Allied forces already during WWI after citrate had been introduced as anticoagulant. As you all know, until some fifteen years ago, blood transfusion was practically synonymous with the transmission of fresh or stored whole blood. A rational consequence was the conception of a widely dispersed system of blood collection with the institution of centralized blood storage and distribution sites. These were established as state-controlled or charitable institutions. The location of these central institutions was chosen according to economic and transport specific principles rather than medical ones.

Independently, hospital-based institutions of transfusion medicine have evolved in some countries. Taking a look at the different countries in Europe, we may distinguish centralized types of organization as, for example, in Switzerland or the Netherlands. There are also regionalized state-controlled structures as in England, France, Sweden or the East European countries, and there is the dual or (if the industrial domain is included) the ternary federal system of the Federal Republic of Germany. One must admit that some competition arose between the two main pillars of the system in the FRG, because of the universally applicable functions of blood collection and blood distribution, which caused some friction.

During the past ten or fifteen years the progress of transfusion medicine proceeded at an extreme pace. Let me just list the most relevant contributions:

- Development of the multi bag systems for blood fractioning, especially for thrombocyte transfusion;
- the introduction of cell separators for substitutional and therapeutic cell- and plasmapheresis;
- the decoding of the HLA system and other immunogenetic systems of cells other than erythrocytes as a prerequisite of transfusions and organ and bone transplantations;
- the diagnostics of viral hepatitis.

With respect to therapy, some differentiation in the use of plasmatic components is discernible:

- the use of unpurified, concentrated products such as factor VIII, albumin or immune globulins approaches economic boundaries, while the application of fresh plasma goes through a certain renaissance.

All these developments, which resulted as a consequence of clinical requirements, brought transfusion medicine - and I might add from my personal point of view 'luckily' so - back to where it belongs: the hospital, into the environment of patient-oriented medicine.

However, there should be no misunderstanding: long-lasting quarrels may have disturbed our realization of the advantages that our bi- or tripartial system provided in a serendipitous manner. I want to state firmly that transfusion medicine would not be feasible without the voluntary support through donations provided free of charge by the entire population. No organization could better be trusted with the related organization than a charitable organization which is not exclusively subject to the laws of a free market. However, transfusion medicine is equally dependent upon hospital-based facilities and the physicians, nurses and technicians serving them. And which institution would be in a better position to provide us efficiently and economically with high quality products on an industrial scale than industry?

It is my firm conviction that the structure of transfusion medicine with its concurrence of local and regional institutions, as it developed historically in the Federal Republic, is best suited to the multiple medical requirements. No party should try to monopolize this field or deny the right to exist to one of the others.

This brings me to the next topic: the goals of transfusion medicine. The global goal is easily formulated: To cure the patient effectively and efficiently without harming the donor. This will hardly be questioned. To name the requirements for achieving this goal is, however more demanding.

The first requirement, is the availability of appropriate space and equipment. I will not cover these since the requirements at least of data processing equipment, will be covered in the following contributions.

I would like to address two kinds of requirements which I have only been able to touch so far: firstly, the question of qualifications and, hence, of training of physicians and other professional personnel; and secondly the question of the scientific orientation of transfusion medicine.

After accepting transfusion medicine as a new subspecialty, the contents of special training have been subject of discussion by the responsible institutions in the FRG. The passing of a training program meeting high standards is, in my view, the basis for the establishment of transfusion medicine as an autonomous and respected discipline.

Nevertheless, it will only persist if it manages to improve integration into clinical medicine. Clinical experience is indispensable for the practice of transfusion medicine. Specialized knowledge and experience in other areas of transfusion medicine, however, is just as necessary in my view. Every specialization program has to account adequately for both aspects. It will not be permissible in the future to assign physicians with exclusively clinical training or pure theoreticians with leading positions in our discipline. We will first have to agree on the criteria for specialty training and to enforce them. This is curently a high priority task for the board of directors in our scientific associations.

It is of no lesser importance to improve the attractiveness of transfusion medicine for our young colleagues. Only if we demonstrate development potential and open up possibilities for qualified education, will we be able to arouse their interest in our discipline. A seminar to this purpose will be offered for the first time this fall.

This brings me to the last but not least important goal of transfusion

medicine, the establishment of its scientific bases. There is no doubt that every discipline stands or falls with the scientific qualification and scientific involvement of not only its younger but also its more experienced representatives. It is my feeling that much remains to be done in this respect. We neither need to nor should judge our selves by the standards of basic sciences, but we will have to meet international standards. This requires studious and critical scientific work for the solution of the many problems which pose themselves continuously. It is a bad sign if a scientific society is only rarely able to award is own prize because of lack of qualified presentations, or if there are no qualified applications for vacancies of scientific positions. It is the duty of us seniors to provide the prerequisites for a successful and, therefore, self sustaining scientific work of our young colleagues and for the maintenance and improvement of the scientific reputation of our discipline.

If this conference can contribute in this respect, it will help us to attain the goal of transfusion medicine. This is my wish to all of you, the organizers, the participants and even to myself as one of the current representatives of the German Society for Blood Transfusion and Immune Hematology.

# Functions of Patient-oriented Blood Transfusion Services.

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## Introduction

Blood transfusion services (BTS) have to facilitate the physicians' task of blood transfusion and the supply of blood components in a quantitative and qualitative manner. Similar to regulations applied to pharmaceutical industry, the German drug law (1) requires the designation of qualified persons responsible for: production, control, distribution. Concerning blood transfusion, comparable regulations exist such as:

- Standards for Blood Banks and Transfusion Services of the American Association of Blood Banks (2)
- Guidelines for Blood Grouping and Blood Transfusion by the Federal Board of Physicians and the Federal Board of Health (3).

Further persons in charge named by these guidelines are:

- clinical pathologist with special serologic experience,
- transfusing (attending) physician,
- hospital administration board for organization,
- assisting medical personnel, working under the supervision of a physician.

Errors in blood transfusion may have fatal results. Therefore, all persons involved must strictly comply with the requirements to provide for safe transfusion of blood and transmission of special information.

## (1) Blood transfusion Service (BTS)

Since most of the blood transfusions are performed during clinical treatment, a hospital BTS has been established by hospitals having emergency or intensive care units. The blood supply of the supporting hospital is guaranteed by a 24-hour-a-day-service of this hospital BTS. Having an extended supply area, these hospital BTS are called "regional" BTS in the FRG. They are supported by the government or communities.

(2) Blood Unit Depot

The number of blood transfusions increased to a great extent since it has become possible to preserve blood and to store blood units. Since 1950, almost a twofold increase in blood demand per decade has been recorded. Using modern stabilizers (nutritive media), the red blood cells as the most important blood component keep their viability at a temperature of $-4^{o}$ C for at least 35 days. The instrument to meet the demand is the blood unit depot. This is maintained by a stock policy which is to comply with the requirements by appropate and constant supervision. Because of dangers of bleeding, the medical demand for a sufficient supply at any time has priority, at least for the supporting hospital. It is followed by the ethical demand that the limited "source" of human blood may not be wasted. The economic demand for low costs ranges third. The blood bank management should endeavour to bring these three criteria into accord by efficient procedures in blood storage.

(3) Blood Donor Service (BDS)

In many cases, blood transfusion services in university and large cities are combined with a hospital blood donor service (BDS). According to the demand, these BDS care for the blood unit supply on the basis of blood donations. The most important instrument for disposition and organization of blood donations is a file of donors. Besides occasional and spontaneous donors, the permanent donor is the important type of blood donor in the hospital BDS. They are donating blood up to five times a year. Their state of health is more extensively controlled than that of the donors mentioned before. They remain on call for blood donation. The hospital BDS contacts these donors (by phone or mail) to donate at an appointed date, sometimes for a certain recipient. For this purpose, the donor always comes to the hospital BDS. In emergency cases, the donor is on call for donations on Sundays or holidays, even during the night. Precise information on his availability and reliability combined with a check of his donation ability with regard to his state of health and interval since last donation are data to be checked in the data base. This type requires complex search, call and control procedures and will soon outgrow the limits of conventional file organization.

The regional BDS of the German Red Cross are a second type of BDS in the FRG which take care of the blood supply of many depots in hospitals. The demand of the depots is covered by the blood unit pool of the center.

The blood units are shipped by train or special refrigerating vehicles to the depots and the hospital BTS. Gaining blood from both sources, recruitment of own donors and delivery of blood units from the regional Red Cross BDS, will in my opinion combine the advantages of both systems (4).

## (4) Special Procedures for Blood Products

According to the patient-oriented demand, the blood bank as a donor and transfusion service has to apply a number of special procedures in collecting and processing blood products. Our blood processing scheme (Fig. 1) shows - without going into details - the four columns:

1. primary donation,
2. first processing steps,
3. standard preparations,
4. additional special preparations.

The four generally used blood units are pointed out:

- WB whole blood (with all components),
- RC red blood cells/erythrocyte concentrate (buffy coat removed),
- PC platelet/thrombocyte concentrate (as a white cell component),
- PL plasma (all cells removed).

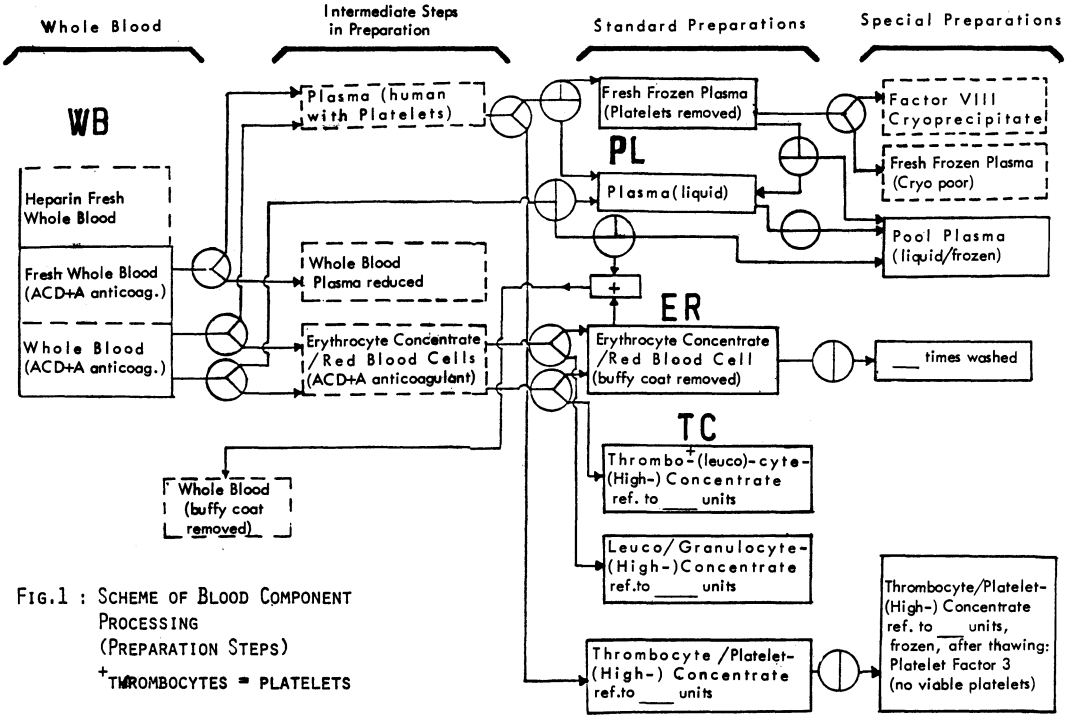



FIG.1 : SCHEME OF BLOOD COMPONENT PROCESSING (PREPARATION STEPS)
+THROMBOCYTES = PLATELETS

The product lines (in Fig. 1) show switches which are in a position to get standard preparations. If requested, they may be switched to other product lines. In special cases, for instance, the blood bank meets the request for platelet rich plasma, plasma-depleted whole blood or (for exchange transfusion in neonates) red cell concentrates with platelets of a first donor and fresh frozen plasma of a second donor as a mixed or hybrid unit. The remarkable diversification is an important feature of patient-oriented blood banks. While regional Red Cross BDS offer nearly 12 products, hospital blood banks have to list at least 66 products, as in our case.

Special preparations, which already start in blood drawing, use multiple bags in order to separate several blood components in a closed system. In pherese techniques, the bags with drawn whole blood are centrifuged. After separation of a distinct blood component (plasma/platelet pheresis) the rest will be transfused immediately. In double pheresis this procedure is repeated again. The identity must be carefully checked, for it is absolutely necessary that the donor is retransfused with his own blood. The 5 min procedure of the normal blood donation increase to 45 min, or to 90 min in double pheresis.

The time necessary for cell separation is in the same range or even longer. Here the donor is linked to a special machine via an extra corporal circuit. In this way, a blood cell component which is found only in low concentrations will be collected from the donor and concentrated up to tenfold in a small volume. While cell concentration is increased, the efficiency of the technicians involved decreases. In this field innovations are needed. Every two years a new type of machine is announced. The latest cell separator models, the FENWAL and the IBM 2997, show several sensors, counters for the circulatory input-output balance, microprocessors for automatic blocks and alarm systems. One can imagine that the future it will be possible for 2-3 donors to be treated at one cell separator by one technician and supervised by one physician as with the standard donation.

Despite an increase of 5-10% a year, the situation concerning blood supply with red blood cells can be regarded to be roughly balanced. Among the white cell components the platelets have limited viability not exceeding 72 hours. Leucocytes have a viability of only 4-6 hours. Furthermore, the leucocytes are about a thousand times less concentrated than red blood cells. The increasing demand is not fully met in platelets and scarcely in leucocytes. Finally, the procedure of autologous blood units should be mentioned: patients donating blood for their own surgical procedure. In rare cases, blood banks are concerned with the

recruitment of donors for bone marrow transfusion.

(5) Special Blood Component Therapy

A blood transfusion service consults the transfusing physician in blood component therapy and is able to perform outpatient transfusions on the premises of the BTS. At least in problem cases, the blood bank director has the opportunity to see the recipient in the ward as a consultant. In the case of special diseases, patients may be transfered to the blood bank for phlebotomy, therapeutical pheresis, or for depletion of certain pathologically increased blood components by the cell separator. In co-operation with the clinicians a patient-oriented blood bank may be suited for therapy controls.

(6) Laboratory

Prior to the issue of a blood unit, it is essential to investigate the donor and to perform several tests with the blood drawn. The normal range reported in the literature or limiting values in guidelines serve as criteria for the application of units for transfusion. Thus the medical staff is familiar at least with the principle of decision tables.

A drawn blood unit is in quarantine until all results of the control tests are available. Here the flow of information from the different laboratories can be markedly accelerated and become more efficient by automatic data processing. Results which implicate an immediately recognizable risk of infection may be used to immediately tag the blood unit as withdrawable via EDP. Also the search for the recipient of component units, issued as fresh blood with medical risk, is much easier by EDP than by the time-intensive conventional procedure.

Blood units may be regarded as special drugs which have always to be serologically determined before use. Compatibility tests have to be performed, using small blood samples from the two participants. For this purpose, special laboratories are established in blood donor services for donors and in blood transfusion services for patients which have the same day and night service as the blood unit depot. Speaking about blood donor service - blood unit depot - laboratory - blood transfusion service as a complex institution for transfusion medicine, I prefer the American abbreviation "blood bank".

Because the different blood types are extremely important for the

compatibility of the blood unit, the data must be repeatedly checked to avoid errors. Only input and storage of correct data in computers saves time and test material. When blood units in blood banks are issued for transfusion to a certain patient, it is necessary to compare the recipient's blood group (just tested or already known) with those of the blood units. As a rule, transfusion recipients and blood units must show the same blood group (ABO and RhD type). In emergency cases, exeptions are allowed depending on the blood group of the recipient and also on the blood unit with its blood component type. Using our system, we have developed decisions tables which lead to special remarks (at the visual display unit and/or transfusion report) in non-identical transfusion (see pg. 23).

## (7) The Organizational Context of a Blood Bank

The organizational assignment of a blood bank can be derived from the hospital with the highest demand, e.g. the department of surgery or anaesthesiology. If the blood bank is assigned to a special field of medicine, then haematology, immunology, microbiology, or serology are preferred. If the blood bank is integrated into an institution of the fields mentioned before, activities such as immuno-haematological diagnostics, general and transplantation immunology, clotting diagnostics and therapy of bleeding disorders (see pg. 23) are provided. Depending on the position of a blood bank in a community hospital, the development of techniques and the training of technicians will be an important goal. In university hospitals lectures for students and research work are additional tasks.

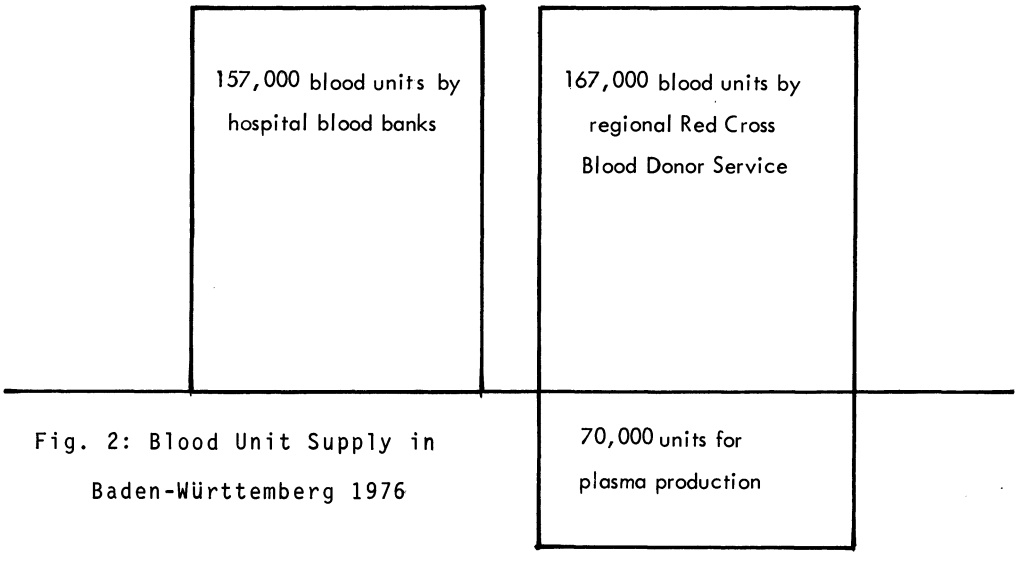


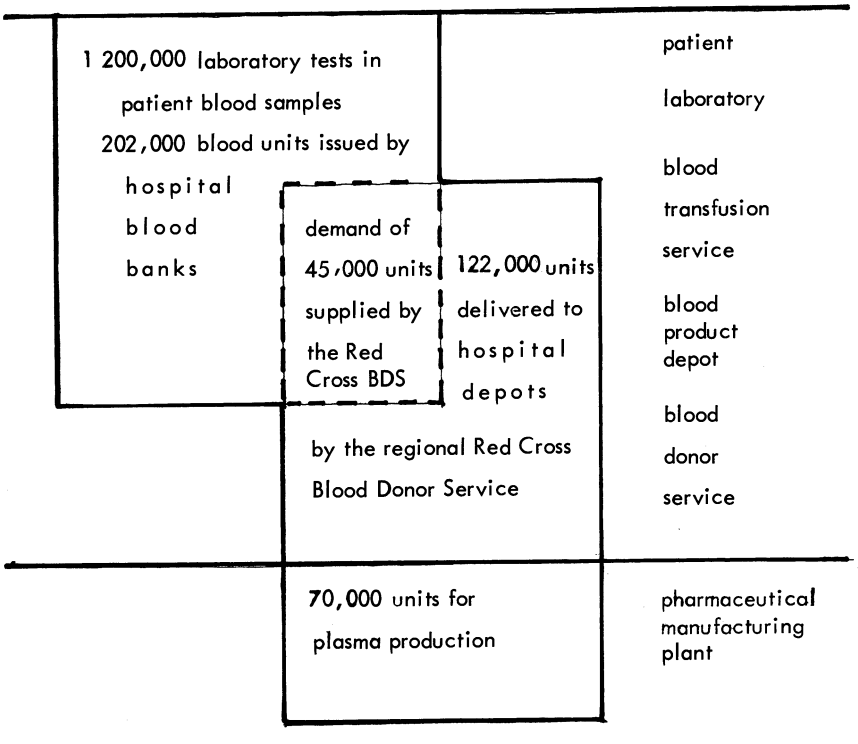

Fig. 2: Blood Unit Supply in Baden-Württemberg 1976

(8) Cooperation of Regional Red Cross BDS and Blood Banks

Finally, I will give more detailed information concerning blood banks in the part of the country where Tübingen, the site of this congress, is situated. Besides the regional BDS of the German Red Cross (DRK) in Baden-Württemberg with its two blood donation centers in Baden-Baden and Ulm, 11 blood banks, supplying the blood needed by the population of Baden-Württemberg are to be found. For 1976 the figures for these two differently organized services were as follows (4):

(1) With respect to blood collections the regional Red Cross BDS was most important performing 2/3 of blood collections (Fig. 2),
(2) concerning blood units for supply of Baden-Württemberg, both types of BDS were involved to the similar extent (blood banks 157.000, Red Cross BDS 167.000 blood units because 70.000 units were used for plasma preparation) (Fig. 2);
(3) in the local provision of blood units for the supply of the various hospitals the blood banks dominated covering 2/3 of the demand (202.000 units resulting from the receipt of 45.000 units of the DRK-BDS) (Fig. 3);

Fig. 3: Blood Production and Distribution in 1976



(4) the major task of the blood bank is the provision of the transfusion blood and the consultation of the attending physicians by a doctor of the blood bank. In this respect, 1.2 million laboratory tests on patient blood samples carried out in 1976.

Somewhat simplified one may note that regional Red Cross BDS and blood banks do not differ in principle but, to a certain degree, in quantity. By the use of EDP an essential improvement in respect of the permanently increasing requirements for both types of services in the field of transfusion medicine can be expected. EDP is supporting several special fields. A number of problems in the field of blood physiology, immunohaematology, and blood bank technology have to be solved. However, special attention should be focussed on the individual care of donors and recipient.

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# TASKS OF A REGIONAL BLOOD TRANSFUSION SERVICE

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Blutspendedienst des DRK Landesverbandes Rheinland Pfalz

The tasks of a local and a regional blood transfusion service seem hardly distinguishable if regarded superficially. Both organizations have to process blood units and blood components and to optimally supply hospitals which are connected to the blood transfusion service.

In spite of having many basic things in common, there are principal differences in the type of organization and the sequence of operations in some fields. The aim of this paper is to describe the most important differences by the data of the German Red Cross Transfusion Service Rheinland Pfalz.

## Blood Collection

One substantial difference to a local blood transfusion service consists in the way of producing blood units. Individual donors or smaller groups of donors are not specially requested for blood donation but, as a rule, all donors of a town, a residential section or a place work are addressed. Blood collections take place predominantly in the evenings outside the blood center by mobile laboratories with substantial assistance of local organizations of the German Red Cross (GRC). Without the effort of local GRC teams, the smooth functioning of a regional blood transfusion organization would be impossible.

The most important data of the GRC Blood Transfusion Service Rheinland-Pfalz is shown in Table 1. In 1980, 1419 blood collections were completed in 536 different places: 170.190 blood units from more than 96.000 donors were collected altogether. This means that, on the average, the various places were visited 2.6 times and that an active donor took part in a collection 1.7 times anually.

One third of the blood units were donated by women (Table 2). The amount of blood units from first-time donors is 14.18% and that from multiple donors 85.82%. The figures show several priorities in the fields of planning and completion of blood collections. The most important task is certainly to retain and care for an active core of

donors. We try to inform all donors known to us regularly, through posters and flyers as well as messages of the press media about the blood collections in their residential area. In the past, we have learnt that individual information by postcard is most effective. For this reason, we sent almost 500.000 postcards in 1980 to produce 170.000 blood units. In the past year, addressing and mailing of the cards was carried out by local GRC volunteers. These postcards are now more efficiently printed and addressed by our EDP system.

TABLE 1

GRC BLOOD TRANSFUSION SERVICE OF RHEINLAND-PFALZ

(time of observation: January 1st - December 31st, 1980)

Number of

| | |
|---|---|
| - Places | 536 |
| - Blood Collections | 1.419 |
| - Collected Blood units | 170.190 |
| - Active Donors | 96.987 |
| - Donors Registered since 1969 | 303.325 |

TABLE 2

| | Number of Collected Blood Units from | | | | |
|---|---|---|---|---|---|
| | Donors Total | Firsttime Donors | | Multiple Donors | |
| | ABS. | ABS. | % | ABS | % |
| MEN | 111246 | 14199 | 12.76 | 97047 | 87.24 |
| WOMEN | 58944 | 9928 | 16.84 | 49016 | 83.16 |
| TOTAL | 170190 | 24127 | 14.18 | 146063 | 85.82 |

Our active donors and the voluntary helpers play an important part in winning new donors, because the personal approach to a potential new donor removes the individual fear of venipuncture and blood collection in the best way.
The aim of every blood transfusion service has to be to supply clinics and hospitals in its service area with blood units and blood components. For an orderly and economical supply it is important to set blood collections in a way that a sufficient amount of tranfusable blood - especially by rare blood groups - is maintained and as much as possible of the produced blood units will actually be transfused. One problem is the difference of blood groups between the core of donors and the blood units needed by the hospitals. Statistics showed that there are large discrepancies, especially in the field of Rh-negative blood groups. Besides the need for and the distribution of blood groups, the planning must also consider influences like seasonal variation of blood donations and local circumstances (like holidays, harvests, etc.). At least one blood collection has to be arranged daily in the vicinity of the blood center. In this way, blood will be available at any time for processing special products which are extremely shortlived or which have to be processed immediately upon collection.

## Processing

Before blood units are shipped to hospitals connected to the blood transfusion service, processings which are requested by the guidelines and the pharmacopoeia must be carried out. So far, there should not be any essential difference compared to a local transfusion service. A difference only exists, in the amount of blood samples to be processed. 500 to 1.000 samples from donors are processed daily in the laboratories of the GRC Blood Transfusion Service Rheinland-Pfalz. The aim of processing is to guarantee the exact labeling of the blood units with the corresponding blood groups and to prevent the delivery of not-transfusable blood units. All results must be documented, of course. The high number of blood samples to be processed requires a far reaching automation of the laboratory. We have learnt that on-line-connections between the laboratory equipment and the central computer are not absolutely necessary.

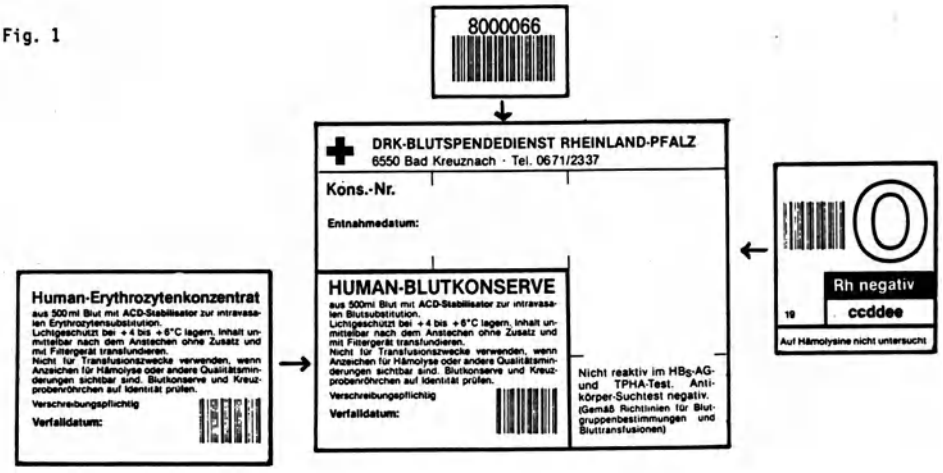
Blood donors represent a healthy group of people. Pathological results are rarely to be found. We only store pathological data in our computer. We have learnt that it is unnecessary to store standard results. A

connection with the central computer makes operations easier in the field of blood grouping, if it is possible to immediately compare the new processing results with the donor's stored data. An unmistakable identification of samples must, however, be guaranteed.

It is necessary to distribute operations among a greater number of medical technicians. It is useful to delegate processing, data input and release of processed blood units to responsible laboratories. But this calls for an excellent coordination of the different laboratories. This can be optimized by a computer. Only after complete release by all laboratories a final release is possible. In this way, blood units which are not completely released by all laboratories are stopped from being labeled and processed to blood components or delivered to hospitals.

The labeling of the blood units can also be controlles with a lightpen by EDP (Fig. 1).

Fig. 1




With such a method, shipping of an incorrectly labeled or non-transfusable blood unit is excluded. The correct assignment of the pilot tube to the blood bag is also secured. In many cases, laboratory operations with routine processing are not completed. Cross-matchings are regularly carried out for 10% of the connected hospitals. If necessary, the remaining hospitals also demand cross-matchings, which are very often connected with a farther-reaching antibody diagnosis, and call for blood units corresponding to the results of the diagnosis. As shown in Table 3, it can be quite reasonable for a regional blood transfusion service to enlarge the existing use of EDP by a patient system.

TABLE 3

GRC BLOOD TRANSFUSION SERVICE OF RHEINLAND-PFALZ

Processing refering to Patients in 1980

CROSSMATCHES

| | |
|---|---|
| Patients | 3.868 |
| Units | 10.649 |

ANTIBODY DIAGNOSIS

| | | |
|---|---|---|
| Patients | ERY Antibodies | 590 |
| | HLA Antibodies | 116 |
| Units | ERY Antibodies | 1770 |
| | HLA Antibodies | 153 |

Production of blood components

In recent years hemotherapy has been more and more accepted in hospitals. More than 80% of the collected blood units of the Transfusion Service Rheinland-Pfalz have to be separated into therapeutically effective components. This leads to a variety of blood units and blood components. They have all been subjected to "Arzneimittelgesetz" (Drug act of the FRG) since January 1978. With the integration of these products to the new act, the legislator demanded new qualifications for the blood transfusion services.
Especially in the field of processing according to Good Manufacturing Practices (GMP) and its control, additional efforts and investments are required.

Developments are similar to the ones we had in laboratory medicine after World War II. Working time for the actual processing is getting shorter while the time for documentation and control is increasing. Our present activity aims at a further development of EDP to assist administrative work. In this way we save work and intensify security

in processing.

Distribution of blood units

Certain problems arise in the field of shipping blood units for a local blood transfusion service. They come up because of the large distances within the service area and the number of hospitals. Our blood transfusion service supplies 121 hospitals within a radius of 200 km. This is done with refrigerator trucks once or twice a week. These large quantities call for the assistance of EDP to write delivery notes and invoices. In the same way as the declaration of blood groups, the correct labeling of products and the prevention of shipping non-transfusable blood units can be controlled with lightpens (Table 4). Statistical data for comsumption control should be available. Documentation of all operations is also of the highest importance. It makes it possible at any time to trace the way of a blood unit from the donor, via laboratory processing to the hospital and finally to the patient.

TABLE 4

GRC BLOOD TRANSFUSION SERVICE OF RHEINLAND-PFALZ

Shipment of Blood Units in 1980

| | |
|---|---|
| Hospital which are regularly supplied by our Blood Transfusion Service | 121 |
| Shipment by refrigirator trucks (driven KMS/year) | 1 - 2 times a week 75000 KMS |
| Shipment by Ambulance Service | 270 |
| other special Transfusion (Taxi, Police, Helicopter) | 166 |
| fast freight shipment | 9595 |
| Self-Service | 8120 |

By describing some operation fields of a regional blood transfusion service we have tried to highlight essential differences to a local transfusion service, related to hospitals and patients. We have tried to demonstrate the possibilities of EDP in facilitting and securing operations.

# DIFFERENT SYSTEM APPROACHES IN TRANSFUSION MEDICINE

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The handling of a huge quantity of data and the retrieval of donors or blood units for a special application present serious problems for blood centres and transfusion services, all the moreso if the transfusion service works near a hospital where an unpredictable demand for special blood units frequently arises DP is well fitted to solve these problems. Though first attemps had been made in the late sixties, it took a long time till DP was accepted by the physicians.

Examining the known DP-systems in this field, we find a uniform trend with regard to the problems to be solved. However, one can find a large variety concerning their technical realization.
Maybe this is why blood centres differ among each other to a greater extent concerning their scopes, their organizational structures and their financial potentials than other medical institutions working in a similar field.

The objectives common to all blood centres, transfusion services and blood banks are:

- supplying the patients of a hospital or a region with blood adequately and timely;
- taking best care of the donor, and
- protecting the recipients against transfusion damages.

Corresponding to the special volume of work or the individual interests of the heads of these institution, there may be further objectives. But the DP-system is also determined by the physician who has to accept it as an appropriate instrument for his daily work.

There are several characteristics of the blood centres which determine the structure of the DP-system:

- the mode of donor recruitment;
- the vicinity of a blood centre to a hospital;
- the demand determined by the therapeutic programs in the hospitals supplied (e.g. ECC-operations);
- the method of distributing a great number of blood units.
- the financial or organizational potential of the blood centres, for example, whether they are community blood centres or Red Cross blood centres.

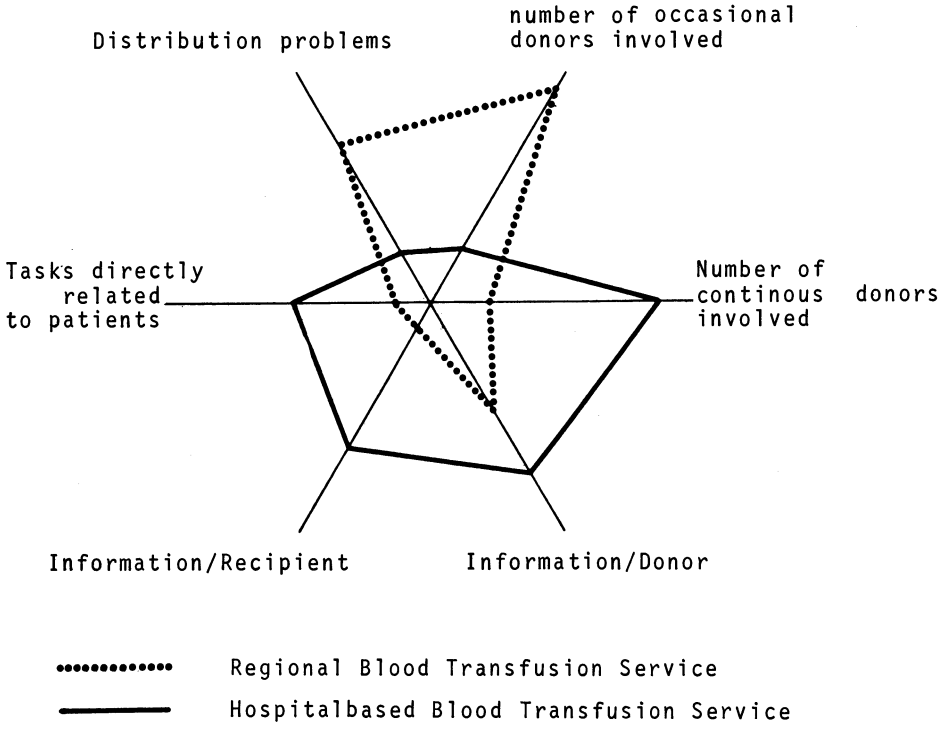


Figure 1

Synopsis of differences between regional blood collection centres and blood transfusion services

Fig. 1 shows the fundamental differences between hospital based transfusion centres and regional blood collection centres.

A regional blood collection centre in West-Germany usually disposes over a great number of persons donating twice a year, thus producing a great number of blood units. These are often processed into blood components and have to be distributed to the hospitals of a region. On the other hand, the blood transfusion service near a hospital relies almost exclusively on donors who are called in when needed and who can donate every eight or twelve weeks because they get a medical check-up every two years. The tasks with reference to the recipients (e.g. blood group typing, selecting an indicated blood unit for special application or cross-matching) are significant for this type of blood transfusion service. There are three entry points for DP-systems determined by medical aspects:

i. Computer systems for blood donor management
They are used for

- retrieving donors, especially rare donors;
- rejecting inappropriate donors as a consequence of pathological findings;
- improving performance in preparing and executing extraction dates.

Important points are ensuring the identity of a person and correctly linking the blood group findings to the records of donors and blood units. For this reason, good coordination of DP-system and information flow is indispensable.
A donor management system as described above includes the acquisition of data of the collected blood units. The need to extend the donor management system to an inventory control system for stored blood and to an aid for the distribution process thus becomes evident. Things become more complicated if the inventory levels of more than one hospital or depot stock are to be controlled.

Even simply designed systems may support donor administration in a very efficient manner. But inventory tracking or improving distribution of blood units in a local blood bank by means of a DP-system require a sophisticated system design and a staff working with discipline and care. Because of the problems hidden in several places, a second system has been built up for

accounting functions. This is why the existing information system was not appropriate to produce a reliable entry for an accounting system.

ii. Computer systems for laboratory data management.
The experiences from developed laboratory DP systems for clinical pathology could not be used before blood grouping machines had been introduced in serologic laboratories. Before that, information systems were built up using worksheets and punchcards to support laboratory work. A manually performed acquisition of qualitative and semi-quantitative findings has to be planned very carefully because of the reliability required of the processed data. There are few examples of secure data entry. In TRAMIDIS (Transfusionsmedizinisches Informations- und Dispositionssystem) in the University Hospital Eppendorf an optical mark reader is used. The known risks of this method are compensated by multiple readings and redundant data entry without any charge to the laboratory staff's account.
Today the use of blood grouping machines may become an entry point for DP in blood banking.

iii. Computer systems for recipient information handling.
There are only few approaches starting with data processing for the recipient - maybe because first of all one must handle information about the donor, then one has to do laboratory work, inventory control and distribution processing, all of which are prerequisites for an adequate blood transfusion treatment. Thus, the recipient himself, though centre of all efforts, is located at the end of a string of activities within the transfusion service.
Physicians ask for retrieval systems for risk patients who require a special treatment.
Transfusion backtracing, necessary when transfusion reaction or a transfusion damage has occurred, is very time-consuming and should, therefore, be supported by data processing.

In the above mentioned sense, the activities from donor management and laboratory work meet in the patient-oriented activities.
Once more, an example from TRAMIDIS may prove this.

The record of the blood unit containing the relevant information

for transfusion is produced immediately before the donation. Blood group typing for patients is done in the serologic laboratory, the findings are stored in the central data base. When the request for one or more blood units is entered, the following will be checked:

a) whether the requested blood group is identical or compatible with the stored blood group finding;
b) whether the blood group of the selected blood unit for cross-matching is compatible with the blood group of the patient.

Differences have to be investigated immediately. Our experience has shown that most errors result from writing mistakes.

Systems designed for the use in transfusion medicine have to fullfill several criteria which are typical for this application:

1. Because of possible lethal consequences of human errors, the data have to be checked seriously and processed correctly. This leads to a sophisticated design in case the system is intended to be used for controlling and supervising activities.

2. The processed data must be topical if the system is intended to be used to support decision making. This leads to interactive systems which must be operable whenever needed.

3. A permanent data acquisition for a quick and complete update of the important files must be guaranteed.

4. The transfusion centre must be in a position to do its work whether or not the system is operable.

5. The DP-system supports the medical staff in decision making or controlling activities, but it can never take the responsibility for those decisions. Thus, the system has to be transparent in each component, and the results have to be understood by the staff.

There are three different approaches to realize DP-systems in transfusion medicine:

A. Distributed systems
These are autonomous systems reaching all or part of the above

mentioned objectives. With this approach it is possible to realize a system exactly corresponding to the special work of the blood centre, taking into account the objective needs and the individual wishes of the medical staff.
In this way, the DP-system can be embedded into the individual worksteps, thus coupling it immediately to the sources of data used for data base update. An information system like this is more than an "electronic" card index which is updated outside the normal work. It is rather tool for process control in blood centres.

B. Shared systems
In this case, blood centres working in the same region use some copies of the same DP-system or share a common DP-system, thus exploiting financial investments to a higher extent. The main objective, however, is often the shared use of stored data, usually to get a broader basis for rare donor retrieval. There is less room for fulfilling individual wishes or needs. The DP-supported functions have to be standardized among the cooperating blood centres.

C. Hospital information systems
The DP-system of a blood transfusion service working in a hospital may be embedded into the overall DP-structure and information flow of the hospital. For example, in TRAMIDIS the recipient file is normally updated by the hospital patient admission system. The blood transfusion service thus gets information which was not available in that simple manner before. This increases rationalization and strengthens safety in record linkage.
An information system for the blood transfusion service may be implemented as one of several special information systems at that hospital, all realized with the same tools and following the same pattern.
The difference in using a shared system and using a hospital information system is that, in the first case, several more or less uniform blood centres use one DP-system as a tool for information handling, whereas, in the second case, several users utilize the same tools for building up special and therefore different information handling systems.

Conclusion
Without DP in transfusion medicine the needed information cannot be handled in a satisfactory way. Human errors may have fatal consequences.

DP-systems in this application field are in the first place information systems which have to present the needed data in an adequate and reliable manner within an acceptable response time. But they are also control systems, designed to prevent human errors. Consequently, the system approach varies for the different institutions practising transfusion medicine corresponding to their responsibility to the recipient. Nearly everywhere donor administration is included. The more important the tasks concerning patients become, the more the approaches differ and lose transferability which exists to a certain degree for donor management systems.
Gathering data sets and standardizing nomenclature may be one way to make systems transferable.
For my part, I would be satisfied if there existed a notation of the central terms in transfusion medicine which would make it possible to print a formula like

$A_1$ Rh pos ccD.Ee Fy(a) pos S neg

on a line printer in a clear, simple and formated manner which can be read easily and without misunderstanding by people outside the transfusion centre.

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# CENTRAL REGISTRATION OF HLA-TYPED BLOOD DONORS

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Summary:

As a consequence of the polymorphism of different antigenic systems on blood cells, blood transfusions may lead to alloimmunization of the recipient. This depends on factors involving both the blood-recipient and the transfused blood. Strong antigens such as Rhesus, Kell and HLA often lead to alloimmunization. When alloimmunization is present, cellular blood products with the respective antigens may exhibit impaired function and/or provoke transfusion reactions. Therefore, transfusions to alloimmunized patients have to be carefully matched. Since the HLA-system is very polymorphous, the local donor pool is sometimes too small to obtain the required antigen profile. Therefore, a central registration of HLA (Human Lencocyte Antigens) and blood group typed donors has been established in West-Germany. The results and problems involved are discussed.

Like other organisms, humans have the ability to react against foreign antigens with a humoral and cellular immune response. The production of antibodies does not necessarily occur; it is dependent on factors involving both the antigen (antigenicity, amount of antigen, modus and intervals of administration, similarity between antigens of the blood product and those of the recipient) and the recipient (immunological responsiveness). Antigens of various different, partly very polymorphous systems, are expressed on blood cells and it can be concluded that

- an absolutely identical blood transfusion is not possible;
- therefore, each transfusion may lead to alloimmunization;
- frequency and strength of alloimmunization are dependent on parameters established by the antigens administered and the antigen make-up of the recipient.

If alloimmunization against red cell antigens occurs, blood products with the respective antigen cannot be administered further because of the danger of detrimental transfusion reactions (for ref. see Mollison (1979). Therefore, the pool of available donors may be reduced to a

great extent.
Alloimmunization against antigens of platelets or leukocytes can reduce recovery and life span of incompatible cells to such a degree that substitution with cells bearing antigens is at least ineffective if not outright deleterious (Yankee, 1974).
The problems occurring when alloimunized patients have to be transfused are largely dependent on the antigenic systems involved and on the type of blood cells required, as the expression of antigens is different on different types of blood cells.
From the antigenic systems on red cells, the most important ones are those of the ABO system and of the Rhesus system:

The phenotype frequencies of the ABO system in Germany are (Hummel,1971):

| | | | |
|---|---|---|---|
| $A_1$ | 36.7 % | $A_2B$ | 0.9 % |
| $A_2$ | 7.7 % | B | 10.6 % |
| $A_1B$ | 3.6 % | 0 | 40.4 % |

Since blood contains regular isoantibodies against A and/or B, transfusions should in general use the same ABO blood group. If the regular isoantibodies are eliminated, blood from donors with blood group 0 can be used as a substitute for other blood groups.
The number of phenotypes in the Rhesus system is much greater than in the ABO system. Their frequencies and the compatible phenotypes differ greatly, as shown in three examples:

| phenotypes | frequency | compatible types | frequency |
|---|---|---|---|
| CcD.Ee | 13.4 % | all others | 100 % |
| ccddee | 15.1 % | ccddee | 15.1 % |
| ccddEE | 0.01 % | ccddEE | 0.01 % |

Other antigenic systems on red cells may also lead to alloimmunization; however, the frequency is low, since incompatible situations and/or antigenicity of the antigens are low. If alloimmunization against very frequent antigens occurs, it may be very difficult to obtain compatible blood.
On patelets some antigenic systems show quite different degrees of importance. In addition to a week expression of A and B blood group antigens, platelets as well as granulocytes exhibit a strong expression of the 5a-5b antigens. HLA antigens are strongly expressed on platelets and on nucleated cells (Svejgaard, 1969). The HLA system is of great importance for platelet transfusions:

- the system shows an extreme polymorphism which makes it very unlikely that random transfusions will be compatible;
- these antigens exhibit high immunogenicity which may lead to alloimmunization in a very short time (Yankee at al., (1969);
- these antigens are also expressed on leukocytes which are usually present in the cellular components of blood products in numbers sufficient for alloimmunization.

Platelet-specific antigens (for example $Pl^a$, Ko, $Pl^E$) are of only minor importance for platelet transfusions because of their low antigenicity and frequencies.
It is imperative that the HLA system and its importance be considered. HLA antigens are coded by three closely linked loci, termed HLA-A, B and C. These antigens are a dominant hereditary factor with at least 17 alleles at the A locus, 8 at the C locus and 32 at the B locus. The number of different phenotypes in the HLA system is:

$$\frac{n_A(n_A-1)}{2} + 1 \quad \frac{n_B(n_B-1)}{2} + 1 \quad \frac{n_C(n_C-1)}{2} + 1 = 2\ 268\ 544$$

$n_A$ are the alleles at the A locus, etc.
For practical purpose in transfusion medicine, however, not all the antigens have to be taken equally into account. Due to strong cross-reactivity, their number may be reduced at the HLA-A locus to 7 and at the HLA-B locus to 13. The antigens of the HLA-C locus are detectable on platelets only to such a small extent that they have no major influence on recovery and survival time in sensitized recipients; hence they can usually be neglected. Reducing the HLA antigens in this way, the number of different phenotypes is still 1.738. Even the most frequent phenotype (HLA-A1, A2, B8, B12) has a low frequency of less than 1 %. The antigenicity of HLA antigens is high, especially those of the HLA-B locus. The antigenicity is not only dependent on the antigen transfused but also on the serological similarity to the antigens of the recipient (strong or weak cross-reactivity between HLA antigens transfused and the HLA antigens of the recipient). Since alloimmunization is dependent on a number of different factors, sensitization time varies: the mean sensitization time is 8 weeks, but often sensitization occurs earlier and can be as short as 2 weeks (Tomasulo, 1978). One has to take into account that even one incompatible transfusion may lead to alloimmunization.
One of the major efforts in blood transfusion should be to protect the recipient against alloimmunization if repeated transfusions are to be expected; some indications are shown below:

| | against red cell antigens | against HLA antigens |
|---|---|---|
| I. Diseases | | |
| A) with long-term red cell transf. | | |
| 1. hereditary spherocytosis | + | + (apl.crisis) |
| 2. paroxymal nocturnal hemoglobinuria | ++ | ++ (apl.crisis) |
| 3. autoimmune hemolytic anemia | ++ | |
| 4. myelofibrosis | + | ++ |
| 5. sideroachrestic anemia | + | |
| 6. anemia due to chronic renal failure | + | + ? |
| B) with intermittent red cell transfusions: for example: ulcerative colitis, Crohn's disease | | |
| C) long-time platelet transfusions: | | |
| 1. aplastic anemia | ++ | ++ |
| 2. malignant hematological disorders | | ++ |
| 3. multiple myeloma | (+) | + |

II Individual factors:

A) prognosis (course, complications, special therapeutic procedures, for example bone marrow transplantation)

B) age of the patient

The local transfusion service should concern itself with prophylactic measures against alloimmunization in these groups of patients. The central registration should only be used when recipients have become refractory to platelets of the local donor pool or when antibodies against hihgly frequent red cell antigens are present. In this case the local transfusion service must consult the central registration concerning a suitable donor. The central registration categorizes and stores data regarding blood donors which have been sent from the local transfusion services. When this data has been computerized, a control file is sent to each submitting blood bank for checking and correcting if necessary. When blood donors of a certain red cell or HLA type are needed, all compatible donors are printed out by the computer and the information is transmitted by mail or phone to the transfusion service requiring the donor. Then this transfusion service

will be able to look for the best donor and contact the respective blood bank if the donor is available (Schneider et al., 1978). At this time, no strict criteria for the selection of blood donors are applied for central registration. It is only necessary that the donor be a long-term blood donor who is HLA typed. The highest degree of efficiency could be expected if the criteria for selection would be:

- fast availability of the donor, since sometimes emergency cases require a special blood or HLA type;
- the blood donors should be younger males because of longer availability and the occurrence of hypervolemia in cell separations for granulocytes which may have more negative effects in older donors;
- donor should behave highly reliably;
- those blood donors who could be used more widely without danger of alloimmunization (blood group 0, Rhesus negative, Kell negative) should have high priority for registration;
- if the HLA type of the donor is already known, those are best suited who are homozygous for antigens which show broad cross-reactivity (for example, a donor with HLA-B5 could be used for cross-reacting antigens HLA-Bw51, Bw52, Bw53, B18, Bw35, Bw49);
- since blood separation with cell separators is easier with donors with good veins, this should be taken into consideration;
- the donor should be free of red cell or HLA antibodies.

For mediation of blood donors via central registration the following criteria are applied:

- if a distinct blood group antigen is needed or has to be avoided, the selection of donors has to be performed with absolute correctness in respect to this requirement. Furthermore, ABO, Rhesus and Kell compatibility should be present
- if a certain HLA phenotype is needed, identity of HLA antigens is sought from a complete match down to 50 %. Since HLA-B antigens are of greater importance, identity for HLA-B is preferred if full identity is lacking. Here, too, ABO-, Rhesus- and Kell-compatible donors are preferred.

Experience with the central registration system has been good. The central registration system was started in 1976; at present 13 887 donors from 20 local blood transfusion services are registered*.

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Footnote, continued on following page.

BDS Bad Kreuznach (Dr. Blitz, BDS Berlin 19 (Prof.Dr. Hoppe), BDS Berlin 45 (Prof.Dr. Brücher), BDS Berlin 21 (Dr. Brandenburg), BDS Bremen (Dr. Zöckler), BDS Bruchsal (Dr. Schuhmacher), BDS Dortmund (Dr. Haase),

The blood group antigens of the registered donors in addition to ABO and Rhesus types are:

| | | | | | |
|---|---|---|---|---|---|
| $Fy^a+$ | 3426 | M + | 5611 | $Kp^a+$ | 3 |
| $Fy^a-$ | 1680 | M - | 1314 | $Kp^a-$ | 177 |
| $Fy^b+$ | 2832 | N + | 4677 | $Kp^b+$ | 262 |
| $Fy^b-$ | 670 | N - | 1916 | Vel+ | 27 |
| $Jk^a+$ | 1965 | P + | 5418 | K + | 107 |
| $Jk^a-$ | 617 | P - | 1793 | K+K+ | 42 |
| $Jk^b+$ | 1844 | $Lu^a+$ | 157 | K+K- | 483 |
| $Jk^b-$ | 640 | $Lu^a-$ | 1870 | K-K- | 13 000 |
| $Le^a+$ | 739 | $Lu^b+$ | 2007 | S + | 767 |
| $Le^a-$ | 3456 | $Lu^b-$ | 6 | S+S+ | 315 |
| $Le^b+$ | 2210 | $Xg^a+$ | 73 | S+S- | 1161 |
| $Le^b-$ | 951 | $Xg^a-$ | 21 | S-S- | 1888 |

Obviously, blood grouping has been performed to a different extent with respect to the different blood groups of the respective donors. While almost all donors are typed for Kell, only a few donors are typed for some other systems. But nevertheless, rare types are registered.

The numbers of donors positive for certain HLA antigens are given below:

| | | | | | |
|---|---|---|---|---|---|
| HLA-A1 | 4099 | HLA-B5 | 1602 | HLA-Cw1 | 524 |
| A2 | 7186 | B7 | 3614 | Cw2 | 1219 |
| A3 | 4138 | B8 | 2962 | Cw3 | 2839 |
| A9 | 1397 | B12 | 2193 | Cw4 | 2593 |
| A10 | 634 | B13 | 899 | Cw5 | 699 |

---

Footnote from previous page continued.

BDS Essen (Dr. Luboldt), BDS Frankfurt (Prof.Dr. Spielmann), BDS Freiburg (Dr. Fetta), BDS Giessen (Prof.Dr. Müller-Eckhardt), BDS Hamburg 62 (Prof.Dr. Heiss), BDS Hamburg 76 (Prof Dr. Hoppe), BDS Hannover (Dr. Eckert), BDS Köln 91 (Prof. Dr. Bube), BDS Köln 41 (Prof.Dr. Krüger) BDS Mainz (Prof.Dr. Arndt-Hanser), BDS Tübingen (Prof.Dr. Schneider), BDS Ulm (Dr. Spieß), BDS Würzburg (Dr. Gossrau).

| | | | | | |
|---|---|---|---|---|---|
| HLA-A11 | 1490 | HLA-B14 | 706 | HLA-Cw6 | 63 |
| A28 | 1099 | B15 | 1952 | Cw7 | 13 |
| A29 | 641 | B17 | 1174 | Cw8 | 4 |
| Aw19 | 58 | B18 | 973 | | |
| Aw23 | 245 | B27 | 1255 | | |
| Aw24 | 1311 | B37 | 319 | | |
| A25 | 362 | B40 | 1716 | | |
| A26 | 626 | Bw16 | 375 | | |
| Aw30 | 143 | Bw21 | 386 | | |
| Aw31 | 118 | Bw22 | 568 | | |
| Aw30/31 | 487 | Bw35 | 2592 | | |
| Aw32 | 600 | Bw38 | 221 | | |
| Aw33 | 33 | Bw39 | 181 | | |
| Aw32/33 | 2 | Bw41 | 61 | | |
| Aw34 | 7 | Bw44 | 1228 | | |
| | | Bw45 | 45 | | |
| | | Bw47 | 10 | | |
| | | Bw48 | 1 | | |
| | | Bw49 | 114 | | |
| | | Bw50 | 59 | | |
| | | Bw51 | 197 | | |
| | | Bw52 | 13 | | |
| | | Bw53 | 37 | | |
| | | Bw54 | 2 | | |
| | | Bw55 | 21 | | |
| | | Bw56 | 9 | | |
| | | Bw57 | 14 | | |
| | | Bw58 | 3 | | |
| | | Bw60 | 58 | | |
| | | Bw61 | 17 | | |
| | | Bw62 | 115 | | |
| | | Bw63 | 4 | | |

From the table it can be seen that rare HLA antigens and HLA antigens difficult to type are present at lower levels than expected. This may be due to uncertain results in HLA typing or due to the fact that very rare antibodies are not always used when typing blood donors.
Most requests for donors via central registration were submitted by our own transfusion service belonging to the Tübingen University Hospital mostly concerning platelet donors for bone marrow transplantation patients. In the case of one such young woman with very

extensive alloimmunization against HLA antigens, it was possible to treat her during the critical period until her HLA-identical brother could be flown in from Australia. The platelet products obtained were good with respect to amount, quality and rapid availability.
In one case, HLA-compatible donors from another transfusion service were sent to us for granulocyte separation within a short, critical period of time.
The requests from other transfusion services are shown below:

| | request for certain HLA type | request for certain blood group |
|---|---|---|
| 1980 | 27 (3x for bone marrow donor) | 1 (anti-C+e) |
| 1979 | 39 | 3 |
| 1978 | 48 | 0 |
| 1977 | 11 | 0 |

Through our central registration one donor for bone marrow transplantation identical for HLA-A,B,C,D and DR with compatible blood group was found for a transplantation done in Munich.
The apparently lower number of requests in 1979 and 1980 is due to the fact that since 1979 a complete file for each local transfusion service has been sent out three times a year so that the local donor pool could be used in a more efficient way.
Despite the fact that the system is working well, some problems still have to be solved to improve it further:

- fast and cheap communication via telex should always be available;
- the infrastructure of different blood banks varies; some of them are still in need of cell separators;
- it is difficult to separate those donors who are still either fully willing and/or able to continue blood donation from those whose status has changed to less availability; this updating is necessary, but difficult to implement;
- some blood banks are very short of man power making it difficult to get rapidly required blood products or those not readily obtainable in an optimal manner;
- HLA-typing and blood grouping results have not all been subjected to extensive quality controls;
- more experience and study is needed in the area of cell preparation transfer between centers.

Though further problems will have to solved, experiences have generally been good and progress in saving lives is being made.

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Chairpersons' Summary of the Discussion.

There seemed to be agreement that the series of papers of this first session had adequately covered the scope of transfusion medicine and of the tasks amenable to EDP support.

A vivid discussion was triggered by the last paper of SHUNTER and SCHNEIDER. Concerning the support of his activities, Prof. SCHNEIDER mentioned that he received lots of encouragement but failed to meet willingness to share the cost. The need for public sponsoring of the central registry of HLA typed donors is obvious.

It was also pointed out that tissue typing of donors is done at a number of other sites but that centrization would be considerably improved if data format and EDP equipment were standardized. This seems to represent a worth while task for the EDP specialists and the Society for Medical Documentation Informatics and Statistics (GMDS).

Finally, the issue of actuality and correctnes of the stored data was raised. Prof. Kluge cited an example where the search for a donor yielded two responses that indicated donors that were no longer active with two out of the four remaining yields being in error with respect to the exact blood type. This emphasizes the formidable problem of maintaining and updating such central registries which can only be improved by dedicated financial and organizational commitments.

J.R. Möhr
R. Roos

# The Integration of Blood Transfusion Service into a Central Hospital Information System

R. Klar

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In a historical review of the development of the Göttingen University Hospital blood transfusion service its decentralized origin should be considered which may be typical for many large hospitals. Several medical disciplines in the same hospital had their own blood transfusion services which were relatively poorly equipped but were fully integrater into their funding disciplines. Only lately was the "service" developed into "transfusion medicine", an independent scientific branch of medicine. In this context and in order to render them more efficient the several transfusion services were centralized and are now seen as a normal medical discipline headed by a physician. This centralization and specialization led to great recent advances in transfusion medicine but may also result in bureaucracy, lack of transparency, isolated points of view, incomplete communications between hospital departments, etc. Such problems are typical for modern medicine.

## Objectives of the Integration

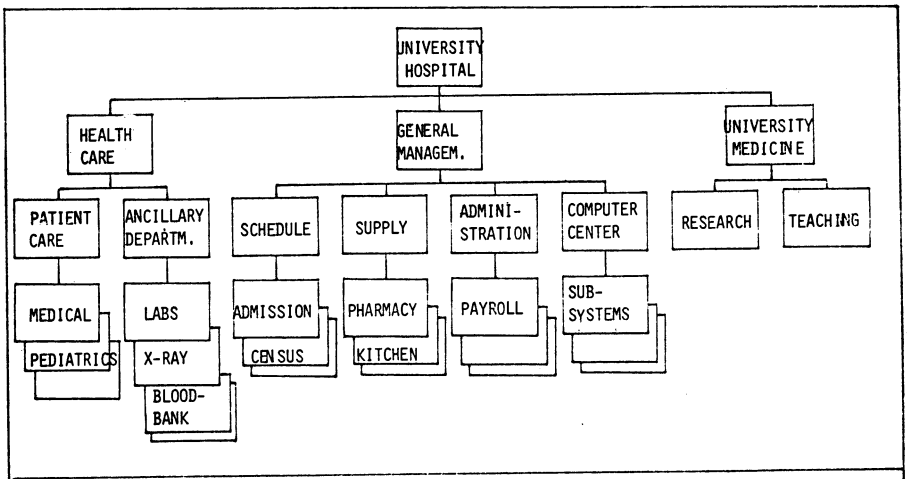
A hospital information system (HIS) can help to solve these problems. The most recent book about HIS (7) describes this situation drastically as a "Balkanization of medizine" but also presents a lot of EDP methods for improvement. In accordance with WARNER (11), COLLEN (1) and LINDBERG (7), Fig. 1 shows the objectives of a HIS.

The realization of HIS is generally oriented on the basic structure of the hospital. Fig. 2 shows the parts of a university hospital (see also COLLEN (2)). Only the main dependencies are drawn as connecting lines. The blood bank (a short term for blood transfusion service) in this model belongs to the ancillary departments and not to the supply systems, as sometimes mentioned (12). Therefore, acquisition and distribution of blood differ necessarily from those of other stock articles.

- IMPROVEMENT OF COMMUNICATION:
  SUPPORT FOR MANAGEMENT, CLINICAL AND
  ADMINISTRATIVE ROUTINES

- EFFECTIVITY AND EFFICACY IN DOCUMENTATION,
  I. E. DATA COLLECTION, UPDATE, SORT, STORAGE
  AND RETRIEVAL

PIC. 1 THE MAIN OBJEKTIVES OF A HOSPITAL INFORMATIONSYSTEM



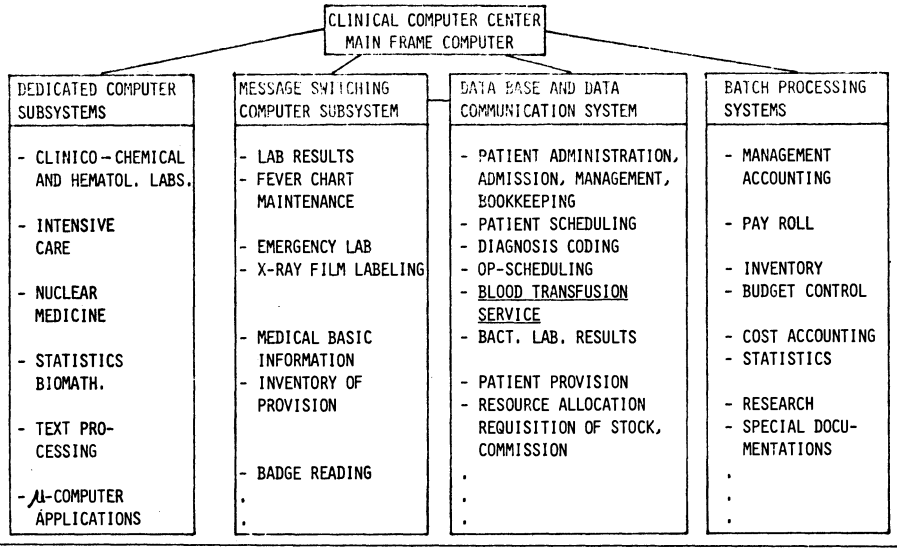

PIC.2: STRUCTURE OF A UNIVERSITY HOSPITAL

Fig. 3 presents the information system of the Göttingen University Hospital as an example of a functioning computerized HIS (4). Four main EDP structures are shown. The computer applications for the transfusion services are part of the data base and data communication system (DB/DC) which is implemented in the large host computer of the clinical computer center. Of course, other EDP concepts are realised and described (synopsis by PAGE (8), EGGERT et al. (3), JURANEK et al. (5) and the present proceedings). But, in our opinion, the centralizing concept using a commercical DB/DC-system specially supports the integration of the transfusion service into a HIS.

Fig. 4 demonstrates the 3 main objectives of this integration: the connection of the flow of information, sharing in the resources of other clinical departments and of the computer center. The last mentioned objective emphasized that, in the normal case, there should be no internal computer department within the transfusion service; the use of computer support is essential for the transfusion service but should be made possible by the central computer department of the hospital - if available. The permanently falling costs of hardware may allow the purchase of an internal computer. But the performance, the system software, the file management, and the restart and recovery procedures, etc. of an internal computer will generally be less effective than those of a main frame computer. The permanently rising costs of software and EDP manpower should emphasize the necessity of sharing in EDP specialists of the clinical computing center. System analysts, programmers, operators, etc. are necessary not only for developing an EDP-system but also for error corrections, improvements and for the production run of the program. Great advantages can be achieved if the EDP specialists are available nearby, but they do not have to work exclusively for the transfusion service.

## Forms of Integration

The possibilities of the integration of transfusion service into a HIS are shown in Fig. 5. As for the transfusion service, the connections with the subsystems of administration, supply and research are drawn mainly in the upper part, those with the subsystem of the health care services are presented in the lower part. The transfusion service is divided into three main parts, referring to the donor, the blood, and the recipient.



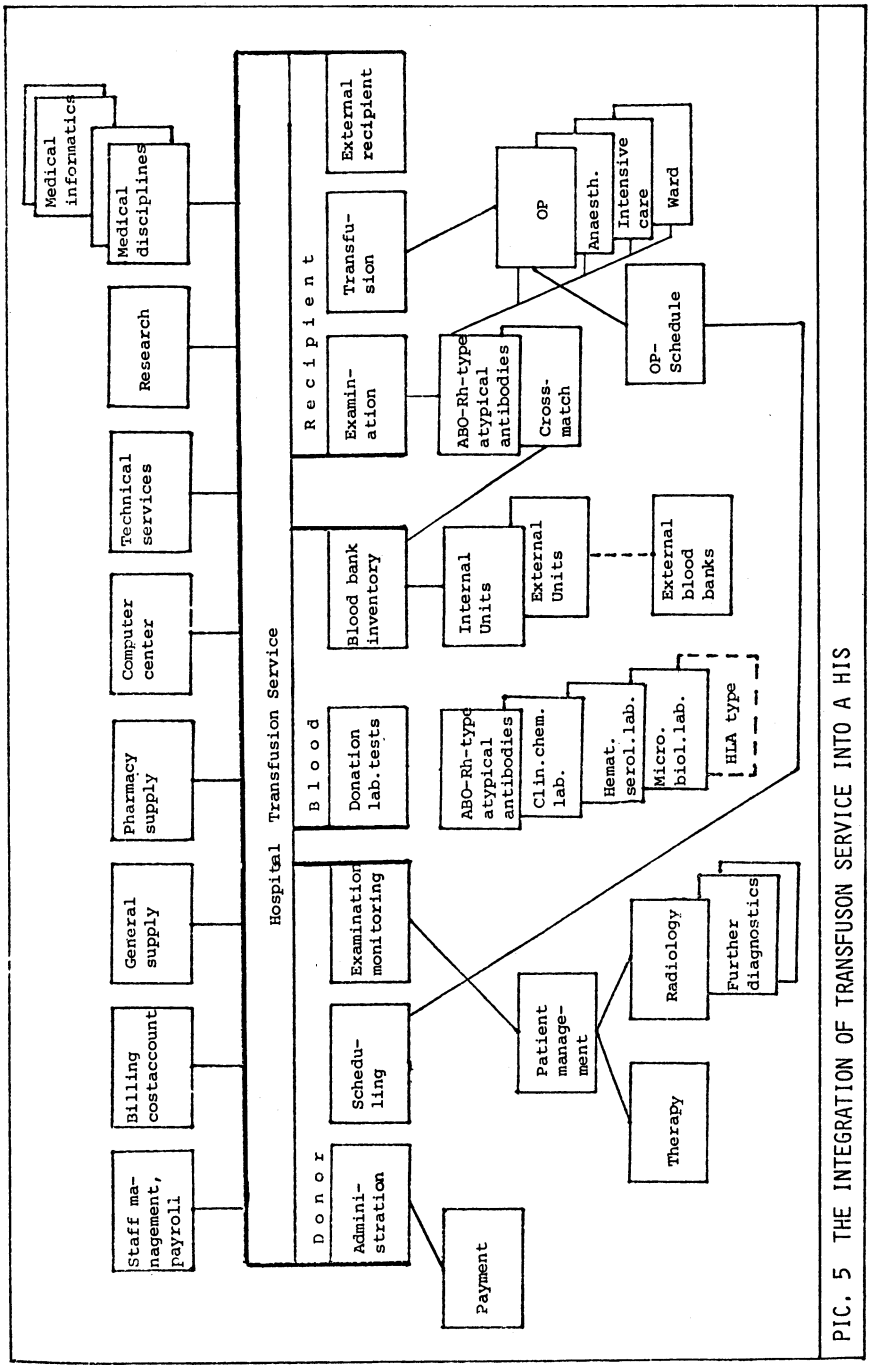

PIC. 3: THE CLINICAL COMPUTER CENTER OF THE GÖTTINGEN UNIVERSITY HOSPITAL. THE COMPUTER APPLICATIONS OF THE HOSPITAL INFORMATIONSYSTEM OR REFERRED TO FOUR BASIC HARD- OR SOFTWARE SYSTEMS.

1.) CONNECTION OF FLOW OF INFORMATION.
- LESS REDUNDANCY (E.G. LESS MULTIPLE ANALYSES FOR THE SAME PATIENT)
- BETTER, MORE AND FASTER COMMUNICATION
- AVOIDANCE OF UNCONTROLLED LOST OF BLOOD
- NO WRONG BLOOD FOR THE PATIENT

2.) SHARING IN THE RESSOURCES OF OTHER CLINICAL DEPARTMENTS
- LABORATORIES
- RADIOLOGY

3.) SHARING IN THE RESSOURCES OF THE COMPUTER CENTER
- HARDWARE
- SOFTWARE
- EDP MANPOWER

PIC. 4 AIMS OF THE INTEGRATION OF THE BLOOD TRANSFUSION SERVICE WITHIN A HOSPITAL INFORMATION SYSTEM.




PIC. 5 THE INTEGRATION OF TRANSFUSON SERVICE INTO A HIS

## Donor-oriented Connection with the HIS

The information about the blood donor can be structured into administration, scheduling, medical examination and monitoring of the donor. There are only few connections to other parts of the hospital, e.g., in hospitals where donors are reimbursed (like in Göttingen) their checks are printed on-line after the admissions dialog, and all necessary information for the budget control of the hospital (on-line) and the accounting system (batch) is prepared. An admission and scheduling system support several internal information flows and an important connection with the recipient-oriented part of the HIS. Already in 1973 ROOS and BUSCH (9) presented detailed concepts for such connections. In this context, a scheduling system for donors, whose blood is required the same day for planned transfusion, e.g., heart-lung machine operations, is most important to guarantee careful coordination of donation and transfusion. In Göttingen, the operation plans of the dialog system for OP-scheduling are used for these purposes by the transfusion service.

For medical examination, to check and monitor the donor's health and ability for donation, the donor, with the aid of the computerized patient management system, is led to the Dept. of Radiology, Dept. of Internal Medicine and, possibly, to various other diagnostic or even therapeutical departments of the hospital. In such cases, the donor and his/her data are managed and treated like a normal outpatient; however, the automatic billing procedure is suppressed.

## Blood-oriented Connection with the HIS

After the blood donation different labs perform various tests. The tests that are carried out externally are of special interest for this paper. In these cases, the classical problems of clinical laboratory medicine arise: different ways of transportation of specimens and requests, linkage of requests and specimens within the lab, transmission of the test results back to the requirer, medical record linkage for all test results and further data of the tested person.

The solution of these problems can be supported by computer methods like positive specimen and request identification by automated reading methods, on-line transmission of results and, in special cases, of the request to the transfusion service and to the data base.

On-line interfaces of the automatic analyzers can fullfill these demands in a well known way shown in the process of automatization of clinico-chemical and hematological labs. These labs should also be used for the transfusion service in cases of breakdown and overloading of the internal analyzers. But the procedures of internal and external labs must be standardized. At Göttingen University Hospital the analyzers (Coulter Counter, Groupamatic, enzyme analyzers are not yet on-line connected to the computer. But this linkage has been realised for several years for the clinico-chemical and hematological central labs. A specially dedicated computer system works for these labs and transmits the results via clinical computing center to the wards and central data base. By using this model it should be possible to transfer the results of blood tests to the blood bank data base in a fast and less error-prone way.

Microbiological tests are often performed in an external lab, and automatic analyzers are rarely used. With the computer terminal of the bact. lab in Göttingen, an on-line transmission might be possible but is not used. A telephone call for the very few positive results and a batch-generated list for all other microbiological blood data are sufficient.

The surveillance of the blood bank itself in the form of a permanent inventory, which in Göttingen is performed in a dialog program system for the general supply an the pharmacy, does not seem to be necessary at our stage of computerization and there are only a few direct connections with the HIS. The receipt of blood and blood component units from external blood banks as well as the return of unused blood or the delivery of own units to other blood banks are registered in the blood bank data base and handled by the financal and administrative systems.

## Recipient-oriented Connection with the HIS

For every potential recipient of blood or blood components, i.e. about 60 inpatients per day, the blood group (ABO-Rh-system) and irregular antibodies are determined already at the beginning of his/her stay. With only a few exceptions, the transfusion service alone performs these tests and the cross matches for all clinical departments. With regard to a HIS, the above mentioned linkage problems of laboratory medicine are to be solved. In addition to the diagnostical tasks of

the normal clinical labs, the labs of the transfusion service are also responsible for therapeutical surveillance, i.e. for the preparation and control of the transfusion. In spite of these facts, it does not seem to be necessary to build up a special communication system for the tasks of the transfusion service in and for other hospital departments; The existing transport and transmission media should also be used for the purposes of the transfusion service. At Göttingen University Hospital the small automatic transport medium (telelift) carries specimens and requests from the diagnostic and treatment units to the labs. The message switching system, mentioned in Fig. 3, sends the lab results back to the wards, OP-office, etc. which are all equipped with very inexpensive telephone terminal sets. More than 70 telephone terminal sets, consisting of a telephone, a TV-set and a miniprinter, are spread over the whole hospital and connected via a front-end computer with the host computer of the clinical computing center. The DB/DC-system supports this connection and performs the data management in the databases.

As mentioned above, the lab results of the clinico-chemical and hematological labs are automatically handled in this way, and in the near future this will also be done for the blood type results. With this method the service for the wards will be improved; a quality control by retrieving previous findings can be supported for the lab; unnecessary multiple determinations for the same patient can also be avoided, and highly valid and reliable data is stored for research purposes. As of now, the information on a patient's blood group is not entered as near to the origin of these data as intended but in the Ward offices by a special dialog program for the support of basic medical data (KLAR et al. (6)).

SHERER et al. (10) have developed and tested three automatic donor-recipient identification systems as a means of reducing human errors. None of the systems proved acceptable under clinical conditions. We had undertaken similar attempts with bar code reading in 1975. But in the meantime further developments were successfully implemented and will also support the integration of a transfusion service in a HIS (ref. to the present processings).

The coordination of blood donation and planned transfusions has been mentioned above. Most orders for blood and blood components units can be met by using the buffer of the blood bank. Different form of distribution are possible (PAGE (8)). In Göttingen, we deliberately do

not apply the common dialog program system used for material requests for blood requests. For orders of blood and blood components from surgical operating theatres the transfusion service receives the entire record of operations one day ahead: patient identification, diagnoses, risk factors, operation, surgeons, anaesthetists, blood group, estimated number of units etc. With this information from the HIS the physician in the transfusion service can decide more easily about type and quantity of needed blood or blood components respectively. On the other hand the ordering person does not have to inform the transfusion service about this data.

A special communication system does not yet exist for all requests coming into the transfusion service from outside the OP-region.

The documentation of the requests and especially of the transfused units and the result of the transfusion can be supported by HIS for every department involved. E.g., in Göttingen there is a separate dedicate computer system for the intensive care units and all transfusion data is processed by this ICU system. The anaesthetists, who are responsible for most transfusions, keep the records of anesthesia and transfusions on a special form which contains patient and unit identification, unit type, infused quantities etc. and which can be used as a data entry form for further computerized evaluations. The above mentioned OP-scheduling system includes a post-operative part for data entry and storage of transfusion data. Of course, the blood transfusion service and the central archive receive a feed-back about the units used or not used. This information is as yet still written by hand in the computer-prepared lists of blood units. Further computerized procedures are known and will perhaps also be introduced in Göttingen.

## Summary

In general, EDP applications for a hospital transfusion service start by supporting the administration of donors' data. This can be done almost independently of a general and patient-oriented hospital information system (HIS). This autonomous start within EDP should not lead to further independent programs which neglect important surrounding clinical interactions. Various connections between the transfusion service and other parts of the hospital can be successfully built up and managed by the computer. The integration of the transfusion

service into HIS supports the transfusion service itself as well as the overall services of the hospital.

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# Experiences with Distributed Data Processing in Blood Transfusion

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## 1. System design

For the last thirty years, the frequency of blood transfusions has been continuously increasing. At the same time, the demands for blood components and for a differentiated selection of blood units increased. Information handling using traditional tools became difficult, was defective and produced intermittent shortages or excesses in bloodbank inventory. Therefore, in the University Hospital Eppendorf (Hamburg) electronic data processing has been used since 1970 for supporting blood transfusion activities. The information system for the Department for Transfusion Medicine in the University Hospital Eppendorf described in this report has been operable since 1979. The development of TRAMIDIS (Transfusionsmedizinisches Informations- und Dispositionssystem) had been sponsored by the Bundesminiterium für Forschung und Technologie (Federal Ministry for Research and Technology). The main interests in building up this information system were the following:

- to guarantee the supply of the hospital with blood and blood components by
  - -- improving the efficiency of the donor pool without additionally burdening the single donor;
  - -- getting a better donor retrieval;
  - -- reducing the rate of outdated blood;
  - -- applying methods of operations research in donor administration and inventory policy.
- to improve medical check-up for donors for preventive-medical reasons.
- to reduce human errors in preparing blood transfusions.

The system was intended to control the information flow and to be the basis for decision making in blood transfusion service. Therefore

- the stored and processed data had to be topical. For this purpose, data acquisition in a machine-readable form has to be guaranteed around the clock seven days a week
- the data has to be correct
- the data has to be complete.

A distributed data processing system was developed which is dialogue-oriented to a very high extent. Though the data should be stored in a central data base which is situated in the central computer - the master node -, each of the different sections-"donor", "inventory and recipient" and "laboratory" - were provided with a small computer - satellite nodes - playing an exactly specified role in the overall system (see Fig. 1).

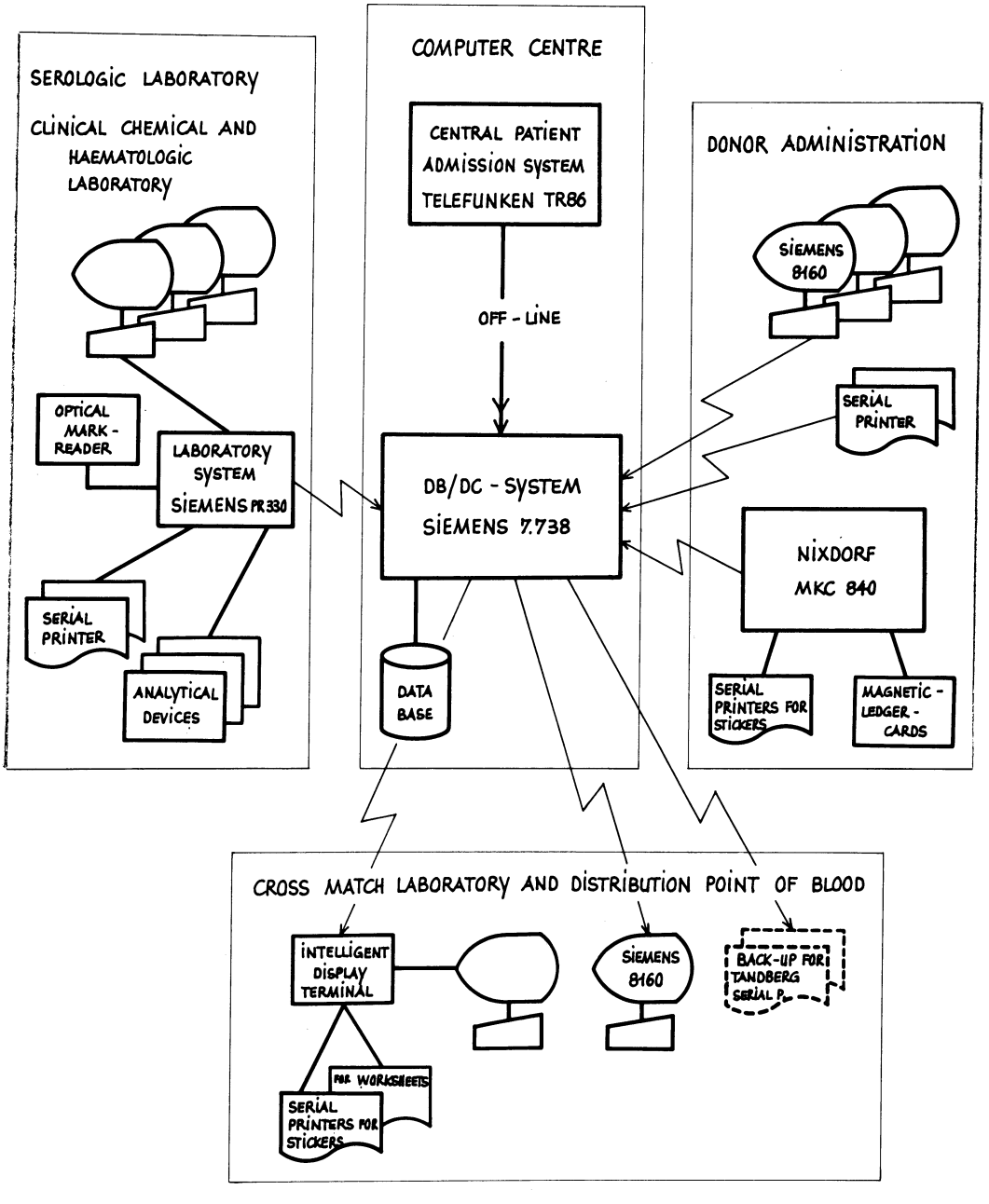
Siemens computer 7.738

The db/dc-system (data base / data communication-system) is operable on a Siemens computer 7.738.
The connected display terminals are used data entry (e.g. for donor administration) or for retrieval (e.g. donor retrieval).

Nixdorf MKC 840

The magnetic ledger card computer MKC 840 is specialized for the following tasks:

- updating a magnetic ledger card index which is eye- and machine-readable. This card index is used for checking the identity of the donor numbers read out from the donor identity card and from the magnetic ledger or from the data base respectively;
- storing machine-readable data outside the central computer, and
- presenting the updated data in an eye-readable form for normal office activities;
- printing worksheets, journals and stickers before donation takes place,
- and if the central computer is not operable, storing the data originating from donations on a magnetic tape until the data base can be updated.




pic. 1 TRAMIDIS - hardware system

Desk computer TDV 2114

There are three peripheral devices connected to the desk computer: a video display unit and two serial printers for producing worksheets and stickers. When the central computer is operating, the desk computer acts as three local terminals of the central computer using its intelligence to emulate the device interfaces and to switch data streams. But when the central computer is not in working order, the desk computer is used for data entry and data storing, checking the entered data with almost the same rules as the central computer would do but without any context check to the data base.

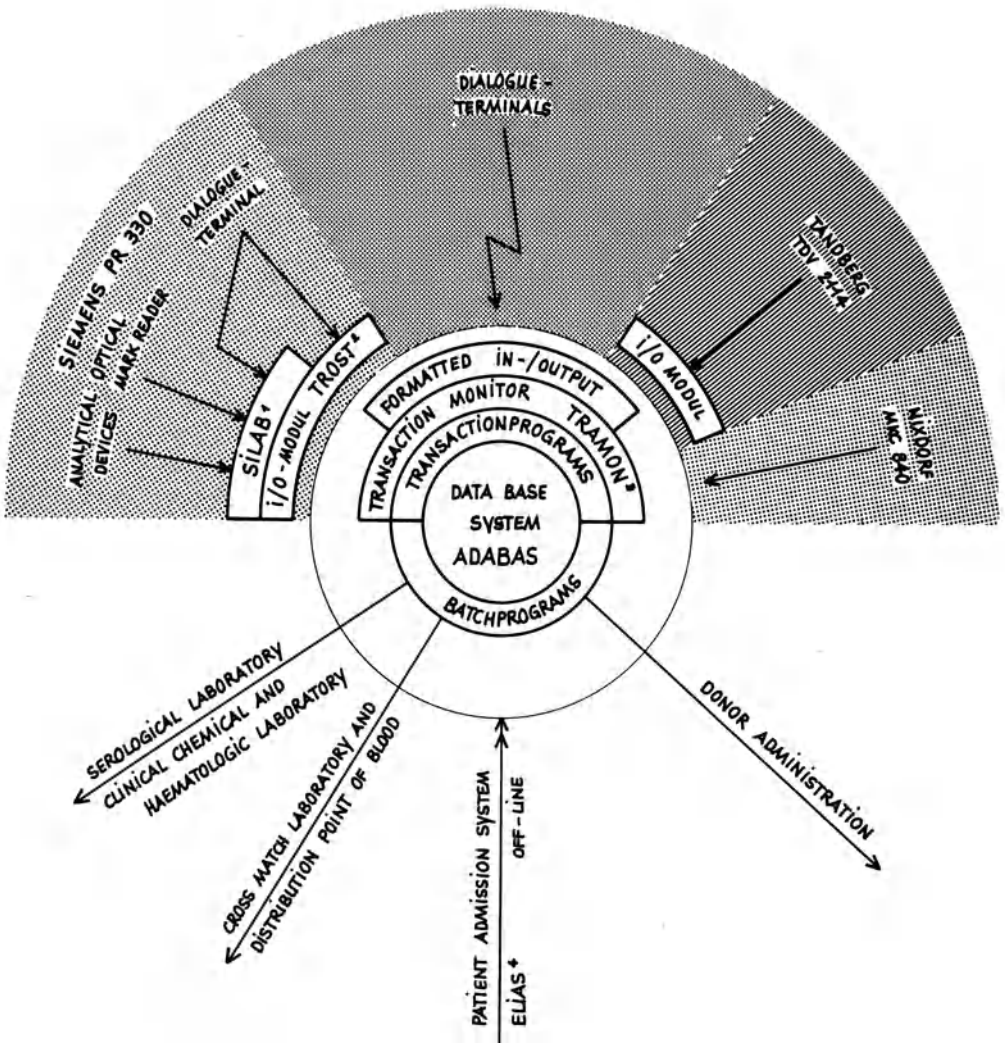
Real-time computer PR 330

The hardware of the data processing system for the medical-chemical, haematologic and immunologic laboratories is a Siemens computer PR 330. The laboratory requests may be directly entered at the video terminals of the PR 330 or may be transmitted via the 7.738 when entered at the MKC 840 or the desk computer. There are only temporary files on the PR 330, long-term data storage being carried out by the db/dc-system.

Real-time system TR 86

The system for patient admission runs on the real-time system TR 86. The recipient file of TRAMIDIS is updated off-line by this system at least once a day. Thus, in TRAMIDIS there normally is a direct access to the personal data of in-patients, their status and their actual ward without any assistance by the medical staff in the transfusion service.

Fig. 2 illustrates the connections of the computers on the software level. There is a very intensive data communication almost exclusively within the transaction system, thus avoiding file transfer. In this software solution a mode of operation exists by which the display terminals of the satellite node PR 330 have equal access rights with the terminals directly connected to the master node.
The star structure at the hardware level corresponds to a star structure at the software level. The different systems play different roles concerning the db/dc-system. This is determined to the working conditions existing when the db/dc-system fails. In this case, the desk computer changes its role and is used only as a comfortable and powerful data entry system. On the other hand, the MKC 840 and PR 330 go on working but without having access to data base. Therefore, the data has to be stored in temporary files of the satellite nodes until the data base update can go on again.




1 SILAB SIEMENS-LABORSYSTEM
2 TROST TRANSAKTIONS-ORIENTIERTES-STEUERUNGSSYSTEM
3 TRAMON TRANSAKTIONS-MONITOR UNI-KLINIK EPPENDORF
4 ELIAS EPPENDORFER LABOR-, INFORMATIONS- UND AUFNAHMESYSTEM

pic. 2 TRAMIDIS - software system

## 2. Experiences

The system has been operable since 1979. Until that time the MKC 840 had been working for a longer period. It, therefore, had to be integrated into the overall system. The experiences gained since that time show some pitfalls and hazards of a system approach based upon distributed data processing.

- Synchronization
  The most dangerous pitfall of the system presented is hidden in the sometimes lacking synchronization of file update, which may occur when the master node is not operable or when data transmission from the patient admission system is interrupted or comes in late. When, in these cases, laboratory requests are processed, personal data may be entered which are not compatible to the data that will later be transmitted from the patient admission system. There is another reason for diverging data:
  when a data base update is directly entered on the terminal of the master node, a search for another occurrence of the updated record in the various satellite nodes is omitted because of the resulting heavy overhead.
  This is why complex rules were set up as to how to proceed in record linkage.

- Compatibility
  TRAMIDIS does not include homogeneous hardware. The dialogue programs communicate with different display terminals connected to different computers. Therefore, renouncing some desirable features, a virtual terminal for all computers in the star had to be defined.

- Complexity
  The system design for a distributed system is more complex than that for a single computer system. The presented system may fail in parts, thus leading to different situations with regard to the consistency of data. This has to be taken into account in program design.

- System structure
  The distributed data processing system is structured like a star. The db/dc-system is the master node to which the satellite nodes are connected. Data flow control is maintained by the central node. Local data flow control within the subsystems is done by the satellite nodes. If there is a failure of the master node, the system disintegrates into independent dedicated systems with no data communication between

them. A ring structure or a fully connected configuration would have more redundant communication paths. To achieve such a system would be much more difficult

- Suboptimization
  In this project the existing MKC 840 was to be integrated into the system. The information flow in this satellite node was formerly fixed to give an optimal support of donor administration as a stand-alone system. But the former optimum within the satellite node prejudiced the total system design and turned out to be a suboptimum within the overall system.

- Manpower expenses
  In the computer centre there is greater need for manpower than for a single, maybe larger computer system. First of all, more specialists have to be familiar with more operating systems; furthermore, programming in different programming languages places a burden on the staff of the computer centre and, last but not least, the operating is more complicated.

The most important advantage of the distributed dp-system is without any doubt the

- higher availability for data entry and process control. If one node fails, the remaining nodes continue to work with a slightly reduced performance. The system structure and the organizational concept are outlined in a way that the working areas remain fully operative even if a satellite node fails.
  With this system, the goal of a permanent data acquisition for on-line od off-line data base update is fully accomplished. The basis for a computerized support of decision making is given.

- Modularity
  The benefits resulting from a modular system are:

  -- the system components can be set in operation successively;

  -- arising errors normally have limited consequences in a distributed system;

  -- trouble shooting is easier. The affected system is comprehensible, or a necessary shutdown of the affected system does not require a coordination between several users.

- Transparency
  The users in the working areas normally communicate with their corresponding node which is, because it is smaller, more transparent than a huge and complex computer system. They are motivated to a higher extent because they work with their own system.

## 3. Conclusion

The benefits of distributed data processing outweigh the drawbacks. Especially two points support the use of this distributed system: the higher availability of the overall system or individual urgently needed system's components and the limited consequence of failures. The system design has been essential for the system being accepted by the medical staff so soon. The above quoted goals for improving blood transfusion service have been attained.

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# The Laboratory Data System as an Integral Part of an EDP System for a Blood Donor Service

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## 1. Introduction

Within the regional blood donor services of the German Red Cross some 2 million blood donations have to be processed per year. Their related data have to be generated, acquired, processed and archived. The volume alone is reason enough to apply EDP. This has been recognized early in the 70ies within the blood donor services of the German Red Cross (DRK) of Rheinland-Pfalz and Niedersachsen (Lower Saxony). Within these institutions smaller EDP systems were installed as a consequence. These were to support subdivisions of a blood donor service such as donor administration, labautomation, the disposition of blood units and blood products but also the administrative sector.
The experience gained prior to the year 1975/76 was incorporated in the systems which are now in operation. These rely on data bases and affect integrativelly all areas of a blood donor service.

## 2. The scope of laboratory investigations

A considerable volume of data in the context of a blood donation is generated in the laboratory. EDP support has to account for the requirements set up by the Bundesärztekammer with respect to the technology applicable to blood group determinations and blood transfusions (1). The guidelines specify the laboratory tests that are required for a release of a blood unit.

These comprise the following programme:

1 Blood typing serology

a) Determination of blood type characteristics -ABO-, Rhesus-, Kell-, others

b) Antibody determinations

- Isoagglutinins, hemolysins

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Translation by J.R. Möhr on the basis of a condensed version of the paper delivered in German.

- Search for and determination atypical or irregular antibodies

2 Lues serology

- TPHA test
- eventually FTA/ABS test
- eventually flocculation test (e.g. CMT)

3 Hepatitis serology

- $HB_s$ Antigen determination (RIA or EIA)

4 Clinical Chemistry

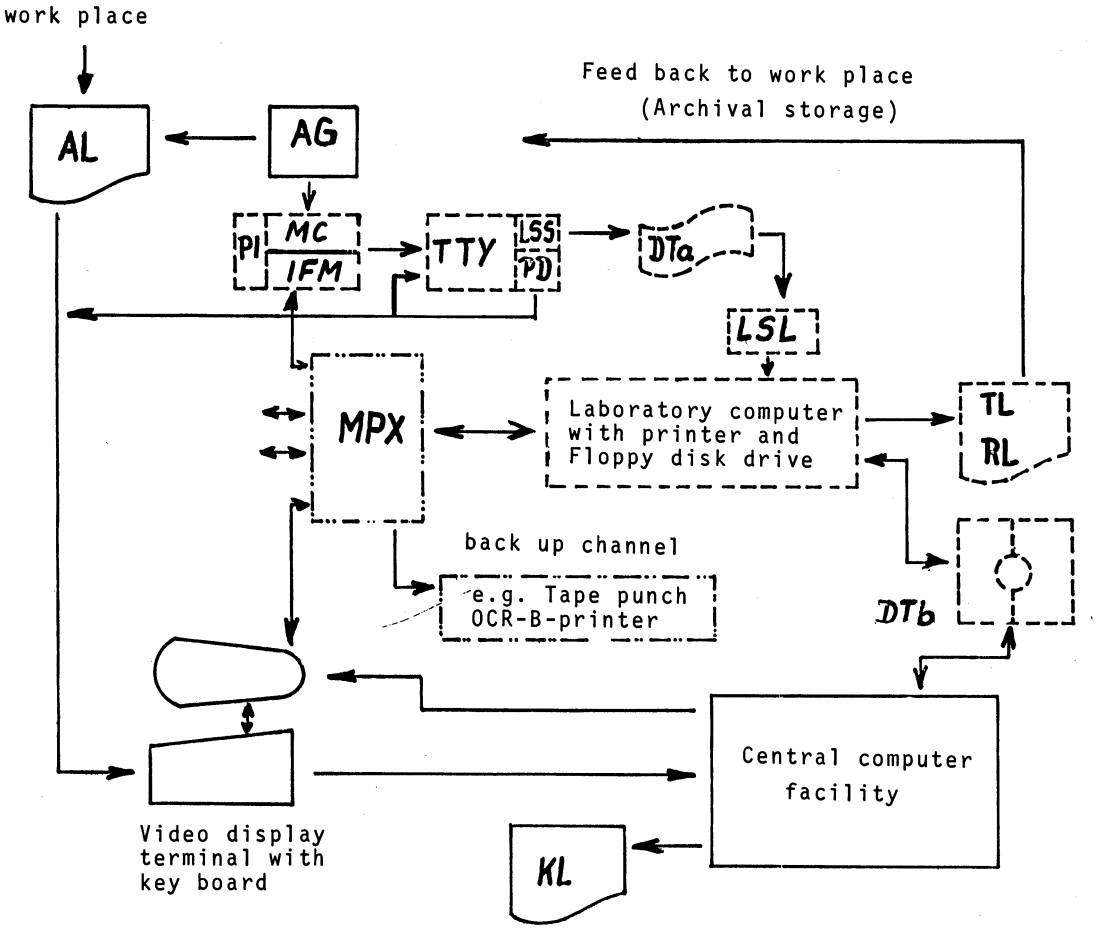
- SGPT determination.

A significant characteristic of this spectrum of laboratory tests is the different data structure of the results. This complicates automated processing.
Particularly the results of blood type serology pose problems since they involved a historically evolved nomenclature.
Since so far no norms have been agree upon - neither nationally nor internationally, the mode of presentation is applicable, which is described in the guidelines and regulations referred to above. It is possible to use internal abbreviated codes in communication between laboratory and EDP system. However the required mode of representation has to be used in the declaration of the blood unit.

## 3. Possibilities for integration of laboratory data

An important task for integrating the laboratory system into a common EDP system for a blood donor service consists in the delelopment of a concept for optimal acquisition and processing of the different structures of data. This can be achieved by stepwise extension of the laboratory system while paying particular attention to a flexible processing of laboratory data and minimal disturbance of the system. The current status of technical laboratory equipment and the work processes within the laboratory facilitates this kind of procedure.

In a laboratory with minimal application of automatic procedures the interface via terminal is adequate. The results of analysis represented in work sheets can be transferred to computer for evaluation, analysis and compact presentations.




Stepwise extension of Laboratory System

Figure 1

1. Extension steps

   Step 1: ————
   Step 2: – – – –
   Step 3: – – –

2. Hardware components

   | | |
   |---|---|
   | AG | analyzer |
   | IFM | interface module |
   | MC | micro computer |
   | PI | sample identification |
   | TTY | teletype |
   | LSS | Tape punch |
   | PD | printer |
   | LSL | punched tape reader |
   | MPX | multiplexer |

3. Listings

   | | |
   |---|---|
   | Al | Work sheets |
   | KL | control listings |
   | TL | daily listings |
   | RL | remaining items |

4. Data carriers

   | | |
   |---|---|
   | DTa | Punched Tape |
   | DTb | Floppy disks. |

The link to a central computing facility results frequently in an undesirable "one way effect" in the direction of the central processor.

This effect may be some what moderated by the issuing of various control listings. However their use is consuming considerable time and personnel. The expected rationalization effect is also hardly discernible since a lot of monotonous work at the terminals has to be accomplished in addition to the manual analysis. This may be associated with an increasing number of errors if the data volume increases.EDP application may therefore be sustainable only for a limited period of time under these conditions.

If data processing is consecutively extended to a decentralized laboratory system, this initial stage of EDP remains only relevant as a back up for the decentral EDP system for data acquisition.

In order to really utilize the advantages of EDP in face of the large quantities of data, it is necessary to automate the laboratory procedures as much as possible. The increase of the cost of laboratory equipment may be a limiting factor, however.
A reasonable solution consists in the creation of modular autonomous analysis equipment. This concept has been developed particularly by the Laboratory Data Processing Group (Arbeitsgruppe Labor EDV) of the Medical School Hannover (2).

These analyzers may be used independently of an EDP system. End-results are, however, presented at the exits of these devices in a uniform standardized manner and completed with identification data. The record structure should comply with recommendations established by a group of experts of the GMDS (3).

The availability of high level low cost micro computers decreases the problems of adaptation and integration in a laboratory system because these may be used for the purposes of evaluation and formatting of such data, on the basis of such standardized interfaces.

Their application for data acquisition and preprocessing increases also the flexibility of laboratory computing, since the microcomputers used for evaluation may be adapted to desired or necessary improvements through programming or exchange of PROMs or EPROMs.

The results of analysis determined by such modules may be transmitted off line as well as on line to a hierarchically superimposed laboratory computer for condensation and processing and may then be

transmitted to a central computer facility. (figure 1, stages 2 and 3)

Sample identification can most easily be achieved by using the serial blood unit number. This may be recorded including the data in an intermediary file for each day. This procedure involves the handling of a person's identification only within the laboratory. This situation is in good accordance with the German legislation pertaining to data confidentiality.

In our system there are fields reserved within the records of the sample number file. These receive the laboratory parameters required for release of a blood unit as they become available during the day. Transmission to the central computer is only effected if all required laboratory results are available. Incomplete data sets are identified as remaining records and retained within the laboratory computer.
This protects the central computer against incomplete data sets and enforces workup of the missing laboratory investigations.

Complete interleaving of laboratory system and central computer includes finally a confirmation from the central computer concerning the acquired complete data sets, and eventually also refused data sets including an explanation of the refuse. This completes the information loop between laboratory system and central EDP facility.

## 4. Conclusions

Consequently a satisfactory integration of a laboratory system into a comprehensive EDP system for a blood donor service has to observe the following principles:

1 Laboratory and EDP Service of a blood donor service should cooperate offline since they represent separated subunits, not only functionally, but also with respect to direction and responsibility. This kind of cooperation has the advantage of decreasing technical demands as well as costs and decreased susceptibility to errors and failures.

2 Equipment (analyzers), computer hardware and software should be composed modularly for increased flexibility. Software should support simple dialogue modules which may be used and adapted within the laboratory without EDP specialists.

3 Data structures should be configured uniformly and simply for simpler processing. The work place should issue the result and related identification number

4 The results of different work places should be processed within the laboratory computer so that actual information concerning the analyzing procedures is available and that only complete records are transmitted to the central EDP facility.

5 A confirming feed back from the central computer is particularly important.

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# ON-LINE DATA ACQUISITION IN THE LABORATORIES OF THE RED CROSS BLOOD CENTER OF ULM (GERMANY)

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## 1. Advantages of Data Processing in the Laboratories

Among several possibilities of data processing in the laboratories of a blood center, on-line connection of automated laboratory equipment is the best way to achieve economical and safe data acquisition. Furthermore, data processing in the laboratories of a blood center is expected to achieve:

- sample identification, either directly or by print out of working lists,
- control readings of blood groups,
- the assembly of all laboratory data and control of further blood processing,
- documentation and storage of all data,
- quality control.

These were our expectations when we started to install data processing facilities in the laboratories of the Red Cross Blood Center at Ulm about three years ago. Since data processing systems of other blood centers could not be used without major modifications, we decided to develop a system of our own.

## 2. Configuration of the EDP Hardware

After requesting offers and looking at those received, we decided on a NOVA 3/D of Data General, which configuration is given in Figure 1.

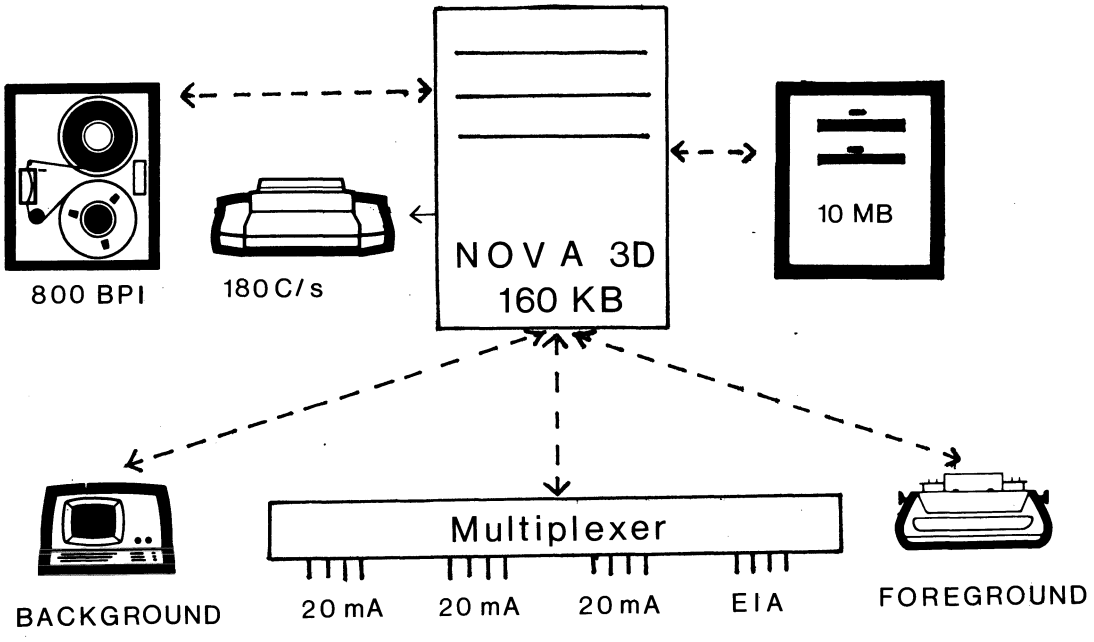


Fig. 1: Configuration of the EDP hardware

The laboratory equipment and the CRT terminals of the laboratories are connected directly or via a microprocessor to the multiplexer of NOVA. Data transmission between the laboratories and EDP takes place by four-wire telephone lines. The maximal line length is about 200 meters. Due to the long lines, we preferred to use 20mA current loop connections.

## 3. Transaminase Laboratory

The first laboratory where we installed EDP was the transaminase laboratory. The devices of the laboratory are given in Figure 2.

Basically we tried to get almost all data which are produced in the laboratory as electrical signals and to transfer them to the EDP system on-line. Of course, sometimes manual data acquisition is necessary. Also a lot of data has to be displayed for control and correction purposes. Furthermore, messages, error messages, and information for quality control have to be passed from the computer to the laboratory. Therefore, we installed a CRT terminal in each laboratory.

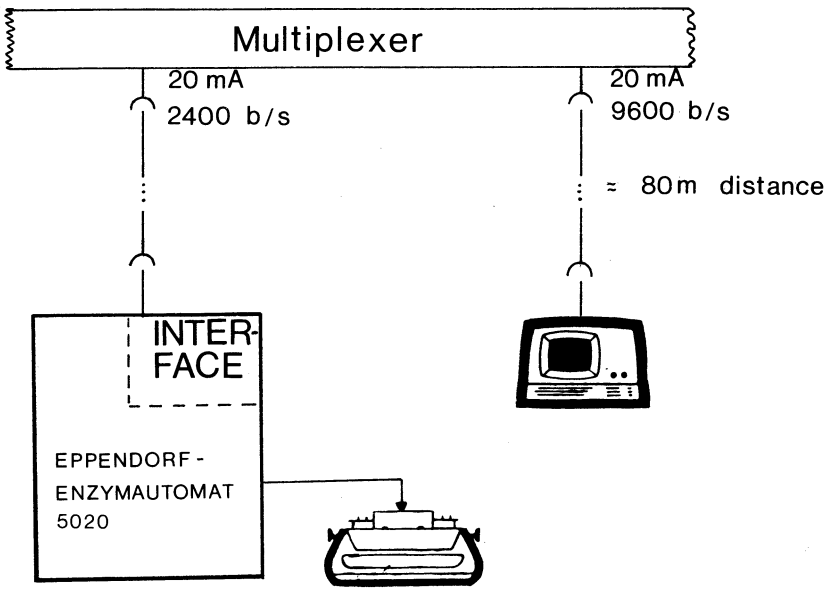


Fig. 2: Devices in the Transaminase Laboratory

Transaminases are determined by an Eppendorf -enzyme-analyzer which is now connected to the data processing on-line. The identification of the samples takes place with the CRT terminal. Therefore, the numbers of samples under investigation are typed into the terminal. Of course, not all the numbers of all the samples have to be typed.

It is sufficient for the technician to put in the location of the blood donations. The computer already knows, which blood bag numbers - which are identical with the numbers of the sample tubes - have been used at this location.

The laboratory technicians can use the CRT terminal for general output and for requests, e.g., the values of all control samples, the values of all samples or the value of anyone sample can be displayed. Values which are outside the expected range are stressed optically and by a peep sound. There were no problems with the on-line connection of this analyzer. Although the machine has already been in operation for 7 years, its manufacturer installed a 20 mA current loop interface with a velocity of 2400 bits per second.

In programming the service routines for this analyzer, we had no serious problems. Merely for the recognition of the zero values and the

We had no problems in building the interface for the W&W gammacounter. Only a few measurements and tests were necessary. However, programming for data acquisition from this gammacounter raised several problems. First, the computer gets all the information which is passed to the printer from the gammacounter as one data block. The lengths of the data blocks are different and they contain headlines, meanes and so on, as well as the data themselves. The end of a data block indicated by a carriage return and line-feed is transfered as the first character of a new data block. To overcome this, we stored the data in a circle buffer. The circle buffer is checked for data values in time slices. In case data values are present, they have to be passed on the processing unit. The programs for all other laboratory equipment and for the terminals filled one task each. Only for the W&W gammacounter were two tasks necessary. One task consists in organizing and controlling the circle buffer, selecting the values and passing them to the second task which processes the values.

In contrast to the W&W gammacounter, the LKB gammacounter has no intelligence. The laboratory technicians had to compute the final results from the output of the counter. This work is now done by the computer which saves time and mistakes. For the on-line connection of this counter we had problems with the hardware. The printer connected to the LKB counter does not have the usual serial input, but it is a special printer with parallel input (s.Figure 4).

From ten wires in all, seven are used for data transmission, one has the strobe, one switches the power of the printer's engine and one is the ground. Parallel data transmission would in itself create no problems but the data pulses on the wires including the strobe have a very poor swinging-in condition. This is due to the mechanism of the printer and can be seen in the lower part of Figure 5. Secondly, the signals on the wires come at different times. The time lags are no problem for the slow mechanical printer but this is the case for the computer. To get a reliable signal identification, we needed a more complicated interface. The interface has to recognize whether a signal is only an error spike or a true 1-bit and it has to overcome the time lags between the signals on the different lines. The solution of the problem was to set a mono-flop for each wire after the start of the signal. The mono-flop has a time constant which falls in the intervel behind $t_{x1}$. After this time the mono-flop gives the information to a RS-flip-flop. For the strobe the same circuit is used as for the data

reference values we had to define in which positions of the sample chain zero values and reference values may occur.

## 4. Radio-Immunoassay Laboratory

The second laboratory which was connected to NOVA was the radio-immunoassay laboratory. The equipment of this laboratory is shown in Figure 3.

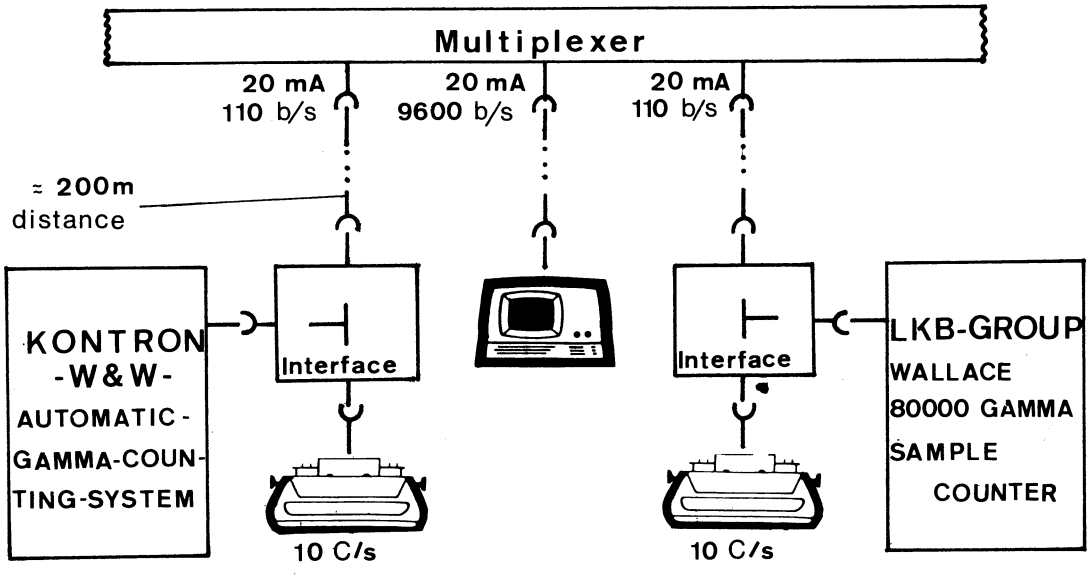


Fig. 3: Devices of the Radio-Immunoassay Laboratory

The CRT terminal does the same job, as in the transaminase laboratory. Sample identification is carried out by a working list which is printed out by NOVA.

The Kontron W&W gammacounter as well as a LKB gammacounter are now online connected to NOVA. These counters are not very modern and the manufacturers were unable to install a data processing connection. Therefore, we had to build up special interfaces for these counters. In order not to make any changes in the counters, we cut the lines between the counters and their printers, mounted cannon plugs and built in our interfaces as an Y-distributor. Thus, we can easily come back to the previous stage at any time for maintainance and service of the counters.

wires. Therefore, the strobe is transmitted later, the duration being in the range of some nano-seconds. When the strobe is transmitted, the RS-flip-flops of the data lines pass their information on, to a parallel to serial circuit. Then the character signal goes via an optocoupler to the multiplexer of NOVA.

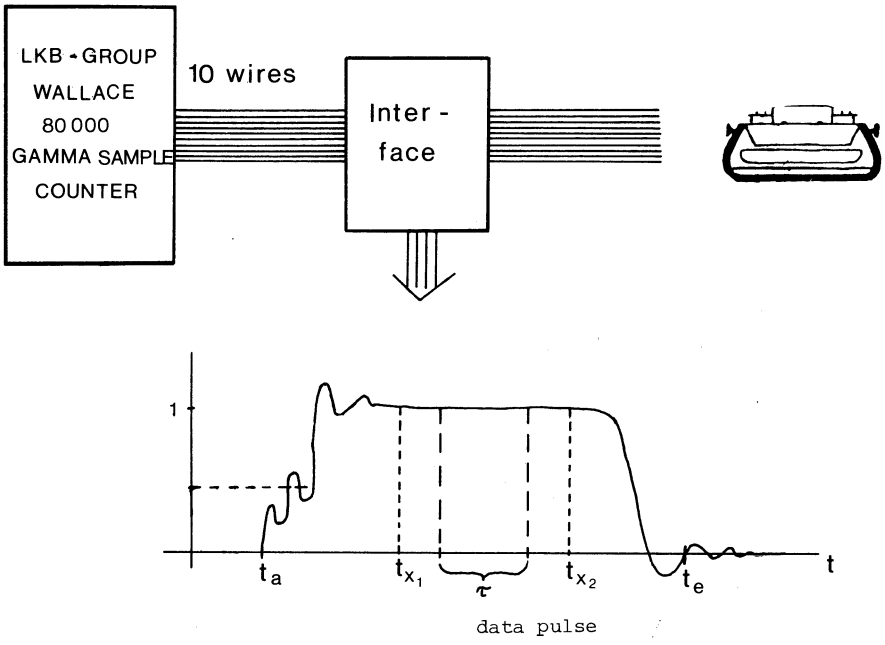


Fig. 4: Interface between the LKB Gamma Counter and the Multiplexer

Data processing of the radio-immunoassay laboratory has now been working for about six months. During this time we had not transmission errors between the gammacounters and NOVA. Programming for this laboratory was rather voluminous. The handlers for both counters, and specially for the W&W counter, were more complex, but much more work had to be invested for the programs for organization and data processing.

Several times we had suggestions from the laboratory technicians which improved the organization of the laboratory and reduced possible mistakes. We had to change several programs and some of the programs had to be completely rewritten. But this does not worry us because one of the reasons for developing our own system was to be able to include suggestions from the laboratory technicians.

## 5. Serological Laboratory

At the present time the laboratory analyzer for automatic determination of blood groups is under construction which is indicated by the

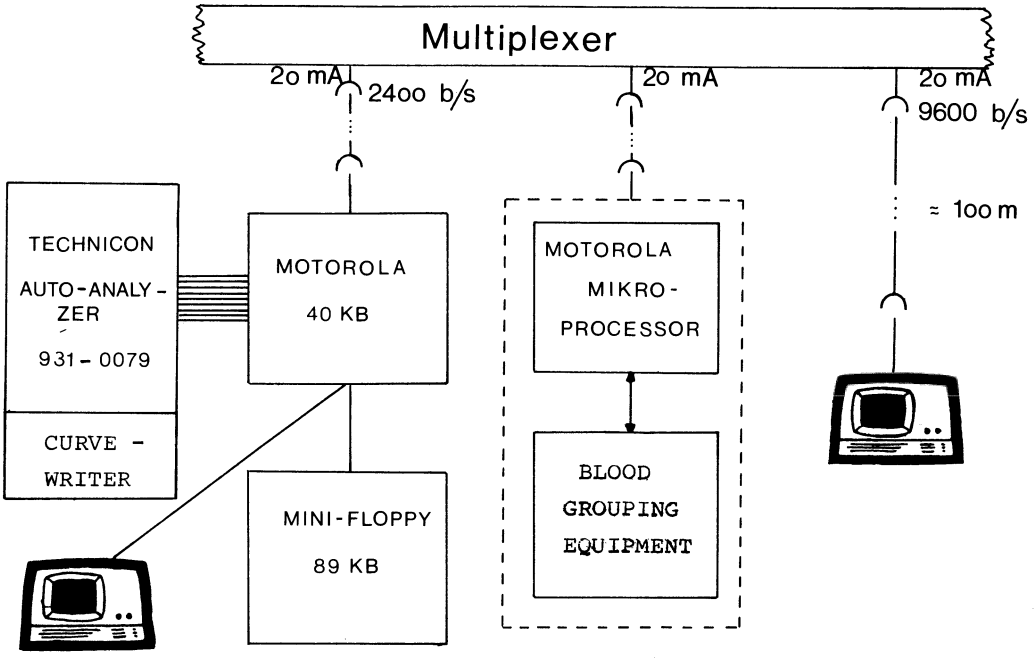


Fig. 5: Equipment of the Blood Group Serology Laboratory

Today all data from the serological laboratory have to be typed into a CRT terminal manually. These data are:

- blood group determinations by a Technicon Autoanalyzer (BGS),
- manual blood typing for first time donors,
- backtyping for first time donors,
- lues screening (TPHA),
- antibody screening,
- haemolysins.

Data acquisition with a terminal had to be programmed anyhow, because in future the machine for the automatic determination of blood groups may have a breakdown and, in this case, manual data acquisition will be necessary. The data are acquired by dialog for which CRT masks are used as well as the terminal roll-up. Of course, all manually acquired data are checked for plausibility in all laboratories. Further, alrea-

dy acquired data might have to be changed, but data which will have to be changed are marked.

In the serological laboratory only one laboratory equipment is now on-line connected. This is an autoanalyzer, manufactured by Technicon, which is used mainly for scientific investigations. This autoanalyzer has no on-line connection, but it has a curve writer, as you can see in Figure 5. On the axis of the curve writer we mounted potentiometers to get analog data signals. The analog digital conversion is performed by a microprocessor system. The microprocessor system has a floppy disk of 89 k-byte and a CRT display. The digitalization frequency can be set by typing into the CRT terminal. Additionally, the laboratory technician can specify, whether the data are to be stored on the floppy disk or sent directly to NOVA. Data transmission between the floppy disk of the microprocessor and NOVA is also possible. The microprocessor was necessary because it was too difficult to transmit analog signals over a distance of about 100 meters. The installation of the potentiometers in the autoanalyzers, the installation of the AD- converter, and the programming of the microprocessor was performed by a small computer firm. The programs are written partially in BASIC and partially in ASSEMBLER. Unfortunately, the operating systems of the microprocessor are not available to us. Thus, we cannot make any changes in the program of the microprocessor system.

## 6. Acquisition of the Information of the Donor Card and Printing of the Blood Bag Labels

Two barcode readers are also connected to the multiplexer of NOVA. One of these barcode readers is produced by the firm Data Logic and the other is manufactured by Inter-Mec. The barcode reader of Data Logic is interfaced to the multiplexer with an E/A interface. First we tried to connect this reader like all other EDP devices with a 20 mA current loop interface. But we had serious trouble with the hardware; probably there were framing errors which could not be corrected by software. In our opinion, this is a worst-case-problem between multiplexer and barcode reader. We were unable to overcome this problem without the cooperation of the field service people of the EDP system. It is a pity that Data General did not give us any help at this point. Finally, we connected the barcode reader to the already mentioned E/A interface and had no problems. This barcode reader is used to read the donor's

most important data, e.g., blood formula, sex etc. from a form, filled in during the donation.

Later on, we connected a barcode reader produced by Inter-Mec without any problems with 20 mA current loop interface. This was necessary because this reader had to be installed in the department to deliver the blood products which is 150 meters away from the computer. With this barcode reader the labels on the blood bags are read for checking purposes.

In future, the labels for the blood bags will be printed out by a coloured-label-dispenser. This device is now under construction and will be in operation in about two or three months. The coloured-label-dispenser is an accumulation of ten small printers, each for a differently coloured label. It is microprocessor-controlled and two of the ten printers are in reserve. A change to one of the spare printers can be effected by hardware or by software.

## 7. Software

NOVA is used with the realtime operating system RDOS in multi-tasking. The foreground as well as the background of the operating system are used for routine work. The initialization of the specially configurated operating system takes place by a seperate task. This initialization task requires the input of the range of the blood bag numbers used at the different collection locations. Then the two grounds can be started or stopped independently. Figures 6 and 7 give an overview of the foreground and background tasks. All application programs are written in FORTRAN with realtime extensions.

In the background there are ten tasks. Only one of these tasks has access to the disc memory. This organization was necessary due to a weak point in the operating system. If more than one task has access to the disc memory, it can happen that the records are written to or read from the wrong disc location. The problem or (to say it more precisely) mistake may be explained by an example. Assume, all tasks have access to a file called "working file". Assume further that the transaminase analyzer sends data to NOVA. The task EPPEN, which is responsible for this equipment, receives the data, processes them, and wants to write them into the "working file", maybe into record X. Assume an

interrupt will happen and control is taken off the task EPPEN after positioning the head of the disc memory on the cylinder which contains the record X, but before the data are actually written. When later on the task EPPEN gets control back, the run-time-system does not check if the head is still on the correct cylinder. The task EPPEN continues to write or read its data. In case the head has been moved during the time when the control was taken off, data are written into a wrong record or read from a wrong record. Therefore, we had to see to it that only one task has access to the disc memory to prevent such mistakes.

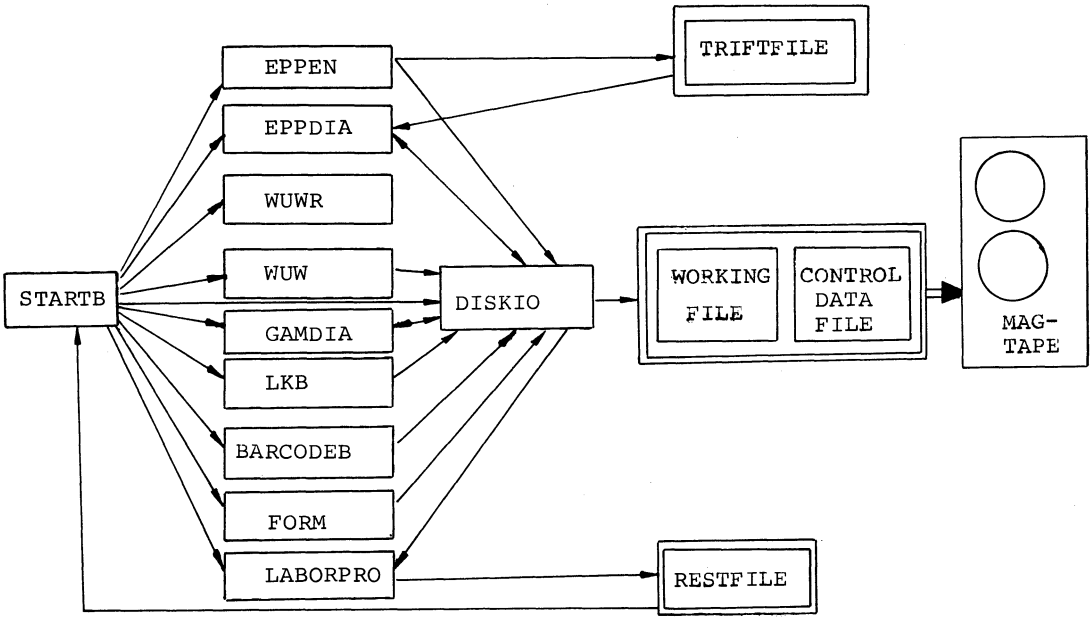


Fig. 6: Structure of the background tasks

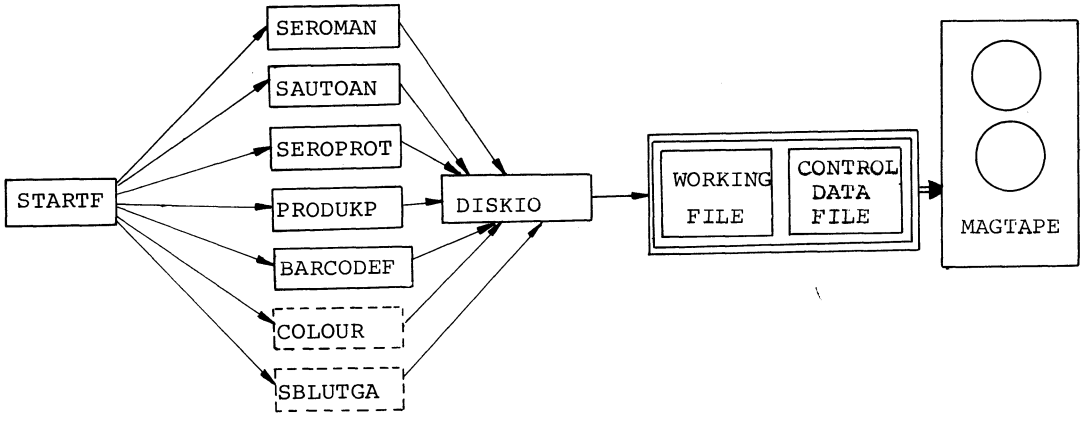


Fig. 7: Structure of the foreground tasks

Except, for the two tasks STARTB and DISKIO, all tasks are servicing devices or do special processing work. Each task consists of several programs which are loaded as overlays. As an example for the structure of a task, we took the task EPPDIA and showed its structure in Figure 8. This task consists of 12 programs, only 3 of them namely "INPUT", "CURS", and "SZNRB", being resident in the main memory. The other programs are loaded as soon as required.

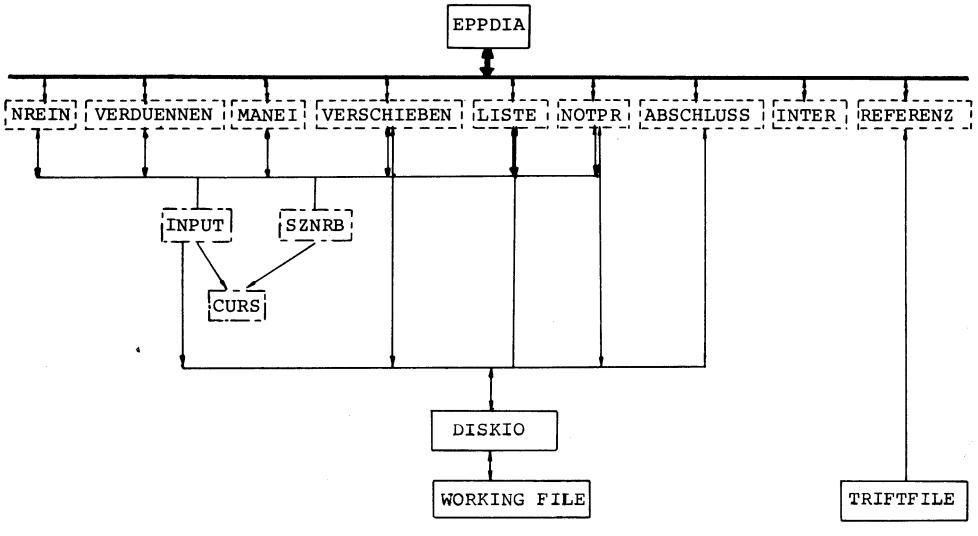


Fig. 8: Programs of the task EPPDIA

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In the discussion the chairman referred to the GMDS standard for interfacing laboratory equipment. This is really a good comment, but our gammacounters could not fullfill this standard.

# ACTUAL DEVELOPMENT IN MACHINE READABLE IDENTIFICATION

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The system of Codabar style labels now used within the United Kingdom was developed by the Working Party for the Introduction of Machine-Readable Labels into the National Blood Transfusion Service.

This Working Party was formed in October 1978, following informal discussions between six of the U.K. Blood Transfusion Regions who, at that time, had acquired automated blood grouping equipment which required the interpretation of bar-coded labels.

The goals of this Working Party were twofold:

> The first was to consider alternative proposals for the design of machine-readable labels with the key information in machine-and eye-readable form and to put forward recommendations to the U.K. Regional Transfusion Directors Committee and
>
> secondly, to ensure that any recommendations had sufficient flexibilitiy to allow for the differing needs of the individual regional transfusion centres.

An early decision taken by this Working Party was to follow the recommendations of the Committee for Commonality in Blood Banking Automation (C.C.B.B.A.) report with respect to the bar code numerics of the various labels, but to use that report as only a guideline when designing the label formats for use in the U.K.

The following will now give you some indication as to the system of labels currently in use within the U.K.

The labels can be divided into 5 types:

> There are the Blood-pack Labels,
> the Donation Numbers,
> the Blood group Labels,
> the Special Oversticker Labels,

and the Product Labels.

The first, the Blood-pack label (see Fig. 1), was designed as the result of teamwork between the Working Party and the Scientific Services Group of Travenol Laboratories (that is to say Fenwal) in the U.K. Fenwal became involved with the working party at a very early stage and has worked in close conjunction with that group for the last 2 years. The label, which I will call the intermediate label for reasons which will become apparent later, was designed by Travenol Fenwal so that it would be acceptable to those transfusion centres using automated systems and also to those using manual techniques. It was designed to provide the most efficient and logical placement of vital information with the correct emphasis on those statements regarded as being of greatest importance - for example:

Cross-match before transfusion;
Identify recipient as partner to X-match, and
Do not vent.

In addition, it was designed so as to retain details of the anticoagulant, various instructions and storage details as dictated by the various regulatory documents such as the British Standards and pharmacopoeial monographs.

As you will see from the slide, the only preprinted information which is in machine-and eye-readable form is the product code, which in this case is ACD whole blood. However, the label was designed so as to act as the matrix for the addition of the various oversticker labels which carry their information in an eye-and machine-readable format. To this end, the basic pack-label is, therefore, mutually compatible with the oversticker labels.

Similary with the transfer pack-labels (see Fig. 2). These pack-labels when fully overlabelled, appear as in the slide (see Fig. 3).

Earlier I mentioned that the blood-pack label was an intermediate label, the reason for this being that it is the intermediate step towards what is referred to as the "simplified Codabar label". This label which will be introduced into the U.K. later this year differs from that presently used, yet still maintains its function in presenting essential information and the matrix for the oversticker labels. As you can see from the draft (see Fig. 4), the majority of the instructions have removed leaving only those which are felt to be the most imp-

ortant, the pack user now being referred to a Department of Health Publication for further information.

Similarly, the constituents of the anticoagulant have been deleted, the solution now being referred to by its official monograph title, in this case CPD anticoagulant solution B.P. This label, which has evolved following numerous discussions between the Department of Health, the Working Party, other transfusion directors and Fenwal, releases more space for use by the transfusion centres and has meant that one of the goals of the Working Party has been achieved.

It is the blood-pack label of choice which should be introduced at an early stage if the regulatory constraints allow it.

Donation Number Labels

Two types of Donation Number Labels can be used:

> The first is a white label for known donors, while the second is a white label with a green stripe through the eye-readable number to denote new donors.

These labels are supplied in rolls of not less than 200 sets of six, four of these being in both eye- and machine-readable format with the other two just eye-readable.

The donation number is present in both eye- and machine-readable form with the eye-readable number printed in bild type for easy reading. The eye-readable number incorporates a letter that denotes the identification of the transfusion centre where the donation originated from, as this was felt to be essential in instances where blood is transferred from region to region. The identifying letter is not, however, represented by a digit in the bar code.

In addition to this identifying letter, a check digit it also used, as it was felt that this was essential to ensure accuracy when manually keying numbers into the computer. Furthermore, this check digit is also incorporated in the bar code as one of the U.K. centres experienced a misread when using light pen.

The C.C.B.B.A. recommended the weighted modulus 11 method for calculating the check digit, but the U.K. directors have found this to be unacceptable as they considered it to be not sufficiently random. The

method now used is the modulus 11 caculation. If, when using this method, a check digit of 10 results, the letter X is substituted in the eyereadable number while the colon was to be used in the bar code. Subsequently, to maintain uniformity, the colon has been changed to a plus sign as per the recommendations of the I.S.B.T. (Internat. Society of Blood Transfusion) Working Party on Automation.

The incorporation of this check digit and identification letter has led to an eye-readable format of six numbers followed by the letter and then the check digit. From the practical viewpoint the donation number is represented by the first six numbers.

Blood Group Labels

The next type of label is that denoting the blood group. The specification for this allows flexibility within the transfusion centres and in itself consists of 4 labels:

The first (see Fig. 6) is a bar coded label identifying the group. The bar code commences with a "d" start and 3b stop. Rh-positive letters are printed in black, while Rh-negative labels have white letters outlined in red, with the words Rh-negative set in white on a thick red band. Underneath this, the words "Tested with anti-D, anti-C, and anti-E" are printed.

The bottom part of this label has a bar code denoting the country of origin and the R.T.C.* at which the blood was collected and grouped. The name of the transfusion centre also appears in an eye-readable format.

The second is a small label denoting the ABO and Rh group both in eye- and machine-readable form. This label is for use on transfer packs or on tubes or records.

The third and fourth are two small labels denoting the blood group in eye-readable format only.

* R.T.C. = Regional Transfusion Centre

Special Labels

On some occasions an alternative special label needs to be used in place of the blood group label. To cover the various possibilities

that may arise, 5 labels have been devised. These are:

Biohazard,
Use in Emergency only,
Not for Transfusion,
Red Cells not for Clinical Use,
and Hold for Further Investigation.

Each carries the appropriate bar code and is of distinctive style (see Fig. 7) and colour.
Finally, we have the Product Oversticker Labels that define the product contained within the pack. In the U.K. 11 are available. Each label describes the product, gives details of the anticoagulant and, where appropriate, an instruction and also carries the appropriate bar code with an aO start and 3b stop. Figure 8 shows a number of these labels.

One final thing: I feel that it is imperative that the preparation of specifications for printers should form an integral part of any move towards using bar code. Details of label format and size should be given as well as the "exact" specifications for printing "Codabar" as specified in the C.C.B.B.A. report.

There is a need to work closely with the printers to ensure that they understand the critical area in which the labels are to be utilized, and to ensure that the quality control of the label print is stringently adhered to.

To summarise, the introduction of machine-readable labels into the U.K. has been a great success which was achieved through the cooperation of all the transfusion centres involved, with support from Fenwal. If you as a country are looking at moving towards a machine-readable label, I would suggest that it would be advisable for everyone to work together as a group with one aim in mind - the introduction of one type of machine-readable label. In the case of Codabar, we at Travenol have a wealth of experience which is available for your use.

References:

(1) JENKINS J. (Ed.): Machine readable labels in the blood transfusion service. (Proceedings of a Symposium held on June 13th, 1979). Lancaster, 1980 (MTP Press Ltd.).

(2) BRODHEIM E., MOORE B.P.L. (Eds.): Automation and Data Processing. Vox Sang. 40, 129-244 (1981) (delivered June 81).

code R0997

Donor Number

Expiry Date

**ACD WHOLE BLOOD (HUMAN)**

ABO Blood Group

FENWAL Sterile, nonpyrogenic

RhType

**Single Blood-Pack** unit with 15 ga. needle for collection of 420 ml blood

**Contains 75 ml Acid Citrate Dextrose Anticoagulant Solution, Formula A.** Contains 17 mmol (approx.) Sodium. Each 100 ml of ACD solution contains: Anhydrous Dextrose B.P. 2.24 g
Sodium Citrate Ph.Eur. 2.20 g
Citric Acid Monohydrate Ph.Eur. 800 mg PL 0116/5106

Transfusion Centre

POM

Lot

1. Mix BLOOD and ACD SOLUTION at frequent intervals during collection.
2. Refrigerate continuously at 4° - 6°C.
3. CROSS-MATCH BEFORE TRANSFUSION.
4. IDENTIFY RECIPIENT AS PARTNER TO CROSS-MATCH.
5. Do not add other medication to the BLOOD-PACK unit prior to administration.
6. Mix blood thoroughly immediately before use.
7. Transfusion set must have a filter.
8. Contents not to be used if there is visible evidence of deterioration.
9. Pack not to be reused.

**DO NOT VENT**

Blood Drawn

FENWAL
TRAVENOL LABORATORIES LTD., Thetford, Norfolk, England 08-17-01-868

FIGURE 1

PRIMARY PACK LABEL

Donor Number

Expiry Date

**ACD Transfer Pack**
400 ml capacity

ABO Blood Group

Lot

RhType

Sterile, nonpyrogenic **DO NOT VENT**

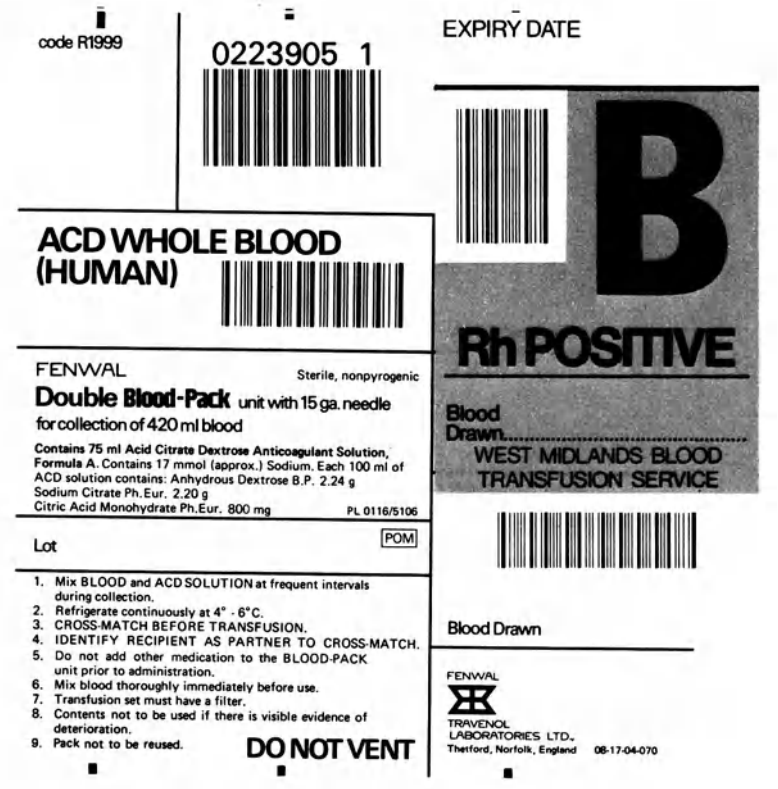
FENWAL
TRAVENOL LABORATORIES LTD., Thetford, Norfolk, England 08-17-20-847

FIGURE 2

TRANSFER PACK LABEL

# FIGURE 3

## FULLY LABELLED PRIMARY AND TRANSFER PACK LABELS



| code R1701 | Donation Number | Expiry Date |
|---|---|---|

**CPD WHOLE BLOOD (HUMAN)**

ABO Blood Group

FENWAL Sterile, nonpyrogenic

Rh Type

**Triple Blood-Pack** unit
for collection of 450 ml blood

**Contains 63 ml Citrate Phosphate Dextrose Anticoagulant Solution B.P.**
Contains 18 mmol (approx.) Sodium.

**DO NOT VENT** PL 0116/5108

Transfusion Centre

Lot POM

1. Refrigerate continuously at 4° - 6° C.
2. CROSS-MATCH BEFORE TRANSFUSION.
3. IDENTIFY RECIPIENT AS PARTNER TO CROSS-MATCH.
4. For futher details of use see notes on Transfusion (DHSS).

TRAVENOL LABORATORIES LTD., Thetford, Norfolk, England
09-57-00-000

Blood Donated

FIGURE 4

SIMPLIFIED CODABAR LABEL

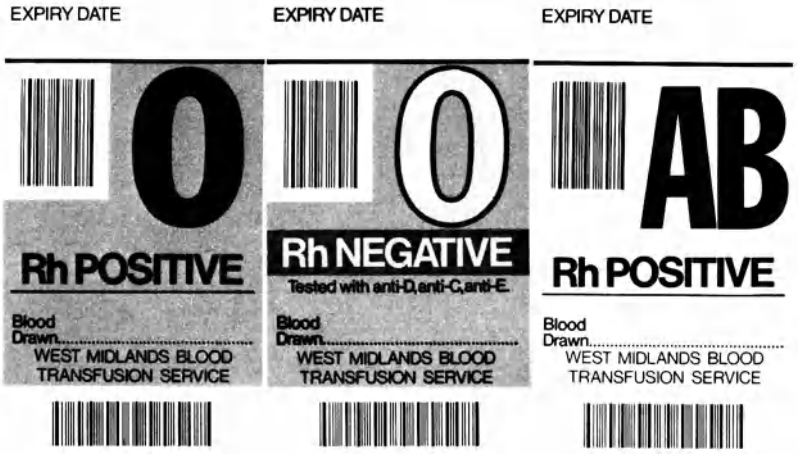



FIGURE 6

EXAMPLES OF BLOOD GROUP LABELS

FIGURE 7

EXAMPLES OF SPECIAL OVERSTICKER LABELS

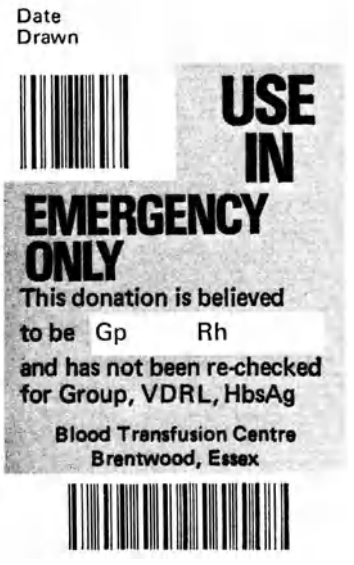
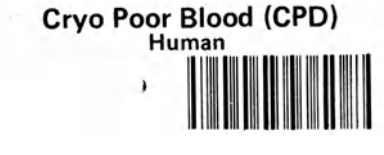




FIGURE 8

EXAMPLES OF PRODUCT OVERSTICKER LABELS






# EXPERIENCE WITH A NATIONAL BLOOD TRANSFUSION SYSTEM INTEGRATING A CENTRAL COMPUTER SERVICE WITH HOSPITAL-BASED MINI-COMPUTER ROUTINES.

by Bertil Cassemar, Claes F. Högman and Jan Säfwenberg

AB Databyran, Stockholm and the Blood Center, University Hospital, Uppsala, Sweden

## CENTRAL COMPUTER SERVICE

An EDP system for the registration and call-up of blood donors and a punch-card system for the registration of serological information on patients,compatibility testings and transfusion files based on data obtained via punch cards has been in continuous use since 1965 at several blood banks in Sweden. At present, 36 hospitals, half of them financially and organizationally independent of each other, use the call-up routine and 8 also the patient routine. More hospitals are planing to join the system. System development and programming has taken place within the National Steering Committee for EDP in Blood Transfusion Service. AB Databyran is the executive, and the computer belongs to an insurance company in Stockholm. The system was described by Högman & Ramgren, 1970, and is also illustrated on posters 1-3 at this conference.

The blood donor call-up routine includes the selection of available donors in weekly runnings. In the files there are about 94.000 active donors, 100.000 passive donors and 208.000 yearly drawn units of blood. The output consists of postcards for call-up, prefilled forms to be completed with data from the blood donations, prognostics of available donors and various other lists, e.g. "who gave which unit?". Some of the lists are transferred to microfiches via COM to facilitate distribution.

Nationwide cooperation offers several advantages: exchange of donor information between centres, common lists of unusual blood types, common files of unsuitable donors, national prognostics of available donors. The call-up routine is inexpensive, corresponding to DM 1.37 per donation.

The patient routine files patient groupings, cross-matchings and transfusions in weekly runnings. The files include blood group results

on about 300.000 patients, 345.000 cross-matched units (information on returned blood, transfusions or other use of blood) per year. The output consists of various lists, often on microfiches, e.g., "who got the unit" or "who gave and who got the unit", cost specification per ward, statistics, etc.

The nationwide cooperation has facilitated common files of patients with antibodies. The system is also inexpensive: DM 0.38 per patient's blood group and DM 0.22 per cross-matching.

## LOCAL MINICOMPUTER SYSTEMS

The Central Computer System has been effective. We never felt a need for an on-line system for the donor call-up routine. On the other hand, an on-line system with patient files and files of available stocks of blood components was expected to be of great use. The general technical development left punch cards and especially card punch machines behind. Our machines were worn out and could not easily be replaced by new ones. Instead, a modern on-line minicomputer-based system was created. Its aims were as follows:

1. To design a system which allows registration in a data base of patient's blood groups, blood types, irregular antibodies and other important serological information; to keep such patient files available round the clock at the blood bank's laboratory for compatibility testing in order to deliver blood components with the highest possible security.
2. To keep up-dated files of blood components and to link information on patients to information on blood units having been reserved for these patients; to register and report on compatibility tests.
3. To allow an effective inventory control of different blood components and the search for blood units belonging to blood types other than ABO and $Rh_0(D)$.
4. To keep a file of transfused patients and the blood units they received.
5. To allow an easy re-entry of unused blood units into the inventory.
6. To present a basis for accounting and statistics.

### System Development

A potent minicomputer with video display terminals and printers is necessary for use of the designed system. The computer recently in operation at the Uppsala Blood Centre and the computer on which the system is being implemented at the Stockholm Blood Centre at Södersjukhuset

are outlined in Table I. Automatic reading of numbers is facilitated by OCR-B wands but this requires that the printers have OCR-B characters and that such characters are used on the blood unit labels. Since a large stock of blood group information has been accumulated on punch cards, a card reader is very useful in our system. The local set up at the Uppsala Blood Centre is shown in Fig. 1 and posters 4-5.

The National Steering Committee for EDP in Blood Transfusion Service has undertaken the task of designing a system to be applied on local minicomputers. In order to allow the use of different machines with different operative systems, the programs have been written in Fortran ANSI-66 but in a way which adjusts to the Cobol language way of handling character strings.

According to plans large parts of the system will still be operated off-line on a big computer. The main reasons are that we want to continue to give computer-assisted service to those blood banks which want to maintain their manual routines without local computer assistance. Further, it does not seem sensible to burden local computers with operations which are already effectively and inexpensively managed in the central system, such as print-out of call-up and thank-you cards to blood donors, accounting and statistics. Another argument is the central file of passive donors and the file of unsuitable donors which are consulted whenever a "new" blood donor is registered. Communication between the central computer and the local minicomputers presently takes place by means of magnetic tape.

The system engineers and programmers employed full time for the management of the central system are those employed in the development of the minicomputer-assisted system. This group has continuously accumulated a profound knowledge of the special problems present in a blood bank as well as the special requirements and limitations set by a minicomputer as compared to a big computer.

Since the new system replaced an obsolete but on the whole well-functioning and inexpensive punch card system, it was not economically feasible to employ a special staff of computer operators at the local blood bank, particularly with regard to the round the clock operation schedule. The central group will continuously supervise the system, make program adjustments and corrections and further develop the mini-computer system, but they will not be responsible for the daily runs. The technical management is taken care of by the technical department of the hospital and by the computer supplier on a service contract.

The laboratory staff at the blood bank have been taught computer technology with emphasis on the operation of video display terminals. A small group of staff members received more intensive training in order to be able to handle some duties normally done by computer operators, e.g., taking the twice daily back-ups of the disc files, up-dating the data base and taking care of problems which may occur due to incorrect handling by the staff or loss of function for other reasons. Thus, the computer has been integrated among other blood bank duties. With sufficient teaching and training this did not cause any serious difficulties, although some reluctance and frustration were noted initially.

The system work has taken about 10 man-years so far. After a full-scale test run for about two months, the management was interrupted. During half a year a number of corrections of hardware, system design, programs and print-outs were made. To a large extent this was based on suggestions from hospital staff members and recommendations from a special working group consisting of blood bank staff members and system engineers. The final start of the system was in February 1981 after two weeks of run parallel to the old routines. The system is now working very effectively, giving information and printing assistance greatly superior to the old system.

Blood Group Serology

Blood grouping (ABO and $Rh_0(D)$) is done partly by manual methods, partly by a Groupamatic 360C which is attached on-line to the computer. Samples which the Groupamatic has refused to interpret are either read visually directly in the reaction cuvettes or investigated by manual techniques. These results are entered into the computer files by a video display terminal. The computer checks that the results of two independent tests agree with each other. Table II shows the daily protocol of the blood grouping laboratory with regard to the communication with the computer. The results are stored in different files for patients, military staff and checking of blood units. The data base is not up-dated until proper controls have been completed. Once a result has been entered into the data base, it cannot be changed, only removed. Thus, a patient's blood group cannot be changed by mistake.

Samples which require more qualified serological investigation are transferred to a separate file. Input of investigation results is achieved using a standard set of promptings. Registration taken place

in a question-and-answer system in which the operator has to enter the information via numerical codes. After some initial experience, when the operator knows the most common codes by heart, it is a fast procedure. Some of these standard sentences, e.g. concerning blood type, antibody specificity and titer values, are introduced in several steps. The system allows detailed statistics. Both the video display terminals and the printers have capitals as well as small letters which means that the existing blood group nomenclature does not create any problems.

The information registered in the data base can be called on and either shown on the video display or printed on paper. An example of the layout of a blood group reply is given on poster 6 and Fig. 2.

Each set of replies consists of four forms. All of them contain the patient's identification (birth date and number, surname, first name) ABO and $Rh_0(D)$ blood group, any other serological information, and the registration number of the test. One of the forms is to be handed over to the patient himself (particularly important when irregular antibodies are present); another is for the patient's record, and the others are order forms for blood components.

In the data base a link is established between all test results of the same patient. This is greatly facilitated by using the "person number", which is given to every Swedish citizen, composed of birth year, month, day, a 3-digit number and a control digit, thus 10 digits in all. This number is used in Social Security, in military service, by insurance companies and tax authorities, etc.

Requisition of Blood Components

One of the order forms is filled in and sent to the blood bank together with a sample for compatibility testing. Via the registration number, read by the OCR-B wand, the patient information is called on and shown on the display. The computer simultaneously checks whether other - earlier or later - test results on the same patient exist in the data base and if irregular antibodies have been found in any of these. Should this be the case, a print-out of the three most recent test results is obtained. If no such information is available, the technician can proceed directly to the next step: registration of the blood units which have been selected for the patient. This is normally done using the OCR-B wand, reading the numbers on the pilot tube label or on the blood unit label. If the number is not readable by the wand, e.g. because the blood unit has been obtained from a blood bank which does

not have the correct type of label, the number is entered via the keyboard. For OCR-reading a start symbol, a check digit according to the modulus 10 system, and an 8-figure number are needed. A test protocol is printed (Fig. 3).

Following compatibility testing the test protocol is again called for on the display and the blood units are approved or rejected. A package slip of all approved units is printed (Fig. 4) as well as a summary of all tested units (Fig. 4). The package slip is folded and attached to the respective blood unit; the summary form will be included in the patient's record and completed with a note as to which units were actually tranfused and when.

Blood units which have been reserved for a patient but not used will be withdrawn to the blood bank, normally within $1\frac{1}{2}$ days. With the OCR-B wand the blood unit numbers are read from the package slips and the blood units are thereby re-entered into the inventory of eligible units.

Input to the Inventory

Newly produced blood units are registered in the inventory as soon as they have passed the quality controls. Information on blood type other than ABO and $Rh_0(D)$ is transferred via punch cards (old routine) or electronic tape (new routine) from the blood donor registry to the central system. The numbers of all available blood units, e.g. of type c-negative, can be obtained via a special program.

A review of all available blood units, both those eligible and those reserved for patients, can be obtained at any time.

## FUTURE DEVELOPMENT

With the rapid development in the computer field it is foreseen that even medium size and small hospital blood banks within a region will operate their own mini- or microcomputers which will be able to perform some of the tasks described above by their own capacity. They shall also serve as telecommunicated terminals which can be connected to the regional minicomputer. The latter will serve the whole region concerning more demanding operations, such as search for patient data in a large, regional patient registry and information about the total inventory. In this way, a number of hospital blood banks are expected to collaborate regionally.

## SUMMARY

An EDP system serving blood group serology routines, cross-matching and blood component delivery procedures, and inventory control is described.
It is emphasized that, because of the large costs of system engineering and programming, such systems should be shared by several customers.

Emphasis has to be laid on sufficient education and training of the blood bank staff.

It is important that the details of the system are rendered such as to satisfy the blood bank staff and other hospital staff in order to achieve rational and well functioning procedures.

The main goal is to improve information and security.



## ACKNOWLEDGEMENTS

This system has been developed by the National Steering Committee of EDP Assistance in Blood Transfusion Services in Sweden which in 1981 has the following members:

Olof Akerblom (Stockholm), Olle Berséus (Örebro) Bertil Cassemar (Stockholm), Bertil Cedergren (Umea), Bengt Gullbring (Stockholm), Jan-Olof Hildén (Linköping), Claes Högman (Uppsala), Klas Levin (Västeras), Bengt Löw (Lund), Olof Ramgren chairman, (Stockholm) and Kaj Sjöström (Stockholm).

Financial support for the system development has been made available within the budget of the above mentioned Committee. The pilot study was made possible by the generous support from the National Swedish Board for Technical Development, grants, no. 78-3333 and 80-3932.


## REFERENCE


Högman, C.F. & Ramgren O. (1970). Computer system for blood transfusion service. Transfusion 10, 121-132.

TABLE I

Computer Equipment used in Local Minicomputer Systems

| | University Hospital in Uppsala | Södersjukhuset in Stockholm |
|---|---|---|
| Central processing unit: | Univac V77/400 | Hewlett-Packard HP 3000 III |
| Internal memory: | 192 K words | 512 K words |
| Disc memory: | 32 Mb | 1x120 Mb for Blood Centre<br>2x120 Mb for Chemical Laboratory |
| Magnetic tape: | 1600 bpi 75 ips | 1600 bpi 45 ips |
| Line printers: | 1 240 l/m | 1 1000 l/m<br>1 600 l/m |
| Card reader: | 1 300 l/m | 1 300 l/m |
| Terminal Equipment: | 5 video display terminals<br>2 line printers (240 l/m)<br>1 printer (90 ch/s) | Blood Centre<br>4 video display terminals<br>3 line printers (240 l/m)<br><br>Chemical Lab<br>30 video display terminals<br>3 microprocessors with printers (30 ch/s) |

TABLE II

CHECK LIST AT THE BLOOD GROUPING LAB TERMINAL

Serie No 0 Date:

| Operation | Time | Run by |
|---|---|---|
| Numbers in the serie. | | |
| Enter patient data from requisition form. | | |
| Enter data from special investigation list. | | |
| Enter data of antibody screening results. | | |
| Enter supplementary data of Groupamatic run 1. | | |
| Check patient file for earlier investigations. Preliminary linking of present investigation to patient file. | | |
| Enter supplementary data of Groupamatic run 2. | | |
| Enter manual series 1. | | |
| Enter manual series 2. | | |
| Tranfer for further testing to serological laboratory file. Enter Grouping laboratory messages. | | |
| List patient's blood groups. | | |
| Run blood group reports. | | |
| Run disc file back-up. | | |
| Up-date data base. Present test results are linked to patient file. Automatic control of blood group results. Deviations are rejected and listed. | | |

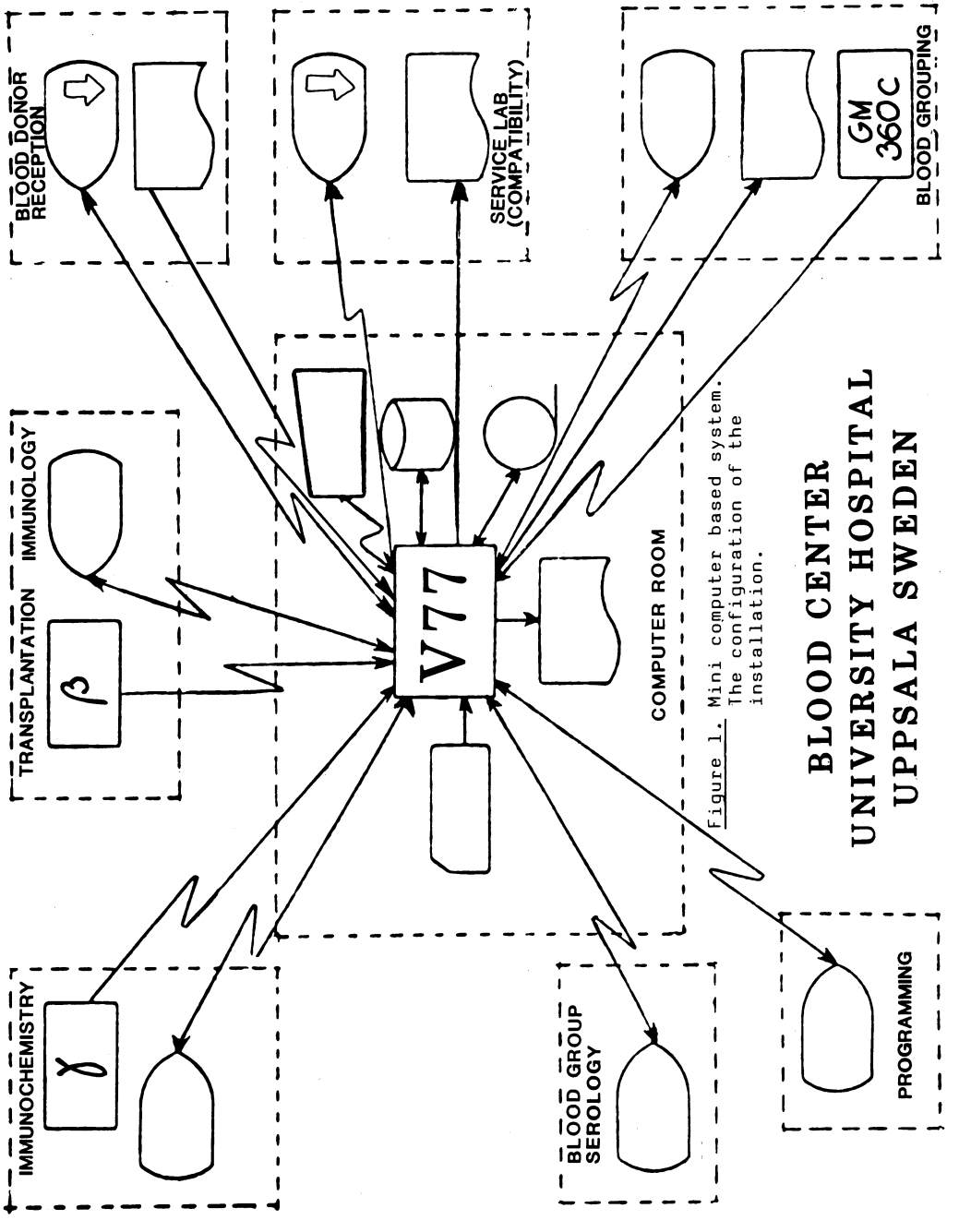



Figure 1. Mini computer based system. The configuration of the installation.

Vidstående blodgruppskort är avsett att avskiljas och överlämnas till patienten. 1.

AKADEMISKA SJUKHUSET
Blodcentralen
UPPSALA 2.

**Blodbeställning** 3.

_____ Helblod

_____ Erytrocytkoncentrat

**Blodbeställning** 4.

_____ Helblod

_____ Erytrocytkoncentrat

_____ Leukocytfattigt erytrocytkoncentrat

_____ Trombocytkoncentrat

_____ Färskfryst plasma

_____ Plasma

_____

_____

_____

Diagnos, särskilda upplysningar

Beställande sjukhus och avdelning Tel/snabbtel

Leverans till Datum, tid

**ID-kontroll** utförd enl gällande föreskrifter intygas

Namnteckning

Pers.nr <460126 XXXXX Blodgruppskort

Namn XXXXXXXXX ANN-MARIE

Blodgrupp

Pers.nr <460126 XXXXX Blodgruppssvar

Namn XXXXXXXXX ANN-MARIE

Pers.nr <460126 XXXXX

Namn XXXXXXXXX ANN-MARIE

Pers.nr <460126 XXXXX

Namn XXXXXXXXX ANN-MARIE

Blodgrupp

```
          A
         AAA            ++
        AA AA           ++
       AA   AA       ++++++++
      AA     AA       ++
      AAAAAAAAA       ++
      AA     AA
      AA     AA    Rh POSITIV
```

Lab.nr/
Reg.dat. C681 0310 76299> 1981-02-05

Blodcentralen Akademiska sjukhuset Uppsala

Särskilt utlåtande Id-Kontroll utförd

Blodtyp:O C+ E- c- e+
Direkt antiglobulinprov (Coombs prov):negativt
Erytrocytantikroppar av följande specificitet har påvisats:

| | anti-E | c |
|---|---|---|
| enzymteknik | 2 | 20 |
| antiglobulinteknik | 2 | 2 |

Vid eventuell blodtransfusion ges blod av typ: E- c-

Figure 2. Blood group reply. 1) Patient's card. 2) For the patient's record. 3) and 4) Order forms

PROTOKOLL SEROLOGISKT FÖRPROV
UAS 008 <18 03 01 XXXXX

LABNR: C781 0310 41978 > UTLOMG: 00 XXXXXXXXGÖRAN
STAMPLAR ANTIKROPPAR
IDKOLL UTF. VID PROVT. FÖR SER. FÖRPROV: JA NÅGON GÅNG ANTIKROPPAR
NEDANSTÅENDE BLODPRODUKTER RESERVERADE 1981-04-05 KL 15:43:13

A1:..... B:..... SCREEN:..... SIGNATUR .....

| BLODGR | PRODUKTBESKRIVNING | BLODNUMMER | PRODKOD | OSP | 1/5 | ICT | ENZ |
|---|---|---|---|---|---|---|---|
| ABRh+ | E-KONC. TVÄTTAT 0200ML | S3 3317 2788 | 1673 | I I....I | I ....I | I ....I | I ....I | I ....I |
| ABRh+ | E-KONC. TVÄTTAT 0200ML | S4 3317 2783 | 1673 | I I....I | I ....I | I ....I | I ....I | I ....I |

Figure 3. Form for crossmatching

F Ö L J E S E D E L

UAS 00B

RESERVERAD T.O.M.
1981-03-26 KL 12.00

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+ PERSONNR:    <180301 XXXXX      +
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+ NAMN:  XXXXXXX GÖRAN            +
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SEROLOGISKT FÖRPROV: SKÄRPT, UTAN ANM.

IDKONTROLL UTFÖRD VID PROVTAGN. FÖR:
BLODGRUPPERING: JA
SEROLOGISKT FÖRPROV: JA

PRODUKT: E-KONC. TVÄTTAT

VOLYM: 0200ML

LABNR: C781 0310 41978 > UTL:00

BLODFÖRTECKNING/TRANSFUSIONSJOURNAL
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LABNR: C781 0310 41978 > UTLOMG: 00 XXXXXXX GÖRAN

IDKOLL UTF. VID PROVT. FÖR SER. FÖRPROV: JA
NEDANSTÅENDE BLODPRODUKTER RESERVERADE T.O.M. 1981-03-26 KL 12.00

| BLODGR | PRODUKTBESKRIVNING | BLODNUMMER | PROD-KOD | ETIKETT FRÅN TRANSF. ENHET | DATUM/SIGN EV TR.KOMPL |
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| ABRh+ | E-KONC. TVÄTTAT 0200ML | 3317-2788 | 1673 | | |
| ABRh+ | E-KONC. TVÄTTAT 0200ML | 3317-2783 | 1673 | | |

Figure 4. Package slip
Summary list of delivered units

# Evaluation of EDP Systems for Transfusion Medicine: Criteria from the User's Point of View

by

J.R. Möhr and A. Kluge

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## 1 Introduction

If the efforts of the programme committee to obtain contributions on the systematic evalutation of the effects of computer support of medical transfusion services were in vain, there might be several reasons:

- the need for systematic evaluation is not perceived during early stages of system construction and, therefore, the evolving systems do not lend themselves to evaluation;
- the merits of transfusion medicine are considered to be self-evident and, consequently, supposed to apply to the supporting EDP systems;
- many systems may not have reached a stage where systematic evaluation is desirable.

The following contribution concerning evaluation criteria from the user's point of view will, therefore, be theoretical rather than based on practical experience. The necessity for formal and systematic evaluation will be outlined together with a sketch of possible approaches. The criteria to be applied to evaluation will then be illustrated in greater detail on the basis of a discussion of the method of "Nutzwertanalyse" (9) (NWA, "value analysis" or "worth analysis (11)").

## 2 Why systems evaluation?

It has been shown that dissemination and penetration of new technologies is quite independent of their eventually proven value and effect, particularly in the medical field. The distribution of essentially useless technologies may quickly take on impressive dimensions, just as the recognition of valuable innovations may progress but slowly (15). The association of a certain product or device with a new technology seems to improve speed and extent of dissemination. Examples are legion among laboratory devices and drugs. Conversely, acceptance of a new technology seems to be impeded if it is part of complex procedures and processes - especially if these are not at the focus of scientific attention. Examples of this type may be found among administrative procedures.

Both aspects are combined in transfusion medicine. Its technology is developed around an identifiable product, the therapeutic efficay and superiority of which

has been proven in many situations. This is the blood unit and its derivatives. On the other hand, the availability of this product depends on a host of supportive procedures from the realization of public support via a great number of individual donors up to the technologies of refrigeration, distribution and stock keeping.

A similar situation applies to medical informatics as an ancillary technology in this context. It involves identifiable products such as programs or computer systems which are furthering propagation.

The subject of these products are frequently complex administrative procedures which are little investigated and often not understood in detail.

Therefore, the effects actually obtained by computer introduction may deviate from prior expectations. This situation has been recognized in medical informatics for some time and, therefore, systems evaluation has become a subject of recognized importance for medical informatics (2,3,4,5,6,8,10).

## 3 Systems evaluation - scope of approaches

Evaluation of EDP systems in transfusion medicine has to suit varying needs. We may distinguish the following levels of evaluation:

level 1 Assesment of basic suitability of EDP systems;
level 2 Identification of an optimal system among several variants;
level 3 Evaluation of medical efficacy.

At the first level, a specification of basic requirements will suffice in order to determine whether a given system is basically suitable. These may be formulated as obligatory requirements that set minimal standards. Failure of a given system to meet one of them will lead to its elimination from further consideration.

One problem at this level is to define sufficiently substantiated minimal requirements. Hopefully, the display of solutions at this conference will be of help. The other problem is to obtain sufficiently complete and comparable system descriptions from suppliers. It is, of course, the responsibility of the evaluator to make sure that this requirement is met.

The goal at the second level is to identify an optimal systems variant for a given set of goals. Local requirements and subjective preferences of certain user groups are of greater importance at this level. Recommendations will therefore have to remain quite general. Actual evaluation will require a detailed specification of the applied criteria. Nevertheless, a method applicable at this level will be outlined below.

The third level comprises the entire spectrum of what has been termed "health care technology evaluation" (10). It includes consideration of economic aspects (15)

as well as aspects of the quality of medical care (7). Especially with respect to the latter issues, methodology is still under development. Cause and effect relations at this level of complexity are quite ramified and analyses require correspondingly increased efforts.

We will not consider such studies further in this context since the relevant methodology is a subject of the parallel conference*, since medical efficacy does not seem to constitute a subject of great concern in transfusion medicine and since even the less complex studies seem to be lacking so far with respect to EDP support of transfusion medicine.

## 4 A standard procedure for multidimensional assessment

A conceptually simple method for the evaluation of system alternatives is NWA ("Nutzwertanalyse" (9), translatable as "value analysis" or "worth analysis"(11)). Recently the method has been increasingly applied in the evaluation of EDP applications in medicine (11,12,13,17).
It involves application of a catalogue of n criteria $C_i$ to m system alternatives or variants Sj. A weight $w_i$ is associated with each criterion $c_i$ and determines the significance of every criterion in the static context of all considered criteria.

Figure 1 N W A NUTZWERTANALYSE
("value analysis" or "worth analysis")

| | | weights | system variants | | |
|---|---|---|---|---|---|
| | | | $S_1$ ... | $S_j$ ... | $S_m$ |
| criteria | $C_1$ | $W_1$ | $g_{i,j}$ | | $g_{1,m}$ |
| | $C_i$ | $W_i$ | $g_{i,1}$ | $v_{i,j}=w_i*g_{i,j}$ | |
| | $C_n$ | $W_n$ | $g_{n,1}$ | | $g_{n,m}$ |

$$N_j = \sum_{i=1}^{n} v_{i,j} = \sum_{i=1}^{n} w_i * g_{i,j}$$

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* K.H. Selbmann, F.W. Schwartz, W. van Eimeren: Qualitätssicherung in der Medizin, 6th Spring Conference of the GMDS, Tübingen, April 9-11, 1981

The fulfilment of every criterion (goal attainment) is marked for every alternative by a grade $g_{ij}$. The partial value ("Teilnutzen") $v_{ij}$ is computed as the product of weight $w_i$ with grade $g_{ij}$. The sum of partial values for each alternative represents the value ("Nutzwert") of this alternative $N_j$ (figure 1):

$$N_j = \sum_{i=1}^{n} c_i * g_{ij}.$$

The result of the procedure is, therefore, a single value assigned to a system variant. In the subsequent examples this value may lie anywhere between 0 and 1000. Because of the great degree of subjectivity involved, a given value for one system is rather meaningless. The values of different system variants may, however, give an indication of their relative importance with respect to the system of criteria applied. Variants in this context may be represented by different combinations of hardware and software - either from different suppliers or at different sites or times.

The procedure has the advantage of allowing the consideration of criteria of various dimensions. The establishment of the system of criteria is an incentive to completeness and to the application of comparable standards to the considered alternatives.

On the other hand, the method does depend on subjective assessment. This affects the establishment of the system of criteria as well as the assignment of values to the weights and finally the grading of the fulfilment of every criterion. The control of subjectivity in these phases may require substantial efforts.

### 4.1 System of criteria

The following roughly structured system of criteria is intended as a frame of reference which would require modification if actually applied.

The catalogue of criteria is divided into two parts:

1 Objective criteria of supplier / product,

2 Application features.

The first part is more or less independent of the spectrum of functions realized for a given application. It contains criteria which are rather easy to verify on the basis of systems proposals and detailed discussions with a supplier.

The contents of the second part firstly depends on the realized or projected spectrum of functions. Secondly, the assessment of the fulfilment of these criteria requires experience with the application of a given variant of a system. It is, therefore, less suitable for the assessment of proposed solutions than for the evaluation of practical experience.

Figure 2: Criteria

1 Criteria Concerning Supplier / Product

1.1 Hardware, Basic Operating Software

1.1.1 Performance
- available random access memory (initial / maximal)
- throughput (CPU, interfaces, peripherals)

1.1.2 Reliability
- availability
- recovery
- data integrity (handling error, system failure)
- archival storage (devices, programs)

1.1.3 Costs
- purchase
- development
- supplies
- maintenance
- education, introduction support

1.2 Supplier

1.2.1 Maintenance Support
- error correction (hardware, basic operating software, application software)
- preventive maintenance
- release concept
- service network

1.2.2 Education, Introduction Support
- need for user education
- availability of education packages/courses etc.
- continuity of support

1.2.3 General Characteristics
- product responsibility
- stability (marketshare, duration of relevant activities)
- application related know how

Figure 2 (continued)

2 Criteria Concerning Application Functions

2.1 General Criteria

- adaptivity to varying demands of application environment
- adaptivity to users of varying experience
- elimination of redundancy during acquisition / storage
- effort required for user education
- effort required for system recovery / data security

2.2 Functions of Various Application Services

2.2.1 Donor Service

- basic data handling
- scheduling (fresh material / stock supply)
- decision support (donor acceptability)
- accounting, billing

2.2.2 Recipient Service

- basic data handling
- decision support (protection of recipient, therapeutic advice etc.)
- billing, accounting

2.2.3 Product, Stock Management

- basic data handling
- demand control, surveillance of deterioration, trend evaluation
- product information

2.2.4 Laboratory

- identification (persons, samples)
- process control
- donor / recipient information
- decision support (investigations)
- accounting / billing / administrative support.

2.3 Back-up Support for 2.2.1 to 2.2.4

2.4 Support of Archival Storage / Data Analysis.

The criteria listed in Figure 2 shall be commented summarily:

Performance, reliability and costs are the mutually related systems characteristics that are of primary importance for product assessment. Hardware performance depends on the CPU architecture and the size of random access memory, performance of peripheral devices and their interfaces with the CPU. Evaluation should account for restrictions in the exploitation of hardware features through inefficient software.

Reliability again comprizes different aspects. For larger hospital information systems it is recognized that an actual availability of above 98 % of the scheduled system availability has to be attained in order to achieve satisfactory service. Average downtime should not exceed 10 minutes in 90 % of breakdowns. These figures are likely to also apply to the support of the functions of transfusion centers with their need for high responsiveness.

Availability and average downtime may be implied with some reliability from figures obtained from other applications of similar hardware and operating software. This is much less the case with the sensitivity of data integrity to handling errors and system failure. Though, to a large extent depending on application software, they are included among the features of global relevance.

The availability of hardware and software features for archival storage of collected data seems to be somewhat neglected at times, even though the value of a computer-based information system is considerably augmented by its support of data analysis. Long-term storage of data in machinereadable form counts among these features as well as software for statistical analysis (see below).

The most important categories of costs are cited, even though not necessarily relevant, simultaneously.

The system may be commercially available or be developed by institutions that are not profit-oriented. Evaluation of suppliers according to the indicated criteria may have to account for the possibility that responsibility for different components is divided among different suppliers (e.g. hardware supplied by industry, application software, support etc. provided by independent developing institutions.)

The maintenance category may be considered most important among the listed criteria. It comprizes concepts and procedures for the elimination of errors and failures at the level of hardware, operating and applications software. These should be available at least locally at the site of application. Also at present one may usually not expect a system to have attained its final stage of development. One has, therefore, to improve, correct and supplement applications, all of which requires a strict discipline to be observed during continuing development in order not to disturb routine use. The relevant concepts of different suppliers and their realization differ drastically at times.

Similarly, wide variation exists with respect to requirements for and realization of introductory support and training.

Considering these aspects, the varying demands of different user groups have to be accounted for:

- project initiator / director
- routine user (technical staff, doctors, nurses, administrators)
- casual user (physicians, administrators, scientists)
- system supporter (programmer, service engineer, systems analyst)
- system operator

Casual users and project initiators should not require additional training. Support by routine users, system developers or operators should suffice. The latter two groups, however, will always require detailed systems documentation and may require additional training, while the type and amount of support of routine users will largely depend on the adequacy of the application packages user interface.

The general characteristics listed in Figure 2 are particularly relevant for commercial vendors. If a substantial development effort is needed, a clear assignment of responsibilities and resources is necessary in order to protect the project against changes in company policy. Stability of the company, its share in the market and problem-related, specialized knowhow will also be appreciated contributions.

Concerning application functions, adaptivity is paramount among general features. One reason is that the spectrum of required functions always varies slightly as between institutions. This makes adaptions necessary. On the other hand, successful implementation of a system usually results in rapidly rising demands, making enhancements necessary. Finally, also the changing state of the art such as adaption to evolving standards and norms has to be accounted for.

Because of these multiple reasons for adaptations, it is not advisable to realize the system functions through a straight-forward program code but rather to create generalized carrier systems (16) that are able to support a variety of functions.

These functions should, in addition, be realized in such a way that users of different background may interface with maximum efficiency.

From the user's point of view, the kind and amount of training required and system reliability as well as efforts for system recovery have to be taken into consideration.

A somewhat varying composition of application functions is relevant for such different application realms as administration of:

- donor
- recipient
- product / stock
- laboratory.

System evaluation with respect to the support of these functions has first to consider

- completeness
- adequacy or validity
- precision
- correctness
- availability

of data. The criteria have to be applied to different types and subsets of data with respect to their related uses. Relevance and adequacy of the realized functions may also have to be considered in the context of a realized application. All these aspects can hardly be determined theoretically but require practical experience. Where this is available, on the other hand, a formal evaluation should structure the gained knowledge and make it available to others.

## 5.2 Weighting

The assignment of weights to the various criteria requires acceptance of a stable system of criteria. The catalogue given in Figure 2 may serve as a guideline. Necessary modifications may include restructuring the suggested hierarchy since such a structure always constitutes an act of brute force applied to the multiple ramifications of relations between such criteria.

Given a stable system of criteria, weighting should proceed using a constant sum of weights (e.g. 1000). This can be distributed proceeding from higher levels of the hierarchy to the lower ones, thus supporting the assignment of mutually balanced weights.

The estimates of different users or user groups may be obtained, independently at this stage. If marked differences are obtained, one may proceed in different fashions: One may either use the Delphi technique (1) to achieve an adaptation of the different standpoints to a "true" estimate. Or the results may be used as such in a sensitivity analysis in order to assess the impact of the contrasting standpoints on the final result of the evaluation. Finally, they may be used as a quantified expression of the difference between relevant standpoints.

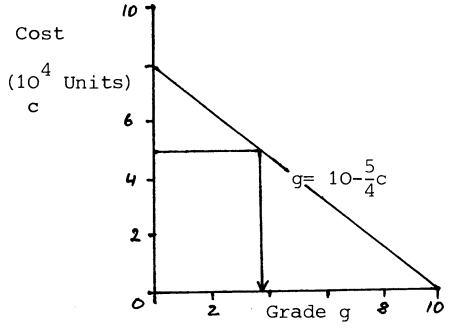
5.3 Assessment of goal attainment

In a subsequent step, the goal attainment of each system variant has to be assessed for every criterion. A defined scoring scale (e.g. 0 through 10) with fixed meaning of extreme values (e.g. 0 = insufficient, 10 = optimal) will have to be agreed upon for this purpose.

Consistency of the transformation of observed characteristics into grades is further improved by defining a transformation function. Because of the preliminary nature of the suggested system of criteria, the transformation functions can only be illustrated by examples here. A complete list of transformation functions would also exceed the available space.

A straightforward approach to transformation functions is possible if a characteristic is expressed on a continuous scale (e.g. weight, volume etc.). A simple example are costs which could be converted into grades by a linear function delimited by the upper size of the budget (corresponding to worst goal attainment) and zero costs (corresponding to optimal goal attainment) (Figure 3). Functions could, of course, be more complicated. Instead of using absolute limits for defining optimal and worst goal attainment as in this case (absolute scale), one could also use the extremes observed among variants as corner values (relative scale). Though this approach is sometimes more practical, problems might arise if an inclusion of further variants at a later stage of the evaluation process yields values exceeding the predefined limits.

Figure 3: Transformation Function for Cardinal scale
(Example: Cost)




cost of $5 \times 10^4$ units implies grade 3.75

Frequently, one has to account for characteristics which are more complex and relate to subjective assessments. Complexity arises, e.g., if the need for certain measures or services varies concurrently with the adequacy of the response to this need. An example is training and introductory support. A system may be designed in such a way as to eliminate the need for a training package. In this case, the lack of a training package has a meaning different from that as in the case of a system that requires thorough training of the user.

Figure 4: Sample of Characteristics to be Considered in Assessing Goal Attainment

| Criteria | Characteristics |
|---|---|
| 1.1.2 Reliability | Duplication of hardware (peripheral storage, IO devices) |
| | Availability > 98 % of scheduled service time |
| | Recovery < 10' in 90 % of failures |
| | Kinds of support for security back up (frequency, handling effort, time required for back up copying etc.) |
| | Availability during scheduled system maintenance |
| - data integrity | Completeness, correctness (precision) actuality. |
| | Means for error detection / correction (check digits, self correcting codes etc.) |
| | identification of author of input (source, user identification) |
| 2.1 General Criteria | |
| - effort rqd. f. user education | Manipulation of I/O devices |
| | Parametric guidance of users |
| | Conversion from the use of habitual codes to machine compatible codes |
| | Learning new codes |
| 2.2.1 and 2.2.2 Donor and Recipient service | Identification of author |
| - basic data handling | Adequate coding of blood Group symbols |

2.3 Back up Support Probability of system failure
- due to handling error
- due to software mistake
- due to hardware deficiency

Duplication of hardware

Availability of machine-compatible back-up documents (for input and output)

Goal attainment will, in the case of such criteria, frequently be characterized by a combination of multiple findings. Therefore, definition of transformation functions provides a stimulus to identify the relevant characteristics. Reliability of certain functions, ease of use, error tolerance, compatibility with agreed norms and standards, etc. are characteristics that may be considered in this context. A sample of relevant characteristics is listed in Figure 4.

Standardization of the conversion of these characteristics into a degree of goal attainment is supported by the creation of an ordinal scale listing certain combinations of features and assigning them to grades (Figure 5). A given combination of observed features may then be assigned a certain grade by arbitrary interpolation.

Figure 5: "Transformation function" for ordinal scale
(example: data analysis software)

| Grade | Characteristic |
|---|---|
| 10 | Usable routines available for all types of data analysis and statistics |
| 6 - 9 | Grading dependent upon scope of functions applicability to data types, ease of use |
| 5 | Analysis routines available, applicability limited to certain data |
| 2 - 4 | Grading dependent on efforts required for development and implementation |
| 1 | No analysis routines available, implementation feasible |
| 0 | Storage format of data does not allow machine analysis. |

## 6. Conclussions

The described method of NWA covers part of the conceivable scope of evaluation of EDP systems.
The given outline of the method serves as a substrate to a discussion of criteria that have to be applied to an evaluation of EDP systems in transfusion medicine.

The method is comparatively easy to apply and is of particular value for structuring the system of criteria as well as for the comprehensive and comparable evaluation of systems. The results are subject to considerable subjective influences. The validity of the results obtained, therefore, largely depends on the thoroughness of the control of subjective influences.

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# SYSTEMS ANALYSIS IN REGIONAL BLOOD MANAGEMENT

By

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## Abstract

One of the main objectives of a Regional Blood Management System (RBMS) is the efficient management of the region's blood resources. This, however, is a complex task. Blood is a perishable product, for which the standard results of inventory theory do not hold. Its demand and supply are uncertain. It must be distributed and inventoried under special medical considerations at hospitals whose annual transfusion volumes, medical practices, and distances from the supplying regional center vary widely. And, in addition to the above issues of analytical complexity, blood bank managers are faced with issues that are typical of a health care management problem: i) the performance of the system can be measured in terms of multiple criteria, some of which are conflicting, and, ii) quantitative measurement of the system's performance can be very difficult, since the estimation of many of the costs involved (e.g., unavailability of blood) is very subjective.

Because of the above factors of complexity, the development and implementation of a RBMS calls for a systems approach to be used. According to this approach, the analyst will identify the system and its components, the system-subsystem activities, goals, and hierarchical relations, will analyze the operation of each component, will develop system objectives, design appropriate organizational structures, formulate and solve mathematical (optimization) models, and implement and monitor the new system. In addition, this approach calls for the cooperative use of several scientific fields during the course of the project, the most important of which are Operations Research, Computer Science, Behavioral and Organizational Sciences, and Transfusion Practice.

This paper outlines this approach as used by the staff of the New York Blood Center in the development and implementation of a prototype RBMS. This system was implemented successfully in Long Island, NY, as well as in a number of other regions. It has been considered as one of the most sophisticated blood systems in the U.S.A., and has been awarded the 1979 International Management Science Achievement Award.

## 1. ON SYSTEMS ANALYSIS

Systems Analysis (SA) can be defined as "the multidisciplinary problem-solving activity that analysts have evolved to deal with the problems of sociotechnical systems" [33]. Some common examples of such systems are the energy system, the transportation system, the health care system, and many others in modern society. A common feature among these systems is that they are complex: they generally involve several subsystems whose internal operations and external relations with the other components of the system are complex, and, maybe, not perfectly known or understood. Also, they always involve people-participants of the system, whose behavior and interests are being affected by the structure and operation of the system, as well as people-decision makers for the system, who generally try to satisfy objectives of efficiency while observing constraints imposed by social, political, legal, or other considerations. Finally, the analysis of these systems generally calls for the cooperative use of several scientific fields, and, therefore, requires the coordination of a multidisciplinary team.

Because of the complexity and multidisciplinary nature of these problems, the success of a SA project depends not only on the analytical modeling of the problem, but, perhaps even more so, on the art of combining the knowledge and methods of several disciplines of modern science and technology with concepts of social goals and equities, elements of judgment and taste, and appropriate consideration of the larger contexts and uncertainties that inevitably attend such problems. It is these features that make SA more of a "craft" [17] than a traditional scientific discipline.

The central purpose of SA is to help public and private decision makers solve the problems and resolve the policy issues they face. The distinguishing characteristic of the approach is that, in addressing a problem, it first identifies a system (or systems) within which it must be considered, and then comprehensively analyzes alternative courses of action by evaluating their costs, benefits or other consequences in light of overall system objectives and constraints. In more detail, the stages of an SA project can be considered to be the following [33]:

1. Problem identification and formulation in a systems framework.
2. Definition of objectives and their translation into evaluation criteria.
3. Formulation of alternative courses of action for achieving these objectives.
4. Estimation of the impacts of the various possible actions.
5. Comparison of alternatives by applying various criteria to their consequences.
6. Presentation of the results to the decision maker in a framework suitable for choice.

In addition, the project could involve implementation, in which case the following three stages should be included:

7. Selection of an alternative.
8. Implementation of the selected course of action.

9. Impact assessment on the basis of initial objectives and interim environmental changes.

These stages/guidelines are quite general since they apply to a great variety of sociotechnical problems. One can be more specific when discussing the use of SA in a particular field, such as health care, and therefore take into consideration any special features of this field. For example, Health Care Systems (HCSs) can be characterized by the following special features:

1. A HCS involves three types of individuals: patients, doctors and administrators. This is not common, since most other systems involve only two types of individuals: participants (patients) and decision makers (administrators). In the case of a HCS one clearly has to take into consideration the role of the physicians as well as their psychology.

2. A HCS is often organized hierarchically. For example, a regional blood management system coordinates the collections of blood at the Regional Blood Center with the disposition of blood at the Hospital Blood Banks.

3. A HCS is dynamic. For example, medical procedures can change with advances in research. Or, the availability of specialized physicians can change with demographic factors, with training policies, etc.

4. The performance of a HCS can be estimated by a set of interrelated quantitative and qualitative indices. We note that the qualitative indices can be equally, if not more, important to the quantitative ones.

5. Almost nothing in a HCS can be subjected to experiments, even at local levels.

6. Introduction of computer automation in a HCS requires special attention, since full standardization of information requirements for medical diagnosis and treatment is very difficult to achieve.

Finally, a real insight into SA can only be obtained through experience with particular case studies, such as the development and implementation of a regional blood management system which is presented here. In this sense, we hope that this paper will contribute to this pupose.

## 2. THE REGIONAL BLOOD MANAGEMENT PROBLEM

Human blood is a perishable product. In the U.S. it currently has a legally defined lifetime of 35 days during which it can be used for transfusion to a patient of the same blood type, and after which it has to be discarded. It is collected in units of one pint per donor at collection sites such as a Regional Blood Center (RBC), and after a series of typing and screening tests, it is ready to be distributed to the various Hospital Blood Banks in the region.

The Hospital Blood Bank (HBB) operates as an inventory location, storing and issuing the appropriate blood units to satisfy transfusion requests. During the course of a day the HBB receives (from the physicians of the hospital) a random number of transfusion requests for each blood type, each request for a random number of units. Once a request for a patient is received, the appropriate number of units of that type are removed from free inventory and,

upon successful crossmatching, they are placed on reserve inventory for this particular patient. Any of those units that are not transfused are returned to free inventory. We define demand to be the number of units requested, and usage to be the number of units used. Any units which are not used within their 35-day lifetime are considered outdated and are discarded from inventory.

The performance of a regional blood inventory management system can be evaluated in terms of several criteria, the two most common of which are the shortage and the outdate rates of the participating HBBs. We define a hospital's shortage rate to be the percentage of days during which a shortage occurs (i.e., the day's demand exceeds the available inventory), and outdate rate to be the percentage of the HBB's supply that eventually outdates.

The management of the blood resources of a region is a complex task. Some of the reasons that contribute to the complexity of the problem are:

- Whole blood is perishable, and, therefore, standard inventory theory results do not hold;
- Its supply and demand are uncertain;
- The demand (units crossmatched) and the usage (units transfused) of blood at each hospital are different random variables;
- There is a large variation in the size of hospitals within a region. They range from those transfusing a few hundreds of units yearly, to others transfusing tens of thousands yearly;
- There is a large variation in the kinds of operations, and the practices among hospitals. As an example, some hospitals typically transfuse whole blood, others red cells;
- There is a large variation in the distances involved. Some hospitals are a few hundred feet away from the RBC, whereas others are as far as hundreds of miles.
- There is a large variation in the frequence with which the 8 blood types appear.

In addition to being analytically complex, the regional blood management problem is a semistructured health care management problem: the decision maker (i.e., the RBC) is faced with several objectives of performance in the region, some of which are conflicting (e.g., availability vs. utilization of blood), and, therefore, has to use subjective judgment in comparing the trade-offs involved, and establishing targets for each objective. Also, quantitative cost measurement of the system's performance, and, therefore, comparison of policies using simple cost criteria, is very difficult, since estimation of the benefits (or costs) resulting from the availability of blood (or lack of it) when and where it is needed can be very subjective.

Finally, any allocation policy has to conform to the laws of the region and to the medical and management practices of the hospitals and the RBC; has to ensure a "fair" and efficient allocation of the scarce resource; and has to be able to adjust rapidly and easily to any changes of the above. In addition, since any system for regional blood management establishes an organizational structure between the participants of the system, special consideration has to be given to the incentives that alternative structures provide, as well as other control mechanisms and practical issues involved with implementation.

Because of the complexity, the traditional approach for the analysis and the management of a "blood region" has been to decompose a region into its individual hospitals, and determine efficient rules for each HBB. This approach established a decentralized mode of operation, where each HBB would call the RBC in the morning in order to place an order for enough units so as to bring its inventories to "safe" levels -- enough to meet demand with high probability, but not so as to induce much outdating. The RBC would try to meet most of these orders, keeping in mind the limited supply, and therefore holding sufficient inventories at the Center for future orders, and for emergencies. This uncertainty for both the RBC (concerning the HBB orders) and for the HBBs (concerning how much of their orders would be met) imposed a competition between HBBs for their supply of blood, created artificial shortages, and resulted in poor utilization of the regional resources. A 1971 national survey reported that approximately 25% of the blood collected was outdated [10]. In addition, instances of shortage were reported to be frequent, resulting in postponements of elective surgeries, and personnel and other resources were inefficiently used.

To address this problem, a National Blood Policy was adopted in 1974 which called for "the introduction of systems management to blood service," and for the establishment of regional associations for the cooperative management and sharing of the regional blood supplies.

The Operations Research Laboratory of the New York Blood Center was faced with this issue: of developing a prototype regional blood management system, and implementing it in Long Island, New York. This paper describes the development and implementation of this sytem. In the next chapter we give a brief overview of the literature and describe the basic principles and decisions made initially that characterized the entire project. In the remaining three chapters we give an overview of the project's three subsequent phases: data collection and analysis, modeling, and implementation. We try to give a global overview, without going into analytical or practical details. Selected references guide the reader to more detailed discussions elsewhere.

## 3. BASIC PRINCIPLES

Let us first selectively review the status of blood inventory management theory and practice, in order to point out some important previously developed results that were useful in our research, and also to explain some assumptions/decisions we made that might otherwise appear arbitrary. For a more complete and up-to-date review of the blood inventory management literature the reader is referred to Prastacos [31].

Blood inventory management can be addressed from two hierarchically related points of view: the micro level of a HBB, and the macro level of a RBC. At the micro level, the analyst is interested in defining, analyzing and evaluating management policies used by the HBB. Such policies include the HBB's ordering policy, the inventory management at the HBB, the issuing of blood for transfusions to patients, and the processing of blood into components. At the macro level, the analyst is interested in examining allocation and distribution policies of blood from the RBC to the HBBs, determining the appropriate topology of the regional network (centers, depots, etc.) and defining efficient and effective organizational structures in the system.

Some of the previously developed important results for the HBB level are the following:

1. The optimal ordering policy for a HBB is not one of the standard inventory policies (e.g., S type, or S-s type). Instead, it is a very complex one, and computationally very difficult to determine (see Nahmias [20], Fries [14] for more details). However, the well-known inventory policy of ordering periodically up to a fixed "desired" inventory level is very close to the optimal one (see Nahmias [21,22], Chazan and Gal [5] and Cohen [6] for details).

2. The demand and usage of blood at hospitals appears to follow some common statistical pattern, as indicated by several researchers (see, e.g., Elston and Pickrel [11,12], Rabinowitz and Valinsky [34], and Yen [38]. These patterns, once determined, can be used to determine inventory levels that will achieve desired shortage and outdate rates.

3. The "first-in-first-out" (FIFO) issuing policy appears to be a good policy to follow when cross-matching units for patients (see Pierskalla and Roach [26]).

Even though the problems to be examined, the methodology to be used, and the results obtained are clearly defined at the HBB level, this is not the case for the RBC level. There, the theoretical problems become more complex since they involve much larger state and decision spaces. In addition, organizational, behavioral and implementation issues play a more important role.

The regional management systems that are usually found can be considered as falling roughly into one of two categories: (i) Decentralized systems, and (ii) Centralized systems. A decentralized system is one where each HBB sets its own inventory levels independently of the other HBBs in the region, and places (daily) orders to meet these levels. A centralized system is one where the RBC allocates the regional resources so as to achieve overall regional objectives. In both cases, blood collection is the responsibility of the RBC, which, because of the time lag between the scheduling and the realization of a blood collection trip, attempts generally to schedule daily collections of equal size.

In each of those systems blood units can be shipped from a RBC to a HBB either on rotation or on retention. A rotation system is one where the units are shipped to a HBB on consignment. The RBC maintains authority over the unit and can transfer it to another HBB (according to a plan, or when needed). The HBB pays only for the units used. A retention system is one where, once the unit is delivered to the HBB, it stays there until either used or outdated.

Finally, a regional management system is characterized by the topology of its network. The two most common ones are the star and the tree networks. In the star network the RBC supplies directly the HBBs in the region. In a tree network, intermediate depots exist between the RBC and the HBBs.

Each of the above organizational structures requires a different mechanism for monitoring and control. As an example, a rotation type system assumes the existence of communication channels that transmit timely and accurate information on blood availability, needs, etc., as well as transportation capabilities for transfer of blood. Also, each structure provides different incentives for participation. As an example, centralized systems often guarantee to the participants (HBBs) assured supply when in need, as an incentive for participation.

Therefore, the relative success of each of these structures in a given region depends very much on the following three important factors:

1. the parameters of the distribution system that will be implemented within a certain organizational structure (i.e., the quality of the algorithm that will determine the size, age and frequency of shipments, distribution schedule, etc.).

2. the mechanisms for communications, monitoring and control that will be used, and the relative cost, efficiency and effectiveness of these mechanisms.

3. the incentives for participation that a given structure provides to the HBBs.

Most of the literature on regional management systems prior to our research concentrated on empirically developed and successfully operating regional systems. Some examples are the ones used in Connecticut [15], and Milwaukee [37]. The most important conclusions that were drawn from this literature are the following:

1. Centralized management and rotation of units generally improve the efficiency of the region. (See, e.g., Graf, et al [15], and Yahnke, et al [37], for more details.)

2. Prescheduled deliveries alleviate some of the uncertainty involved and they help towards better scheduling of the use of the resources, and, therefore, contribute towards the efficiency of the region (see Yahnke, et al [37] for more details).

3. Computer information systems can be of big help in the monitoring and in other logistical issues of the distribution system (see Frankfurter, et al [13], Hogman and Ramgren [16], Masouredis, et al [18], and Pegels, et al [25] for some examples).

On the basis of these empirical conclusions it was decided that the class of policies to be developed should be characterized by centralized management, some form of rotation, and prescheduled (to a great extent) deliveries to the HBBs. Also, because of the analytical complexity of the system, the existence of multiple objectives, and the complexity imposed by using the systems approach, an interactive computer system should be developed, to be used as a decision support tool to the RBC management. This way, alternative goals, strategies or scenaria could be effectively evaluated by combining the use of analytical models and data stored in the computer, together with subjective judgement and trade-offs on the part of the decision maker.

Specifically, the questions that this sytem was set to address are the following:

1. What are the minimum achievable outdate and shortage targets that can be set for the region?

2. What distribution policy should be used to achieve those targets?

3. What should the level of the regional supply be, in order to achieve these (or other) targets?

## 4. DATA COLLECTION AND ANALYSIS

A fundamental task in the design of a regional blood management system is the analysis of the statistical patterns of demand and usage of blood at each hospital, and the derivation of probability models that can confidently describe these patterns. To address this issue, data collection forms were designed, data were collected and analyzed, and models were formulated.

There are three uncertain quantities in each HBB's daily demand and usage pattern of each blood type: the number of daily requests (N), the size of each request (n), and the usage of each request (u). To capture the daily variations of N, and the variations of n and u among different requests, the two forms that are shown in Figure 1 were designed. Form 1 is used to record the total number of requests received daily by the HBB, for each blood type. The analysis of these data provides us with the statistical pattern of N. Form 2 is used to record the demand and usage of each request, over a certain period, for all types together. These data provide us with the statistical patterns of n and u. It is assumed here that the blood type does not affect the size or usage distribution of a request, and that data will be collected over a significantly long (say, 3 months) period of time.

Hospital: _____

Month: _____

| Date | O+ | A+ | B+ | AB+ | O- | A- | B- | AB- |
|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | |
| 2 | | | | | | | | |
| 3 | | | | | | | | |
| 4 | | | | | | | | |
| 5 | | | | | | | | |
| 6 | | | | | | | | |
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| 27 | | | | | | | | |
| 28 | | | | | | | | |
| 29 | | | | | | | | |
| 30 | | | | | | | | |
| 31 | | | | | | | | |

Figure 1a: FORM 1: No. of Daily Requests

Hospital: _____ Period: _____

Blood type: _____ Page _____ of _____

Units Used (m)

| Units Requested (n) | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10+ | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | |
| 10+ | | | | | | | | | | | | |

Figure 1b: FORM 2: Size and Usage of Requests

The results show that there are indeed similar patterns between HBBs: the number of daily requests N can be approximated by a Poisson random variable, the size of a request n can be approximated by a modified lognormal random variable, and the usage u out of a request of size n can be approximated by the weighted sum of a Poisson-type truncated probability distribution, and of an inverted Triangular distribution. These analyses show that these patterns are functions of HBB parameters which turn out to be easily computable from HBB records. These are the mean number of daily requests, the mean size of a request (or, alternatively, the percentage of requests that are made for one unit), and the ratio between the mean demand the mean usage. The reader is referred to Brodheim and Prastacos [4] for an explanation of the above distributions and parameters and for a more detailed presentation of these results.

## 5. ANALYTICAL MODELING

### a. Class of Policies

As explained earlier, the class of policies to be implemented was decided on the basis of previous empirical evidence of success, as well as discussions with the members of the blood banking community (HBB and RBC administrators, etc.). This class can be described as a centralized allocation policy, with prescheduled rotation and retention shipments.

Specifically, each HBB periodically receives scheduled shipments. Each shipment is composed of a fixed number of fresh (1-2 days old) rotation units, and a fixed number of older (6-7 days old) retention units. The retention units are permanently retained by the HBB until transfused or discarded at the end of their useful life. The rotation units that are in excess of a fixed "desired inventory level" at the end of the period are returned to the RBC for re-distribution as retention units. It is understood that the length of the period, the size of the shipment, and the proportion between rotation-retention units will generally vary between HBBs.

b. HBB Modeling

Before analyzing the regional problem, we need a detailed analysis of the HBB behavior when the HBB participates in a regional system as the one described above. Specifically, a model is required that relates demand and usage to shortage and outdate rates, as functions of the RBC blood distribution policy and the HBB's blood stocking policy. Such a model was established by a combination of statistical analysis and Markov chain modeling.

i) Shortage rate

The shortage rate of a given type at a HBB depends only upon the total inventory level, and the statistical pattern of demand. Since this pattern is known (from chapter 3) as being a function of a HBB parameter, a model was derived relating a HBB's expected shortage rate to its daily inventory level. Figure 2 presents the inventory level-mean demand curves for certain typical values of availability rates. Note that availability rate is the complement of shortage rate; e.g., a 90% availability rate implies 10% shortage rate). The reader is referred to [2] for more details on this model.

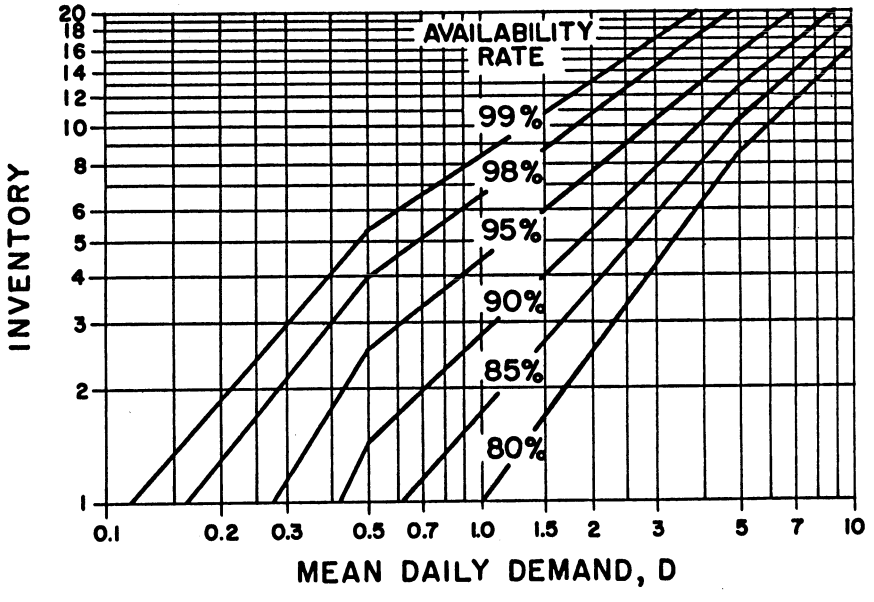


Figure 2: Availability Rate Model

ii) Outdate rate

In contrast to the shortage rate (which depends on the total shipment), the outdate rate is only a function of the retention units. The number of retention units in inventory at a HBB immediately after each delivery can be represented by a finite-state Markov chain, whose transition probabilities are a function of the fixed periodic input (i.e., the fixed retention shipments), and of the variable demand and usage. Under the assumption that the oldest unit in inventory is transfused first, the steady state solution of the system can be computed and related to the utilization rate. This model was examined in [1], where analytical approximations were derived for Poisson usage, relating the number of retention units in each shipment to the resultant outdate rates with the desired inventory level as a parameter.

It was shown that this stocking procedure maintains the mean inventory close to this desired inventory level most of the time. It was also shown that adding additional stages of returns and re-distribution would make only slight improvements in the shortage and outdate rates achieved. Since multiple re-distributions introduce several logistical problems and significant transportation costs, distribution strategies involving more than two stages of distribution were not investigated.

c. RBC Modeling

i) Properties of desirable regional allocation strategies

Having derived models enabling us to predict the shortage and outdate rates of a HBB for any policy implemented by the RBC, the regional allocation problem was examined. It was assumed that some fixed penalty costs were associated with every non-available unit and every non-utilized unit, and the objective was to determine the distribution policy parameters so as to minimize the total expected regional cost.

First, the policy that minimizes the total expected one-period cost was derived [28]. It was shown that this policy involves the following operations:

1. first allocate all available retention units so as to equalize the outdate rates at all HBBs;

2. then allocate all available rotation units (which are not subject to spoilage) so as to equalize the shortage rates at all HBBs.

It was also shown that this policy is independent of the unit penalty costs, and that it minimizes both the shortage and outdating of blood in the region, simultaneously. That is, any deviation from the policy that would increase outdating would also result in increased shortages for the next period, and vice versa. It was next shown [27] that this policy was not only myopically optimal but also stochastically optimal in the long run. Further, in a large number of cases that were tested by computer, the outdate and shortage rates computed from the myopic results also corresponded to the absolute optimal values computed.

This result established the principle that a distribution policy should seek to equalize outdate rates and shortage rates. This is also a policy that has the essential elements of "fairness" in equally spreading the non-availability risk among hospitals regardless of their relative size and is consequently a highly defensible policy.

Finally, it was shown that achieving the lowest possible shortage and outdate rates is equivalent to selecting the desired inventory level for each blood type in each HBB so as to minimize the total number of rotational units that are required to achieve these shortage and outdate rates.

ii) Adding practical constraints

The above distribution model of equalizing shortage (or, availability) rates and outdate (or, utilization) rates among the HBBs is illustrated by the two curved lines in Figure 3. The upper curved line shows the minimum total shipments required to achieve a fixed availability rate at a HBB of given mean usage. The lower curved line shows the maximum retention shipments to achieve a fixed utilization rate. Note that the utilization rate is the complement of the outdate rate. As an example, a 90% utilization implies 10% outdating, and vice versa. The area between the curves would have to be met by rotational shipments. As can be seen from the right tail of the curves, this results in a situation where the larger usage HBBs receive almost all of their shipments in older retention units, while the smaller usage HBBs receive almost all of their shipments in fresh rotation units.

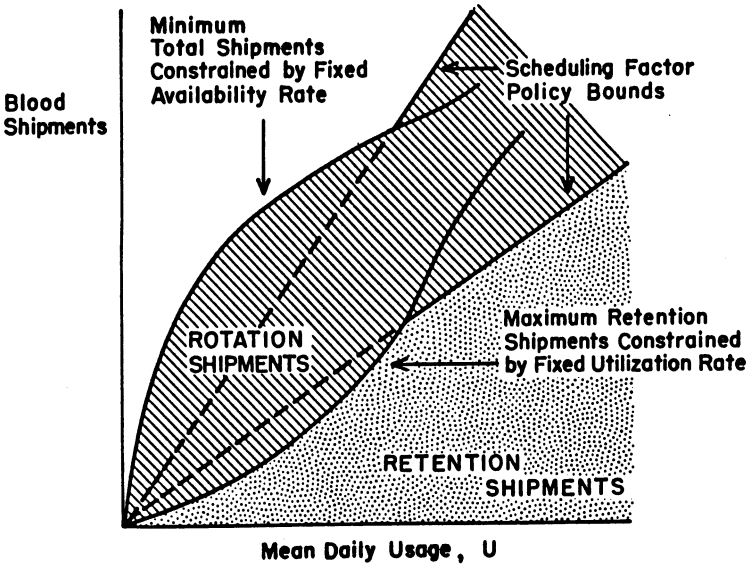


Figure 3: Shipping Policy Constraints

To alleviate this situation, and provide all HBBs with a reasonable mix of fresher and older bloods in inventory, an upper bound was placed on the scheduling factor (the proportion of mean usage replaced by retention shipments). The total amount delivered to each HBB was further constrained to exceed the mean usage by at least the complement of the scheduling factor. These constraints are represented by the "scheduling factor policy bounds" in Figure 3. It can be seen from this figure that this policy modification acts to equalize the mix of fresh to older bloods between HBBs. The scheduling factor was left as a decision parameter since the mix of larger and smaller HBBs varies as a function of the region and also to provide an extra degree of freedom to adjust regional blood distribution in times of overall blood shortages.

Finally, the effect of varying the interval between deliveries was investigated using the mean number of units on rotation as a basis of comparison. The week is divided into 6 delivery days with Saturday and Sunday counting as a single delivery day. It was determined that for blood types where mean daily usage is small, the mean required number of units on rotation is independent of whether the delivery interval is one, two or four delivery days. For higher values of mean daily usage, the difference between one day and two days delivery intervals remains slight, but increasing the delivery interval to four days causes significant increases in the mean number of rotational units required to achieve the policy objectives.

As a result of these observations, HBBs that transfuse less than approximately 1,500 units per year are receiving deliveries every four delivery days. Since analyses showed little distinction in the number of rotational units required between one day and two day intervals between deliveries, all larger HBBs were encouraged to utilize two day intervals between shipments.

iii) The Final Model

On the basis of the above, the final model was formulated as a mathematical program. The decision variables determined by the program are the distribution parameters: size of rotation and retention shipments, frequency of deliveries, and desired inventory levels for each HBB.

The objective of the program is to achieve the set "target" values for availability and utilization rates, while conforming to the operational constraints, with the minimum possible amount of total fresh rotational blood needed in the region.

Even though the model is highly nonlinear, its structure is decomposable, and the optimal solution is easily obtained by parametric enumeration.

## 6. IMPLEMENTATION AND OPERATION

The Programmed Blood Distribution System (PBDS) is the tool used to implement the above model in any region. The system is broken down into three, interrelated functions which are:

1. to plan the regional distribution and to forecast performance measures;

2. to implement the regional distribution plan;

3. to evaluate the actual performance with respect to forecast and to indicate changes required in the distribution plan when appropriate

The inter-relationship between these functions is illustrated in Figure 4 which acts as the basis for the discussion which follows. The planning and evaluation functions involve the top management while the implementation function is intended to be carried out by middle level management.

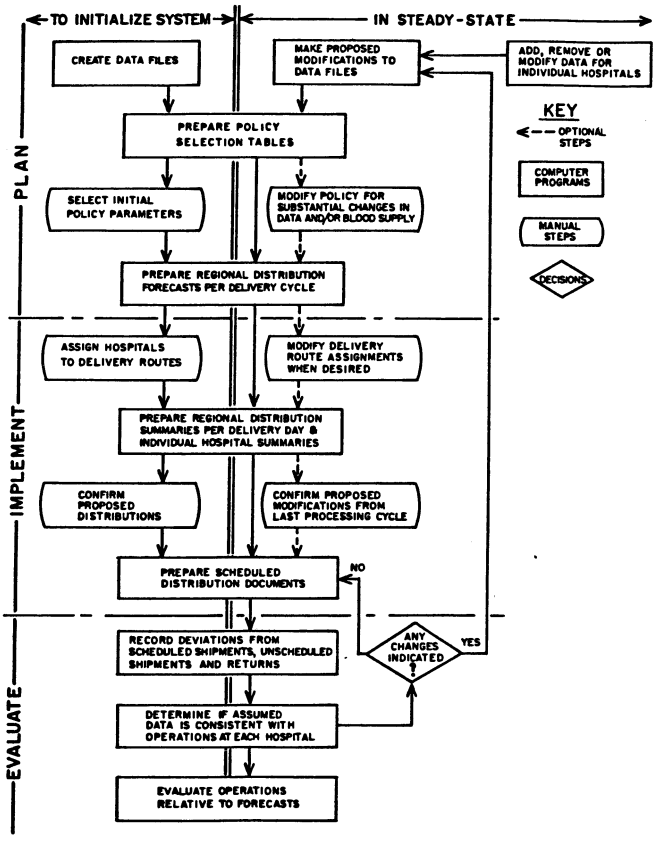


Figure 4: Programmed Blood Distribution System Flow Chart

a. The Long Island Blood Services (LIBS) Prototype

LIBS was set up as a prototype regional association of blood service units to demonstrate and evaluate the effectiveness of PBDS. LIBS is approximately the median size of existing regional associations and processes approximately 100,000 units of blood per year. It serves a diverse area ranging from the rural parts of Suffolk County to urban parts of New York City with a combined population of 2 million persons. LIBS is one of four divisions of the GNYBP which serves approximately 18 million people in the greater New York area. This facilitates interaction between these regions for such purposes as to smooth out local short-term shortages and surpluses.

The implementation of the program was carried out in a series of planned stages. At first only four hospitals were invited to join the program. These were provided support to correct rapidly the start-up problems that occurred. Once these were working to the satisfaction of the HBB supervisors, they described the system to supervisors of other HBBs at seminars where the Operations Research staff, wherever possible, played a passive role of providing information when requested to do so. By this technique, all but 4 very small HBBs in Long Island voluntarily joined the program within two years, and none has dropped out.

b. Overview

The initial planning starts with collecting the initial estimates of demand and usage for each of the HBBs in the program. This information, together with additional data required for shipping and other purposes, is used to create data files. From these data files, and using the model described above, "policy selection tables" are generated. These tables indicate the minimum total fresh supply needed to be distributed on rotation in the region over a two week period, in order to achieve certain "acceptable" values for availability and utilization. On the basis of these tables, of the amount and the stability of the collections, and of the reserve to be kept at the RBC, the attainable values are determined, and the "target" values are selected for these performance measures.

Once the planning phase is completed, hospitals are assigned to delivery routes. These delivery routes are constrained to provide for deliveries to all hospitals at a fixed time each delivery day. Delivery day intervals are either one, two or four days, depending on the size of the hospital and special requirements or strong preferences expressed. From these assignments "regional distribution summaries" per delivery day are prepared for evaluation. These are revised as needed to equalize the amount of blood distributed each day as far as possible. Individual hospital "summaries of delivery schedules" and of "desired inventory levels" are then prepared and sent to all HBBs. After discussions during which the above distribution schedules are confirmed or modified as required and extensive educational sessions with the HBBs' management and operational personnel take place, the operation is ready to start. The final step is the preparation of packing documents which are prepared in the order in which deliveries are to be made.

Once operational, data files or distribution schedules are modified by one of two means. As new hospitals are added, as hospitals are removed, as changes in usage occur, such as those from increased bed capacity, or as changes in usuage are detected by the control procedure, the data files are modified. The policy selection tables are revised each time there are revisions in usage estimates. The revised tables are then manually evaluated to determine if the changes are substantial enough to require a change in targets. A change in targets may also be required if a substantial increase or decrease in the blood supply is anticipated from other information. If such changes are required, then the regional distribution forecasting procedure is peformed again as described above.

c. Scheduling Deliveries

A major advantage of PBDS, both to the RBC and to the HBBs, is the ability to pre-schedule most deliveries. Prior to PBDS being implemented, a number of delivery vehicles were dispatched as orders came in. For urgent orders, vehicles were dispatched immediately, while for more routine orders an attempt was made to hold vehicles back until several deliveries in the same geographical area could be combined. This procedure was expensive and, perhaps more importantly, resulted in situations where even urgent orders were delayed, since delivery vehicles were not always available during peak delivery hours.

With the PBDS most deliveries are pre-scheduled, and take advantage of known traffic patterns in order to minimize delivery time. An interactive, computer-aided procedure was devised which assigns HBBs to delivery routes so as to meet their time and frequency of delivery requirements. The twelve delivery day planning cycle is split into three groups of four delivery days, after which the delivery cycle repeats. In each four delivery day cycle each HBB receives either one, two or four deliveries. The procedure tries to satisfy the delivery

requirements without leaving gaps in consecutive time slots, since an empty time slot indicates idle time.

d. Major Modules of PBDS

i) Policy Selection

This is the first module to be run in order to implement PBDS in a region. The user (regional center) interactively specifies alternative values (targets) for the performance measures, and the system computes the corresponding minimum fresh supply needed in the region to achieve these targets. The results of the computation are shown on a policy map, such as the one shown in Figure 5. The entries of the map indicate the quantities of the most common blood type (0+: relative frequency 38%) that need to be distributed as rotational blood every 2 weeks in order to achieve the targets shown in the corresponding coordinates.

Referring to Figure 5, to achieve a 2% outdate rate and 10% shortage rate, and maintain a 110% replacement of the mean usage at every delivery to every hospital, a quantity of 723 fresh units has to be distributed in the region every 2 weeks. This implies that collections in the region have to be at least equal to this quantity (usually higher, to maintain a buffer at the center) in order to implement such a policy. Given the region's level of collections (say 750 units in two weeks), the center can therefore draw a "policy boundary," as indicated in Figure 5, and select the regional target along the boundary, by evaluating tradeoffs between the components of the target vector.

These maps can be used by the center either to determine the best achievable performance targets (given the existing size of collections, and hospital mix), or to determine the appropriate size of collections needed in order to achieve desirable performance targets.

OUTDATE RATE = 0.020

BLOOD TYPE O+

| SHORTAGE RATE | FRACTION OF USAGE REPLACED 1.05 | 1.10 | 1.15 | 1.20 | 1.25 | 1.30 |
|---|---|---|---|---|---|---|
| 0.20 | 375 | 444 | 600 | 750 | 906 | 1089 |
| 0.18 | 399 | 486 | 639 | 807 | 975 | 1161 |
| 0.16 | 447 | 528 | 690 | 867 | 1035 | 1230 |
| 0.14 | 498 | 582 | 750 | 936 | 1110 | 1305 |
| 0.12 | 555 | 642 | 831 | 1017 | 1191 | 1374 |
| 0.10 | 636 | 723 | 921 | 1110 | 1290 | 1473 |
| 0.08 | 729 | 843 | 1038 | 1233 | 1413 | 1596 |
| 0.06 | 873 | 996 | 1185 | 1392 | 1566 | 1752 |
| 0.04 | 1080 | 1203 | 1407 | 1602 | 1767 | 1977 |
| 0.02 | 1437 | 1569 | 1758 | 1965 | 2136 | 2340 |

Figure 5: Policy Selection Table

ii) Distribution Schedules

Once the target values have been selected, the detailed rotation and retention parameters for each hospital are calculated, using the solution algorithm described above, and daily shipments are computed. Figure 6 shows a computer output of a typical distribution schedule, indicating the shipments made over a 2-week period. We note that the shipments repeat themselves every 4 delivery days. No shipments are made on the other days.

SCHEDULED SHIPPING TO HENRICO DOCTOR'S HOSPITAL DATE EFFECTIVE
USAGE DATA SET NO. 9 SHIPPING POLICY NO. 9

| BLOOD GROUP & TYPE | TOTAL | | WHOLE BLOOD (WB) | | | PACKED CELLS (PC) | | |
|---|---|---|---|---|---|---|---|---|
| | RETENTION | ROTATION | LONG DATE | STOCK DATE | SHORT DATE | LONG DATE | STOCK DATE | SHORT DATE |
| **DELIVERY DAY 4** | | | | | | | | |
| O+ | 4 | 9 | 4 | 2 | 0 | 5 | 2 | 0 |
| A+ | 2 | 9 | 4 | 1 | 0 | 5 | 1 | 0 |
| B+ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AB+ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| O- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| A- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AB- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 6 | 18 | 8 | 3 | 0 | 10 | 3 | 0 |
| **DELIVERY DAY 8** | | | | | | | | |
| O+ | 4 | 9 | 4 | 1 | 0 | 5 | 3 | 0 |
| A+ | 2 | 9 | 4 | 1 | 0 | 5 | 1 | 0 |
| B+ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AB+ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| O- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| A- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AB- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 6 | 18 | 8 | 2 | 0 | 10 | 4 | 0 |
| **DELIVERY DAY 12** | | | | | | | | |
| O+ | 3 | 9 | 3 | 1 | 0 | 6 | 2 | 0 |
| A+ | 2 | 9 | 3 | 0 | 0 | 6 | 2 | 0 |
| B+ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AB+ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| O- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| A- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| B- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| AB- | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 5 | 18 | 6 | 1 | 0 | 12 | 4 | 0 |

THE NEW YORK BLOOD CENTER-OPERATIONS RESEARCH LABORATORY-PROGRAM PBDS3

Figure 6: PBDS: Distribution Summary Form

iii) Controlling the System

The shortage deliveries and the rotational returns for each hospital are monitored in order to detect changes in hospital requirements. Every two weeks the "discrepancy" between the hospital's estimated and expected usage during these two weeks is computed. This discrepancy is added to the cumulative discrepancy from prior weeks to form an updated cumulative discrepancy, which, together with the number of weeks included in it, and the value of the

hospital's expected usage, are used to compute the "normalized cumulative discrepancy" of this week. This last value is compared with a statistically established "limit;" if it exceeds the limit, it is concluded that a shift in usage level has occurred. New usage estimates are computed, and new distribution shcedules are prepared. Otherwise, no action is taken. We note that the cumulative discrepancy is computed for a period of up to 20 weeks. After the first 20 weeks and every 10 weeks thereafter, the oldest 10 weeks are dropped and a new cumulative discrepancy based upon the most recent 10 week period is formed. In this manner, a dynamic procedure is established that proved to be effective in detecting shifts in usage.

e. Regional Blood Flow

The resulting regional blood flow is illustrated in Figure 7. In this figure the aging of the RBC inventory is indicated down the center of the figure with the scheduled movement of blood to HBBs indicated to the left of the figure and the non-scheduled movement to the right. The long dated, stock dated and short dated RBC inventories refer to blood units that are suitable, respectively, for rotation shipments, for retention shipments and solely for supplemental shipments -- which are filled by the oldest available units. The arrows indicate the blood flow that is normalized to 1,000 bloods collected.

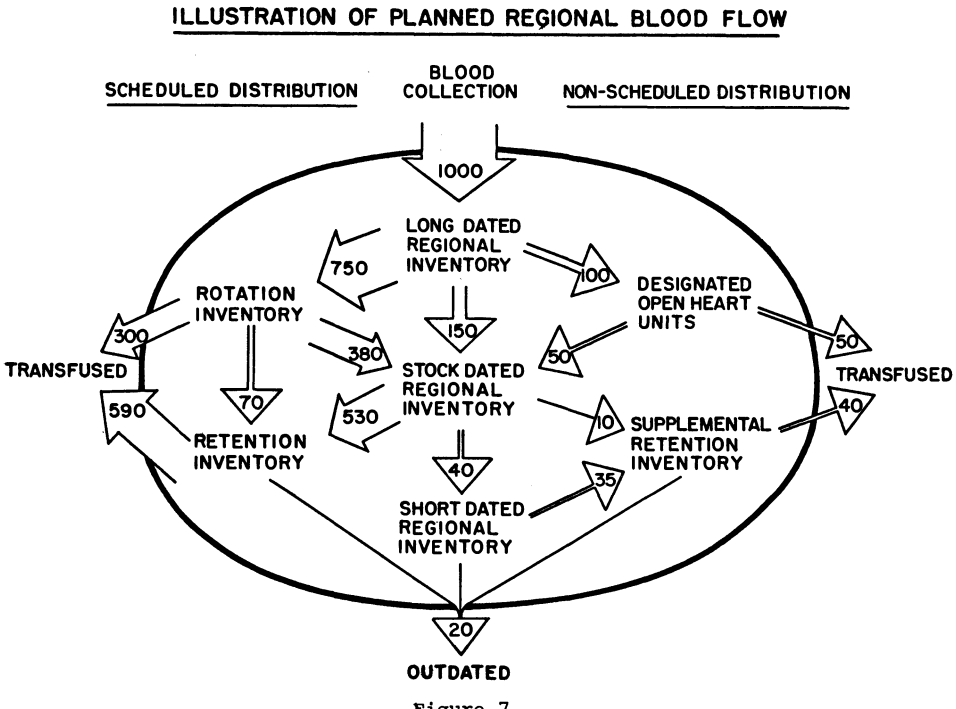


Figure 7

f. Computer Operation

The effectiveness of PBDS depends upon accurate and timely data on operations, which is achieved in part by running the system on a minicomputer, and by utilizing machine-readable bar codes on blood products and on test samples. The machine-readable codes on test samples are used in conjunction with automated equipment which peforms blood type determinations and links the

data concerning the unit and its test results directly in the computer. This provides the earliest possible indication of what products will be reaching inventory during that day. The bar codes, which indicate product, blood type, identification numbers, etc., are also scanned as blood units are shipped out and returned, to maintain perpetual inventory. In this manner, the total inventory picture at the RBC is accurately maintained in real time.

The light pen techniques are also utilized to control computer operations and to identify the locations to which blood products are shipped or from where they were received. This is done by scanning bar codes on menu sheets that list all shipping locations, all types of transactions and all available types of computer operations. This way, the computer is effectively used by non-technical personnel, and any errors in entering data are minimized.

In order to maintain a modular approach that can be utilized by all RBCs regardless of size, a network of minocomputers is being used to handle all the RBC blood processing needs. In a larger operation, such as LIBS, the operations are split functionally (i.e., separate minicomputers in the laboratory and distribution areas), while in the smaller centers a single minicomputer would handle all functions.

## 7. IMPACT

PBDS has already made a significant and permanent impact on the management decision process in Long Island. In the previously prevailing "reactive" mode of operation, the hospital blood bank and the regional blood center each made daily decisions on blood distribution from differing viewpoints. Each HBB regarded the situation from the point of view of its own inventory while the RBC regarded each order from a blood bank from the point of view of the reserves for the entire region. This inherently had to lead to an adversary relationship. With PBDS, the RBC assumes responsibility for the long-term distribution policy, while each HBB assumes responsibility for the daily adjustment of its inventory level with respect to a pre-agreed level. As a consequence, the relationship in Long Island has shifted from an adversary one to a recognition of their common objective of distributing the blood supply available to the region in an equitable manner, and a recognition that mismanagement of the supply by any HBB in the system affects the entire system and consequently each individual HBB.

PBDS has also made a significant impact on the performance of the region's blood distribution system. Before it was implemented, the reactive distribution system that was in effect resulted in an outdating of approximately 20% of their blood resources, and an average number of 7.8 weekly deliveries per hospital, all of which were unscheduled. With PBDS the regional outdating has been reduced to approximately 4%, with an average of 4.2 weekly deliveries per hospital, out of which only 1.4 are unscheduled. The target outdate rate has been set at an average of 2% and the target number of total deliveries at an average of 3.8. These values are shown in Figure 8.

The long-range objective of PBDS is to provide a basis for a planned inter-regional blood distribution network, which would establish a measure of cooperation between regions, and thus provide a mechanism for a more efficient utilization of the blood resources at the national level. For this to be achieved, further research is needed on the modeling of both operational as well as strategic type decisions associated with blood inventory management, and on the design of decision support systems, that will evaluate these decisions in view of existing or alternative management structures.

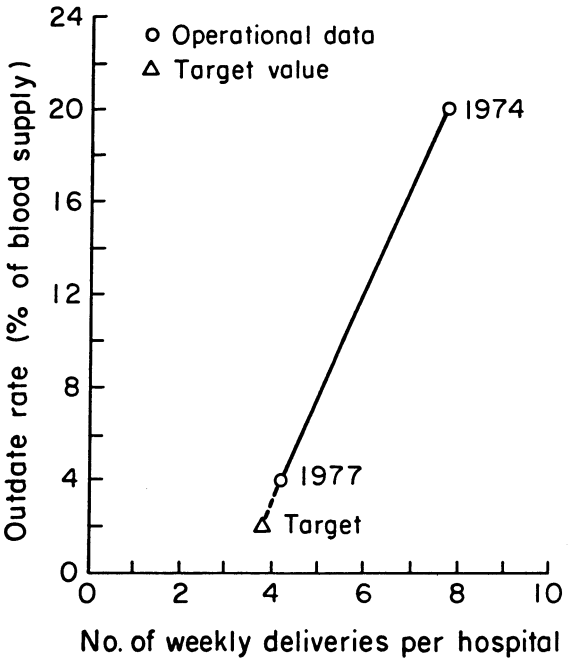


Figure 8

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# THEORETICAL FOUNDATIONS OF A CONCEPT FOR A DECISION SUPPORT SYSTEM

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## 1. Introduction

Regional blood donor services and hospital blood banks have been confronted with a constantly increasing demand for whole blood and components during the last couple of decades. At the same time, new organizational and technological concepts did not evolve rapidly enough to meet the increasing workload and higher quality standards in an appropriate manner.
In particular, the following shortcomings appear typical for many regional and hospital blood banks:

- little control on the number and blood types of donations;
- limited overview in the regional centers on the storage place of blood units after delivery as well as in the hospitals themselves because of organizational and information deficiencies;
- overordering by hospitals, especially for rare blood groups.

The result of these shortcomings are seasonal and local imbalances in blood supply with high outdating and shortage rates. An outdating of 15 % to 25 % (5), in some cases up to 30 % (4), is quite common. For the Berlin Blood Donor Service a rate of around 20 % was found in a statistical analysis from 1976. At the same time, 25 % of the deliveries were emergency shipments by taxi or errand. The application of modern computer technology (see (10)) and later of statistical and operations research methods for improved inventory policies (see (9)) are promising approaches to overcome these difficulties.
For several years a data base-oriented computer information system has been under development for the Berlin Blood Donor Service (BBD). The BBD is producing more than 90 % of the overall whole blood demand in West-Berlin with around 70 client hospitals. A short description of the computer system is given in the poster session of this conference report.
It is planned to implement a decision support function as part of this information system in a later development phase. The

theoretical foundations of the concept were developed in a simulation study which will be briefly summarized in the following paragraph. For a more detailed discussion, see references (7) and (11).

## 2. The Theoretical Model and its Restrictions for Real Applications

A simulation model was designed to investigate alternative inventory and distribution policies in a centralized regional blood banking system using real data from the BBD. The model describes a closed regional blood supply system with a blood donor service as the central blood supplier for any number of client hospitals of different sizes in terms of transfusion patients and emergencies, with and without blood depots of their own.
The structure of the model is shown in Fig. 1.
On-call donors are only requested if blood of the desired group is not available in the total system. An emergency shipment is initiated if the blood group needed is not in the unassigned blood inventory of the respective hospital. Inter-hospital transfers take place if the central donor service cannot deliver.

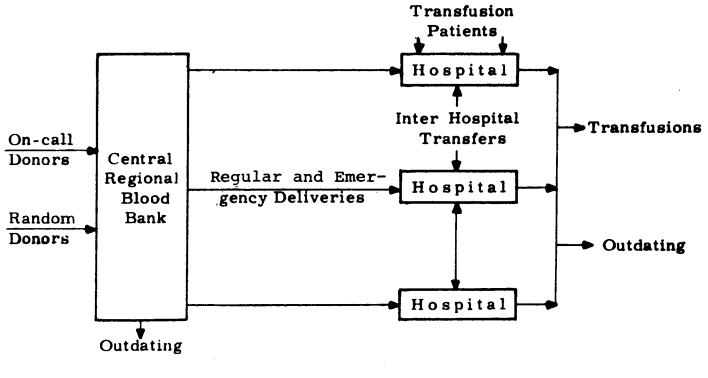


Fig. 1: The Structure of the Model

With the simulation model, a heuristic allocation procedure for an optimal distribution of blood units and a statistical donor call-up were tested. The results showed a reduction in inventory costs to

almost one third due to a decrease in blood outdating to less than 5 % and in shortages to 10 %.
It is clear, however, that these results are of a theoretical nature and have to be considered as a lower bound for what reduction might be achievable under optimal conditions. But these are not usually found in real applications. In this simulation study, full information and central control of the donor service on the inventories of client hospitals were given. Rapid and accurate to all inventory information can only be provided by an on-line computer network connecting the blood donor service with the client hospitals. Under present conditions, this solution cannot be justified economically, unless other functions outside the field of blood banking are added. But even with the restriction of limited information in a real blood banking system, the mathematical inventory methods mentioned could lead to a considerable cost reduction in blood inventory if they were adapted to this situation.
In the next paragraph the concept for a decision support function within the BBD-information system is outlined which adopted its basic ideas and some of the algorithms from the simulation study.

## 3. The Concept of a Decision Support System

As dispositive or decision support functions, respectively, of the computer information system for the Berlin Blood Service an Automatic Allocation Proposal for Blood Units and an Automatic Donor Call-up Proposal were developed.

### 3.1 Automatic Allocation Proposal for Blood Units

The content of this procedure is a method for the demand-adjusted assignment of blood units available at the BBD for delivery to the client hospitals. The aim is the promotion of an adequate and balanced blood inventory policy in the hospitals in order to reduce outdating and shortages.
Following the telephone reception and the on-line computer data entry of the hospital's blood orders for the regular delivery tour at the BBD, an allocation of whole blood units and blood components to the different hospitals is performed by the computer. The allocation algorithm carries out the following seven steps:

(1) Allocation of Preorders

Preorders a few days in advance help the regional center with their

delivery arrangement and should be encouraged. In addition, pre-orders are usually placed with a certain patient in mind.

(2) Allocation of Special Blood Components

If the blood components ordered (fresh frozen plasma, red cells, etc.) are on stock, they will be allocated. If this is not the case, whole blood units (fresh ones only if required) are assigned for the production of the components.
Since blood components are only employed for special transfusion indications, such a hospital order is intended for a special patient.

(3) Allocation of Blood Units with Special Blood Group Characteristics

In this step orders with additional blood group classifications to the common ABO- and Rh-system are processed (Kell, Lewis, P. HLA, etc.). Again it is assumed that more specialized orders are field for certain patients only. This assumption - as well as the one in step (2) - might not be valid for university hospitals and hospitals with specialized transfusion-medical wards, but it will certainly hold for the regular municipal hospitals which account for the larger share of the blood orders at the BBD.

(4) Allocation for Fresh Whole Blood (ABO, Rh)

Here fresh blood 1 to 3 days old is assigned (youngest first). Since fresh blood units are only required for special indication, it is usually ordered for special patients and transfused shortly after delivery.

(5) Allocation of Whole Blood (ABO, Rh) to Small Hospitals

In this step small hospitals and private practices are addressed which place blood orders only occasionally. Since they do not stock blood in depots of their own, their orders will be for immediate use.

(6) Processing of Urgent Whole Blood Orders (ABO, Rh)

Here only medium-sized and large hospitals with own blood depots, not covered in step (5), are included. Orders are called urgent if they are filed for patients awaiting immediate transfusion. Hospitals have to specify how many units of their order are urgently needed. If the available inventory at the regional center is sufficient, all urgent orders are dealt with. If not, an allocation algorithm

is initiated which has been adopted from the simulation study. It allocates the blood to the hospitals in such a way that all urgent orders are dealt with at the same rate.

(7) Processing of the Remaining Orders

In the last step the remaining orders are processed. Basically, the same allocation algorithm is used as above, with the exception that the relative inventory level of each hospital is considered. For every available blood unit the hospital with the minimal ratio of actual inventory (as reported by thelephone and incremented by additions from the allocation procedure) and average transfusions for this blood group receives the allocation. In this way, all hospitals have the same relative inventory level and imbalances in the supply system are avoided.

The function of the automatic allocation procedure is not to determine the final delivery scheme. It is rather provides a proposal, a decision aid for the physician in charge. He can rearrange the blood unit allocation and decide on specialized orders himself. Only after the changes have been fed into the computer system, the delivery scheme is ultimate and the delivery forms are printed automatically. The weakness of the stepwise procedure described is its dependency on inventory and urgency information from the hospitals which will probably not be very accurate. This data might be even purposely biased to receive more blood. In real applications we simply do not have perfect information as in a simulation model.

A control program could be developed to check the hospital's data transmitted by telephone with the computer after receiving the transfusion protocols in the regional center. In this way, the inventory level in each hospitals could be compared with orders and transfusion on that day. Such an analysis would become totally obsolete, however, and the regional center could not do much more than put some moral pressure on negligent hospitals afterwards.
In a more sophisticated and effective approach, the hospitals would have to report their inventory departures by blood unit number when they place their orders over the telephone. In this way, a central inventory file of all hospitals could be kept at the blood donor service and used for the automatic allocation procedure. It would not be as up-to-date as an on-line system, but would be an effective off-line approach with daily updating (at least for the medium and larger hospitals with regular orders). Hospitals could

benefit directly from the additional time invested in telephone reports if they were provided with inventory lists, printed by the BBD-computer, arriving with the morning deliveries. They could be used for inventory control at the blood depots and updated manually during the day, and they could be used as order forms for the next delivery.
The great advantage of this approach is that hospitals are encouraged and supported in keeping track of their blood inventory and using the same forms throughout.

## 3.2 Automatic Donor Call-up Proposal

The content of this procedure is forecasting the blood unit supply two weeks in advance and the demand-adjusted call-up of blood donors on the basis of this forecast. The aim is a permanent adjustment of the blood inventory in the total supply system to the demand in order to smooth out seasonal imbalances.
Forecasting and donor call-up are performed twice a week and two weeks in advance. Three steps are followed by the procedure:

### (1) Inventory Forecast for the Blood Donor Service

The following forecasting equation is used:

$$F\left\{BI^{(BDS)}_{b,t+14}\right\} = BI^{(BDS)}_{b,t} + ID_{b,t+14}\ F\left\{PRF_{b,p}\right\} - F\left\{HO_{b,t+14}\right\} - F\left\{LB_{b,t+14}\right\} \qquad (3.2\text{-}1)$$

with blood group b=1,2,...,8, request period p=1,2,...
and t=1 (=Monday), 3 (=Wedn.), 8 (next Mond.),...

were

| | |
|---|---|
| $F\{\}$ | Forecast |
| $BI^{(BDS)}_{b,t}$ | Blood inventory of group i at blood donor service at day t |
| $PRF_{b,p}$ | Percentage of donation requests followed by donors by group b in period d |
| $HO_{b,t+14}$ | Hospital orders of blood group b until day t |
| $LB_{b,t+14}$ | Lost blood units of group b until day t+14 at the donor service (outdating, suspensions, etc.) |

(2) Desired Donations for Call-up Period

$$DBD_{b,p} = DBI_b^{(BDS)} - F\left\{BI_{b,t\ 14}^{(BDS)}\right\} + F\left\{HO_{b,p}\right\} \qquad (3.2\text{-}2)$$

with blood group b=1,2,...,8, t=1,3,8,..., and p=1,2,...

were

$DBD_{b,p}$ Desired blood donations with group b for half week request period p

$DBI_b^{(BDS)}$ Desired blood inventory of group b at blood donor service

$HO_{b,p}$ Hospital orders with blood group b for period p.

(3) Donor Call-up for Request Period

Since not all donors called upon actually do show up, more donors will have to be called up than are actually needed:

$$DC_{b,p} = \frac{DBD_{b,p}}{F\ \ PRF_{b,p}} \qquad (3.2\text{-}3)$$

with b=1,2,...,8, and p=1,2,...

were

$DC_{b,p}$ Donor call-up with blood group b for request period p.

An easy adaptive forecasting method for computing the forecasts in equations (3.2-1) to (3.2-3) with little effort is the approach by CHOW (/2/), which is a modification of the well known Exponential Smoothing.
The automatic call-up procedure, described above, is again not more than a proposal, a decision aid for the blood bank management in determining how many blood donors of each group should be requested. The forecasts and the call-up proposal are given on a printout, and corrections by the physician in charge are expected before the

program screens the donor data base to select donors for call-up, using criteria such as last donation date, results of last medical examination, appointment preferences, reliability or location. Finally, the request letters are printed automatically.
The shortcoming in this approach is again the limited information available in real applications, as opposed to the theoretical modelling situation. Since hospital orders used as demand determinant, a bias is introduced into the procedure. In addition, merely the inventory in the regional center is used, neglecting the larger stock in the hospitals. With the off-line system as outlined above with daily inventory reports from the hospitals by telephone, however, an improvement of the forecast and call-up procedure could be achieved. Instead of the hospital orders we could introduce the actual transfusions and outdating as demand determinant and the total supply, including the hospitals, into the equations.

## 4. Summary and Conclusions

Many blood banks face the problem of high outdating and shortage rates because of inadequate inventory policies. A simulation model was briefly discussed which was used to test alternative blood inventory and distribution procedures in a regional blood supply system. These procedures showed a large reduction in blood waste and shortages and, therefore, in costs.
To apply the methods in a real environment, modifications and extensions were necessary to make up for the limited information available. This was demonstrated with the concept of the decision support function which will be part of the computer information system for the Berlin Blood Donor Service. An automatic allocation proposal for blood units and an automatic donor call-up procedure were introduced.

Although it cannot be expected that the full cost reduction of the simulation study could be realized with this decision support function, some improvement seems within reach. It has been reported elsewhere (1, 13) that a decrease in blood outdating of 6 to 7 % was attained after the installation of a computerized inventory system. This system merely provided inventory statistics without any decision support functions. Therefore, a reduction of approximately 10 % appears to be a realistic estimation for the BBD. Annual cost savings of more than 400.000 DM could be realized due to reduced blood purchases from external sources. Fewer taxi rides for emergency deliveries because of lower shortages woul add to cost savings.

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# A COMPARISON OF DECENTRALIZED AND CENTRALIZED DISPOSITION SYSTEMS FOR RED CELL CONCENTRATES

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## 1. Introduction

It is well known that the centralization of decision rules for the disposition of Red Cell Concentrates [RCC] in practice has demonstrated considerable advantages in most cases, e.g. by the reduction of shortages and outdates. Some results by Prastacos and Brodheim [4] - for Long Island, N.Y. - and by Lau and Morand [1] - for Ohio - are presented in Table 1.

| Performance measures / Region | Percentage of outdates | | Percentage of shortages | |
|---|---|---|---|---|
| | dc | c | dc | c |
| Long Island | 23 | 4 | 27 | 9 |
| Ohio | 14.7 | 6.8 | - | - |

Table 1: Comparison of decentralized (dc) and centralized ( c ) disposition systems

In Section 2 of this paper a rough framework of a multistage decision system for the disposition of RCC is described, with a distinction made between decisions for emergency and routine cases. For the routine cases the two types of decision systems that can be used (namely decentralized and centralized) will be described in Sections 3 and 4 respectively. In Section 5 these two types of decision systems are compared for data of RCC of blood type A+ that was collected in some Swiss hospitals.

1) The authors are indebted to Prof. E. Brodheim, Sc.D., Vice President, The New York Blood Center, New York, NY, for stimulating discussions and comments.

## 2. Framework

Usually a regional center (RC) is connected with a certain number of hospitals (HS) by an exchange of information and goods. (See Figure 1).

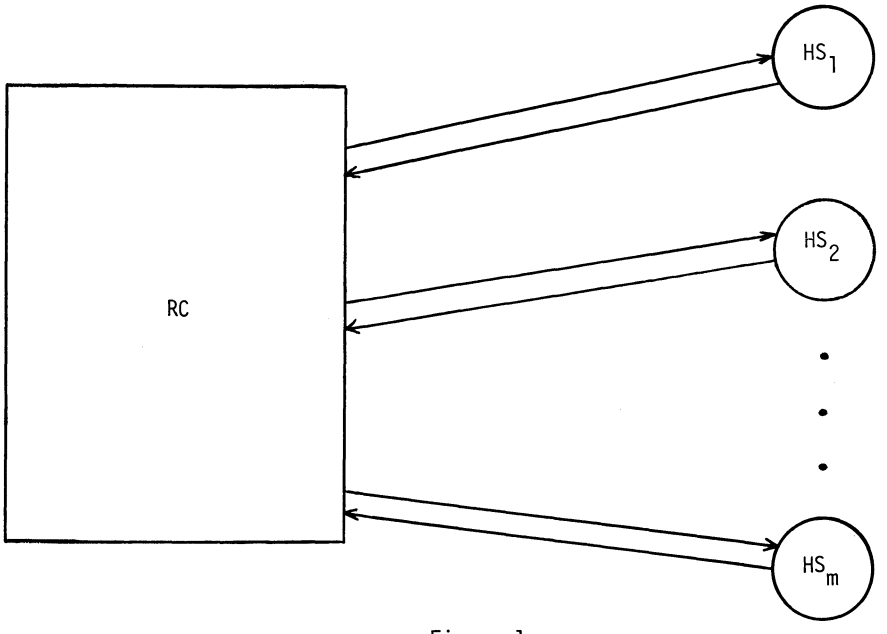



Figure 1

Figure 2 shows a framework of a multistage decision system for one regional center and one representative hospital. The demand for each blood group - defined by numbers of units and by transfusion dates - is determined by the medical staff in the hospital and reported to the hospital depot. The delivery of the crossmatched units occurs in time for the transfusions; unused units are returned to the depot. The delivery of units from the hospital depot for transfusions is possible in two ways: by routine or emergency delivery.

In Figure 2 the field indicated by broken lines can be completed by modules for decentralized and centralized decision rules. It can be seen that the emergency decision lines and a considerable part of the routine decision system remain unchanged by the integration of the different modules.

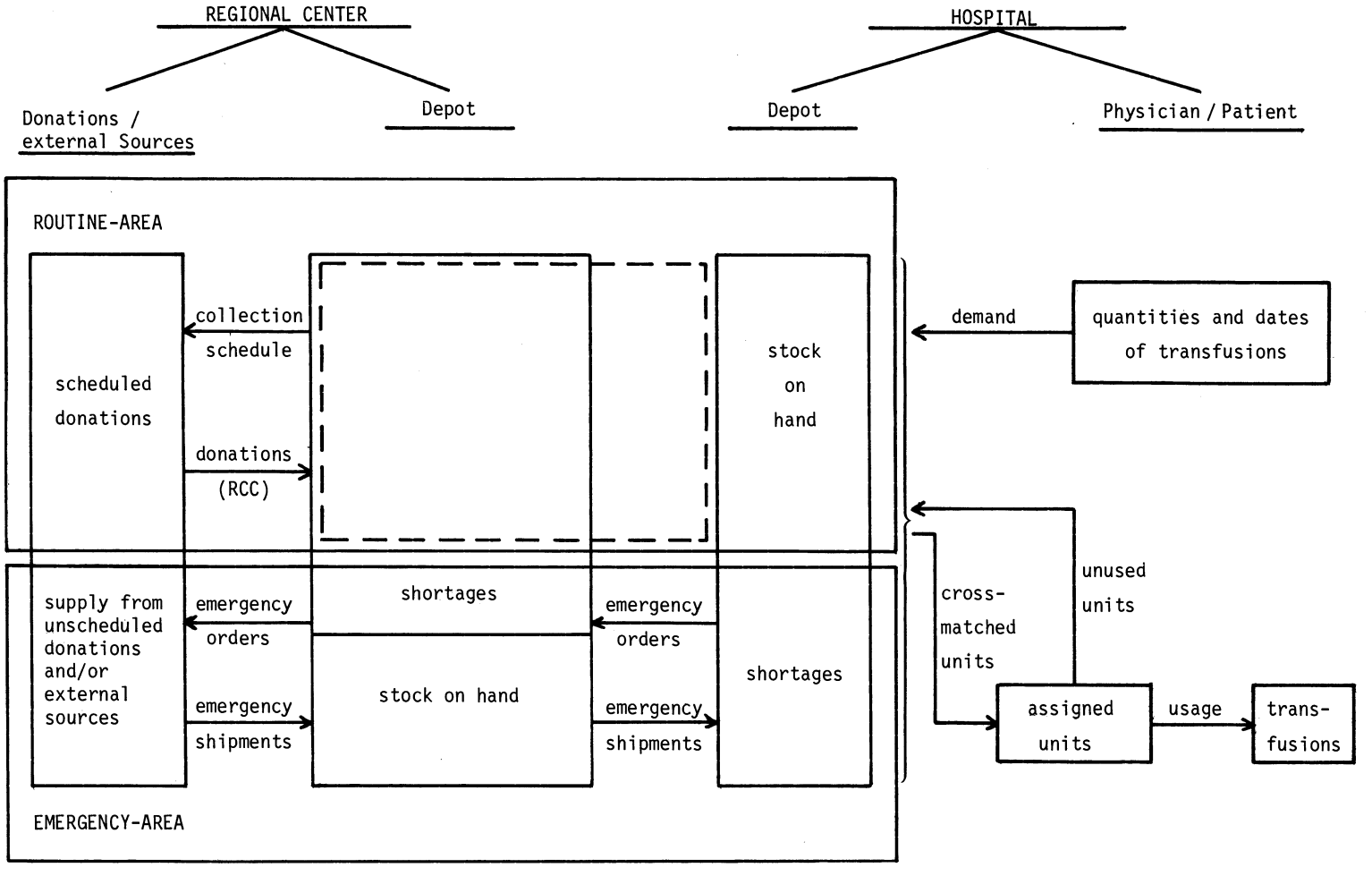

REGIONAL CENTER
HOSPITAL
Donations / external Sources
Depot
Depot
Physician / Patient
ROUTINE-AREA
scheduled donations
collection schedule
donations (RCC)
stock on hand
demand
quantities and dates of transfusions
unused units
cross-matched units
supply from unscheduled donations and/or external sources
emergency orders
emergency shipments
shortages
stock on hand
emergency orders
emergency shipments
shortages
assigned units
usage
trans-fusions
EMERGENCY-AREA

Figure 2

## 3. Decentralized Decisions

Figure 3 illustrates a decentralized decision situation. For routine orders from the hospital to the regional depot, the following alternative ways to meet the orders are possible: from stock by routine shipments or by emergency activities in urgent cases.

Based on the organizational structure of Figure 3 a simulation model can be formulated. Its planning horizon is dynamic with time steps of one day. Demand and usage are given per time interval by probability distributions. The cost coefficients for outdates, shortages and for routine and emergency shipments are known.

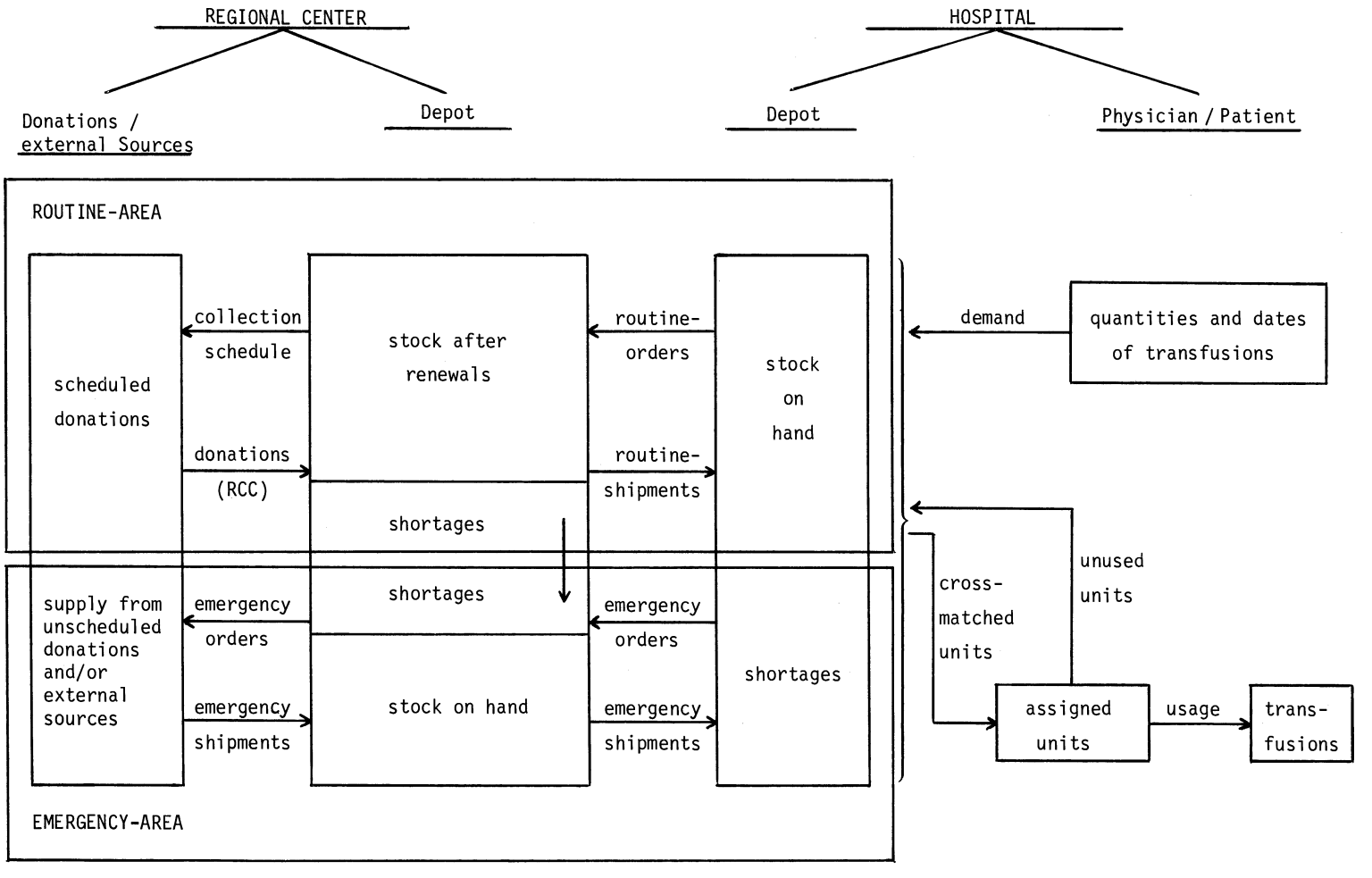
Performance measures of the model are:
- shortage rate
- outdate rate
- disposition cost per unit transfused
- average age of units transfused

Definitions of these measures are given in the Appendix.

The simulation model includes structural relations for hospitals, the regional center and between the hospitals and the regional center. The following relations are defined (along with others):
- inventory equations for the depots in hospitals and in the regional center, including stocks, outdates, shortages, renewals, deliveries and the FIFO-rule as issuing policy;
- a S-policy for routine renewals in the depots, i.e. at each day with renewals the stocks are filled up to upper stock levels (S-levels);
- emergency orders as a function of shortages in the depots;
- a collection schedule, worked out by the regional center, with a given horizon, e.g. 8 days.

By the simulation process the S-levels for renewals in the regional center and in the hospitals have to be determined together with the deliver frequencies, so that the performance measures do not exceed given upper bounds.

For a detailed description and discussion of the model refer to [3].


REGIONAL CENTER
Donations / external Sources
Depot
HOSPITAL
Depot
Physician / Patient
ROUTINE-AREA
scheduled donations
collection schedule
donations (RCC)
stock after renewals
routine-orders
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emergency orders
emergency shipments
shortages
stock on hand
emergency orders
emergency shipments
shortages
assigned units
usage
trans-fusions
EMERGENCY-AREA

Figure 3

## 4. Centralized Decisions

Figure 4 illustrates a centralized routine decision situation. Forecasts are made at the regional center, which are the basis for the allocation of units to the hospital depots. Furthermore it can be seen that rotational blood is considered in this system.

Again the given system can be formulated as a simulation model. The planning horizon is dynamic with days as time steps. Demand and usage are defined by distribution functions, and cost coefficients are available for outdates, shortages, routine and emergency shipments.

The decision variables of the model are:

- frequencies for routine deliveries from the regional depot to the hospital depots
- upper bounds for outdates and shortages in regional and hospital depots

The performance measures of the model do not differ from the decentralized case.

Structural relations to be considered are:

- inventory equations for the depots in hospitals and in the regional center; these deviate from the equations of Section 3 by the consideration of rotational blood, with a LIFO-rule as issuing policy for the rotational units;
- a decision rule for routine deliveries, which starts with a prediction of demand and usage in the hospitals for a given number of time intervals. Based on this prediction and additional information from the hospitals, e.g. of shifts of demand, an allocation schedule is worked out by the regional center. Renewals can occur in the regional center too by returns, coming back form the hospitals with an age of 5 to 6 days, determined for immediate usage;
- emergency orders are again a function of shortages;
- based on the prediction of demand and on the allocation schedule, a collection schedule is worked out by the regional center for the planning horizon of the allocation schedule.

By the simulation process the decision variables have to be determined so that the performance measures of the model do not exceed given upper bounds.

A detailed description and discussion of the model can be found in [6].

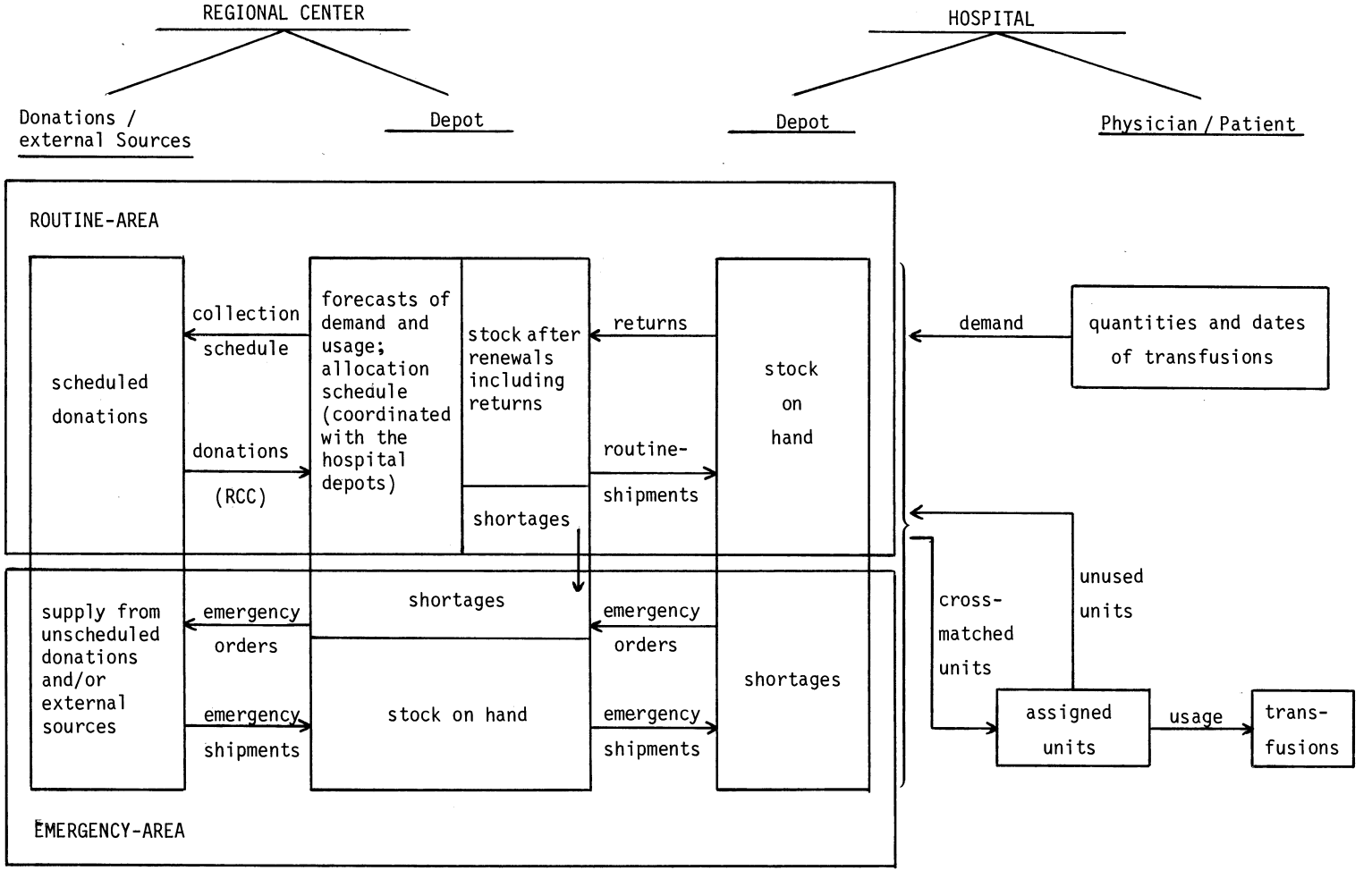
REGIONAL CENTER
HOSPITAL
Donations / external Sources
Depot
Depot
Physician / Patient
ROUTINE-AREA
scheduled donations
collection schedule
donations (RCC)
forecasts of demand and usage; allocation schedule (coordinated with the hospital depots)
stock after renewals including returns
shortages
returns
routine-shipments
stock on hand
demand
quantities and dates of transfusions
supply from unscheduled donations and/or external sources
emergency orders
emergency shipments
shortages
stock on hand
emergency orders
emergency shipments
shortages
cross-matched units
unused units
assigned units
usage
trans-fusions
EMERGENCY-AREA

Figure 4

## 5. A Comparison Based on Empirical Data

The analysis of demand and usage in some Swiss hospitals, with data of half a year, showed that the time series of demand and usage can be considered as stationary random processes with a Gamma-distribution. The parameters of the Gamma-distributions can be calculated as functions of mean and variance of the values in the time series. For example, for the blood group A+ Table 2 shows estimates of the mean and variance of demand respectively usage for 8 hospitals.

| No. of the hospitals \ Estimates | DEMAND | | USAGE | |
|---|---|---|---|---|
| | mean | variance | mean | variance |
| 1 | 27.25 | 108.96 | 16.91 | 64.73 |
| 2 | 19.32 | 88.75 | 12.71 | 66.51 |
| 3 | 19.21 | 98.6 | 11.41 | 47.57 |
| 4 | 17.64 | 63.43 | 10.09 | 34.05 |
| 5 | 5.84 | 28.13 | 2.92 | 12.77 |
| 6 | 5.41 | 26.6 | 2.67 | 16.54 |
| 7 | 5.84 | 14.02 | 2.94 | 10.5 |
| 8 | 5.12 | 11.67 | 3.06 | 10.32 |

Table 2: Estimates of mean and variance of demand respectively usage

A further input for the comparison of the decentralized and the centralized model is given by the following assumptions on cost coefficients:

- outdate cost per unit Sfr. 40.--
- shortage cost per unit Sfr. 10.--
- cost per routine shipment Sfr. 10.--
- cost per emergency shipment Sfr. 15.--

Table 3 shows a comparison of the simulation models with decentralized respectively centralized routine decisions, based on the following performance measures:

- disposition cost per unit transfused [Sfr.]
- shortage rate [%]
- outdate rate [%]

| NO. OF THE HOSPITALS | GIVEN DELIVER FREQUENCY | DISPOSITION COST PER UNIT TRANSFUSED [Sfr.] | | SHORTAGE RATE [%] | | OUTDATE RATE [%] | | AVERAGE AGE OF UNITS TRANSFUSED [days] | |
|---|---|---|---|---|---|---|---|---|---|
| | | dc | c | dc | c | dc | c | dc | c |
| 1 | 1 | 1.06 ± 0.13 | 0.60 ± 0.01 | 1.07 ± 0.45 | 0 | 0.54 ± 0.23 | 0 | 7.4 | 7.3 |
| 2 | 2 | 0.87 ± 0.20 | 0.40 ± 0.01 | 0.18 ± 0.14 | 0 | 0.85 ± 0.41 | 0 | 8.8 | 7.2 |
| 3 | 2 | 0.71 ± 0.16 | 0.45 ± 0.01 | 0.18 ± 0.15 | 0 | 0.45 ± 0.31 | 0 | 9.3 | 7.3 |
| 4 | 2 | 0.71 ± 0.14 | 0.51 ± 0.01 | 0.06 ± 0.05 | 0 | 0.36 ± 0.28 | 0 | 9.4 | 7.4 |
| 5 | 4 | 3.56 ± 1.73 | 1.04 ± 0.09 | 0.57 ± 0.37 | 0.18 ± 0.15 | 2.04 ± 1.34 | 0 | 11.5 | 6.6 |
| 6 | 4 | 4.47 ± 1.40 | 1.33 ± 0.27 | 0.76 ± 0.58 | 0.26 ± 0.21 | 3.32 ± 1.71 | 0 | 11.6 | 6.1 |
| 7 | 4 | 1.70 ± 0.42 | 0.90 ± 0.08 | 0.11 ± 0.10 | 0.10 ± 0.09 | 0.45 ± 0.43 | 0 | 11.3 | 6.7 |
| 8 | 4 | 1.83 ± 0.55 | 0.94 ± 0.16 | 0.30 ± 0.29 | 0.14 ± 0.10 | 0.45 ± 0.44 | 0 | 9.8 | 7.0 |
| FOR ALL THE HOSPITALS | | 1.13 ± 0.11 | 0.55 ± 0.01 | 0.55 ± 0.15 | 0.06 ± 0.03 | 0.90 ± 0.22 | 0 | 9.1 | 7.2 |
| FOR THE REGIONAL CENTER | | 0.52 ± 0.10 | 0.07 ± 0.05 | 2.62 ± 0.51 | 0.33 ± 0.27 | 0 | 0 | | |
| FOR HOSPITALS AND REGIONAL CENTER | | 1.65 ± 0.62 | 0.62 ± 0.05 | 3.17 ± 0.55 | 0.39 ± 0.26 | 0.90 ± 0.22 | 0 | | |

Table 3: Simulation with decentralized and centralized disposition for A+ (dc resp. c)

- average age of units transfused [days]

The performance measures depend on the frequency of deliveries from the regional depot to the hopsital depots, which differ from hospital to hospital. Usually the small hospitals have a delivery-frequency of 4 (i.e. a routine shipment occurs each fourth day) whereas the larger hospitals have frequencies of 1 or 2 (i.e. routine shipments occur each day or every 2 days).

The simulation results for blood group A+ presented in Table 3 allow the following conclusions[1) 2)]

1. The centralized disposition brings in comparison to a decentralized disposition system better results for all performance measures mentioned above; especially from the last two columns of Table 3 it can be seen, that the average of units transfused and the outdate rate can be reduced considerably - without an increase of the shortages.

2. Improvements in small hospitals, e.g. with a decrease of average age of units transfused, do not exclude simultaneous improvements in large hospitals.

3. A regional center improves its efficiency too by the step from a decentralized to a centralized system - especially with respect to the shortages.

1) The simulation results for all blood groups can be found in [3] resp. [6].

2) The entries in Table 3 for disposition costs, shortage rate and outdate rate are mean values with 95 %-confidence-regions. For the average age of units transfused only average values have been computed.

# APPENDIX

## Definition of the Performance Measures

### Symbols

| | |
|---|---|
| $T$ | planning horizon, $t=1,\ldots,T$ |
| $m$ | number of hospitals, $k=1,\ldots,m$ |
| $i$ | age of units, $i=1,\ldots,20$ |
| $c_v$ | outdate cost per unit |
| $c_f$ | shortage cost per unit |
| $c_r$ | cost per routine shipment |
| $c_e$ | cost per emergency shipment |
| $D_{k\cdot t}$ | demand |
| $U_{k\cdot t}$ | usage |
| $F_{k\cdot t}$ | shortages of hospitals (equal to emergency deliveries) |
| $F_{o\cdot t}$ | shortages of the regional center (equal to emergency deliveries) |
| $V_{k\cdot t}$ | outdates of hospitals |
| $V_{o\cdot t}$ | outdates of the regional center |
| $L_{k\cdot t}$ | routine shipments from the regional depot to the hospital depots |
| $U^i_{k\cdot t}$ | transfused units with age |

Performance Measures

1. Shortage rate:

$$\frac{\sum_t F_{k\cdot t}}{\sum_t D_{k\cdot t}}$$ for hospital k

$$\frac{\sum_t \sum_k F_{k\cdot t}}{\sum_t \sum_k D_{k\cdot t}}$$ for all the hospitals

$$\frac{\sum_t F_{o\cdot t}}{\sum_t \sum_k D_{k\cdot t}}$$ for the regional center

$$\frac{\sum_t (F_{o\cdot t} + \sum_k F_{k\cdot t})}{\sum_t \sum_k D_{k\cdot t}}$$ for hospitals and regional center

2. Outdate rate:

$$\frac{\sum_t V_{k\cdot t}}{\sum_t (V_{k\cdot t} + U_{k\cdot t})}$$ for hospital k

$$\frac{\sum_t \sum_k V_{k\cdot t}}{\sum_t \sum_k (V_{k\cdot t} + U_{k\cdot t})}$$ for all the hospitals

$$\frac{\sum_t V_{o\cdot t}}{\sum_t (V_{o\cdot t} + \sum_k U_{k\cdot t})}$$ for the regional center

$$\frac{\sum_t (V_{o\cdot t} + \sum_k V_{k\cdot t})}{\sum_t (V_{o\cdot t} + \sum_k V_{k\cdot t} + \sum_k U_{k\cdot t})}$$ for hospitals and regional center

3. Disposition cost per unit transfused

$$\frac{1}{\sum_t U_{k\cdot t}} \cdot \sum_t \{c_v V_{k\cdot t} + c_f F_{k\cdot t} + c_r \delta(L_{k\cdot t}) + c_e \delta(F_{k\cdot t})\} \quad \text{for hospital } k$$

$$\frac{1}{\sum_t \sum_k U_{k\cdot t}} \cdot \sum_t \sum_k \{c_v V_{k\cdot t} + c_f F_{k\cdot t} + c_r \delta(L_{k\cdot t}) + c_e \delta(F_{k\cdot t})\} \quad \text{for all the hospitals}$$

$$\frac{1}{\sum_t \sum_k U_{k\cdot t}} \cdot \sum_t \{c_v V_{o\cdot t} + c_f F_{o\cdot t} + c_e \delta(F_{o\cdot t})\} \quad \text{for the regional center}$$

$$\frac{1}{\sum_t \sum_k U_{k\cdot t}} \cdot \sum_t \{c_v (V_{o\cdot t} + \sum_k V_{k\cdot t}) + c_f (F_{o\cdot t} + \sum_k F_{k\cdot t}) + c_r \sum_k \delta(L_{k\cdot t}) +$$

$$+ c_e (\delta(F_{o\cdot t}) + \sum_k \delta(F_{k\cdot t}))\} \quad \text{for hospitals and regional center}$$

$$\text{with} \quad \delta(\cdot) = \begin{cases} 1 & \text{if } (\cdot) > 0 \\ 0 & \text{otherwise} \end{cases}$$

4. Average age of units transfused:

$$\frac{\sum_i i \sum_t U^i_{k\cdot t}}{\sum_t U_{k\cdot t}} \quad \text{for hospital } k$$

$$\frac{\sum_i i \sum_t \sum_k U^i_{k\cdot t}}{\sum_t \sum_k U_{k\cdot t}} \quad \text{for all the hospitals}$$

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# RESTRICTIONS CONCERNING AUTOMATED DISPOSITION SYSTEMS FROM THE MEDICAL POINT OF VIEW.

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Summary:

"Disposition" has different connotation in transfusion medicine depending on who takes the initiative and for which institution such a system is intended. Wile the systems described in the literature - most of them with strong theoretical emphasis - favour an economic concept, a medically oriented system has been planned as part of the TRAMIDIS (Transfusions Medizinisches Informations- u. Dispositions-System) project which is intended to prepare and support decision processes in the sequence donor - product - patient. The system which, in its first version, is conceived as a local system supporting a large hospital-based transfusion service, is intended to be extended to a regional system for Hamburg. Within the contrainsts of the project, only a few disposition programs could be realized in addition to the information system. This is partly due to the complexity of the subject, partly to organizational characteristics of the environment which prevent routine use of available programs. The bulk of scheduling is still done conventionally, however with much improved quality due to the availability of the information system. Some of the difficulties so far preventing a complete realization and acceptance of the available programs will be discussed in the following on the basis of the goals envisaged.

## 1. Introduction

When the program of this conference was worked out six month ago, the program committee agreed that accounts of practical experience should be given preference over plans and concepts.

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Translation by J.R. Möhr on the basis of the manuscript in German and figures in English.

New systems may be evaluated only after considerable routine application. Usually there are unforeseen circumstances often minor ones, that determine acceptance of a system - response time is an example.

The behaviour of complex systems - including the human component - may not even become evident before the limits of functional capacity are reached - and then it is often too late.

This kind of unforeseen difficulties will be discussed in the following:

Automatic disposition systems are particularly prone to impediments from such factors, since a multitude of circumstances may exert influence the consequences of which are hard to assess. Evaluation is, however, particularly difficult since only a few systems have been in operation long enough.
Therefore, the planning material for an automatic disposition system within TRAMIDIS will be the basis for a discussion of the problems that have prevented realization so far.

There are a variety of interpretations of the goal of a disposition system for transfusion medicine. This depends on who addresses the problem (operations research specialist, administrator, physician) and on which kind of institution is supposed to use the system (regional transfusion center with distribution problems, large patient-oriented transfusion service, cooperative endeavour of several transfusion services).

Most approaches available in the literature are based on economic considerations. Guidelines for the optimization of the storage of blood units were given by ELSTON and PICKEREL already in 1965 (2). Thereafter, JENNINGS (3, 4) treated the subject theoretically. He emphasized the relation between outdating rate and shortage and investigated various influences affecting the 'shortage outdating operation curve'. YAHNKE and coworkers published in 1972 and 1973 investigations of the blood unit distribution process in a regional data bank serving multiple hospitals including the return of blood units and proposed an optimization procedure, without, however, taking medical aspects into consideration.

Analogous simulations were published in Germany by PAGE (7, 8) using a simulation model based on an analysis of the Berlin blood bank system. His claim that the optimization is merely a problem of minimizing storage costs per transfused unit in view of a given

availability (rate of missing units) and of an accepted average age of the transfused unit is not acceptable in my opinion. It does not account for the full complexity of the problems. However, this oversimplification is comprehensible if one knows the structural backlog of the blood banking system in Berlin which is due to lack of public support.

Our developments in Hamburg were based on different (clinical) concepts when we started the TRAMIDIS project with support of the BMFT (Federal Ministry for Research and Technology) in the beginning of the 70ies (5, 6, 10). The overall goal was an encompassing disposition system based on an information system that was supposed to yield automated preparation and support of decision concerning the chain DONOR- PRODUCT- PATIENT. In its first stage, it was intended to be limited to a large local hospital-based transfusion service. At a later stage, extension to the shared support of all transfusion services in the Hamburg area was envisioned. The main aims were to secure supply and improve the quality of services for donors and patients. Economic aspects were given secondary place.

A break down of individual objectives would list the following:

1. Demand related preparation and storage of blood units including the following steps:
   - determination of demand
   - plan to meet demand
   - optimized selection and notification of donors
   - quick response in stock control

2. Patient-oriented selection of blood units considering medical and stock control aspects in the following steps:
   - proposed blood unit selection on the basis of quantity and quality stated (blood type, kind and age of product)
   - proposed blood unit selection for different transfusion programs with varying optimization standards (e.g. in the case of large quantity transfusion combination of old red cell sedimints with fresh whole blood; in the case of single transfusions, washed red cell preparations.) and under consideration of individual risk constellations.

3. Shared multicenter service through stepwise extension of the principles outlined under 1 and 2.

During the sponsoring period, only few disposition programs could be realized in addition to the information system. Even though donor and blood unit disposition are markedly improved by the information system, they are still essentially effected by conventional means.

The extended multicenter service was not funded by the regional administration of Hamburg. Despite the fact that considerable financial savings were expected at a later stage, the high initial investments and considerable development costs were considered prohibitive. Therefore, this part of the project could not be persued.

In the following, some of the problems arising from the medical point of view will be discussed in the sequence of the objectives stated. The discussion will be limited to the experience gained in large hospital-oriented transfusion services. They include 30 institutions that account for some 30% of blood banks and transfusion centers in the FRG. Usually they are responsible for the service of a maximum care facility or a university hospital. Some of them also serve other hospitals in the vicinity. The required blood units are usually available from registered donors in the large cities. In smaller university towns the services frequently depend partly on the supply from regional Red Cross services.

In order to meet the need for exceptional quantities per patient – even in emergency situations - a large pool of active donors is necessary. The consumption of an individual patient may amount to more than 100 units during a single weekend. This corresponds to 20-25% of the stock supply. More than 50 units per patient are no exception, quantities of up to 20 almost routine.

Such extents of consumption, which affect single blood types represent of course considerable requirements for a transfusion service. Emergency calls for additional donors may only partially balance the need, since the collection capacity is limited. Other means to achieve a balance will be outlined lateron.

Most of our transfusion services have to consider Rh subtypes and Kell antigens in addition to the ABO system and rhesusfactors because of the high fraction of poly-transfused patients. Figure 1 summarizes the resultant subdivision of the stocks.

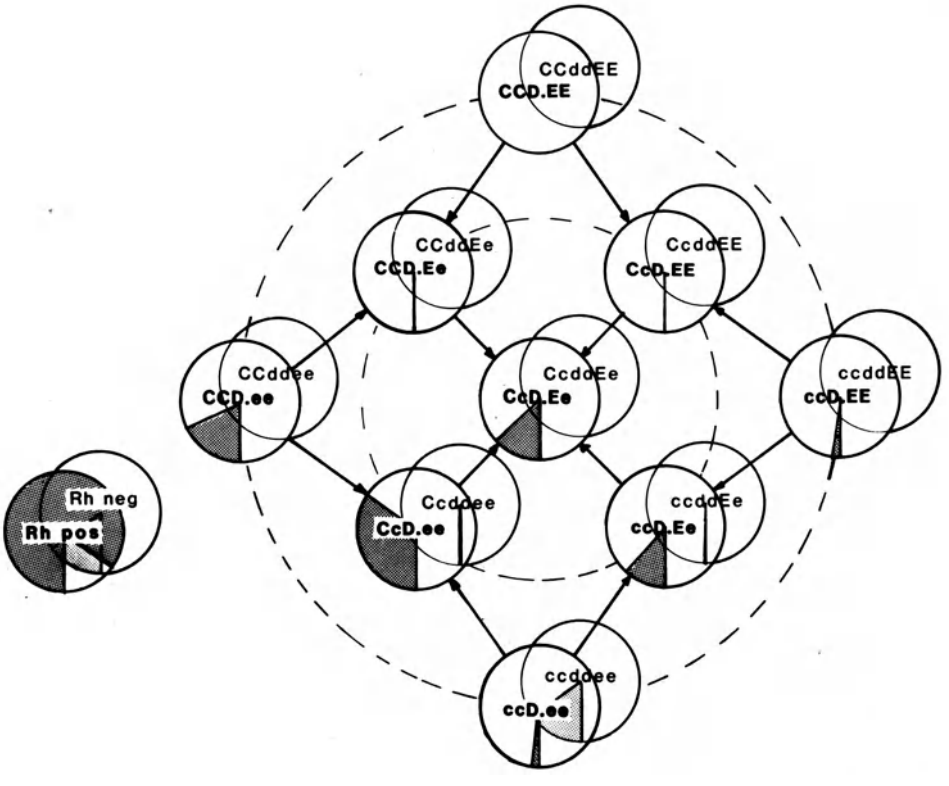


Figure 1: Rhesus sybtype schema

Left: If merely the rhesus factor 'D' is considered, only two groups result, one of which (Rh negative) is entirely replaceable by the other (Rh positive)

Right: If all rhesus antigens are included in the consideration, 18 different subgroups are distinguishable. Their relative frequency is symbolized by the dotted area in the circles. Every pair of circles represents mutually corresponding rhesus positive (lower left) and rhesus negative (upper right) subgroups. If the rhesus negative subgroups are available in reasonable quantities, they may replace the corresponding rhesus positive subgroups. Otherwise, substitution in the direction of the arrows is feasible without risking sensitization.
This means that the groups represented on the outer circle are not replaceable without risk. Rhesus negative blood of the subtype ccddee is not universally acceptable.
Five rhesus subtypes have a relative frequency of above 10% and will,

therefore have to be considered in stock supplies. One of the four groups occurring with a frequency of 0.5 to 2.5% will have to be accounted for because it is not substitutable. The remaining groups can be accounted for summarily. This then results in 6 to 7 relevant Rh subtypes.

Multiplying the rhesus groups by 4 ABO and 2 KELL groups yields a multitude of subdivisions which poses problems for automatic disposition, especially in times of excessive demands. This situation forces us to consider separately foreseeable excessive demand and to be in command of donors specifically for certain patients. For this reason, open heart surgery in our institution is planned in cooperation with the surgeous including donor availability. Only reliable donors are considered in this case. They are requested to notify us by telephone if they are not available.

Disturbances result from short-term alterations in the surgical schedule. A surplus of stock supplies for rare blood types may result with hardly a chance of removal. The increasing frequency of emergency operations scheduled at short notice, which is due to the increasing frequency of coronary interventions, is of particular concern. This part of donor scheduling may evade any efforts of automated scheduling.

Usually donors are notified in writing 8 to 10 days in advance. For this purpose, the usual demand of blood units has to be estimated in addition to the patient-specific demand assuming a stochastic distribution of blood types. The necessary quantity of blood units depends on season, holidays and vacation periods, operation load affected by relevant scientific conventionts, and the like. Values based on long-term experience are used in this connection. Approximately 10% of the calls are usually used to compensate modifications of the stock supplies.

Planning repletion of supplies through actual blood collections results from considerations of donor availability, blood collection capacity, estimated volume of accidental (random) donations and the possibility of purchases from other sources.

The next step includes 'optimal' donor selection and notifications. This takes into consideration:

- distribution of blood types
- category of assignment of donors

- actual and general accessibility
- scheduling preferences of the donor
- reliability of the donor.

Optimal selection" in this instance means

1 achieving an adequate distribution of blood types accounting for an alteration in the distribution of blood types among available donors;
2 emphasizing the reservation of easily accessible, universally suitable donors or donors suitable for special emergency situations;
3 safeguarding sufficient remaining fraction of reliable donors and even distribution of calls on donors in order to maintain motivation for continued cooperation.

Optimization of the selection of donors seems feasible if the data on donors is sufficiently valid. In contrast, the support of determining the demand and planning for its coverage seems difficult, at least in autonomous transfusion services, because too many parameters have to be considered and because the effect is dispropartionate to the effort.
We try to achieve optimization of donor selection by informing the donor about the data stored about him when he is notified of a request for donation. Control and updating through the donor are however affected by a process of habituation. Therefore, the greater part of the data is nevertheless incorrect.
At present determination of parameters for donor selection is effected by the system user during trial runs. An optimum is looked for by variation of the parameters.
Unforeseen excessive demand require another function: short-term compensation of supplies. This is achieved by an exchange with other transfusion services, by emergency requests of donor or - exceptionally - by cancellation of requested donations or by turning down drop-in donors.
Getting rid of excessive stocks by delivery to regional blood banks is at present excluded in the FRG.
The need for short-term stock corrections results from the variation of the success rate of notifications. In our case, this lies at a range of 60% for a given date of blood collection. Even though an online acquisition system is available, only alterations concerning heart surgery are recorded. An inclusion of all variations would exceed the data acquisition and data gathering capabilities.

This may be sufficient reason why we consider automatic disposition only exceptionally feasible in this application area. It seems more important to improve the organizational structure of the individual services and of the entire organization. It is also important to present the information quickly and in an easily perceivable form to the physician who has to alter his dispositions.

Our second main objective, the patient-specific selection of units, has been realized by appropriate programs according to the first level. For organizational reasons it is, however, only applied exceptionally. A program operating in dialog mode suggests that units of a certain blood type be selected, starting with a specified age of the units. If present, irregular antibodies are taken into consideration. The user has to decide whether or not the unit will have to be reserved for the patient. The risks of sensitization, incompatibility of the plasm, etc are indicated by the system. Despite the fact that the program lowers the task of data input for the technician, the the usual way of serving the request directly from the stored stock is still preferred. (In this case, the unit number has to be linked to the request by manual input via terminal in order to generate the documents required for compatibility tests and unit issuing.)

Figure 2: Stocked blood units in refrigerated room.
For lack of space, an orderly storage in unit number order is usually not feasible. This impedes quick access.

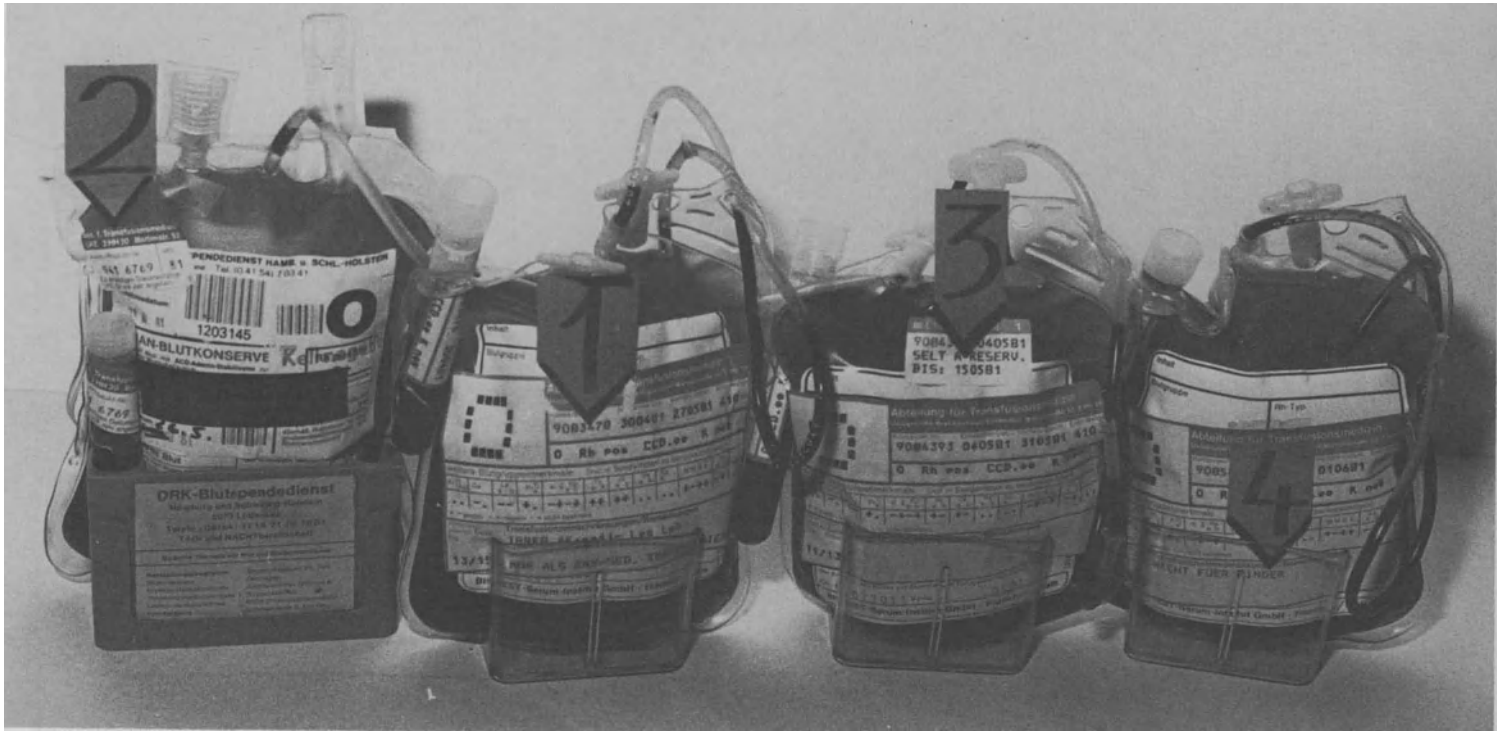


Figure 3: Examples for unit identification in 1 unit from alien sources and 3 units from own sources.

1 Unit number: though printed in red, it is hard to recognize from a certain distance because it is generated by a matrix printer

2 Inclusion of alien unit: This requires assignment of a compatible unit number

3 Indication of a rare type of antigen: The unit has to be reserved longer than usual for emergency cases.

4 Indication of limited applicability of a unit: the unit is not to be used for children.

The reason for the lack of acceptance of this program is simply the difficulty to locate the stored units by referral to the unit number. Since immediate access to units has to be guaranteed for emergency situations even during system failure units have to be sorted according to blood type and age.
The program is only used if units have to be selected for patients with irregular antibodies. This requires the consideration of special antigens. Figure 2 gives a close-up view of the contents of our storage shelves. Though printed in red, the unit numbers printed by matrix printer are hard to read.

This also applies to units purchased from the Red Cross which are assigned a system-compatible unit number. It would be advisable to acquire special purpose printers and to increase storage space. However, there are strict limitations to such measures.
This kind of experience made us drop our plans to extend automatic disposition even though an objective improvement of the quality of medical care is expected from this type of measures.

The task of disposition is supported by tagging the units with respect to special applications - either on the basis of certain algorithms or by manual input (cf. Fig. 3, No. 3 and 4). Listing and presentation of available stocks serves the same purpose. Apart from this, the system merely controls the manual selection of units retrospectively. If relevant, sex- and age-dependent risks of sensitization and incompatibilities are indicated.

As already stated, the third objective was dropped, mainly for external reasons, at an early stage of planning. This consisted in an extension of the system to the support of the region. Difficulties were expected in transforming diverse institutional organizations into a uniform organization. Moreover already during the early planning stages difficulties with regard to an imminent redistribution of physicians' responsibilities became apparent. Differences of opinions concerning the optimal size of stocks and optimal procedures are frequently based on traditional relations between clinicians and transfusion services that have to be respected.
The realization of a common pool, as depicted in Figure 4 had been envisioned as the first stage. Every participant was supposed to be able to report blood units at his discretion for consideration in the common pool. It would then have been possible to serve every participant from the common pool in order to save his own supplies.

A pool manager was supposed to ascertain minimal outdating of units in the pool.

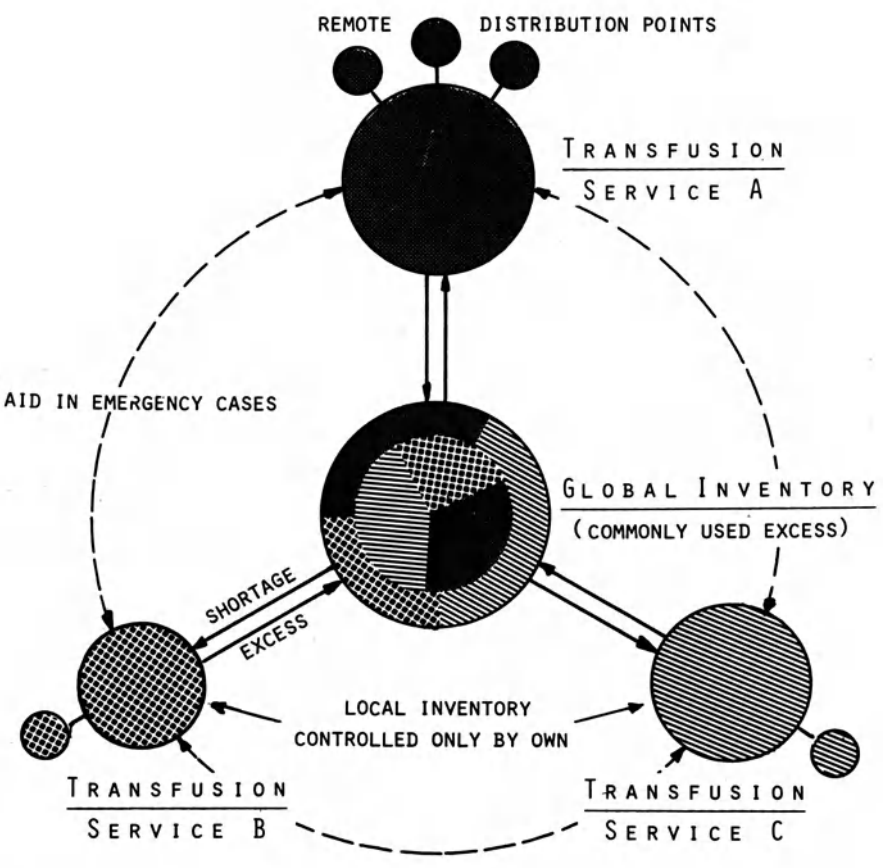


Figure 4: Common pool system

Further steps in the direction of a common disposition and stock control were anticipated at a stage when thorough experience with the system had accumulated, and even then only under close obsevation of the system's behaviour.

Even though the idea of a common stock is attractive because of a decrease in the required size of the stock, it seems extremely difficult to put it into practice. The multiplicity of constraints resulting from the many alternative solutions proffered to avoid a lack of units in depicted in Figure 5.

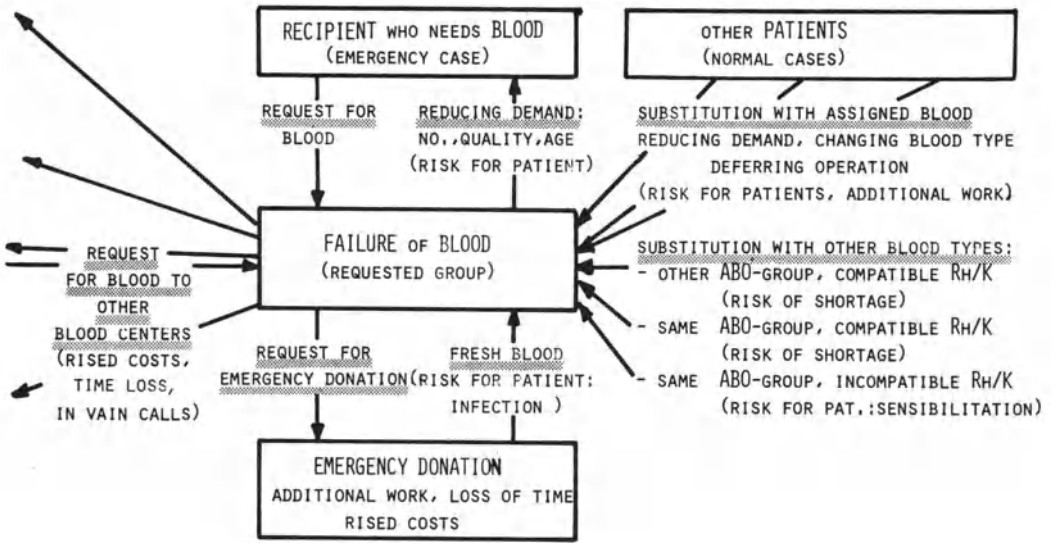


Figure 5: Alternative measures to meet shortage of blood ('failure of blood') of a given type.

Every measure indicated is associated with a number of drawbacks affecting the patient who needs the blood as well as other patients directly or indirectly. The choice of an alternative depends on many aspects of the given situation (stock size, time of day, work capacity, demand situation, traffic situation, patient's prognosis, etc.). It is therefore hard to define an algorithm suitable for automation. If there are no straightforward solutions available - such as supplementation from a bloodbank in the vicinity - the decision has to be left to the physician. He is able to judge the entire situation and must also accept the responsibility for possible risks. Even in case of a centralized service, this responsibility has to remain decentralized and related to the patient concerned. A comprehensive disposition system sould provide support by quickly indicating the available alternatives. This, however requires a reliable performance of the entire system, for beyond the stage that we have currently achieved in Hamburg. In the FRG further difficulties might arise from data security legislation.

These somewhat somber views are not an expression of a pessimistic assessment of the use of EDP applications in transfusion medicine

in general. However, I felt it was necessary to point out some of the obstacles one has to consider in the automation and especially in the cooperative support of transfusion services. These are of a structural and organizational nature rather than problems of computer science technology. Consequently, it appears necessary to consider an improvement of structures and procedures independently of their support by EDP.

Among the features of improved system concepts high flexibility, optimal data presentation and other "minor details" deserve first consideration. Efforts to optimize will fail as long as there is no appropriate organizational background.
Optimization may be an acceptable motive for acquiring the necessary hardware and developing capacity - at least for a while.
The actual goal of our efforts should, however, remain the improvement of the patient's health and security, and this should also be the crucial argument in dealing with funding agencies.

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12. YAHNKE, D.P., A.A. RIMM, G.G. MAKOWSKI and R.H. Aster:
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## Section of Disposition Systems - Summary of Discussion

B. Page

As the main objection to the theoretical models and dispositive procedures presented in this section, the lack of patient orientation was stated in the discussion, in particular by the specialists for clinical transfusion medicine. For transfusion medicine the optimal, i.e. most differentiated and specific patient care possible, is of central importance. Economical aspects, which were emphazised in the models and dispotive functions, had to take second place.

The trend in transfusion medicine is towards a permanently increasing differentiation in blood group systems which was neglected in the models. If all blood group systems relevant for transfusion medicine were introduced into a model, a large number of partly overlapping inventories would have to be modelled. The model would become too complex. On the other hand, a better differentiation than in the standard blood group system (ABO, Rhesus pos/neg) seems possible without too many difficulties and was shown in a decision support system presented.

A centralized system with only one large blood unit procedure with low product differentiation was termed inappropriate for modern transfusion medical requirements. Instead, a "ring" system of several local, clinical transfusion services - possibly connected to a regional blood donor service - with exact blood product differentiation was proposed, where part of the blood unit inventory was made available to a pool. In this way the proven advantages of a common inventory policy could be utilized to a certain extent. But models might also be developed for this organizational form.

In essence, disposition systems in the patient-oriented recipient section of transfusion services were considered to be hardly implementable in clinical practice. Better chances were seen in the donor section and in services, where the distribution of blood products is one of the main activities.

# Experience with a National Blood Transfusion System Integrating a Central Service with Hospital-Based Mini-Computer Routines.

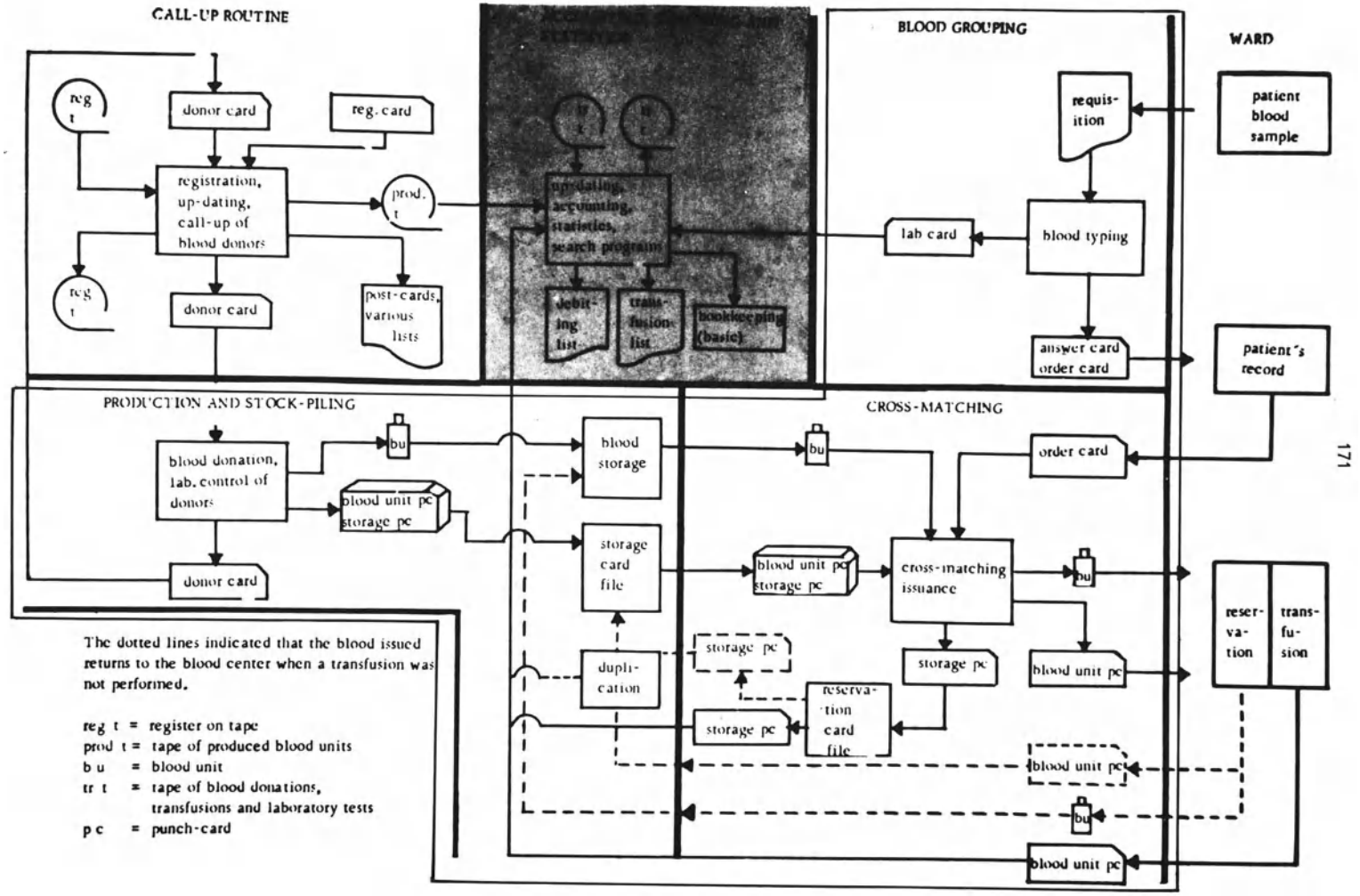
by

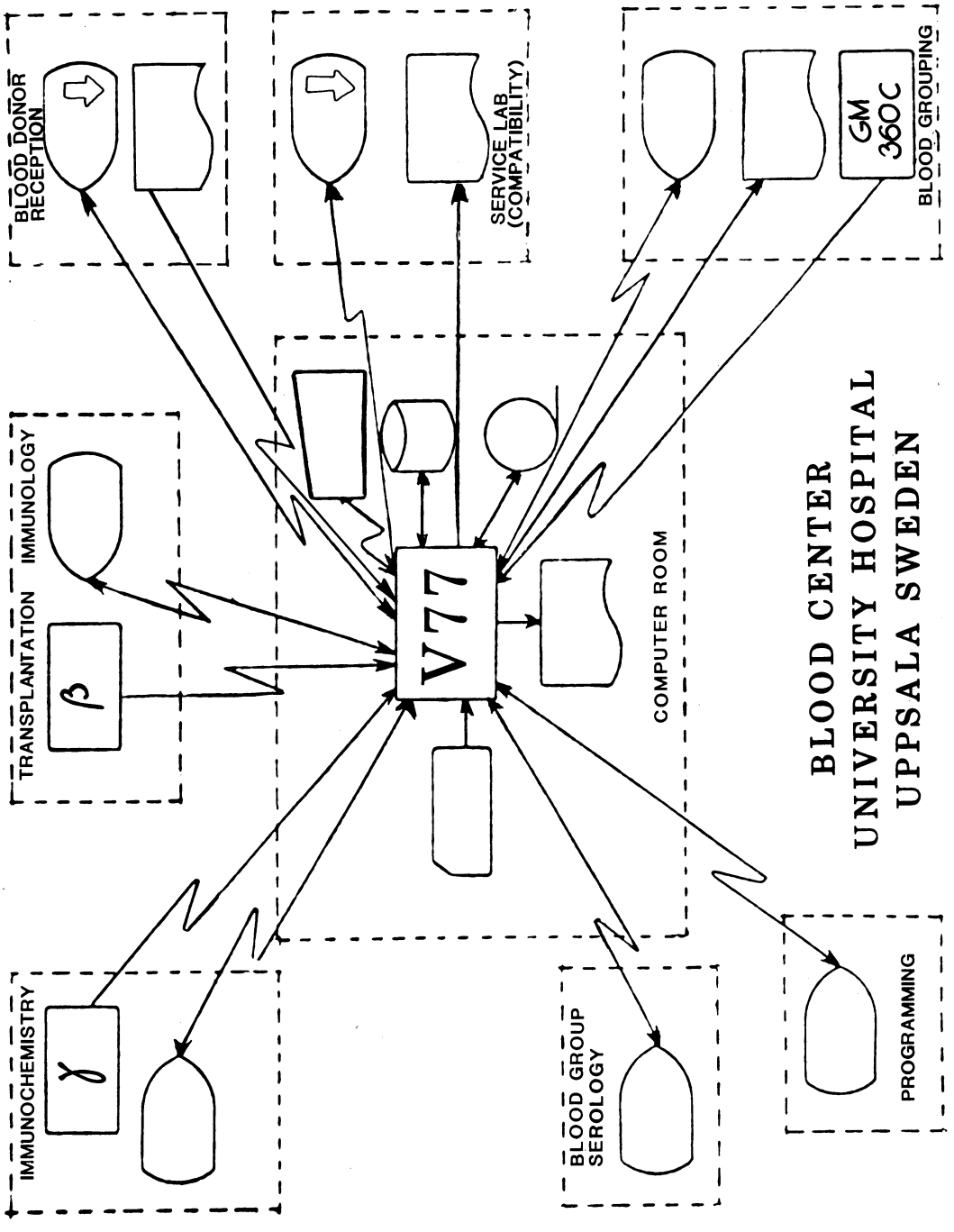
Bertil Cassemar, Claes F. Högman and Jan Säfwenberg

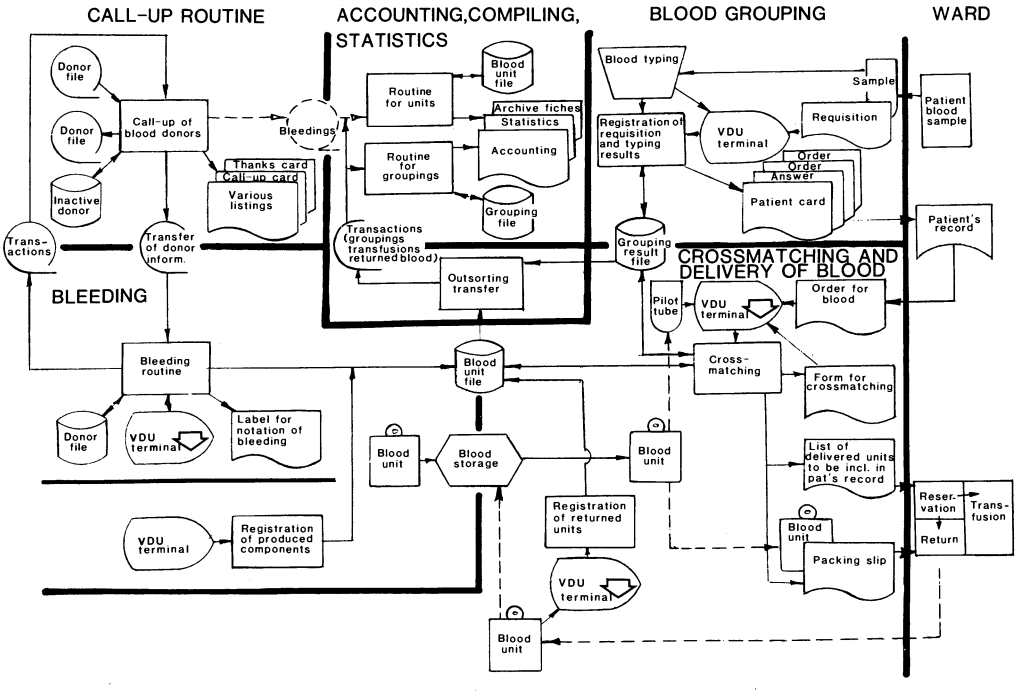
AB Databyran, Stockholm and the Blood Centre,
University Hospital, Uppsala, Schweden

Central Computer Service. EDP system for registration and call-up of blood donors and a punch card system for the registration of serological information on patients, compatibility testings and transfusion files based on data obtained via punch cards. A routine in use since 1965. Flow chart.

Flow chart of the mini-computer-based system.


CALL-UP ROUTINE
BLOOD GROUPING
WARD
reg t
donor card
reg. card
registration, up-dating, call-up of blood donors
prod. t
reg t
donor card
post-cards, various lists
up-dating, accounting, statistics, search programs
debit-ing list
trans-fusion-list
bookkeeping (basic)
requis-ition
patient blood sample
lab card
blood typing
answer card order card
patient's record
PRODUCTION AND STOCK-PILING
blood donation, lab. control of donors
bu
blood unit pc storage pc
donor card
blood storage
storage card file
dupli-cation
storage pc
CROSS-MATCHING
order card
blood unit pc storage pc
cross-matching issuance
storage pc
reservation card file
storage pc
blood unit pc
reser-va-tion
trans-fu-sion
blood unit pc
bu
blood unit pc
The dotted lines indicated that the blood issued returns to the blood center when a transfusion was not performed.
reg t = register on tape
prod t = tape of produced blood units
b u = blood unit
tr t = tape of blood donations, transfusions and laboratory tests
p c = punch-card


BLOOD DONOR RECEPTION
SERVICE LAB (COMPATIBILITY)
BLOOD GROUPING
GM 360C
TRANSPLANTATION IMMUNOLOGY
β
V77
COMPUTER ROOM
BLOOD CENTER
UNIVERSITY HOSPITAL
UPPSALA SWEDEN
IMMUNOCHEMISTRY
γ
BLOOD GROUP SEROLOGY
PROGRAMMING




Since 1981, the Blood Centre routines in Uppsala and Lund are supported by mini-computers instead of card punching machines. Input data to centralized computer routines are transferred via magnetic tape.

| | |
|---|---|
| Central | Weekly runnings for call-up donors |
| Computer | Weekly runnings assembling data from groupings, crossmatchings and bleedings |
| Local | On-line routine for patient groupings |
| Mini- | On-line routine for bleedings and produced blood components |
| computer | On-line routine for crossmatching, delivery of blood and returning of unused blood |

# AUTOMATION OF ADMINISTRATIVE AND LABORATORY DATA PROCESSING IN A HOSPITAL TRANSFUSION SERVICE

## PHASE I: BATCHWISE DATA PROCESSING

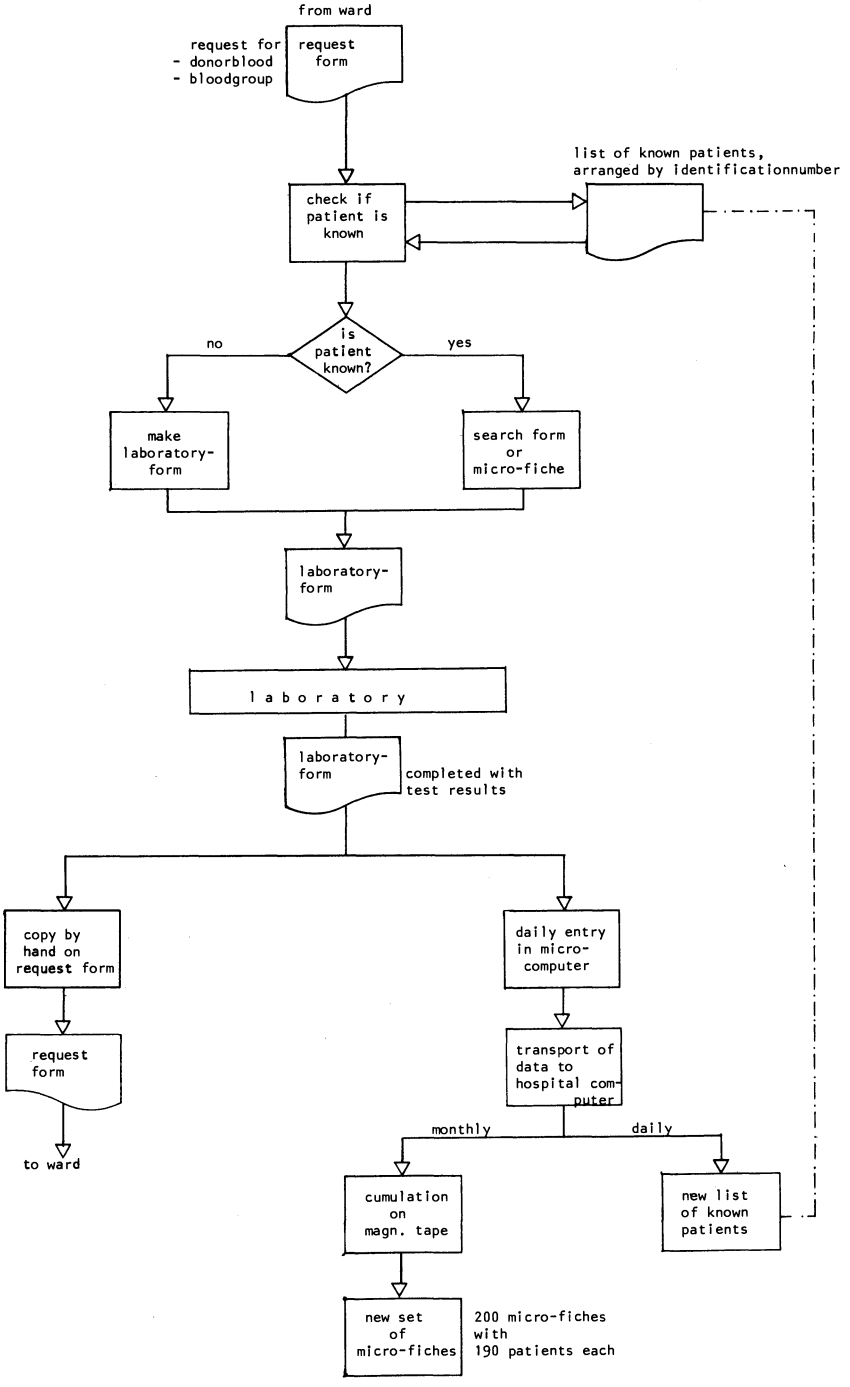
V.A.J.M. Kunst and J.H. Bloo, University Transfusion Service;
A. Bezemer, Organisation Department; B. Nederkoorn, Department for Medical Information Processing.
St. Radboud University Hospital, Nijmegen, The Netherlands.

For 3 years a system of batchwise data processing has been in operation. The data is stored on magnetic tape with a copy on a COM system (computer output on microfilm), now consisting of 150 fiches with 190 patient records on each.
The data stored are: 1) the patient's personalia including his identification number issued by the hospital; 2) ABO and rhesus D blood group with an indication if this determination has been made once or twice; 3) rhesus phenotyping if done; 4) the presence of irregular antibodies; 5) the need for specially processed donor blood; 6) the results of cross-matches; 7) all donor blood and cell concentrates given; and 8) if further blood group serologic determinations are performed, reference is made to a hand-processed card index.

The data is entered daily by terminal into a minicomputer which controls several items for consistency and validity.
The data is stored for a limited period only. The magnetic tape with all data is updated monthly, and after that a new issue of all microfiches is given, with all patients arranged by identification number. When a request for laboratory determinations or for donor blood or blood products arrives (always accompanied by the patient's identification number), a search is made if the patient is know at the Transfusion Service.
This is done with a computer printed list of identification numbers which is generated daily and which also indicates if the patient is on microfiche or only on handwritten forms. Data not older than 4 weeks and, therefore, not yet on microfinche have to be taken from the handwritten forms. Data stored on microfiches are copied on a sheet appropriate for handwritten additions. New cross-matches and donor blood given are noted on this form and from this entered into the minicomputer daily. All patient samples are marked with a label provided by the hospital patient data base by means of an on-line printer.

This system enables us 1) to save the space needed for the ever-growing card index; 2) to find stored patient data more quickly; 3) to generate statistic data for management; 4) to furnish data to the hospital financial department for billing the patient; 5) to make the archive multi-accessable by using several copies of the COM system; and 6) to prepare a well thought out on-line system.

For the near future a change-over to a complete on-line system is planned. The laboratory data will be entered by the technicians as soon as they are generated and they will be available immediately for consulting or further processing. In addition to the data mentioned before, simple results of other blood group serologic investigations can also be stored, thus reserving the hand-processed card index for complex data and limiting its expansion. The data will be stored in the accessible on-line system for one year. After that time they are stored on microfiche. A reference to the microfiche system remains in the on-line system, indicating if the patient is known. The on-line system enables us 1) to generate work lists for the laboratory technicians; 2) to make available blood group and results of cross matches directly to the patient wards via screens and printers; 3) to install an automated controlled linkage between donor blood group and patient blood group; 4) to install optical mark or character readers; and 5) to install other automated safety controls.

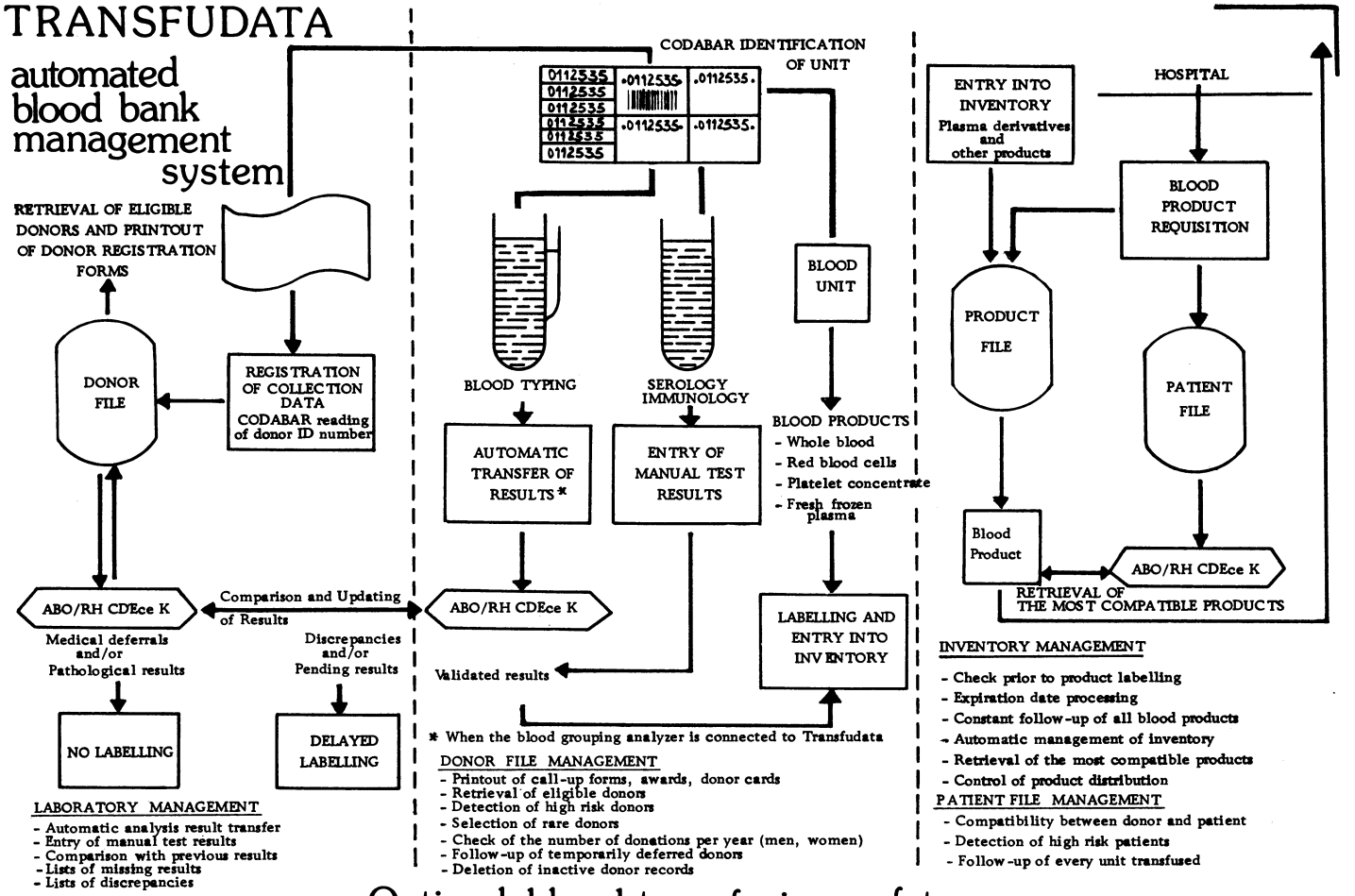

from ward
request for
- donorblood
- bloodgroup
request form
list of known patients, arranged by identificationnumber
check if patient is known
is patient known?
no
yes
make laboratory-form
search form or micro-fiche
laboratory-form
l a b o r a t o r y
laboratory-form
completed with test results
copy by hand on request form
request form
to ward
daily entry in micro-computer
transport of data to hospital com-puter
monthly
daily
cumulation on magn. tape
new list of known patients
new set of micro-fiches
200 micro-fiches with 190 patients each

# DATA PROCESSING IN A BLOOD BANK CENTER

J.-L. Rufener
KONTRON INTERNATIONAL
Blood Bank Systems
Montigny-Le-Bretonneux, France

A large number of blood bank centers today are investigating the modern concepts in data processing which have become available in the past few years. The essential question posed by these centers is "Why should data processing be included?" Experience has shown that the most important goals in modern blood banking are efficiency, economy, flexibility and certainly, safety. These goals must be achieved in order to assure the security link which begins with the blood donation and continues up to blood transfusion.

Centers are now able to easily assure this security link by means of a new automated blood bank management system which is called "TRANSFUDATA". This comprehensive data processing system incorporates the widely-used and positive Codabar® identification system and can be connected to a fully automated blood grouping analyzer such as Groupamatic®. The Transfudata system is composed of the following subsystems which work simultaneously as self-contained modules for a total management of : donor files, inventory, patient files, and the laboratory. The system can be perfectly integrated into the organization and daily activities of a blood bank center in order to obtain optimal blood transfusion safety.




Optimal blood transfusion safety

# A Laboratory System for Blood Group Typing

H. Kalinowski, S. Lensch, D. Roos[1], W. Müller

IMDM - RECHENZENTRUM
ABT. F. TRANSFUSIONSMEDIZIN[1]
UNIVERSITÄTS-KRANKENHAUS EPPENDORF
HAMBURG

In the serologic laboratory the acquisition of laboratory requests for blood group typing takes place in two different ways:

- for recipients:
  The staff performs a dialogue on a display terminal. After typing in the patient's ID-number, the laboratory computer (L-C) communicates with the data base computer (DB-C) where a check is performed to determine previous entries into the data base. Data related to the given ID-number are sent to the L-C. In case a recipient is unknown in the data base, the personal data of the patient have to be typed in.

- for donors:
  The requests and the ID-data are automatically transmitted from the donor-DP system via the DB-C to the L-C.

After that, another dialogue is started in which the requests are related to sample numbers. Then stickers with the ID-data of the patient or donor and the sample number are printed on a local laboratory printer. These can be separated into four parts which are used for labelling mark sense forms, document cards and test tubes. Later on the findings of blood group typing are recorded on mark sense forms. The forms are processed in two steps:

1. Input of the form containing the first reading into the computer via the optical mark reader (see pic. 2).
   Multiple checks are made by the system (if possible checks against previous findings, too). Messages concerning the evaluation are printed on an protocol printer; stickers with the ID-data and the findings of the recipient of donor are printed out and are tagged

to the request form and the mark sense form.

2. A physician has to read independently a second time; he has to mark the finding for a second time. Then he compares his result with that of the previous (first) reading
   If there are no differences, he signs the stickers on the request form and the mark sense form respectively for external release (see Fig. 4).
   The mark sense form is fed into the system a second time. After an additional check (all findings have to be identical), the findings are transmitted to the DB-C for internal release (see Fi8. 3).

In this way, greater security in blood group typing is achieved. Furthermore, the entire laboratory documentation is computerized leading to a considerable rationalization of the laboratory work. It is probably for this reason that the system was well accepted by the medical staff.

The development of this laboratory system as a part of TRAMIDIS was sponsored by the Bundesministerium für Forschung und Technologie (Federal University of Research and Technology).

Zur Sicherung der Identität Röhrchenetikett und Begleitschein bitte vollständig ausfüllen! Das Risiko unleserlicher oder unvollständiger Eintragung trägt der Einsender! Nur bei vollständigen Angaben durch den Arzt können die Untersuchungen durchgeführt werden!

Universitäts-Krankenhaus Eppendorf
Martinistraße 52, 2 Hamburg 20

An die
**Abteilung für Transfusionsmedizin**
(Bluttransfusionsdienst der Universitäts Kliniken)
Chirurg. Universitäts-Klinik und -Poliklinik

5112701
Frikenmeyer, Eulalia
geb. 10.1.34
1. Kcd HRC 9

(Raum für Adressetten-Abdruck)

**Begleitschein für die Blutgruppenbestimmung**

Blutentnahme am: 31.3.81
Vorläufige Diagnose: Plasmocytom

Erhielt der Patient schon früher Transfusionen? ja/~~nein~~ Geburten? ja/nein wann:_____
Wenn ja, wann: Febr. 1980 Bei weibl. Pat.: Fehlgeburten? ja/nein wann:_____
Reaktionen bei früher erfolgten Transfusionen? ja/nein Besteht z.Z. eine Gravidität? ja/nein
Wenn ja, welche: _____
Besondere Bemerkungen: _____

31.3.81 _____ 2880
Datum, Unterschrift des Stationsarztes, Telefon

Blutgruppenbefund

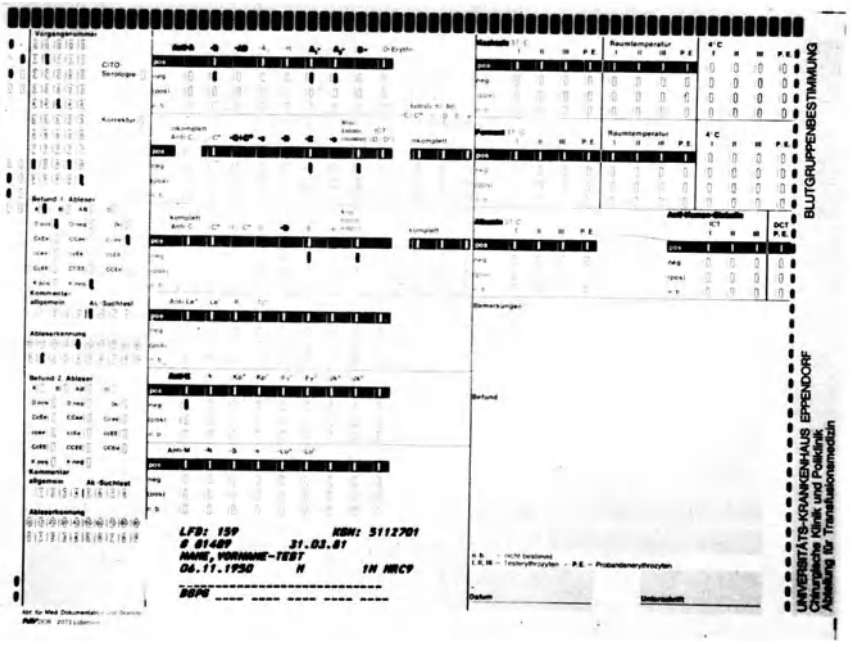
Antikörper-Suchtest: positiv negativ
Enzym – NaCl – Albumin-Milieu
indir. Antihumanglobulintest
37°C 20°C 4°C
Eigenkontrolle: positiv negativ

NAME, VORNAME TEST
06.11.1950 M 1M HRC9
KGN: 5112701 # 81489

Antikörperbefund: A Rh pos CcD.ee K neg
(bei positivem Suchtest)

BITTE AUF DEM KONSERVENANFORDERUNGS SCHEIN VERMERKEN:
ANTIKOERPER-SUCHTEST NEGATIV.
31.03.81 16:37 h

PIC. 1


BLUTGRUPPENBESTIMMUNG
UNIVERSITÄTS-KRANKENHAUS EPPENDORF
Chirurgische Klinik und Poliklinik
Abteilung für Transfusionsmedizin
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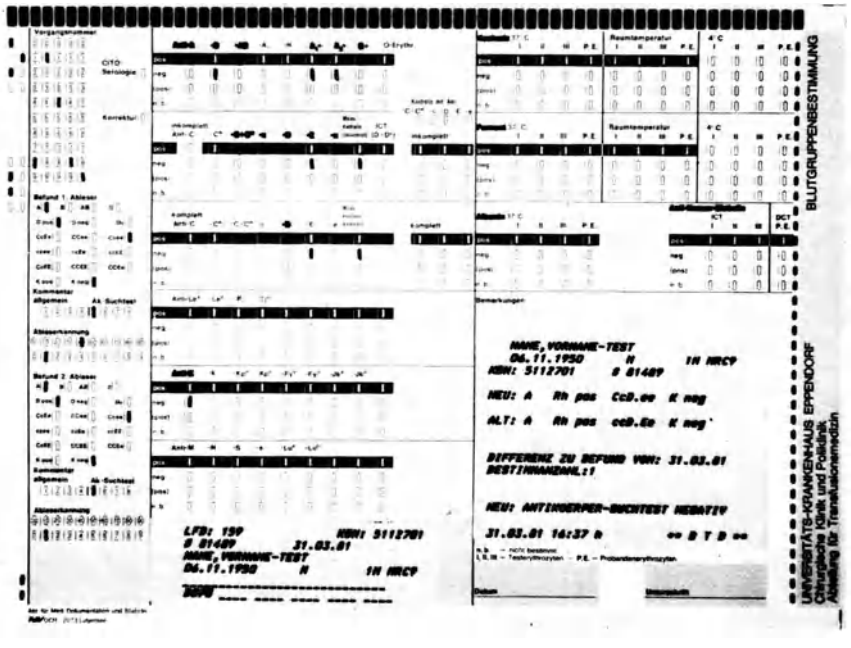
1H MRC9

PIC 2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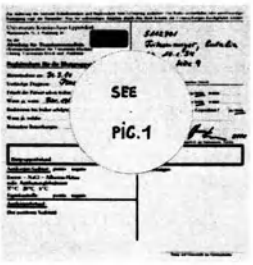
UNIVERSITÄTS-KRANKENHAUS EPPENDORF
Chirurgische Klinik und Poliklinik
Abteilung für Transfusionsmedizin
NAME, VORNAME-TEST
06.11.1950
H
1H MRC9
KBH: 5112701
NEU: A
ALT: A
DIFFERENZ ZU BEFUND VOM: 31.03.81
NEU: ANTIKÖRPER-SUCHTEST NEGATIV
31.03.81 16:37 h
LFD: 159
KBH: 5112701
31.03.81
NAME, VORNAME-TEST
06.11.1950
H
1H MRC9

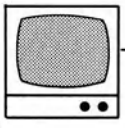
PIC 3




PROCESS CONTROL
COMPUTER PR 330
LABORATORY SYSTEM

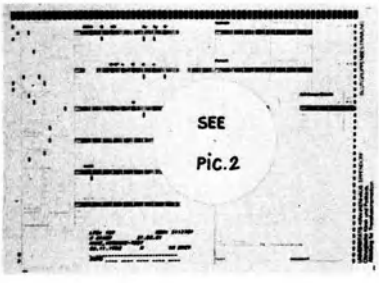
REQUEST FORM FROM WARD
FOR BLOOD GROUP TYPING

DB-COMPUTER



DISPLAY TERMINAL
3974

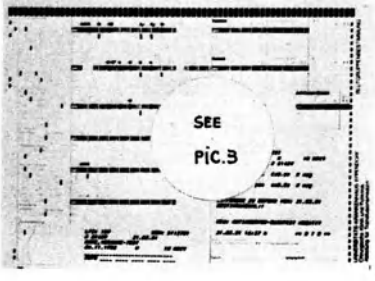
- ACQUISITION OF REQUESTS
- START PRINTING OF REQUEST STICKERS
- RELATION: REQUEST ⟷ SAMPLE NUMBER




- FIRST READING OF
MARK-SENSE FORM
BY THE OPTICAL MARK READER

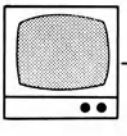
OMR LD 3540

- (MARKINGS INCLUDE THE
MTA-ID-NUMBER FOR
THE SYSTEM)

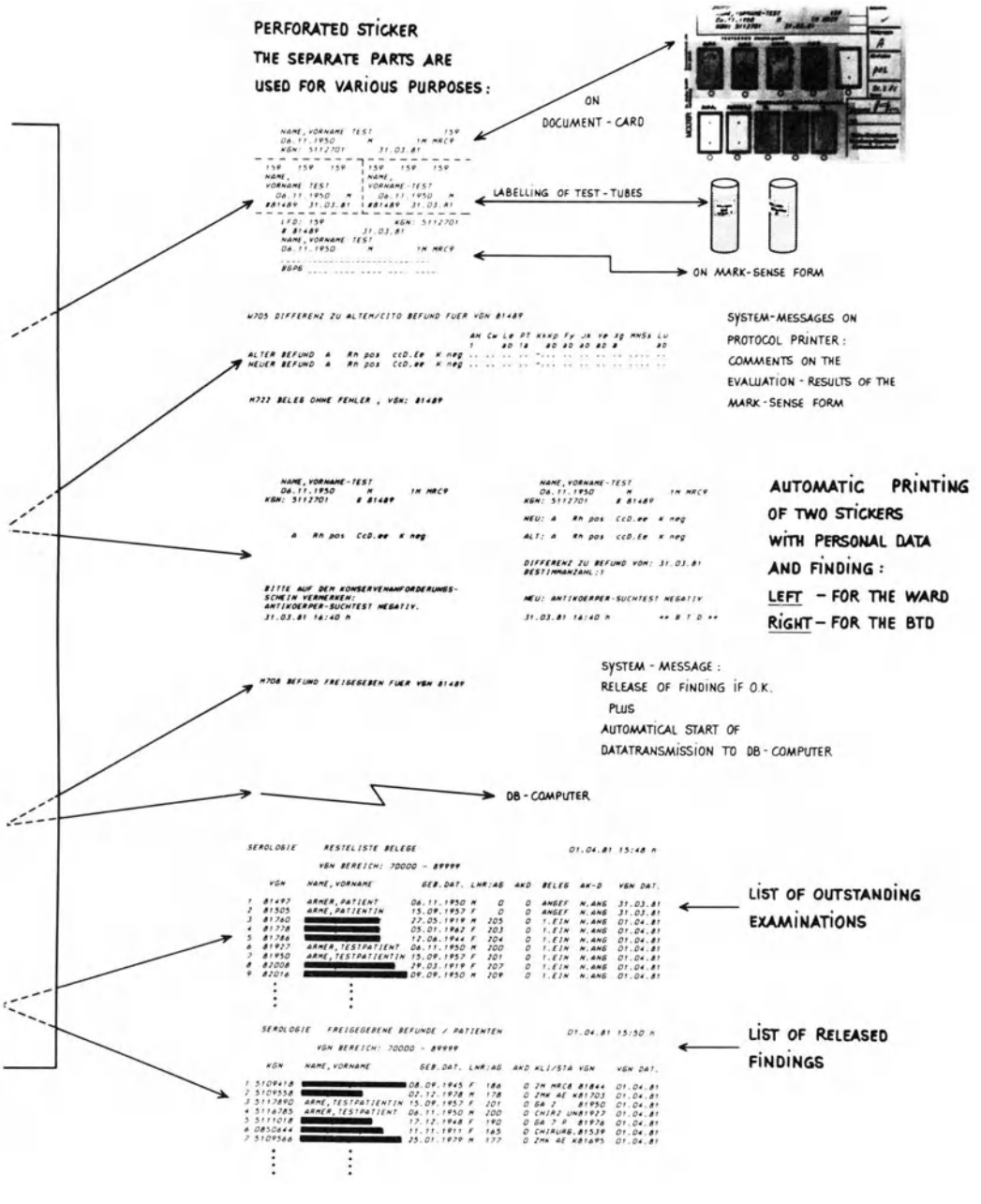


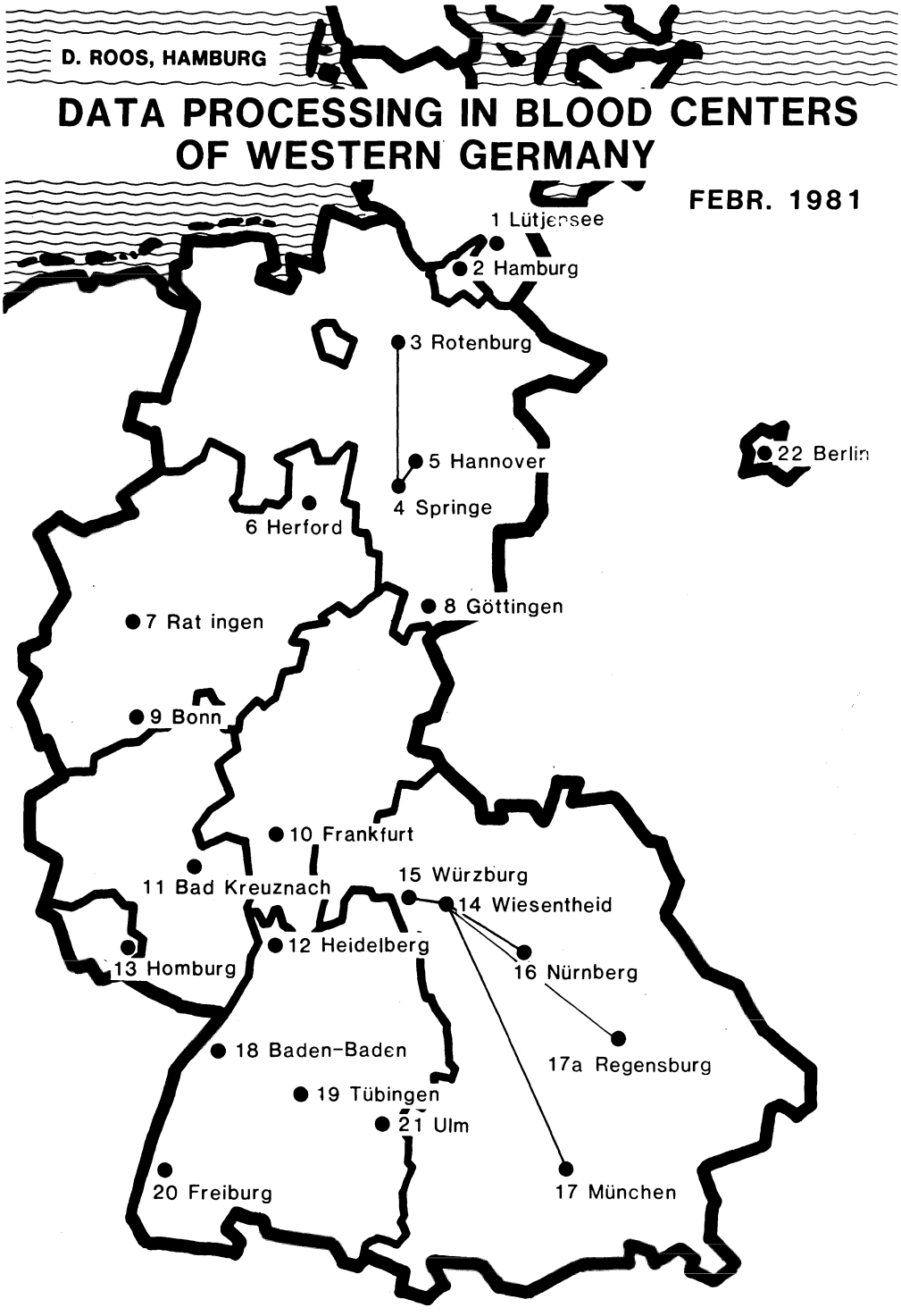

- SECOND READING OF
MARK-SENSE FORM

- (MARKINGS INCLUDE THE
DOCTOR'S ID-NUMBER FOR
THE SYSTEM)



START PRINTING SPECIAL CHARTS:
WORK SHEETS FOR LABORATORY STAFF


PERFORATED STICKER
THE SEPARATE PARTS ARE
USED FOR VARIOUS PURPOSES:
ON
DOCUMENT - CARD
LABELLING OF TEST-TUBES
ON MARK-SENSE FORM
SYSTEM-MESSAGES ON
PROTOCOL PRINTER:
COMMENTS ON THE
EVALUATION - RESULTS OF THE
MARK-SENSE FORM
AUTOMATIC PRINTING
OF TWO STICKERS
WITH PERSONAL DATA
AND FINDING:
LEFT - FOR THE WARD
RIGHT - FOR THE BTD
SYSTEM - MESSAGE:
RELEASE OF FINDING IF O.K.
PLUS
AUTOMATICAL START OF
DATATRANSMISSION TO DB - COMPUTER
DB - COMPUTER
LIST OF OUTSTANDING
EXAMINATIONS
LIST OF RELEASED
FINDINGS


D. ROOS, HAMBURG
DATA PROCESSING IN BLOOD CENTERS
OF WESTERN GERMANY
FEBR. 1981
1 Lütjensee
2 Hamburg
3 Rotenburg
5 Hannover
4 Springe
22 Berlin
6 Herford
8 Göttingen
7 Rat ingen
9 Bonn
10 Frankfurt
11 Bad Kreuznach
15 Würzburg
14 Wiesentheid
12 Heidelberg
13 Homburg
16 Nürnberg
17a Regensburg
18 Baden-Baden
19 Tübingen
21 Ulm
20 Freiburg
17 München

| NO. | INSTITUTE | | COMPUTER USE | |
|---|---|---|---|---|
| 1 LOTJENSEE | BLUTSPENDEDIENST DES DRK HAMBURG UND SCHLESWIG-HOLSTEIN | | PDP 11/60 (SYSTEM BAD KREUZNACH) | DON, PROD |
| 2 HAMBURG | ABT. FÜR TRANSFUSIONSMEDIZIN UND RECHENZENTRUM UNIV.-KRANKENHAUS EPPENDORF | | SIEMENS 7.740 (NETWORK) 330<br>NIXDORF MKC 840/35 (TERMINAL C.): DON<br>TANDBERG TD 2114 (TERMINAL C.): PAT, PROD | DON, PROD, PAT LAB |
| BLUTSPENDEDIENST DES DRK NIEDERSACHSEN, OLDENBURG U. BREMEN: | | | | |
| 3 ROTENBURG | INSTITUT ROTENBURG | | SIEMENS 7.541<br>IBM 5110 | DON, PROD<br>LAB |
| 4 HANNOVER | ZWEIGSTELLE HANNOVER | | REMOTE TERMINAL OF SPRINGE | |
| 5 SPRINGE | INSTITUT SPRINGE | | SIEMENS 7.541<br>IBM 5110 | DAN, PROD<br>LAB |
| 6 HERFORD | BLUTSPENDEZENTRALE DES KREISKRANKENHAUSES | | DEC 10 (OFF-LINE) | DON, PROD |
| 7 RAT INGEN | BLUTSPENDEDIENST DES DRK NORDHEIM UND WESTFALEN-LIPPE | | IBM 38 | DON, PROD, LAB |
| 8 GÖTTINGEN | BLUTSPENDEDIENST DER UNIVERSITÄT UND INST. F. MED. DOK. UND DATENVERARBEITUNG | | IBM 370 - 158 | DON, (PAT) (HOSPIT INFORM. SYSTEM) |
| 9 BONN | INSTITUT FÜR EXPERIM. HAEMATOLOGIE UND BLUTTRANSFUSIONSWESEN DER UNIVERSITÄT | | IBM 370 - 125 | PAT HAEMOPHILIA |
| 10 FRANKFURT | BLUTPLASMA DIENST GMBH (BIOTEST) | | SIEMENS 7.740 (?) | DON |
| 11 BAD KREUZNACH | DRK-BLUTSPENDEDIENST RHEINLAND-PFALZ | | PDP 11/60 | DON, LAB, PROD |
| 12 HEIDELBERG | INSTITUT F. IMMUNOLOGIE DER UNIVERSITÄT BLUTSPENDE- UND TRANSFUSIONSZENTRALE | | SIEMENS 404 | LAB |
| 13 HOMBURG | ABT. KLIN. HAEMOSTASEOLOGIE UND TRANSFUSIONSMEDIZIN DER UNIV.-KLINIKEN DES SAARLANDES | | HP 9835<br>COMMODORE-PET-COMP. | DON<br>PAT. HAEMOPHILIA |
| BLUTSPENDEDIENST DES BAYERISCHEN ROTEN KREUZES: | | | | |
| 14 WIESENTHEID | ZENTRALE | NETWORK OUT OF: | SIEMENS 7.722 | DON, LAB, PROD |
| 15 WORZBURG | INSTITUT WÜRZBURG | | 310 | SATTELLITE SYSTEMS |
| 16 NORNBERG | INSTITUT NÜRNBERG | | 310 | OF |
| 17 MONCHEN | INSTITUT MÜNCHEN | | 310 | WIESENTHEID |
| 17A REGENSBURG | INSTITUT REGENSBURG | | 310 | |
| 18 BADEN - BADEN | BLUTSPENDEZENTRALE DES DRK-BLUTSPENDEDIENSTES BADEN-WÜRTTEMBERG | | GROUPAMATIC/PDP | LAB (?) |
| 19 TOBINGEN | INST. F. ANÄSTHESIOLOGIE U. TRANSFUSIONSMEDIZIN KARL-EBERHARD-UNIVERSITÄT | | IBM 370 - 135 | DON, HLA |
| 20 FREIBURG | BLUTSPENDEDIENST DER UNIV.-KLINIKEN | | PHILIPS P 310 | DON |
| 21 ULM | BLUTSPENDEZENTRALE DES DRK-BLUTSPENDEDIENSTES BADEN-WÜRTTEMBERG | | DATA GENERAL NOVA 3/D | LABOR |
| 22 BERLIN | BERLINER BLUTSPENDEDIENST U. GES. F. SYSTEMFORSCHUNG U. DIENSTLEISTUNGEN IM GESUNDHEITSWESEN | | ONLY SOFT-WARE FINISHED | DON, PROD |

DON : DONOR FILE (DONATING SYSTEM)
PROD: PRODUCT/BLOOD UNIT FILE (INCL. DISTRIBUTION AND BILLING)
LAB : LABORATORY SYSTEM (BLOOD-GROUPING, HLA-TYPING, CLINICAL CHEMISTRY ETC)
PAT : PATIENT (BLOOD RECIPIENT) FILE
HLA : CENTRAL REGISTRATION OF HLA-TYPED DONORS OF WESTERN GERMANY

# TRAMIDIS II DONOR DISPOSITION

D. Roos, W. Mueller, S. Lensch, W. Kalinowski

Division of Transfusion Medicine and Computer
Center of the University of Hamburg, Hospital Eppendorf

Approximately 15.000 donors are registered in the TRAMIDIS (TRAnsfusion Medizinisches Informations und DIspositions System) data base. 8.500 of these are considered "active" and regularly called up for donations. Some of the "inactive" ones are considered unqualified; the remainder may be "reactivated" upon request. The poster displays on the left the - approximately quantified - distribution of the pool of donors relevant for differential disposition. In the depth of the picture the distribution among groups of different availability is displayed. In the vertical direction, main application fields are depicted. This grouping allows discriminating call-up and reservation of donors for special purposes.

The diffentiation of different blood types was disregarded in order to facilitate a better overview. Donor data are available on-line using various programs for selection and presentation. Also standard lists, and special purpose lists are generated off-line.

The right part of the poster depicts the process of call up for routine and emergency purposes. The scheduling of blood collection sessions is based on an estimate of the demand, taking into consideration the available stock supply, standard values and the schedule of open heart sugery. Various parameters allow a control of donor selection. The search for the relevant group of donors takes place in the order of the date of availability. In this way, the donors with the longest interval between donations are investigated first for medical qualification for donation. Unreliable donors thus accumulating in the pool of donors are eliminated if they fail to turn up on more than a certain number of occasions, this being one of the controlling parameters.

It is one of the goals of donor scheduling to meet the demand in such a fashion that the pool for emergency calls and special purpose calls is suitably maintained. Requirements that have to be met on the part

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Translation by J.R. Möhr on basis of German text and translated figures.

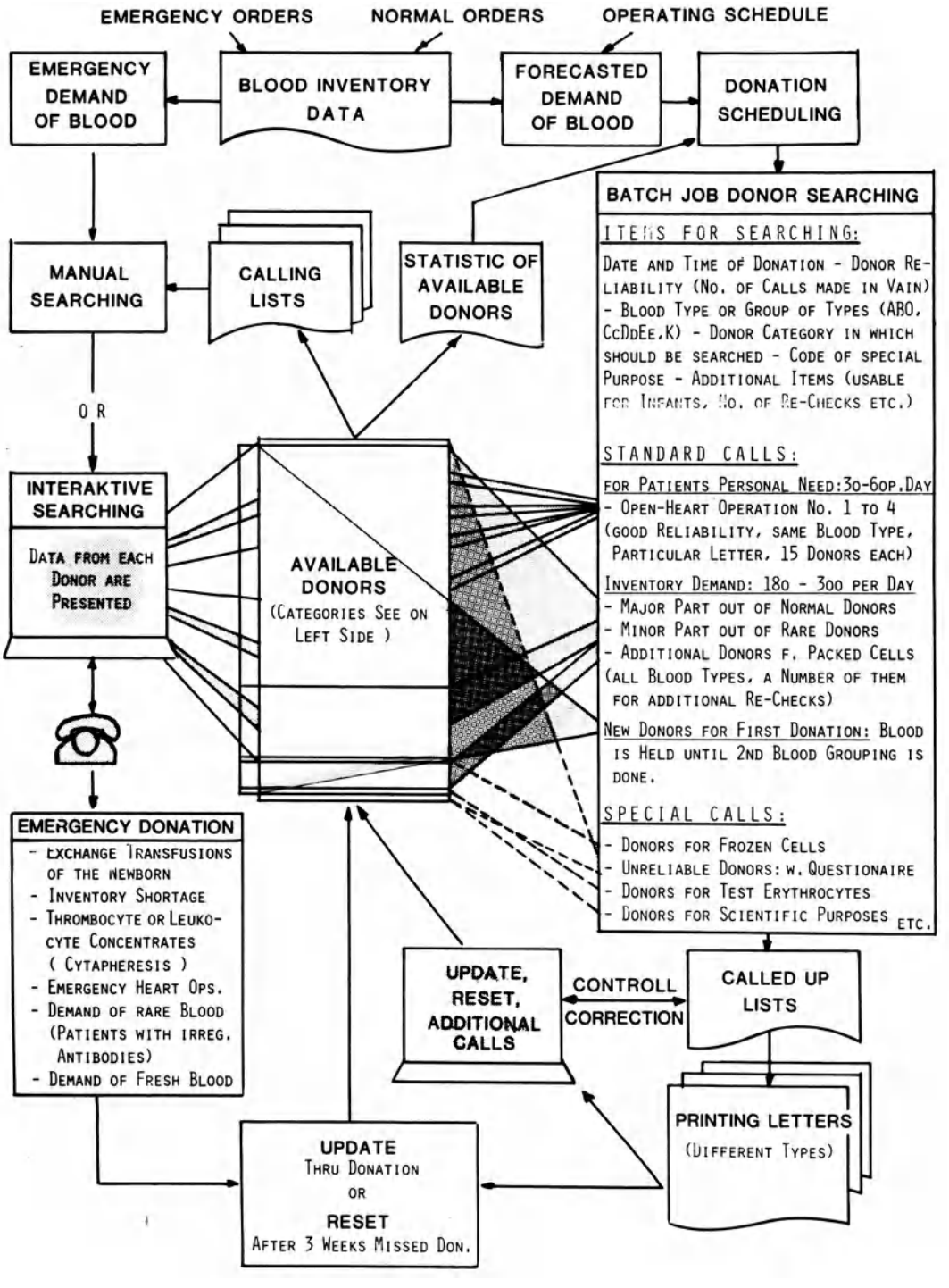
of the donor include accessability by adequate organizational or by telephone in addition to medical qualification. A uniform frequence of calls depending on individual intervals between donations is also desirable.

In order not to exhaust the supply of universally suitable blood units, an attempt is made to meet the demand for donors for heart surgery in the first place by drawing on donors in the standard category. If this does not suffice, "normal" or "rare" donors are included in the search to fill the stocks.

Using a special letter of invitation, new donors are called independently of their category of service.
Separate calls are generated for other purposes (test erythrocytes, blood for deep freezing applications, donors for scientific purposes). Reminders for unreliable donors are generated in the same way, depending on a defined minimal number of fruitless calls. A questionnaire is included for completion by the donor. Depending on its results, it is decided whether or not he is to be kept among the active donors.

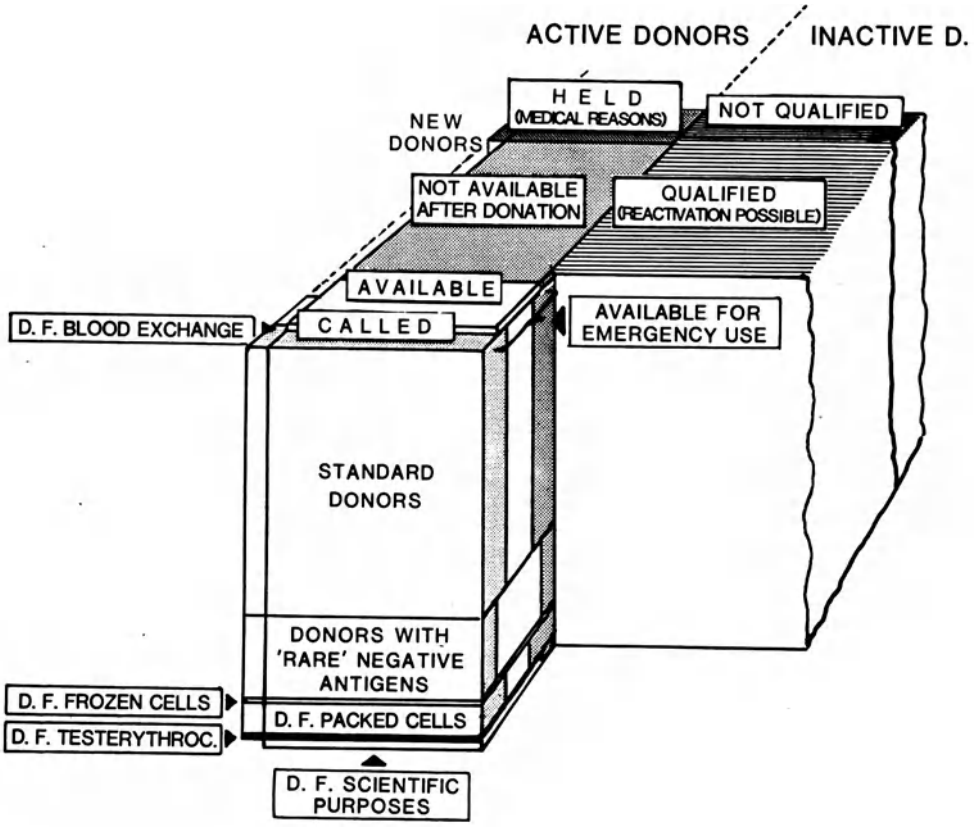
Optimal search parameters may be determined during trial runs. The program yields lists of donors to be called. These are controlled visually and may be corrected interactively. Only then are the letters of invitation generated. Three weeks later the run is restored, the number of fruitless calls is updated and the donor is filed among available donors once again unless he has shown up for a donation in the meantime.

Emergency calls are managed interactively, using the on-line selection program or manually using the generated lists.


EMERGENCY ORDERS
NORMAL ORDERS
OPERATING SCHEDULE
EMERGENCY DEMAND OF BLOOD
BLOOD INVENTORY DATA
FORECASTED DEMAND OF BLOOD
DONATION SCHEDULING
BATCH JOB DONOR SEARCHING
ITEMS FOR SEARCHING:
DATE AND TIME OF DONATION - DONOR RELIABILITY (NO. OF CALLS MADE IN VAIN) - BLOOD TYPE OR GROUP OF TYPES (ABO, CcDdEe,K) - DONOR CATEGORY IN WHICH SHOULD BE SEARCHED - CODE OF SPECIAL PURPOSE - ADDITIONAL ITEMS (USABLE FOR INFANTS, NO. OF RE-CHECKS ETC.)
STANDARD CALLS:
FOR PATIENTS PERSONAL NEED:30-60P.DAY
- OPEN-HEART OPERATION NO. 1 TO 4 (GOOD RELIABILITY, SAME BLOOD TYPE, PARTICULAR LETTER, 15 DONORS EACH)
INVENTORY DEMAND: 180 - 300 PER DAY
- MAJOR PART OUT OF NORMAL DONORS
- MINOR PART OUT OF RARE DONORS
- ADDITIONAL DONORS F. PACKED CELLS (ALL BLOOD TYPES, A NUMBER OF THEM FOR ADDITIONAL RE-CHECKS)
NEW DONORS FOR FIRST DONATION: BLOOD IS HELD UNTIL 2ND BLOOD GROUPING IS DONE.
SPECIAL CALLS:
- DONORS FOR FROZEN CELLS
- UNRELIABLE DONORS: W. QUESTIONAIRE
- DONORS FOR TEST ERYTHROCYTES
- DONORS FOR SCIENTIFIC PURPOSES ETC.
MANUAL SEARCHING
CALLING LISTS
STATISTIC OF AVAILABLE DONORS
OR
INTERAKTIVE SEARCHING
DATA FROM EACH DONOR ARE PRESENTED
AVAILABLE DONORS
(CATEGORIES SEE ON LEFT SIDE )
EMERGENCY DONATION
- EXCHANGE TRANSFUSIONS OF THE NEWBORN
- INVENTORY SHORTAGE
- THROMBOCYTE OR LEUKOCYTE CONCENTRATES ( CYTAPHERESIS )
- EMERGENCY HEART OPS.
- DEMAND OF RARE BLOOD (PATIENTS WITH IRREG. ANTIBODIES)
- DEMAND OF FRESH BLOOD
UPDATE, RESET, ADDITIONAL CALLS
CONTROLL
CORRECTION
CALLED UP LISTS
PRINTING LETTERS
(DIFFERENT TYPES)
UPDATE
THRU DONATION
OR
RESET
AFTER 3 WEEKS MISSED DON.

# TRAMIDIS 2 - DONOR

## STRUCTURE OF DONOR POOL AND AVAILABILITY OF DATA




### ON-LINE DATA PRESENTATION

Direct Access to all Data of one Donor
by NAME - DATE OF BIRTH - PHONETIC CODE or ID-NUMBER.
Data are Presented on Display. Update and additional Output on Printer are possible.

Direct Access to all Called Donors
to an Appointed Donation Date.
Reset of Call is possible.

Direct Access to all Available Donors
with a Definite Blood Type and Donor Category.
Calling Up is possible with Normal Mail, Express Mail, Letter with additional or only Re-Check-Call etc. or by Phone.

### OFF-LINE DATA PRESENTATION

Standard Output:

Lists for Emergency Calls:
- Called Donors List
- Available Donors List, Blood Type sorted
- List of Available Donors sorted according to neg. Antigens (Lea,Leb ... Lub)

Total Donors Lists:
- Alphabetic List¹
- Date of Birth List¹
- ID-Number List¹ (Short and Long Mode)

¹) Microfiches

Special Output: (only activated if asked for)
- List of all New Donors (held or available)
- List of all held Donors
- List of all Inactive Donors
- Lists selected by Combinations of Blood Types, Antigens and Donor Categories etc.

# The Recipient-Information-System

W. Müller, D. Roos [1], S. Lensch
IMDM - RECHENZENTRUM
ABT. F. TRANSFUSIONSMEDIZIN [1]
UNIVERSITÄTS-KRANKENHAUS EPPENDORF
HAMBURG

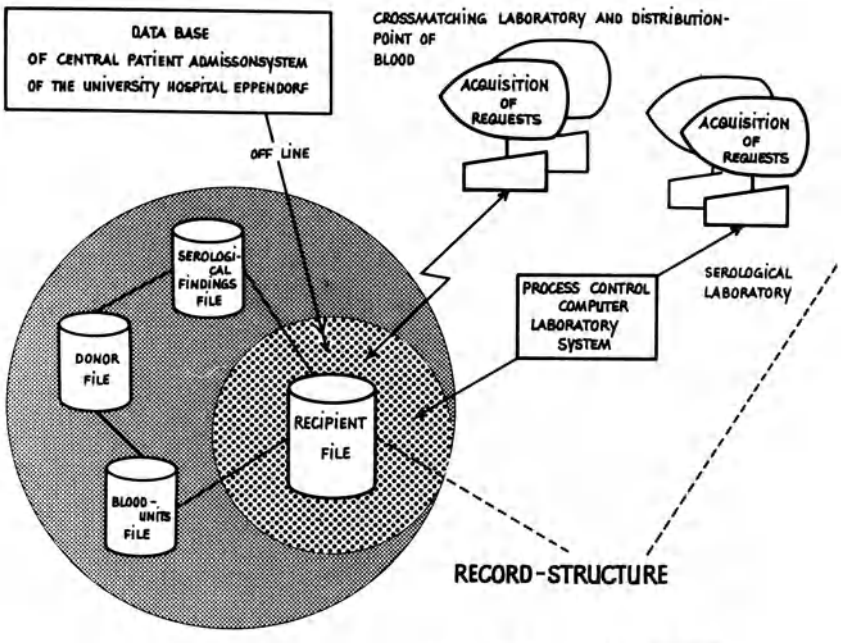
The recipient file is part of the TRAMIDIS data base. The update of the personal data of the recipients is done in two ways:

- The social-anamnestic data are transmitted off-line from the central patient admission system of the hospital at least once a day.
- If the patient is unknown in the TRAMIDIS system when a laboratory request is processed, the personal data are entered by the laboratory staff.

Only the data of those patients are stored permanently whose blood was typed or who got a blood transfusion.
The permanent recipient file is useful for blood group typing and helps to improve security in blood transfusion for the following reasons:

- When typing a blood group, a check can be made against previous findings. Differences will lead to serious warning.
- A request with wrong personal data of the recipient will be recognized immediately.
- When the request for blood units is processed, the blood group finding of the laboratory is usually stored in the data base. A check can be made as between the blood group given on the request and the blood group finding stored in the data base. A request relating to a wrong blood group in the ABO-system can be recognized before cross-matching. Furthermore, a possible sensitization which is not pointed out by the cross match may be avoided.

To take advantage of these possibilities, the data of the actual treatment have to be linked to those of earlier treatment. Because we have not found an algorithm for an automatic record linkage which performs well in every situation, this work is done by the laboratory staff assisted by a computer listing indicating possibly identical patients.




UNIQUE IDENTIFICATION NUMBER
- 6 DIGITS NUMBER (UNIQUE WITHIN A YEAR)
- 2 DIGITS YEARS OF ALLOCATION

PERSONAL ID-DATA
(NAME, ADRESS, DATE OF BIRTH, SEX)

DATA OF ACTUELL RESIDENCE
(DATE OF RESIDENCE AND DISCHARGE, CLINIC, WARD, DATA-ACQUISITOR, ETC.)

DATA OF EXAMINATION OF BLOOD
(BLOODGROUP, DATE OF BLOODGROUP-EXAMINATION, ETC.)

LATEST DIAGNOSIS

ORDER NUMBER AND DATE OF
- REQUEST OF BLOOD UNITS
- REQUEST OF BLOOD EXAMINATION

DATA OF HISTORICAL RESIDENCES

UNIVERSITÄTS-KRANKENHAUS-EPPENDORF
IMDM-RECHENZENTRUM

THIS RECORD-STRUCTUR ALLOWS FOLLOWING ACTIVITIES:

- DURING THE ACQUISITION OF REQUESTS OF BLOOD UNITS PRESENTING THE PERSONAL ID-DATA AND THE BLOOD GROUP (IF ALREADY TYPPED)

- DURING THE ACQUISITION OF SEROLOGICAL REQUESTS PRESENTING THE PERSONAL ID-DATA

- CHECKING THE BLOOD GROUP AGAINST PREVIOUS BLOOD GROUP FINDINGS

- REFERENCE LISTING OF ALL ORDERS OF BLOOD UNIT REQUESTS

- REFERENCE LISTING OF ALL ORDERS OF SEROLOGICAL REQUESTS

- MERGING OF ACTUELL AND HISTORICAL RECIPIENT RECORDS

- TRANSFUSION BACK TRACING
  - RECIPIENT TO DONOR
  - DONOR TO ALL RECIPIENTS OF BLOOD UNITS OF THIS DONOR

- STATISTICS

# CUTRAMED - Computer-assisted Transfusion Medicine at the University of Tübingen

H. Juranek, I. Hengstler-Häfner

The task of the Blood Bank of the University Hospital of Surgery in Tübingen (about 1.850 beds) is to provide all patients with blood and cellular blood products if required. Up to 16.200 blood transfusions are given in one year. A blood donor central office, which - like the one described is working almost exclusively with donors called up to six times a year, is not only responsible for the care of the patients but also for the health of the donors. An increase in their number leads to inefficiencies in the management and clinical supervision of the donors. In addition, an adequate treatment of patients requires an increasingly differentiated selection of blood serological data. Registration with a manual card index is completely insufficient, as it is impossible to keep account of such a large variety.

In 1974 the Department of Transfusion asked the Department of Medical Documentation and Data Processing to support donor surveillance and call-up by EDP.
As no information was available concerning a transferable prototype at that time, the University of Tübingen developed, for the specific needs of the Blood Bank, its own model of Blood Donation call-up and information system. This was planned to take into consideration the needs of a medium-sized transfusion service at a University and of a modern bedside transfusion therapy (the number of current and achieved blood donors is about 13.200, and in 1979 29 % was supplied from outside).
The system we have developed is composed of blood donor initial registration, call-up, data updating and medical care.
The medical inquiry system allows the user a quick selection of blood donors taking into consideration specified erythrozytic antigens or certain HLA-profiles.

This system has been working in routine now for over five years and is being continuously adjusted to changing requirements.

In autumn 1979 the existing blood donor call-up and inquiry system was expanded to include a recipient system which stores personal data of

regularly admitted recipients together with serological test data necessary to control the state of sensibility. This can be evaluated with variable criteria (diagnosis, transfusion anamnesis, preparation, degree of compatibility ect.).

The system in Tübingen "CUTRAMED" has been implemented on an IBM 370/138 The batch programmes are written in PL/1, whereas Assembler was chosen for the on-line programmes to ensure a quick response time.

(Literature reference:

Akademischer Oberrat Herbert Juranek, Dipl.-Math. Wilhelm Birgel, Heinz-Dieter Vohrer
Professor Dr.med. Werther Schneider, Dr.med. Dietlind Möller, Jutta Joel, Dr.med. Udo Sugg
Universität Tübingen, Zentrum für Chirurgie und Orthopädie

Das DV-unterstützte System für den Bluttransfusionsdienst der Universität Tübingen

in: "IBM-Nachrichten, 28. J., Heft 241, S. 227-234)

# COMPUTER-ASSISTED TRANSFUSION MEDICINE

# AT THE UNIVERSITY OF TUEBINGEN

## DEMAND ON CONCEPTION

- INTEGRATED AND COMPLETE SYSTEM
- VARIABLE SYSTEM
- EASY TO HANDLE

## AIMS

- IMPROVED MEDICAL SURVEILLANCE OF BLOOD DONORS
- EXTENSION AND ACCELERATION OF BLOOD TRACING POTENTIALITY IN CASE OF TRANSFUSION REACTIONS
- IMPROVED MEDICAL TREATMENT OF TRANSFUSION PATIENTS THROUGH CONSIDERATION OF ADDITIONAL BLOOD GROUP SYSTEMS
- WELL-BALANCED USE OF DONOR POOL
- REDUCTION OF RISK IN TRANSFERRING ERRORS IN COMPARISON WITH FORMER PAPERWORK
- BETTER STATISTICAL ANALYSES

## STATISTICS

- 1 850 BEDS
- 43 000 IN-PATIENTS
- 16 121 TRANSFUSIONS IN 1979
- 13 233 DONORS
- 7 296 CURRENT DONORS
- 5 937 ARCHIVED DONORS
- 29 % FOREIGN SUPPLY

## HARDWARE/SOFTWARE

- CUTRAMED RUNS ON IBM 370/138 TIMESHARING-SYSTEM UNDER DOS/VS
- DB/DC AND CICS-VS FOR DIALOGUE PROCESSING
- BATCH PROGRAMS IN PL/I, ONLINE IN ASSEMBLER

C U T R A M E D

## DONOR-SYSTEM

- OPTIMAL EXPLOITATION OF AVAILABLE DONOR POOL
- CONSIDERATION OF INDIVIDUAL PREFERENCES FOR DONATION FREQUENCY AND APPOINTMENT DAY
- SUPERVISION OF ROUTINE CHECK-UPS AFTER EVERY 10 DONATIONS
- OBSERVANCE OF MEDICALLY ACCEPTABLE DONATION INTERVAL
- AUTOMATIC CALL-UP OF DONORS FOR NEEDED BLOOD GROUPS
- USE OF DETERMINED STANDARDS IN DEFAULT OF EXPLICIT CALL-UP NUMBERS OF DONORS FOR EACH BLOOD GROUP
- UP TO 10 CALL-UP DATES POSSIBLE AT ONE SESSION
- AUTOMATIC PRINTING OF CALL-UP LETTERS TO DONORS
- AUTOMATIC OUTPUT OF AN EMERGENCY LIST AFTER EACH CALL-UP SESSION
- PRINTING OF PERSONAL AND SEROLOGICAL DATA ON DONOR-ID-CARD FOR DOCUMENTATION
- OUTPUT OF A PRESCRIBED WORK-SHEET FOR CURRENT DONORS
- AVOIDANCE OF TRANSFER ERRORS IN BLOOD TESTS THROUGH IDENTIFICATION STICKERS ON WORK-SHEET
- DOCUMENTATION OF DEVELOPMENT OF BLOOD DONOR'S CHANGING MEDICAL DATA
- AUTOMATIC PRINTING OF BLOOD DONATION PASS

## MEDICAL INQUIRY-SYSTEM

- DONOR SELECTION WITHIN SECONDS
- MORE SELECTIVE TRANSFUSION BY INDIVIDUAL BLOOD UNIT SELECTION WITH CONSIDERATION OF ERYTHROZYTIC ANTIGEN AND HLA-PROFILES
- PERMANENT ACTUALITY OF DONOR FILE BY TRANSFERENCE OF FORMER DONORS AND REASONS TO ARCHIVE FILES
- AVAILABILITY OF DATA MATERIAL FOR MEDICAL RESEARCH
- STATISTICAL ANALYSES OF DONOR POOL BY EXISTING PROGRAMS

## RECIPIENT-SYSTEM

- RECORDING OF DATA OF PATIENTS CONTINUALLY GETTING SPECIAL BLOOD PREPARATIONS (EXACT IDENTIFICATION)
- STORAGE OF PREPARATIONS RECEIVED BY RECIPIENT AND HIS REACTIONS ACCORDING TO LYMPHOZYTIC- AND TFT-TESTS TO CONTROL INCREASE AND DECREASE OF ANTIBODIES
- STORAGE OF SEROLOGICAL DATA OF RECIPIENTS TO AVOID EXPENSIVE MULTIPLE ANALYSES
- ANALYSIS OF RECIPIENT DATA WITH DIFFERENT CRITERIA (DIAGNOSIS, TRANSFUSION ANAMNESIS, PREPARATION, DEGREE OF COMPATIBILITY ETC.)

# Computer Applications for the Blood Transfusion Service of the Göttingen University Hospital

R. Klar, H. Lange
(Department of Medical Informatics, Göttingen University Hospital)

The blood transfusion service of the Göttingen University Hospital provides this hospital and some external institutions with blood or blood components. Approximately 26,000 units are needed each year, 10,000 of which are obtained from other blood transfusion services. At this time, the service handles 1,000 people who donate more than once and 1,000 regular donors. Altogether the personal data of 18,000 donors has been acquired and stored. Yearly about 4,600 new donors are registered.

Since the spring of 1976, a computer-supported system for the administration of conserved blood and donors has replaced the manual procedure.

With the help of two display terminals and one on-line printer the clinical computing center (IBM 370-158MP4, MVS, IMS/VS) supports the following applications:

- acquisition and/or updating of the donor's personal data in dialog with the blood donation data base
- control of blood quality by refusing donations from previous donors whose blood is not acceptable;
- printing of unit description slip and identification labels in the blood service office;
- acquisition in dialog of blood test results from the blood type laboratory and the updating of the data bases containing donor's personal data and unit information

When returning donors'pre-register, their personal data is viewed on the display terminal and permission to donate blood is accessed. If the control check is negative, the blood type and donor name are stored for the desired appointment time in the blood donation data base. Positive checks result in an examination request for referral to the policlinic for internal medicine. Using a retrieval program, it is possible for the blood transfusion service to locate and notify regular donors having

a specific blood type. The selection of regular donors can be limited with respect to a desired set of conditions using predefined input codes (for example donors from Göttingen and not from the rural district). The receipt of blood from other blood services as well as the return of unused blood units is registered in dialog. The corresponding labels are also printed.

In the afternoon, when blood donations have been completed, the following lists are produced on the printer within the transfusion service:

- daily unit reports containing local donations and those from other blood transfusion services;
- lab tests results and evaluations of Lues and Australia examinations;
- work lists for the blood type laboratory and for donor-unit-recipient linkage;
- list of pre-registered donors containing blood type, name and identification.

In addition, required donor cards, usage statistics, and lists of regular donors, etc. may be printed in the computing center.
The programs described above help to avoid clerical and administrative errors in blood banking and relieve the personnel of much clerical work. These programs are a component of a computerized hospital information-system with multiple connections to other departments of the hospital (see KLAR, ref. present proceedings).

# EDP-PROJECT BERLIN BLOOD DONOR SERVICE

R. Meyer

GSD-Gesellschaft für Systemforschung und Dienstleistungen im Gesundheitswesen mbH Berlin

The Berlin Blood Donor Service (BBD) is a non-incorporated institution of public law under technical supervision of the Senator for Health in the City Government. It is responsible for the provision of the supply of transfusion blood in Berlin as well as for its distribution, for a demand-adjusted transfusion blood inventory and for conducting research and processing scientific, technical and organizational problems in matters of blood donation.
The BDD has a stock of about 36.000 donors and is producing approx. 85.000 whole blood units, plasma, plasma fractions and other blood products per year which cover about 95 % of the total blood demand in West Berlin.
Main consumers are about 10 Berlin hospitals. In addition, medical practitioners and, in some cases, outside clients are supplied.
The Berlin Blood Donor and Transfusion System is, therefore, organized in two parts:

- Central production and distribution of blood units and inventory of a two to three day supply at the BBD;
- decentralized depots and recipient (patient) serology and transfusion therapy at the Berlin hospitals.

The hospitals are obliged to write a transfusion protocol and return it to the BBD. In cases of transfusion incidents and suspicion of disease transmission caused by transfusion, requests for backtracing are issued in order to trace those donors whose blood was transmitted at the respective transfusion and possibly earlier recipients of blood from these suspicious donors.
The project "Operation of an EDP-System to Assist the Berlin Blood Donor Service" pursues the aim to increase security, effectiveness and transparency in blood transfusion. Thus, it is the aim of the project to develop and test automatic procedures for the sections: Donors, Recipients, (Patients), Laboratory and Inventory.
At the computer support of the internal BBD routine operation data of the donor, recipient, laboratory and inventory section are entered on-line. This data is the precondition and basis for the extension of the functional scope of the BBD for a qualitative improvement of the Berlin transfusion system, for example, by specialized selection and call-up

of donors, by providing on-call donors, by increased consideration of blood sub-group characteristics, surveillance of client hospitals, extension and acceleration of back-tracing capabilities in transfusion incidents, inclusion of allocation and disposition aids, supply of data for planing, comparison, evaluation and research purposes. Data collection must, therefore, ensure a multiple application of identical basic data for different purposes.
An Information exchange with participants in the case of transfusions outside the BBD (for example, donors, recipients, hospitals, etc.) is initially achieved off line by telephone or forms.
An interface for on-line communication, especially with the main clients among the hospitals, concerning blood unit inventory and use is under consideration.
At the most recent stage of project development, a cooperation between the Berlin Blood Donor Service, the new blood bank under construction at "Klinikum Steglitz" (University Hospital), and the Blood Donor Service at "Klinikum Charlottenburg" (University Hospital) is planned. All these blood banks will eventually use the data processing procedures developed in the course of the project and run a shared computer system. A first practical test as a pilot application will now be made at "Klinikum Charlottenburg". For this, the program system will be extended by the functions of history data entry and inclusion into the donor qualification check, individual laboratory data entry, billing, printing of health certificates, health offices reporting and pathological findings and some list programs.
The project is fully funded by the Federal Ministry for Research and Technology.
Program implementation was carried out on SIEMENS computer of the 7000 series, under the operating system BS 2000, using data base system ADABAS and the display mask generator BIMAGE.
The programs were largely written in COBOL, a few in ASSEMBLER.
A detailed description (project review) of the functions of the program package and system presentations can be arranged with the GSD at the following address:

Gesellschaft für Systemforschung und Dienstleistungen im Gesundheitswesen mbH Berlin
Einemstr. 9, D-1000 Berlin 30

# BERLINER BLUTSPENDEDIENST (BBD)

## BERLIN BLOOD DONOR SERVICE

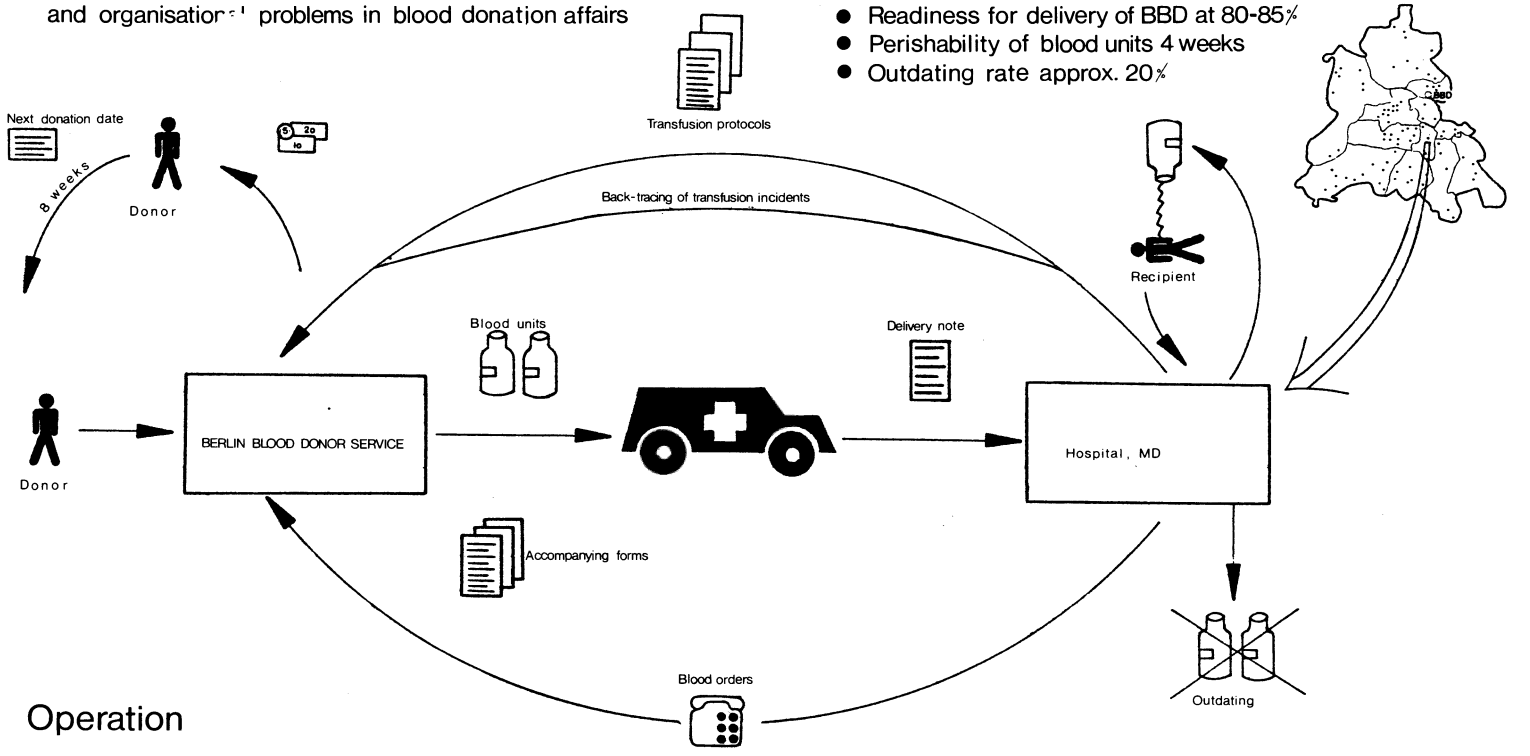
Environment

### Functions

- Securing of the supply with transfusion blood and its distribution
- Demand adjusted inventory of transfusion blood
- Completion of investigation and treatment of scientific, technical and organisational problems in blood donation affairs

### Statements of quantity

- Approx. 70 hospitals and in addition private physicians as customers
- Approx. 1000 deliveries per month
- Readiness for delivery of BBD at 80-85%
- Perishability of blood units 4 weeks
- Outdating rate approx. 20%

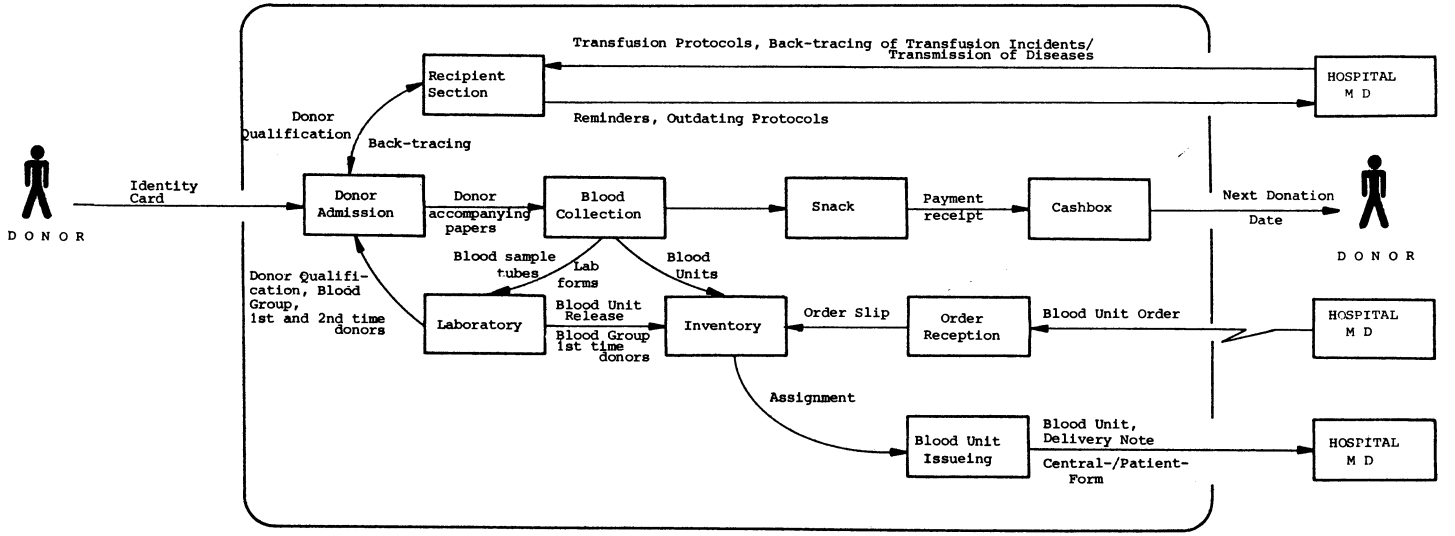



### Operation

BERLINER BLUTSPENDEDIENST (BBD)
BERLIN BLOOD DONOR SERVICE

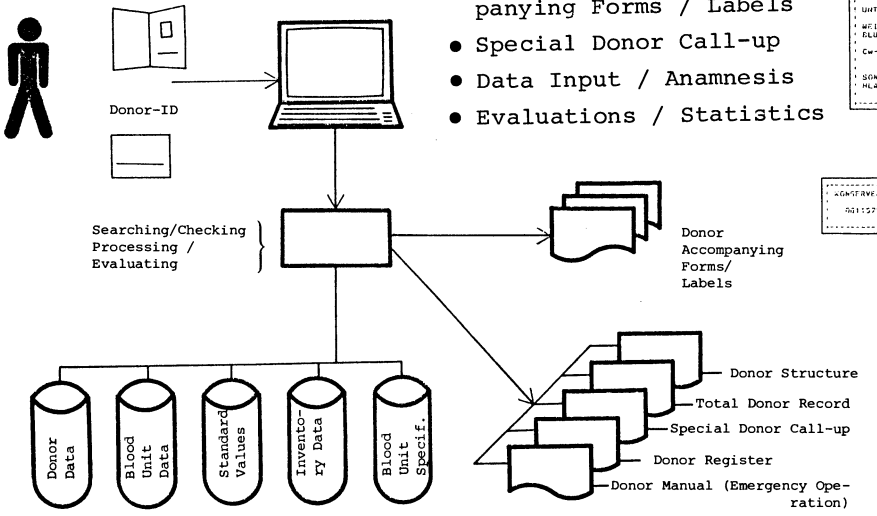
## Statements of quantity

- 36ooo Donors
- Approx. 350 donations per collection day
- 85ooo Blood units per year



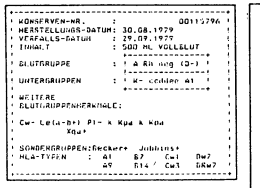
# Donor Section

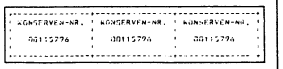
- Donor Data Entry
- Medical Qualification Surveillance
- Set-up of Donor Accompanying Forms / Labels
- Special Donor Call-up
- Data Input / Anamnesis
- Evaluations / Statistics

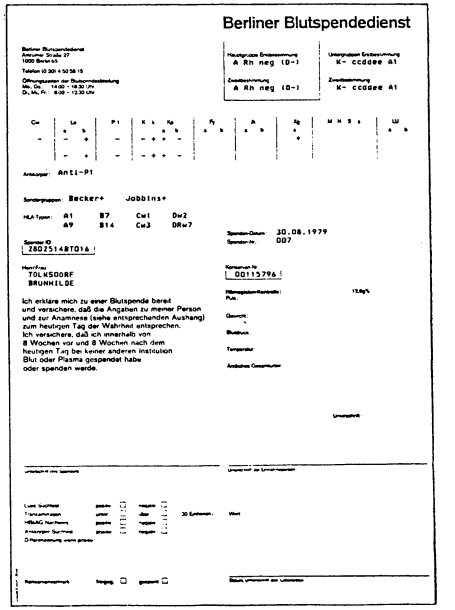


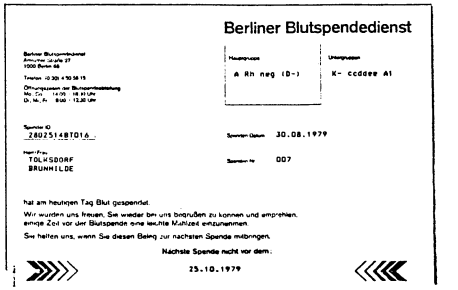

## BERLINER BLUTSPENDEDIENST (BBD)

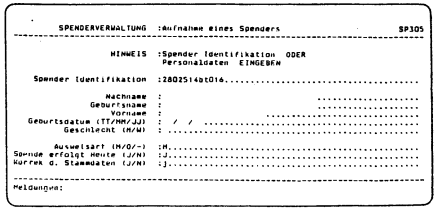
BERLIN BLOOD DONOR SERVICE

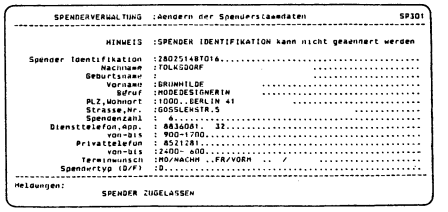


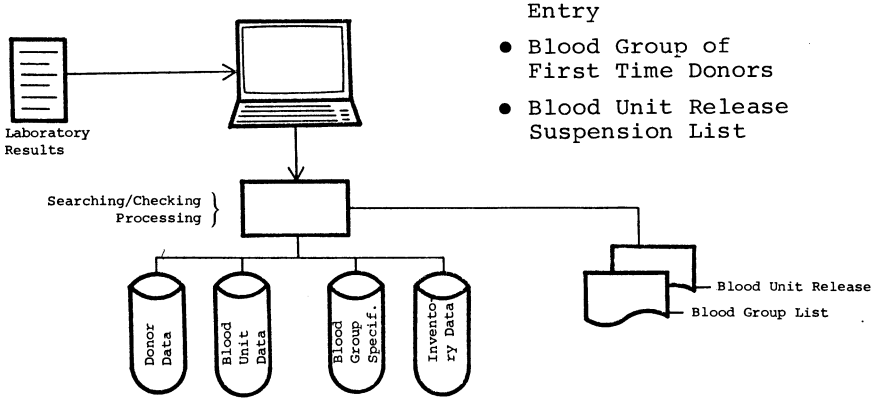



# Laboratory Section

- Laboratory Data Entry
- Production Data Entry
- Blood Group of First Time Donors
- Blood Unit Release Suspension List




## BERLINER BLUTSPENDEDIENST (BBD)

BERLIN BLOOD DONOR SERVICE

```
LABORDATENERFASSUNG  :Programmstart                                  L0001

          HINWEIS  :Bitte Passwort oder
                    Schraegstrich (*Abbruch) eingeben

          Passwort :ANWENDER.....................................

Meldungen:
        ACHTUNG, NACH DEM DRITTEN UNGUELTIGEN PASSWORT WIRD DER
        PROGRAMMLAUF ABGEBROCHEN.
```

```
LABORDATENERFASSUNG  :Aufruf                                         L0002

          HINWEIS  :Bitte vollstaendige Spender-ID oder
                    Schraegstrich (*Ende) eingeben.

          Spender-ID :28025148t016.....................................

Meldungen:
```

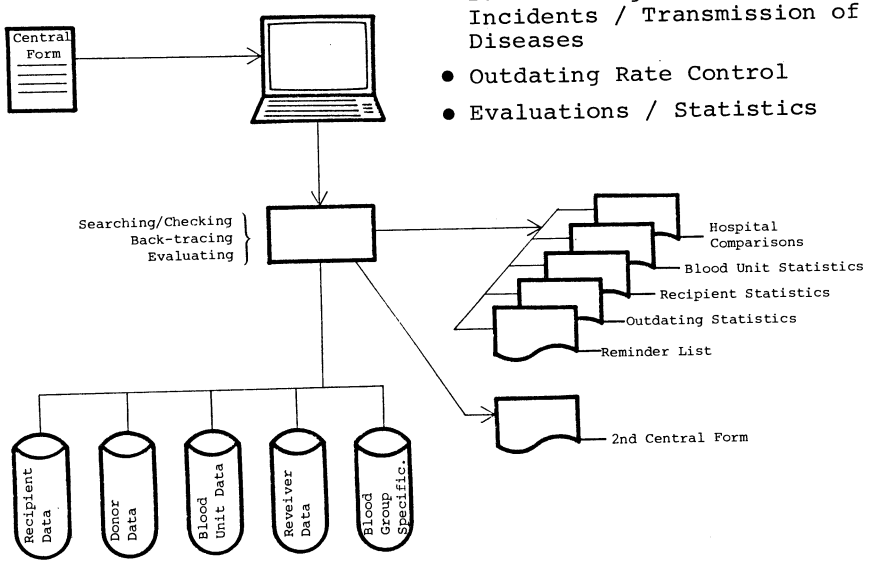
```
LABORDATENERFASSUNG  :Erfassung Teil 1                               L0003

          HINWEIS  :GE =Geeignet      VD =Verdaechtig  UN =Ungeeignet
                    FR =Freigegeben   SP =Gesperrt     KK =Keine Konserve

        Spender-ID  :28025148T01A
          Nachname  :TOLKSDORF
          Vorname   :BRUNHILDE

Spende mit Alkohol (J/N)  :N.......
Haemagl.-Index (J/</=/>)  :>12,9g%.        BLUTFORMEL  | ABAO | A CcDEe AA |
  Labor-Status (GE/VD/UN) :GE.......                    |  B   |    12      |
Hepat.-Status (GE/VD/UN)  :GE.......      ---------------|------|------------|
Konservenvera. (FR/SP/KK) :FR.......        Erstbestimmung :! -  | - ----- + |
                                            Zweitbestimmung :! -  | - ----- + |
  WEITERE EINGABEN? (J/N)  :J.......

Meldungen:
```

```
LABORDATENERFASSUNG  :Erfassung Teil 2                               L0004

          HINWEIS  :Zum Zurueckblaettern / eingeben (Feld 1)

        Spender-ID  :28025148T01A                    BLUTFORMEL:
          Nachname  :TOLKSDORF                       A Rh neg (D-)
          Vorname   :BRUNHILDE                       K= ccdee A1

                  Weitere  | CW | LA | P1 | KKKg | Fy | JK | Xg | MNSs | Lu |
Blutgruppenmerkmale        |    | ab |    | ab   | ab | ab | 3  |      | ab |
-------------------------  |----|----|----|------|----|----|----|------|----|
          Erstbestimmung :! -  | -+ | -  | +--- |    |    | +  |      |    |
         Zweitbestimmung :!    | -+ | -  | +--- |    |    |    |      |    |

  WEITERE EINGABEN? (J/N)  :J.....

Meldungen:
```

```
LABORDATENERFASSUNG  :Erfassung Teil 3                               L0005

          HINWEIS  :Zum Zurueckblaettern / eingeben (Feld 1)

        Spender-ID  :28025148T01A                    BLUTFORMEL:
          Nachname  :TOLKSDORF                       A Rh neg (D-)
          Vorname   :BRUNHILDE                       K= ccdee A1

          Antikoerper  :Anti-P1      ....                  ....
                       :             ....                  ....

        Sondergruppen  :Becker+ .....Jobbins+.....          .....

                  HLA-Typen  | A-Locus | B-Locus | C-Locus | D Locus |
                             |         |         |         |         |
          1. HLA-Merkmale :! A1      | B7      | Cw1     | Dw2     |
          2. HLA-Merkmale :! A9      | B14     | Cw3     | DRw7    |

Meldungen:
```

# Recipient Section

- Recipient Data Entry
- Reminder
- Back-tracing of Transfusion Incidents / Transmission of Diseases
- Outdating Rate Control
- Evaluations / Statistics




```
EMPFAENGERRUECKVERFOLGUNG  :Spender                                    EM155
-------------------------------------------------------------------------------

              Spender-ID  :2304174EZG15
                    Name  :CHUTSCH
                Vorname   :ERNA
                Strasse   :BELFASTER STR. 50
                    Ort   :1000  BERLIN 45

VERDACHTSVERMERKE (Status)

                Anamnese  :1
                Roentgen  :0
                Hepatitis :0
             Transfusion  :0
                   Lunor  :0

          weitere Angaben
    des Spenders ? (J/N)  :n.....................................................
-------------------------------------------------------------------------------
MELDUNGEN:
```

## BERLINER BLUTSPENDEDIENST (BBD)

BERLIN BLOOD DONOR SERVICE

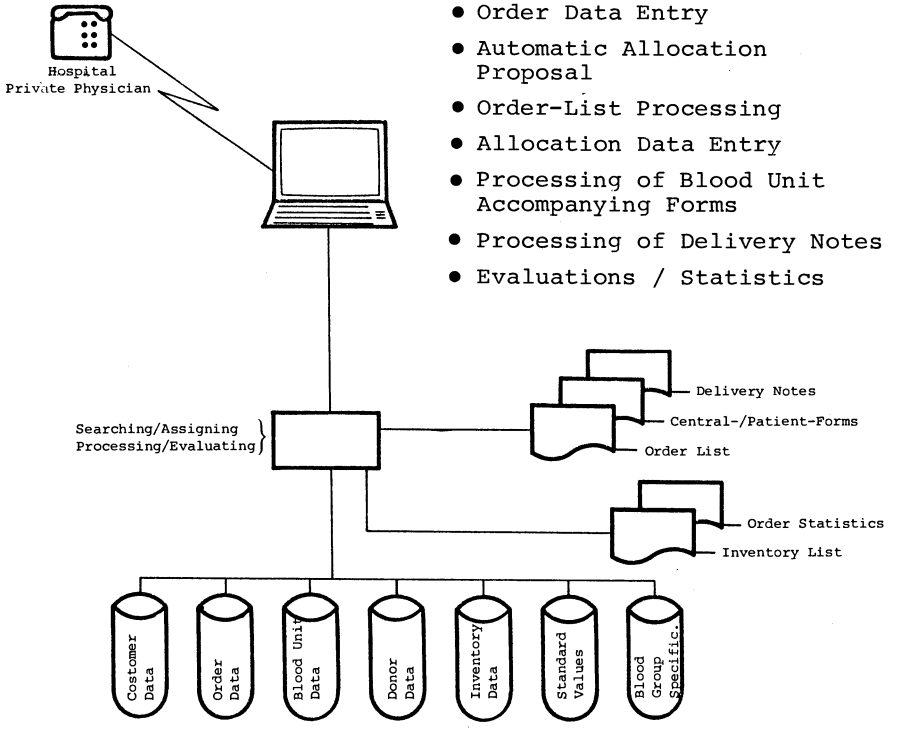
```
EMPFAENGERVERWALTUNG  :Auswahl einer Funktion                          EM001
-------------------------------------------------------------------------------
                HINWEIS  :

           BITTE WAEHLEN

             Neuerfassung  :NEU
                  Ausgabe  :AUS  (Empf-Id)
  Ausgabe und Aenderung    :AEN  (Empf-Id)
               Korrektur   :KOR  (Kons-Nr)
       Rueckverfolgung     :RUE
                  Ende     :/

           BITTE EINGEBEN

                 Funktion  :aus.....................................................
  Empf-Id oder Kons-nr     :1304454HA026.............................................
-------------------------------------------------------------------------------
MELDUNGEN:
```

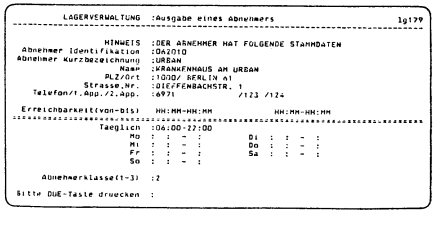
```
EMPFAENGERVERWALTUNG  :Ausgabe                                         EM090
-------------------------------------------------------------------------------
          Empfaenger-ID  :1304454HA026
                   Name  :ALLERS
               Vorname   :HANNELORE
          Geburtsname    :ALBACH
          Geburtsdatum   :13.04.1945
             Geschlecht  :W
       Erfassungsdatum   :05.05.78

      Trans.Einrichtung  :URBAN
            Archivnummer :1234567890123
        Grundkrankheit   :OBERSCHENKELHALSFRAKTUR
    Trans.Indikation     :HOCHGRADIGE ANAEMIE
     Komplikationen?     :NEIN

          Weitere Daten
    ausgeben ? (J/N)     :n.....................................................
-------------------------------------------------------------------------------
MELDUNGEN:
```

```
EMPFAENGERRUECKVERFOLGUNG  :Spender                                    EM160
-------------------------------------------------------------------------------

          Empfaenger-ID  :1304454HA026

                   Name  :ALLERS
               Vorname   :HANNELORE
          Geburtsname    :ALBACH
          Geburtsdatum   :13.04.1945
             Geschlecht  :W
            Archivnummer :1234567890123
      Trans.Einrichtung  :URBAN
          Trans.Datum    :01.04.78
        Komplikationen   :N
  Konserven-Nummern      :26020763 26018781 24823786


          Ausdruck ? (J/N)  :n.....................................................
            weiter ? (J/N)  :j.....................................................
-------------------------------------------------------------------------------
MELDUNGEN:
```

# Inventory Section

- Customer Data Entry
- Order Data Entry
- Automatic Allocation Proposal
- Order-List Processing
- Allocation Data Entry
- Processing of Blood Unit Accompanying Forms
- Processing of Delivery Notes
- Evaluations / Statistics



LAGERVERWALTUNG :Ausgabe eines Abnehmers 1g179

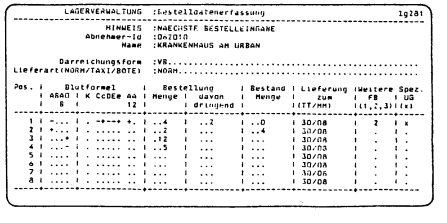
HINWEIS :DER ABNEHMER HAT FOLGENDE STAMMDATEN
Abnehmer Identifikation :0A2010
Abnehmer Kurzbezeichnung :URBAN
Name :KRANKENHAUS AM URBAN
PLZ/Ort :1000/ BERLIN 61
Strasse,Nr. :DIEFFENBACHSTR. 1
Telefon/t.App./2.App. :6971 /123 /124

Erreichbarkeit(von-bis) HH:MM-HH:MM HH:MM-HH:MM

Taeglich :06:00-22:00
Mo : : - : Di : : - :
Mi : : - : Do : : - :
Fr : : - : Sa : : - :
So : : - :

Abnehmerklasse(1-3) :2

Bitte DUE-Taste druecken :



LAGERVERWALTUNG :Bestelldatenerfassung 1g181

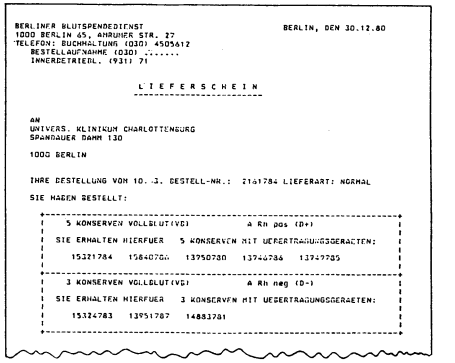
HINWEIS :NAECHSTE BESTELLEINGABE
Abnehmer-Id :0A2010
Name :KRANKENHAUS AM URBAN

Darreichungsform :VB
Lieferart(NORM/TAXI/BOTE) :NORM

| Pos. | Blutformel A B | ABAO K CcDEe Aa 12 | Bestellung Menge | davon dringend | Bestand Menge | Lieferung zum (TT/MM) | Weitere Spez. FB | Weitere Spez. UG |
|---|---|---|---|---|---|---|---|---|
| 1 | +... | . -+--+ +. | ...4 | ...2 | ...0 | 30/08 | 2 | k |
| 2 | +... | . ..... .. | ...2 | ... | ...4 | 30/08 | . | . |
| 3 | ...+ | . ..... .. | ..12 | ... | ... | 30/08 | . | . |
| 4 | ... | . ..... .. | ...5 | ... | ... | 30/08 | . | . |
| 5 | ... | . ..... .. | ... | ... | ... | 30/08 | . | . |
| 6 | ... | . ..... .. | ... | ... | ... | 30/08 | . | . |
| 7 | ... | . ..... .. | ... | ... | ... | 30/08 | . | . |
| 8 | ... | . ..... .. | ... | ... | ... | 30/08 | . | . |

## BERLINER BLUTSPENDEDIENST (BBD)

BERLIN BLOOD DONOR SERVICE



BERLINER BLUTSPENDEDIENST BERLIN, DEN 30.12.80
1000 BERLIN 65, ARNIMER STR. 27
TELEFON: BUCHHALTUNG (030) 4505612
BESTELLAUFNAHME (030) .....
INNERBETRIEBL. (931) 71

L I E F E R S C H E I N

AN
UNIVERS. KLINIKUM CHARLOTTENBURG
SPANDAUER DAMM 130

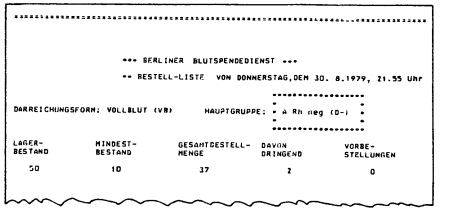
1000 BERLIN

IHRE BESTELLUNG VOM 10. 3. BESTELL-NR.: 2161784 LIEFERART: NORMAL

SIE HABEN BESTELLT:

5 KONSERVEN VOLLBLUT(VD) A Rh pos (D+)
SIE ERHALTEN HIERFUER 5 KONSERVEN MIT UEBERTRAGUNGSGERAETEN:
15321784 15840780 13750780 13740784 13749785

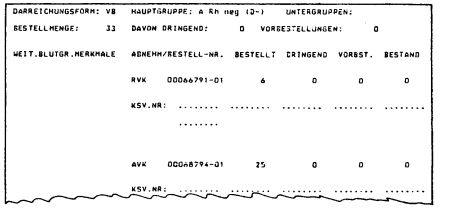
3 KONSERVEN VOLLBLUT(VD) A Rh neg (D-)
SIE ERHALTEN HIERFUER 3 KONSERVEN MIT UEBERTRAGUNGSGERAETEN:
15324783 13951787 14883781



*** BERLINER BLUTSPENDEDIENST ***
** BESTELL-LISTE VOM DONNERSTAG,DEM 30. 8.1979, 21.55 Uhr

DARREICHUNGSFORM: VOLLBLUT (VB) HAUPTGRUPPE: A Rh neg (D-)

| LAGER-BESTAND | MINDEST-BESTAND | GESAMTBESTELL-MENGE | DAVON DRINGEND | VORBE-STELLUNGEN |
|---|---|---|---|---|
| 50 | 10 | 37 | 2 | 0 |



DARREICHUNGSFORM: VB HAUPTGRUPPE: A Rh neg (D-) UNTERGRUPPEN:
BESTELLMENGE: 33 DAVON DRINGEND: 0 VORBESTELLUNGEN: 0

| WEIT.BLUTGR.MERKMALE | ABNEHM/BESTELL-NR. | BESTELLT | DRINGEND | VORBST. | BESTAND |
|---|---|---|---|---|---|
| | RVK 000A6791-01 | 6 | 0 | 0 | 0 |
| | KSV.NR: ..... ..... ..... ..... ..... ..... | | | | |
| | AVK 000A8794-01 | 25 | 0 | 0 | 0 |
| | KSV.NR: ..... ..... ..... ..... ..... ..... | | | | |

# Pilot Project Laboratory Data Processing in Immunology and Serology

A. Kluge and K. Rother

Institute of Immunology and Serology
University of Heidelberg (FRG)

Since 1972, an EDP pilot project in the field of laboratory data processing in immunology and serology has been realized in Heidelberg. Its function is the reporting of the test results of all samples of patients and donors from the selections of immunochemistry, protein immunology, transplantation immunology, serodiagnostics of infectious diseases, immunohematology, and bloodgroup serology. In the blood bank, each blood unit, processed and issued, and all cross-matches are quantitatively recorded. In detail, the EDP is fed off-line by dialogue via various peripheral devices with the values established by 20 laboratory working areas and 37 medical technicians. Only test values controlled by laboratory doctors are issued. The reports (Fig. 1 "Befundbericht") have to be signed (Fig. 1 "GEZEICHNET") by special EDP-procedures. Immediately after printing the report, complete and correct billing of the work performed is automatically provided by the EDP. The functions are accomplished by a SIEMENS 404/3 Computer by means of laboratory standard (SILAB) hard- and software and own user-specific programs. From 1973 - 1977 the total costs amounted to about 650.000 DM (see Fig. 1: scheme of configuration. Ref. 1-4). The important steering data files include the data of: 600 requestors (physicians, wards, hospitals), 400 costs carriers (medical insurance companies), 800 procedures (steering parameter sets for tests or blood units), 1.275 alphanumerical texts for medical results (and EDP error announcements), 1.200 figures selected from 3 tables of rates for billing the procedures, 400.000 counters for the accounting and statistical data file. Annually, the main data of the multitude frame are 90.000 samples sent with 220.000 tests, including 15.000 cross-matches and 20.000 issued blood units. The costs determined by means of applied economics amounted to -.95 DM per test in 1979 for laboratory EDP (including froms) and -.67 DM for administration of the institute (manual book keeping). Despite a global reduction in personell of 5%, there was an increase of nearly 230% in efficiency at the institute from 1972 - 1980. This increase would have been impossible without the establishment of EDP. The positive results encouraged us to start another project for an EDP support of the section of transfusion medicine beginning with a

comprehensive pre-analysis and followed by a detail-concept (5).

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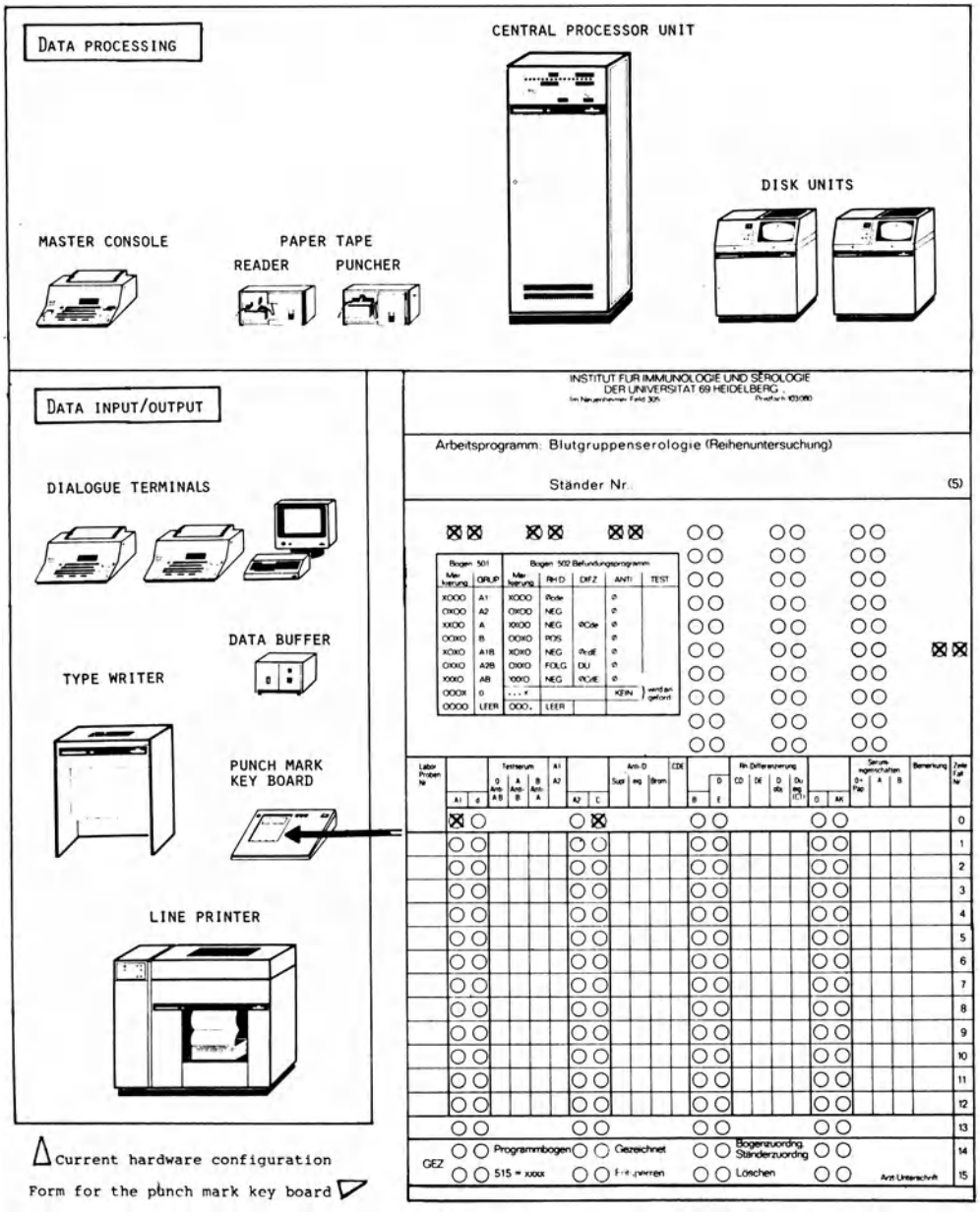
(5) Schneider, Martina:
Bluttransfusionswesen. Vergleich von EDV-unterstützten Systemen und Entwurf einer Lösung für das Universitätsklinikum Heidelberg.
Diplomarbeit (Med.Inform.) Univ. Heidelberg, Fachhochschule Heilbronn, 1979.

# PILOT PROJECT LABORATORY DATA PROCESSING IN IMMUNOLOGY AND SEROLOGY

A.KLUGE and K.ROTHER



HEIDELBERG, DEN 06.04.81 BLATT 1


# Institut für Immunologie und Serologie der Universität Heidelberg

Institut für Immunologie und Serologie · 6900 Heidelberg · Postfach Nr 30 60

Serodiagnostische Untersuchungsstelle
Direktor: Prof. Dr. med. K. Rother
Im Neuenheimer Feld 305 (Theoretikum)
Postfach 10 30 60 · Telefon (0 62 21) 56-40 10


ST. VINCENTIUS-KRHS.
U.NECKARSTR. 5

6900 HEIDELBERG

## Befundbericht

Blutgruppenbefundsicherung durch:
CODE 1 = A, 2 = B, 3 = AB, 4 = 0.
Die Befunde sind nicht handschriftlich signiert. Dem maschinenschriftlichen „GEZEICHNET" entspricht die Originalunterschrift des Arztes im Laborprotokoll.

| Labor-Nr. | Pat.-Name | Ihr Zeichen/Station | Geb.-Datum |
|---|---|---|---|
| 42000-5 | SOMEBODY-WEST HENRY 03.04 | DR.WEBER | 15.01.99 |

[redacted] AM 06.04.81
Mitteilung über:

| Verfahren | Befund/Ergebnis | | |
|---|---|---|---|
| VORBEMERKUNG | AUSGEFUEHRT WEGEN REAKTION IN KREUZPROBE | | |
| ** BLUTGRUPPE | | | |
| ABO-BLUTGRUPPE | --------A2B------(CODE 3)---------- | | |
| RHESUS-FAKTOR (D) | --------NEGATIV--(CDE-NEGATIV)---------- | | |
| ** IRREG.ANTIKOERPER | | | |
| IRREG.ANTIKOERPER | POSITIV.VORSICHT,ANGEBEN BEI TRANSFUSION--- | | |
| FUER BLUTGRUPPEN: | G E Z E I C H N E T PROF. KLUGE | | |
| ** IMMUNHAEMATOLOGIE | | | |
| IMMUNHAEMATOLOGIE | ERYTHROZYTEN-AUTOANTIKOERPER-TESTS | | |
| DIREKT.COOMBS-TEST | STARK P O S I T I V<br>IGG AUF PAT-ERY NACHWEISBAR,KOMPLEMENT NEG | | |
| FREIE WAERMEAGGLUT | TITER 1/16 | | |
| ANMERKUNG | VERDACHT AUF AUTO-IMMUN-HAEMOLYSE | | |
| FUER IMM.HAEMATOL: | G E Z E I C H N E T PROF. ROELCKE | | |
| ** L.-SERODIAGNOSTIK | | | |
| CARDIOLIPIN-FLOCKG | NICHT REAGIEREND /KEINE LIPOID-ANTIKOERPER | | |
| T P H A - TEST | NICHT REAGIEREND/KEINE PROTEIN-ANTIKOERPER | | |
| FUER L.-SERODIAGN. | G E Z E I C H N E T DR. HUSCHKA | | |
| ** PROTEIN-IMMUNOLOG. | | | |
| PROTEIN-IMMUNOLOG. | | NORMALBEREICH | |
| QUANT. HAPTOGLOBIN | 0,00 MG/ML | | |
| QUANT. HAEMOPEXIN | 0,15 MG/ML | 0,70 - | 1,30 |
| HAPTOGLOBINTYP | NICHT NACHWEISBAR | | |
| FUER SERUMPROTEINE | G E Z E I C H N E T PROF. ROTHER | | |

Jeder Blutspender erhält kostenlos einen:

**Blutspender-Pass**
mit Blutgruppendokument im
**NOTFALL-AUSWEIS**


**Universitäts-Blutspendezentrale im Altklinikum · 6900 Heidelberg**
Voss-Straße 2 · Telefon 53 26 55/53 25 55
Seiteneingang: Schneidmühlstraße 19
(hinter Neckarhotel nahe Bismarckplatz)


Spendezeiten
Montag-Donnerstag
9.00-11.30 · 16.00-17.30 (Dienstag 18.30)
Freitag 8.00-11.30
Vormittagsspende nach (tel.) Vereinbarung

Untenstehender Befund kann in entsprechenden Paß/Notfallausweis eingeklebt werden, vorher hier abtrennen

Patienten (Proben) Name
SOMEBODY-WEST HENRY
GEB.DAT. 15.01.99

Labornummer Untersuchungsbefund
42000-5 AM06.04.81


INSTITUT F. IMMUNOLOGIE + SEROLOGIE D. UNIV.
6900 Heidelberg, Neuenheimer Feld 305, Postf. 10 30 60
(Blutgruppen-CODE 1 = A, 2 = B, 3 = AB, 4 = 0)
Nicht handschriftlich signierter Computer-Ausdruck.


| | |
|---|---|
| VBEM | WEG.KREUZPR. |
| **BLUTGRUPPE | |
| GRUP | -A2B(CODE 3) |
| RH D | NEG(CDE-NEG) |
| **IRREG.ANTIKOERPER | |
| TEST | POSITIV |
| GEZ. | PROF. KLUGE |
| **IMMUNHAEMATOLOGIE | |
| IMMH | ERY-AUTO-AK. |
| D.CT | POSITIV(+++) |
| ERY: | IGG-NACHWEIS |
| WAGP | TITER 1/16 |
| ANM. | AUTOIMUNLYSE |
| GEZ. | PROF.ROELCKE |
| **L.-SERODIAGNOSTIK | |
| CAFL | NICHT REAG. |
| TPHA | NICHT REAG. |
| GEZ. | DR. HUSCHKA |
| **PROTEIN-IMMUNOLOG. | |
| PRIM | |
| QHP | 0,00MG/ML |
| HPEX | 0,15MG/ML |
| HAPT | NICHT NACHW. |
| GEZ. | PROF. ROTHER |

**NOTFALL-AUSWEIS**
Emergency Certificate
Certificat pour des cas d'urgence

Label to cover a Blood Donor Certificate or an Emergency Certificate

Laboratory Report

## Gebühren-Rechnung

für Laborleistungen bei amb./stat. Behandlung

| Leistungsart, Tarif-Nummer ggf. Pat.-Labornummer | | Betrag |
|---|---|---|
| BLUTGRUPPE | 067200 | 18,00 |
| ANTIKOERPERSUCHTEST (3-STUFEN) | 068013 | 18,00 |
| DIR.COOMBS/ANTIGLOBULIN-TEST | 068002 | 6,00 |
| INK.WAERMEAUTOAGGLUTININE | W86.27 | 6,20 |
| TITER:INK.WAERMEAUTO-AGGLUTIN. | 068200 | 14,40 |
| L-SERODIAGNOSTIK (TPHA) | 690761 | 31,10 |
| L-SERODIAGNOSTIK (CARD-FLOCKG) | 691102 | 6,20 |
| HAPTOGLOBINTYP | 064203 | 45,90 |
| QUANTITATIV HAEMOPEXIN | 064255 | 18,80 |
| QUANTITATIV HAPTOGLOBIN | 064254 | 18,80 |
| DIFF.CT.M.3.MONOVAL.ANTISEREN | 068003 | 18,00 |
| UNTERGRUPPE A1/2 | 067600 | 8,00 |
| GESAMTSUMME DM | | 205,50 |

Automatic addressing and billing

# 1. Organizational Concept for the Data Transmission with External Data Media

J. Vonier, A. Kluge, G.K. Wolf

Institute of Immunology and Serology,
and Institute of Medical Documentation,
Statistics and Data Processing,
University of Heidelberg (FRG)

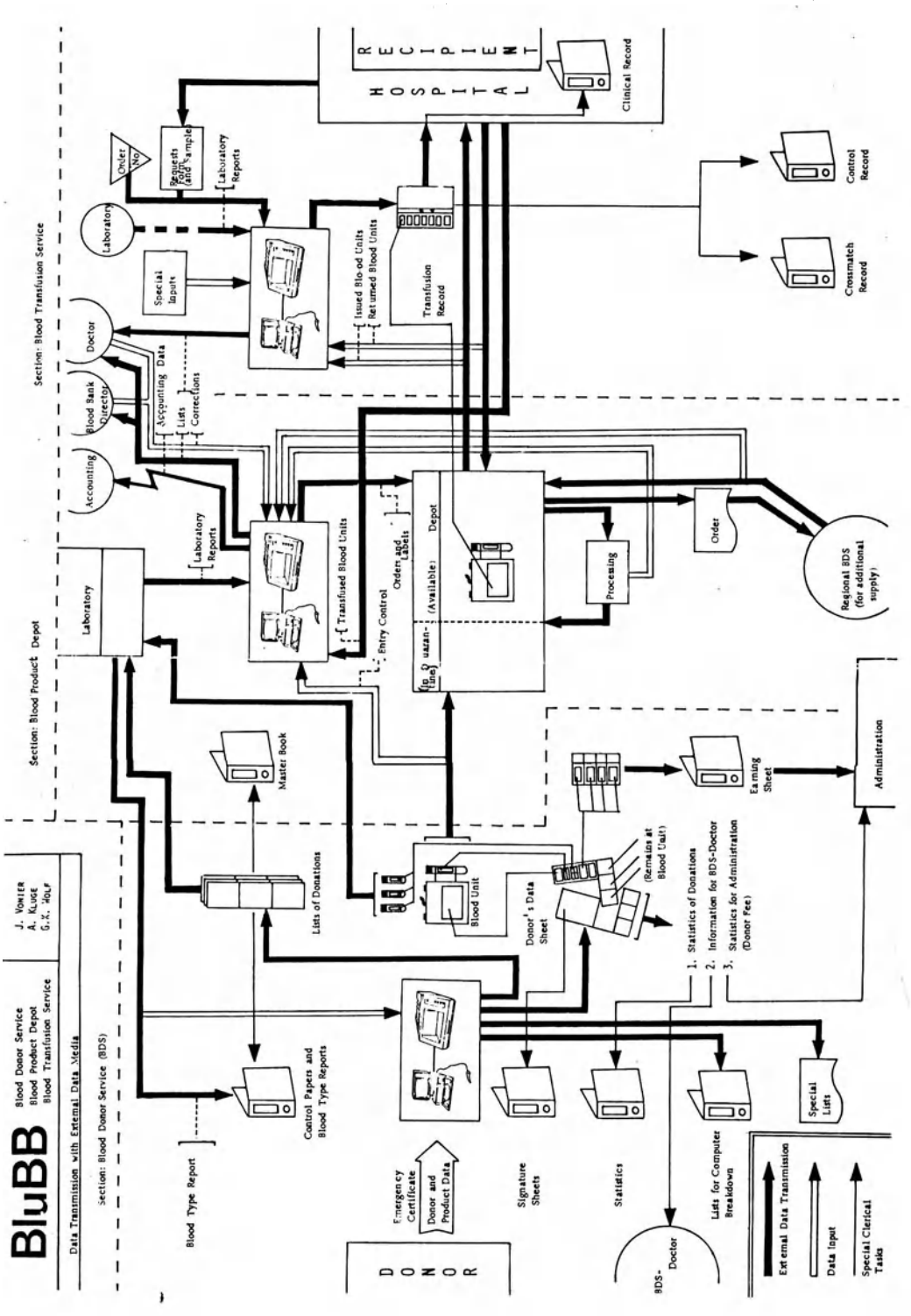
Most of the important data carriers the donor's data sheet, laboratory papers, labels for blood unit, and transfusion record are also organizational tools. These data are passed mainly between the laboratories, the administration and the hospitals and serve to identify persons and substances (e.g., recipient, blood donor, and blood unit).

Besides the detailed description of the different functional components of the donor's data sheet (see also contribution: Vonier et al. "Donor's Data Sheet"), the destination of these data (e.g. signature sheet, earning sheet, statistics of donations, laboratory reports) are also demonstrated.

The external data transmission for safety of product, processing and documentation takes place by means of the laboratory papers. The transport of these laboratory papers and their individual components (papers with the function of a masterbook, papers for the examination in the laboratories for serology, serodiagnostic of infectious diseases, and clinical chemistry) are also shown.

From the organizational concept, the bilateral functional influence of the external data is recognizable, especially from the resulting intermediary state of the blood unit between the donor and the recipient.

The external data are all in OCR-B writing and can, therefore, be read by man and machine.


BluBB
Blood Donor Service
Blood Product Depot
Blood Transfusion Service
J. Vonier
A. Kluge
G.X. Wolf
Data Transmission with External Data Media
Section: Blood Donor Service (BDS)
Section: Blood Transfusion Service
Section: Blood Product Depot
H O S P I T A L
Clinical Record
Control Record
Crossmatch Record
Transfusion Record
Issued Blood Units
Returned Blood Units
Laboratory
Special Inputs
Order No.
Request Form and Sample
Laboratory Reports
Doctor
Blood Bank Director
Accounting
Accounting Data
Lists
Corrections
Transfused Blood Units
Entry Control
Orders and Labels
Depot
(Available)
(to be taken)
Processing
Order
Regional BDS (for additional supply)
Master Book
Lists of Donations
Blood Unit
Donor's Data Sheet
(Remains at Blood Unit)
1. Statistics of Donations
2. Information for BDS-Doctor
3. Statistics for Administration (Donor Fee)
Earning Sheet
Administration
Control Papers and Blood Type Reports
Blood Type Report
Emergency Certificate
Donor and Product Data
Signature Sheets
Statistics
Lists for Computer Breakdown
Special Lists
BDS-Doctor
D O N O R
External Data Transmission
Data Input
Special Clerical Tasks

## 2. Specifications by Step-wise Refinement of the System for the Blood Donor Service.

J. Vonier, A. Kluge, G.K. Wolf, R. Schlevogt

Institute of Immunology and Serology,
and Institute of Medical Documentation,
Statistics and Data Processing,
University of Heidelberg (FRG)

On the review poster, the subdivision of the three sections, "Blood Donor Service", "Blood Product Depot", and "Blood Transfusion Service" are illustrated. In each section, one subsystem can be called up at the same time and the respective work is performed.

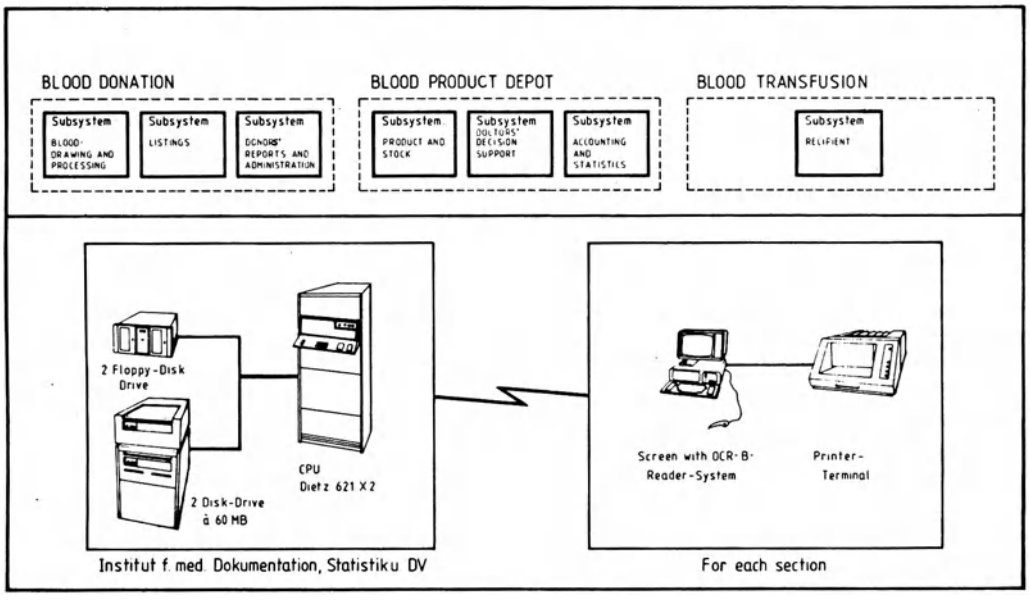
Each section has the same basic equipment for data input and output. It consists of

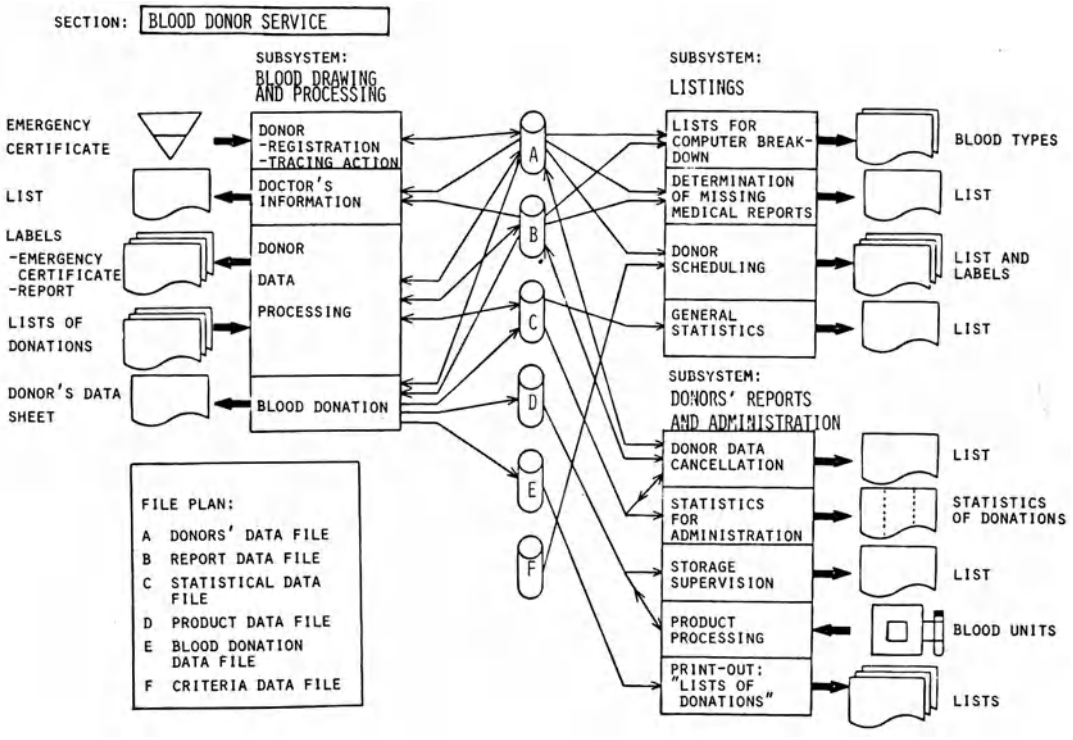
- a screen terminal,
- a small OCR-reader,
- and a printer terminal.

As an example for the next step-wise refinement of the design, data transmission within the computerized system (internal data transmission) of the "Blood Donor Service" is shown. There are three subsystems: "Blood Drawing and Processing", "Listing", and "Donor's Reports and Administration".

BluBB | Blood Donor Service, Blood Product Depot, Blood Transfusion Service | J. Vonier, G.K. Wolf, A. Kluge

# SECTIONS OF BLOOD-BANKING



# 3. Section "Blood Donor Service" with Donor's Data Sheet as Major Data Carrier

J. Vonier, A. Kluge, G.K. Wolf, R. Schlevogt

Institute of Immunology and Serology,
and Institute of Medical Dokumentation,
Statistics and Data Processing,
University of Heidelberg (FRG)

Many of the mistakes, which can happen in a conventional blood banking system are related with blood drawing, product processing, and associated clerical tasks.

Therefore, a new blood banking organization system we are developing in Heidelberg which specially emphasizes the organizational process, linking together the chain donor - product - recipient - accounting and vice versa.

The main document for this computer-supported system for blood donor service, blood product depot and blood transfusion service is the donor's data sheet. With this data sheet various processes are organized:

- Information about the donor for the medical personnel,
- Medical and legal safeguarding of product processing,
- Documentation concerning donor and product processing,
- Printing labels for the various data media,
- Fully prepared labels (convering about 95% of the line of products).

The most important aspect of our donor's data sheet is the fact that, instead of completing a number of forms, only one is used. This data sheet is hand-carried by the donor himself through the different stages of the blood donation process, resulting in a reduction of the workload for the personnel and the risk of a mix-up.

The data media accompanying the products contain data about donor and recipient as well as fully prepared labels for future processing of the blood components (erythrocytes, thrombocytes, and blood plasma). The labels contain the characteristic data (readable with an OCR-reader) of potential blood unit components.

Klinikum der Universität Heidelberg
Institut für Immunologie, Blutbank

# SPENDER-LAUFZETTEL

**ANGABEN ZUR SPENDE**

| | |
|---|---|
| Blutkons.-Nr. | 123453 |
| Spende am | 10.12.80 |
| Spendetechnik | ZYTOPHORESE:IBM SEP2997 |
| Spendemenge | 2000ml |

**BEFUNDE NACH LETZTER SPENDE**

```
11.08.79 Bilirubin i.S. 1,2
02.05.80 Arztvorstelle. Herz-Kreislauf o.B.
02.05.80 Fe(Serumeisen) 50
05.07.80 Fe(Serumeisen) 120
05.07.80 Thrombozyten   290000 ante
05.07.80 Thrombozyten   200000 post
```

**FÄLLIGE UNTERSUCHUNGEN**

| | |
|---|---|
| Labor am | 04.03.81 |
| Röntgen am | 18.06.81 |
| Arztvorstellung am | 11.11.81 |

**BEMERKUNGEN**

Spender hat seinen Schirm vergessen

**UNTERSUCHUNGEN**

Hämoglobin-Kontrolle Sign.: > 129 g / ($CUSO_4$-Test)

| | |
|---|---|
| Puls | /min |
| Gewicht | kg |
| Blutdruck | mmHg / kPa |
| Temperatur | °C |
| Ärztliches Gesamturteil | spendetauglich ☐ / ☐ spendeuntauglich |

**BEMERKUNGEN (handschriftlich)**

**ANGABEN ZUM SPENDER**

| | |
|---|---|
| Spenderstatus | Zytophorese/Heuschnupfen |
| Spenderart | Dauerspender |
| I-Zahl | 01045595315 |
| Nachname | WUNDERSCHOEN-KLEINSCHMIDT |
| Vorname | Friedrich-Wilhelm |

**Erklärung des Spenders**

Ich erkläre mich zu einer Blutspende bereit und versichere, daß die Angaben und Fragen zur Gesundheit (Anamnesebogen) zu meiner Person (siehe entsprechenden Aushang) bis zum heutigen Tag der Wahrheit entsprechen.
Ich versichere, daß ich innerhalb von 8 Wochen nach dem heutigen Tag bei keiner anderen Institution Blut oder Plasma gespendet habe oder spenden werde.
Weiterhin wurde ich unterrichtet, daß ich nach abgeschlossener Spende mindestens 30 Minuten nicht am öffentlichen Straßenverkehr teilnehmen soll. Bei Ausübung einer Tätigkeit, die das Leben anderer oder die eigene Person gefährden kann (z.B. Taxi- oder Busfahrer), soll diese Tätigkeit mindestens 6 Stunden nicht ausgeübt werden.

**BLUTGRUPPENMERKMALE**

Test — Klinikum der Universität Heidelberg, Institut für Immunologie, Blutbank

```
AB.Rh neg.ccddee.Cw..K+K2+.A2.
Lea+b-.Fya+b+.Jka-b+.MNSs.P1+.
Lua+b-.                    HLA-
A1 .AW24.B7 .B8 .CW2 .CW...
DR2 .DR3 .                 05.07.80
Irregulaeres Anti-A1.
X123459 15:SPM 101280-160181
```

WUNDERSCHOEN-KLEINSCHMIDT
F.141279 2000ml 140.--DM
123459 Phoresespende
Spendeentgelt erhalten:

Unterschrift des Spenders

Unterschrift des Spenders — Arztsignatur — Unterschr.d.Entnahmeperson

---

Klinikum der Universität Heidelberg
Institut für Immunologie, Blutbank

AA B/B
A A / B
AAAA/BBB
A / B B
A /A BBB
Rh neg

Blutbestandteilkonserve zur Transfusion verschreibungspflichtig
Blutgruppe AB Rh negativ
Stabilisator ACD—A falls nicht anders angegeben

Eigenblut---Retransfusion (Spende-Verfall)

| Produkt | ml | Blutkonserven-Nr.: |
|---|---|---|
| | | 101280-101280 |

V1234519

---

2. Pilotröhrchen — Klinikum der Universität Heidelberg, Institut für Immunologie, Blutbank

```
AB.Rh neg.ccddee.Cw..K+K2+.A2.
Lea+b-.Fya+b+.Jka-b+.MNSs.P1+.
Lua+b-.                    HLA-
A1 .AW24.B7 .B8 .CW2 .CW...
DR2 .DR3 .                 05.07.80
Irregulaeres Anti-A1.
X123459 15:SPM 101280-160181
```

Für Kreuzprobe (nicht injizieren) — Klinikum der Universität Heidelberg, Institut für Immunologie, Blutbank

| Blutkons.-Nr. | Spende-Verfall | Blutgr. |
|---|---|---|
| X123459 | 101280-160181 | AB- |

---

| | |
|---|---|
| S11<01045535712 X123459 AB- | S11<01045535712 X123459 AB- |
| S11<01045535712 X123459 AB- | S11<01045535712 X123459 AB- |
| S11<01045535712 X123459 AB- | S11<01045535712 X123459 AB- |

---

Klinikum der Universität Heidelberg
Institut für Immunologie, Blutbank

AA B/B
A A / B
AAAA/BBB
A / B B
A /A BBB
Rh neg
Thrombo--zytenkonz.8-fach

Blutbestandteilkonserve zur Transfusion verschreibungspflichtig
Blutgruppe AB Rh negativ
72.0 mal 10 hoch 10 Zellen
Stabilisator ACD—A falls nicht anders angegeben
Stabilisator:ACD

(Spende-Verfall)

| Produkt | ml | Blutkonserven-Nr.: |
|---|---|---|
| T81645200 | | 10-131280.16h15 |

V1234560

---

Klinikum der Universität Heidelberg
Institut für Immunologie, Blutbank

AA B/B
A A / B
AAAA/BBB
A / B B
A /A BBB
Rh neg
Frisch---Plasma
gefroren

Blutbestandteilkonserve zur Transfusion verschreibungspflichtig
Blutgruppe AB Rh negativ
Stabilisator ACD—A falls nicht anders angegeben
Stabilisator:ACD

(Spende-Verfall)

| Produkt | ml | Blutkonserven-Nr.: |
|---|---|---|
| T11670250 | | 101280-101281 |

V1234538

---

Univ.Klinik HD, Immunologie, Blutbank

AA B/B
A A / B
AAAA/BBB
A / B B
A /A BBB

```
AB.Rh neg.ccddee.Cw..K+K2+.A2.
15:SPM HLA 101280-160181 ANTI
123453 Zytophorese/Heuschnupfen
```

| Eigenblut---Retransfusion | | EigEryRe | |
|---|---|---|---|
| Produkt | ml | Blutkonserven Nr.: | Produkt ml |

| Erythro--zytenkonzentrat | | Erythro-- | |
|---|---|---|---|
| Produkt | ml | Blutkonserven Nr.: | Produkt ml |
| Erythro---zytenKonzentrat | | Erythro-- | |
| Produkt | ml | Blutkonserven Nr.: | Produkt ml |
| Erythro--zytenKonzentrat | | Erythro-- | |
| Produkt | ml | Blutkonserven Nr.: | Produkt ml |
| Erythro--zytenKonzentrat | | Erythro-- | |
| Produkt | ml | Blutkonserven Nr.: | Produkt ml |

---

Univ.Klinik HD, Immunologie, Blutbank

AA B/B
A A / B
AAAA/BBB
A / B B
A /A BBB

```
AB.Rh neg.ccddee.Cw..K+K2+.A2.
15:SPM HLA 101280-160181 ANTI
123453 Zytophorese/Heuschnupfen
```

| Thrombo--zytenKonz.8-fach | | Thrombo--gefroren | |
|---|---|---|---|
| Produkt | ml | Blutkonserven Nr.: | Produkt ml |

| Produkt | ml | Blutkonserven Nr.: | Produkt ml |
|---|---|---|---|
| Leukozytenkonz.(8-fach) 10-101280.22h15 | | | |
| T81654200 | | V1234557 | |
| Granulozyten-Konz(8-fach) 10-101280.22h15 | | | |
| T81659100 | | V1234557 | |
| Speziol-Leukozyten-Konz. (8-fach) 10-101280.22h15 | | | |
| T81669100 | | V1234576 | |

---

Univ.Klinik, HD, Immunologie, Blutbank

AA B/B
A A / B
AAAA/BBB
A / B B
A /A BBB

```
AB.Rh neg.ccddee.Cw..K+K2+.A2.
15:SPM HLA 101280-160181 ANTI
123453 Zytophorese/Heuschnupfen
```

| Frisch---Plasma gefroren | | Fluessig-gefroren | |
|---|---|---|---|
| Produkt | ml | Blutkonserven Nr.: | Produkt ml |
| | | | T11370250 |

| Frisch---Plasma gefroren | | 101280-101281 | Fluessig-gefroren | |
|---|---|---|---|---|
| Produkt | ml | Blutkonserven Nr.: | Produkt | ml |
| T11670250 | | V1234541 | T11370250 | |
| Frischeplasma-Kryofrei | | 101280-101281 | Kryoprazz (1-fach) | |
| Produkt | ml | Blutkonserven Nr.: | Produkt | ml |
| T81674230 | | V1234582 | T81674020 | |
| Frischeplasma-Kryofrei | | 101280-101281 | Kryoprazz (2-fach) | |
| Produkt | ml | Blutkonserven Nr.: | Produkt | ml |
| T81674230 | | V1234595 | T81374020 | |
| Eigenblut---Retransfusion | | 101280-101280 | EigEryRe | |
| Produkt | ml | Blutkonserven Nr.: | Produkt | ml |
| | | V1234522 | | |

# 4. Section "Blood Product Depot" with State of Product and Internal Data Transmission

J. Vonier, A. Kluge, G.K. Wolf

Institute of Immunology and Serology,
and Institute of Medical Documentation,
Statistics and Data Processing,
University of Heidelberg (FRG)

The tasks connected with the work of the section "Blood Product Depot" are, in contrast to the other two sections, not related to persons but to the product only.

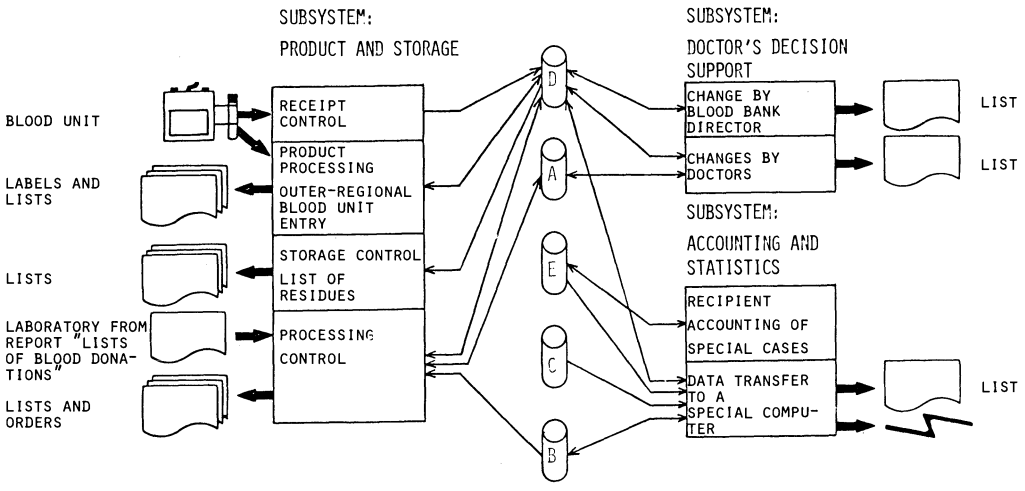
Intermediary states of the blood unit between blood donor and recipient (for example: return in a working cooling system, return after missing an appointment exceeding temperature limit, return after an invoice has already been mailed, storage of blood units in external depots, rejection of blood units...) are projected into the system as "state of product". By this it is possible to describe and handle the frequently complex paths of the blood unit as "state of product" and =product paths".

In the subsystem "Product and Storage" control and product processing are accomplished. On the other hand, in the subsystem "Doctor's Decision Support" the doctor makes decisions relative to the condition of the product and the necessary changes. These changes regarding the condition of the product are mainly based on laboratory reports or defective blood units. The subsystem "Accounting and Statistics" compiles the necessary data for accounting purposes.

# BluBB

BLOOD DONOR SERVICE
BLOOD PRODUCT DEPOT
BLOOD TRANSFUSION SERVICE

J. VONIER
A. KLUGE
G.K. WOLF




## FILE PLAN

A DONORS' DATA FILE
B RECIPIENTS' DATA FILE
C ACCOUNTING DATA FILE
D PRODUCT DATA FILE
E SPECIAL ACCOUNTING DATA FILE

## PRODUCT STATES AND PRODUCT PATHS

- DONATION REGISTERED FOR PROCESSING
- RECEIPT OF BLOOD UNIT ENTERED INTO DEPOT
- BLOOD UNIT
  - IN QUARANTINE
  - NOT RELEASABLE
  - AVAILABLE
  - RESERVED, RESP. PREPARED
  - ISSUED, RESP. PROCESSED
  - TAKEN FOR COMMISSIONING AND NOT ACCOUNTED FOR
  - TAKEN FOR COMMISSIONING AND ACCOUNTED FOR
  - AND SERVICES ACCOUNTED FOR

# 5. Transfusion Service including Transfusion Record and Blood Recipient Risk Data File

A. Kluge[1], M. Zsakai[3], W. Stucky[3], G.K. Wolf[2]

1) Institute of Immunology and Serology,
2) and Institute of Medical Documentation, Statistics and Data Processing, University of Heidelberg (FRG)
3) Institute of Applied Informatics and Formal Descriptive Processes, University of Karlsruhe (FRG)

Usually, a university blood transfusion service is patient-oriented; this means, blood units have to be issued, prepared ect. directly for the patient. This includes the cross-matching of blood sample of patient and blood unit. Additionally, blood unit data is checked against recipient data. This can be described by a decision table. The data file provides information, e.g.

- whether blood types of patients are known (this eliminates unnecessary typing);
- whether blood units have been reserved or prepared for this patient before (so they can be used immediately);
- whether a blood sample is already in typing process for an older order (so that a new sample is unnecessary).

A risk file for data of patients with irregular antibodies against blood types improves security, saves time, and economizes the number of test runs. Such a card risk file has existed for thirty years, but only the new computerized systems guarantee timely and regular interrogation.

The data medium, as shown in the poster, has been developed as a general form which can be used for:

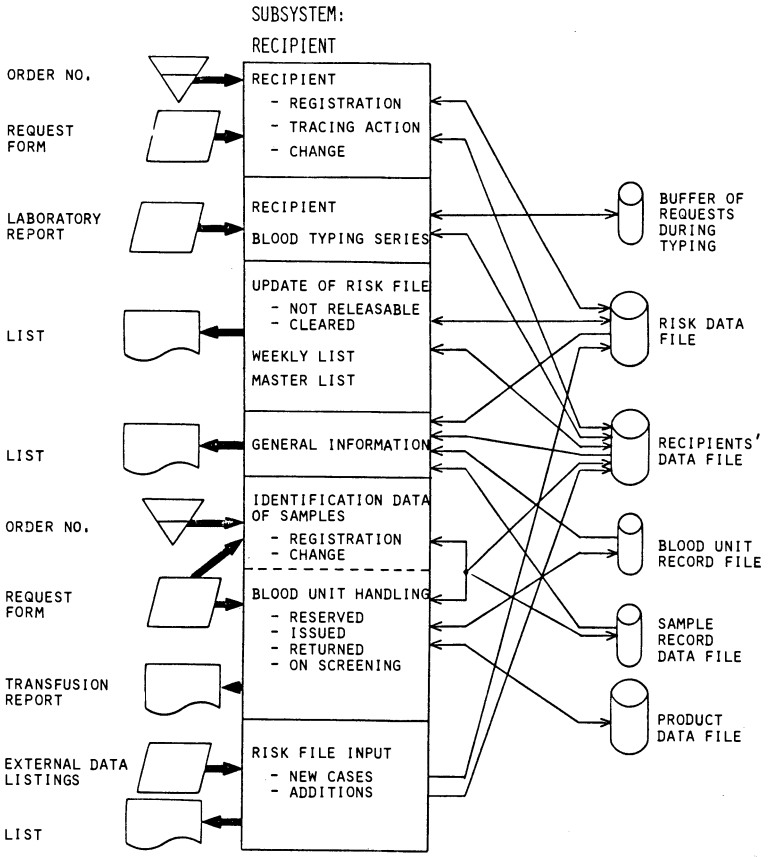
1. Delivery,
2. Transfusion record,
3. Check of information about individual case/check of changes in data,
4. Risk data file master index.

Within the system the distinction of cases is shown by means of a structogram according to NASSI-SHNEIDERMAN.

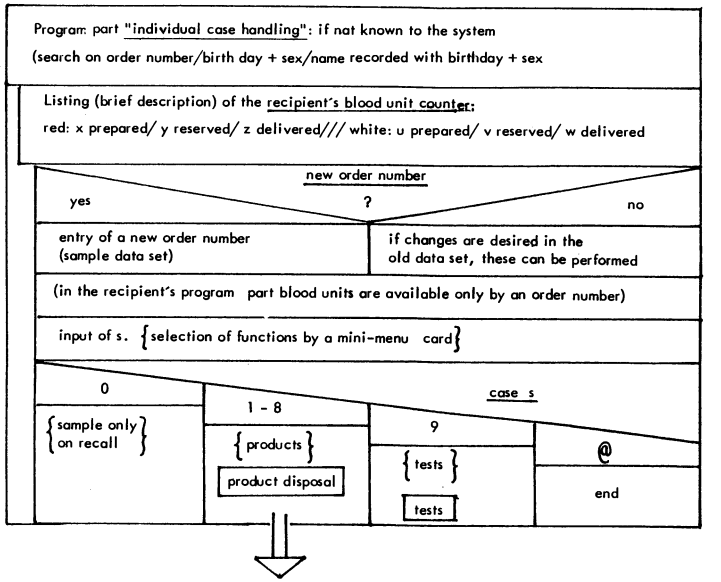
# BluBB

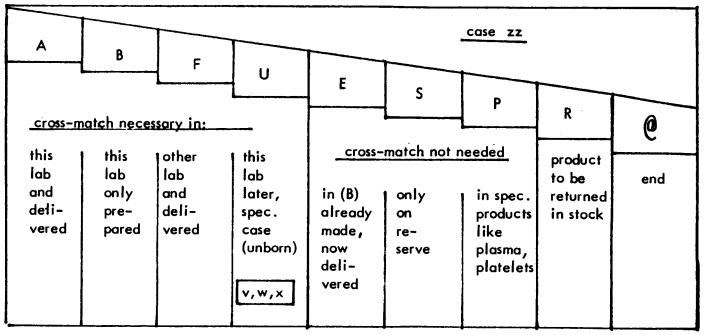
BLOOD DONOR SERVICE
BLOOD PRODUCT DEPOT
BLOOD TRANSFUSION SERVICE

A. KLUGE
M. ZSAKAI
W. STUCKY
J. VONIER
G.K. WOLF




BLOOD RECIPIENT PROGRAM PART: 2 NASSI-SHNEIDERMAN STRUCTOGRAMS (ABBREV.)

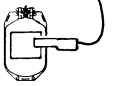


INPUT:

KNOWN
ORDER-NUMBER

OR NEW RECIPIENT'S DATA
- KIND OF ORDER
- UNIT NUMBER



OUTPUT (DESIGN):

TRANSFUSION RECORD
FOR 1-8 BLOOD UNITS

DISTRIBUTION:
ORIGINAL: WARD (RECIPIENT)

COPY: LABORATORY
(CROSSMATCH PROTOCOL)

COPY: STOCK CONTROL
(EDP BREAK-DOWN)

LABELS (LEFT HAND):
LABORATORY (TEST TUBES)

BLOOD UNITS
(COMBINED WITH RECIPIENT'S DATA)

---

Klinikum der Universität Heidelberg
Institut für Immunologie, Blutbank

--- Transfusions-Dokument ---

| AkStCoo | AkStPap | AB-Test | Anti-D |
|---|---|---|---|
| C350006 | 350006 | 350006 | 350006 |
| I Ma3Ph | I MaEnz | TKB | TKC |
| C350006 | 350006 | 350006 | 350006 |
| PatSe/Pl | Protokoll | | |
| C350006 | 350006 | 350006 | 350006 |

OrderNr C350006

8276309
Krhaus: St.Vincentius St:2/3a
15.01.99M SOMEBODY-WEST
Beachte Kreuzprobenergebnis!

15.01.99M SOMEBODY-WEST HENRY
AB Rh neg,ccddee, A2,MNS.,P1+,
Waerme-Auto-Antikoerper nach-weisbar,Vorsicht: unbek.Spez.
Wg.AutoAk:Kreuzpr.m.Vorbehalt IgGposCoombs-T,Trfus-Reaktion,
Krhaus: St.Vincentius St:2/3a
20.03.81 C350006 1.TA:Ko Probe zeigt Haemolyse:Risiko!

Kreuzprobe einwandfrei (erst bei Unterschrift) — für die Richtigkeit der Blutentnahme (Identitätskontrolle) Unterschrift

530ml Vollblut
A Rh neg,ccddee, K- ,A1,
V8276309 Eigenherstellung
Frischblut-Risiko:trfund.Arzt!
Blutgrup-unvertraegl.notfalls:
Dies B-lysinfreie Blut verwdb.

Beachte Kreuzprobe
Kontrolle bei Transfusionsbeginn Datum, Uhrzeit, Signatur trfd. Arzt

OrderNr C350006

8275314
Krhaus: St.Vincentius St:2/3a
15.01.99M SOMEBODY-WEST
Beachte Kreuzprobenergebnis!

250ml Erythrozytenkonzentrat
AB Rh neg,ccddee, K- ,A1,
V8275314 Eigenherstellung

Beachte Kreuzprobe
Kontrolle bei Transfusionsbeginn Datum, Uhrzeit, Signatur trfd. Arzt

OrderNr C350006

8276425
Krhaus: St.Vincentius St:2/3a
15.01.99M SOMEBODY-WEST
-- Ohne Kreuzprobe verwendbar

50ml Thrombozytenkonzentrat (2-fach)
A Rh pos,CcD.ee,Cw-,K+K2+,A2,
V8276425 Eigenherstellung
Frischblut-Risiko:trfund.Arzt!
Blutgrup-unvertraegl.notfalls:
Alle weiss.Zellkonz.verwendbar

-- Ohne Kreuzprobe
Kontrolle bei Transfusionsbeginn Datum, Uhrzeit, Signatur trfd. Arzt

OrderNr C350006

8275033
Krhaus: St.Vincentius St:2/3a
15.01.99M SOMEBODY-WEST
-- Ohne Kreuzprobe verwendbar

250ml Frischplasma, gefroren
AB Rh pos,
V8275033 Eigenherstellung
Bald trfd(kurze Restlaufzeit)

-- Ohne Kreuzprobe
Kontrolle bei Transfusionsbeginn Datum, Uhrzeit, Signatur trfd. Arzt

OrderNr C350006

12345678 zum Sa 21.03.,10h30
Krhaus: St.Vincentius St:2/3a
15.01.99M SOMEBODY-WEST
Beachte Kreuzprobenergebnis!

250ml Erythrozytenkonzentrat
AB Rh neg ccddee
12345678 V8275901 DRK-BBad
Termin: zum Sa 21.03.,10h30

Beachte Kreuzprobe
Kontrolle bei Transfusionsbeginn Datum, Uhrzeit, Signatur trfd. Arzt

OrderNr C350006

23456789 Abruf bis Mo 23.03.
Krhaus: St.Vincentius St:2/3a
15.01.99M SOMEBODY-WEST
Beachte Kreuzprobenergebnis!

250ml Erythrozytenkonzentrat
B Rh pos
23456789 V8215901 DRK-Ulm
Termin: Abruf bis Mo 23.03.
Gefahr:Rh neg Pat:Rh+KonsEry!
RisikoUebernahme:behand.Arzt!
Blutgrup-unvertraegl.notfalls:
A/B-Zellkonzentrat verwendbar

Beachte Kreuzprobe
Kontrolle bei Transfusionsbeginn Datum, Uhrzeit, Signatur trfd. Arzt

Kontrolle bei Transfusionsbeginn Datum, Uhrzeit, Signatur trfd. Arzt

Kontrolle bei Transfusionsbeginn Datum, Uhrzeit, Signatur trfd. Arzt

# 6. Experiences Gained from the Newly Developed Programming Language "System PASCAL" upon Realizing the Information System for the Clinical Blood Donor Center in Heidelberg

R. Schlevogt, G.K. Wolf

Institute of Medical Documentation,
Statistics and Data Processing,
University of Heidelberg (FRG)

PASCAL is a programming language with exceptional qualities for training as well as for programming within the framework of small-scale software. Above all, the well-structured blocks of PASCAL programs, the possibility to define (abstract) data types and data structures, and also the quality of the programming language for the design of programs along the line of "stepwise refinement" should be emphasized. To make the programming workable in practice, various manufactures of minicomputers (for example DIETZ) now offer a "System PASCAL" which allows the use of external modules. Thereby it is possible to access program libraries as well as overlay structures, and even to interface to other programming languages. A "prolog" or "prefix" as a first module can obtain definitions that are global to all subsequent modules.

With the help of "System PASCAL" it was an easy task, to realize the missing input and output for screens as well as to utilize an existing index-sequential external data file administration ("DFMS").

The programs are easy to read, easy to change and to expand. Nevertheless, the compilated programs are much more efficient than similar programs, for example in the C-BASIC system ("Commercial BASIC" system with expansion). As examples for the application we display program part parts for data structures and screen lay-out and management for the registration of blood types.

**BluBB** | Blood Donor Service
Blood Product Depot
Blood Transfusion Service

R. Schlevogt, G.K. Wolf

SYSTEM-PASCAL FOR THE REALIZATION OF SOFTWARE

## PROLOG

DEFINITIONS OF GLOBAL OBJECTS (CONSTANTS, TYPES, ETC.) E.G.

CONSTANTS FOR THE SUBSYSTEM

DEFINITIONS OF DATA TYPES FOR DONOR MANAGEMENT

```
CONST
  MINDESTALTER   =   18;
  MAXIMALALTER   =   65;
  SPENDELISTE1   =   'BLUTGRUPPENSEROL.UNTERSUCHUNGEN';
  SPENDELISTE2   =   'UNTERS. IM KLIN.-CHEM.LABOR    ';
  SPENDELISTE3   =   'BELEG FUER DIE BLUTSPENDEZENTRALE';
TYPE
  BYTE           =    0..255;
  ZWEIZEICHEN    =    ARRAY [1..2] OF CHAR;
  ABNULLSYSTEM   =    (A,B,AB,NULL);
  AUNTERTYP      =    1..2;
  DATUM  =  RECORD
              TAG, MONAT, JAHR : ZWEIZEICHEN
            END;
  BLUTGRUPPENSATZ = RECORD
                      HAUPTGRUPPE : ABNULLSYSTEM;
                      AUNTERGRUPPE: AUNTERTYP;
                      RHFORMEL, KELL : BYTE;  (*VERSCHLUESSELT*)
                      .
                      .
                      HLA:ARRAY ['A'..'D', 1..2] OF BYTE;
                      HLABESTIMMUNGSJAHR : ZWEIZEICHEN
                    END;
  SPENDERSATZ = RECORD
                  NACHNAME, GEBURTSNAME, VORNAME:ARRAY [1..26] OF CHAR;
                  GEBURTSDATUM : DATUM;
                  .
                  .
                  BLUTGRUPPE : BLUTGRUPPENSATZ
                END;
  SPENDEDATEN = RECORD
                  KONSERVENNUMMER : INTEGER;
                  SPENDEDATUM     : DATUM;
                  PRODUKTART      : (VOLLBLUT, ERYTHROZYTENKONZEN-
                                     TRAT, ....,THROMBOZYTENKONZENTRAT);
                  SPENDEMENGE     : INTEGER
                END;
```

## TYPE

DATA TYPES AND STRUCTURES

## MODULE

MODULAR STRUCTURE OF THE SYSTEM WITH A PRECISE DEFINITION OF THE INTERFACES
- EXPORT: DECLARATION OF THE NON-HIDDEN OBJECTS (VARIABLES, FUNCTIONS, PROCEDURES) OF THIS MODULE.
- IMPORT: DECLARATION OF OBJECTS WHICH ARE USED WITHIN THIS MODULE, BUT WHICH ARE DEFINED ELSEWHERE

THE CONCEPT OF MODULES ALLOWS EASY EXPANSION AND MODIFICATION OF PROGRAM BLOCKS

```
MODULE BLUTSPENDE (INPUT, OUTPUT);
  EXPORTS TAUGLICHKEITSTEST, SPENDENVERBUCHUNG;
  IMPORTS DATUMSEINGABE, DATUMSVERGLEICH,
          TAGESDATUM,
          .
          .
          NORMALWERT, MELDUNG;
  VAR
    SP, LR : SPENDERSATZ
    NEUESPENDE : SPENDEDATEN;
```

# SCREEN

EASY-TO-USE SCREEN MANAGEMENT
BY OWN FUNCTIONS, E.G.

DEFINITION OF DISPLAY CONTROL CODES AS PASCAL-CONSTANTS

```
CLEARSCREEN     =   %7E1%;
{SCREEN FILLED WITH FOREGROUNDSPACES, CURSOR HOME}
CLEARTOEOS      =   %7E18%;
{CLEARING OF SCREEN FROM CURSORPOSITION}
CLEARTOEOL      =   %7EOF%;
{CLEARING OF SCREEN LINE FROM CURSORPOSITION}
BACKGROUND      =   %7E19%;
{ALL FOLLOWING SIGNS SHOWN BACKGROUND}
FOREGROUND      =   %7E1F%;
{ALL FOLLOWING SIGNS SHOWN FOREGROUND}
```

PROCEDURE FOR POSITIONING THE CURSOR

```
PROCEDURE POS (Y,X : INTEGER);
{PUTS CURSOR ON SCREEN POSITION (Y,X)}
BEGIN
 WRITE (%7E11%,CHR (X),CHR (Y))
END;
```

```
        Spenderverwaltung :BG von:  MAIER                    ID:030333520310
-------------------------------------------------------------------------------
 1              Blutgruppe :10  A1B+                 0          20  Bw42
 2           Rhesusformel : 4  ccD.ee                1  B5      21  Bw44
 3                     Cw : 1  -                     2  B7      22  Bw45
 4                  Lewis : 4  a-b-                  3  B8      23  Bw46
 5                     P1 : 2  -                     4  B12     24  Bw47
 6       Kell-Untergruppen :    K+ K2+Kpa+  b-       5  B13     25  Bw48
 7                  Duffy : 4  a-b+                  6  B14     26  Bw49
 8                  Kidd  : 1  a+b-                  7  B15     27  Bw50
 9                   Xga : 2  -                      8  Bw16    28  Bw51
10                  MNSs :    MMSs                  9  B17     29  Bw52
11               Lutheran : 3  a-b+                 10  B18     30  Bw53
12 Irregulaere Antikoerper :                        11  Bw21    31  Bw54
13              HLA A-Locus : 5  A10      8  Aw23    12  Bw22    32  Bw4
                HLA B-Locus : 0           0         13  B27     33  Bw6
                HLA C-Locus : 0           0         14  Bw35
                HLA D-Locus : 0           0         15  B37
                                                    16  Bw38
                                                    17  Bw39
Erstspender                                         18  B40
Nummer der gewaehlten Blutgruppe :9                 19  Bw41
-------------------------------------------------------------------------------
```

EXAMPLE FOR A DIALOG SCREEN FOR THE INPUT OF BLOOD TYPES WHICH WAS PROGRAMMED IN S-PASCAL

# MAINTENANCE

EASILY READABLE PROGRAMS BECAUSE OF STRUCTURING AND SELF-EXPLANATORY NAMES.

EASY ELIMINATION AND REPLACEMENT OF PARTS BECAUSE OF EXACT INTERFACES AND MODULAR STRUCTURE

# DATA FILES

INDEX-SEQUENTIAL FILE MANAGEMENT CAUSES RELATIVELY GREAT EFFORT IN PROGRAMMING

BUT

OUR OWN INFORMATION SYSTEM IS MORE EASY-TO-USE THAN AVAILABLE UNFLEXIBLE DATA BASE CONCEPTS FOR MINICOMPUTERS.

# The installment of an Electronic Documentation System at the Blood Donor Service in the State Hospital in Homburg

H. Jäger, K. Nienhaus, E. Wenzel

Dept. of Clinical Haemostaseology and Transfusion Med., FB 3/4, Univ of Saarland, D-6650 Homburg/Saar

The Blood Donor Service in Homburg is responsible for the following:

1. Acquisition, storage and distribution of stored whole blood concentrates, and plasma derivatives for the hospital;
2. Covering the need for transfusion blood

The Blood Donor Service in Homburg is divided into 4 departments:

1. Blood Donor,
2. Laboratory,
3. Storage (Blood Bank),
4. Blood Recipient.

On the basis of an analysis of the workday routine, an Electronic Documentation System for the Blood Donor Service has been realised in the first place for the Blood Donor Department and the laboratory.

Acquisition of the donor's data is a prerequisite for the processing of a Blood Donor's form, controlling the donor and notifying him when necessary, and this also makes it possible to contact the particular donor rapidly in emergency cases. Information is recorded on the donor's identification, suitability of his blood, his blood classification and the number of blood donations. In connection with the blood recipient's data, it is possible to backtrace the donor of the blood, for example, when suspicion of infection from blood transfusion arises.

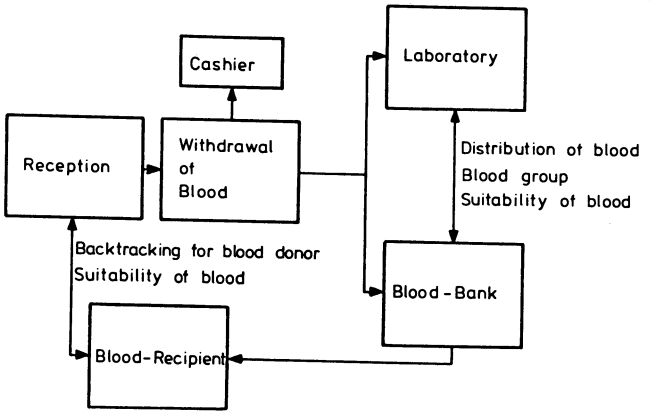
The system for the donor has now been fully implemented (Einplatzsystem, HP 9835). The data is stored momentarily on rapid cassettes and plans are underway to supplement this with disc units. We are also aiming at an eventual link up to the Host Computer (Siemens 7.760) at the Hospital.

Considering the task a Blood Donor Service must be able to perform, this project is being pursued in order to improve the effectiveness safety , and intelligibility of transfusion medicine here in Homburg.

Dept. of Clin. Haemostaseologie and Transf. Med., Fb 4/3, Univ. of the Saarland, D-6650 Homburg / Saar.

# THE INSTALLMENT OF AN EDS AT THE BLOOD DONOR SERVICE IN THE STATE HOSPITAL IN HOMB. / SAAR.

Jäger, H.; Nienhaus, Kh.; Wenzel, E.




2000 donors stored

30 donors per day

6000 blood-bags per year

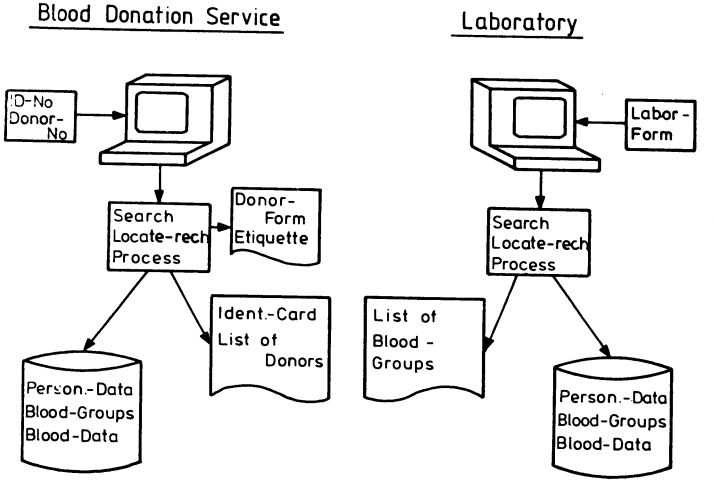
20000 total need per year

Personal: 1 physician
2 nurses
1 secretary

Software : Basic

Hardware: HP 9835
Rapid cassettes
Line-printer
planed: Direct connect. to a Host-Computer (Siemens 7.760)
Wincester DISC

Costs: Hardware: DM 24 000,-
Software : DM ?




```
I                    I
I Blutsruppe : A2B   I
I                    I
I Rhesus     : neg.  I
I                    I
```

```
Platznummer              :  2
ID-Nummer                : 2801601GS700
Nachname                 : Stephan
Vorname                  : Georg
Geburtsdatum             : 28.01.60
Laborstatus              : geeignet
Rhesusuntersruppe        : CcdEe
Kell                     : neg.
Antikoerper              : neg.
Hla-Gruppen              :   A :
                             B :
                             C :
```

```
Spendedaten :

  Spende ml  [ I I ]
  Hgb g%     [ I I I ]
  Blutdruck  [ I I ]  [ I I ]
  Puls       [ I I ]

Labordaten :

  HB/AG          neg.[ ] pos.[ ]
  GPT               [ I ]
  GOT               [ I ]
  GAMMA-GT          [ I ]
  Konservennummer   [ I I I I ]
  Konservenstatus :.....
  Laborstatus :  ..............
```

# Experiences with the Philips-P-310-Office Computer in a University Blood-Bank

A.M. Jansen, K.P. Schätzle, N. Kleine

Medizinische Universitätsklinik Freiburg
Innere Medizin I, Director Prof.Dr. G.W. Löhr

The bloodbank of the Freiburg University Hospitals is responsible for supplying ACD- and heparin-whole-blood units and blood component units to the University Hospitals as well as to the hospitals in the surrounding area. In 1980, 60.001 units were cross matched; 25 % of these did not come from our own production.
The infrastructure of the blood donation centre is made up of the following components: A) donor, B) product, C) laboratory, D) storage, E) transfusion, F) administration. Until 1979, these areas were conventionally processed. Since October 1979, the donor component has been computerized; donor-involved aspects of product, laboratory, transfusion and administration have also been handled with the aid of EDP, using a Philips P 310 office computer. The P 310 is a one-terminal system without a visual display unit with 16 K Bytes storage capacity, on floppy. At present 2610 O Rh pos donors, 2450 A Rh pos donors, and 2305 donors of the other combinations have been computerized. Either all donors with O Rh pos or all donors with A Rh pos features or all donors with the other ABO and Rh combinations are simultaneously available by random access. The computer handles donor data entry, donor data actualization and donor data elimination; data elimination proved necessary due to the limited storage capacity and a great fluctuation in casual donors.
The stored data increases the accuracy of donor identification which is carried out by surname, first name, birthday, blood group, Rh-factor, donor number and computer number, both numbers being additional identifying features. They facilitate a precise selection by erythrocytic antigen patterns, leukocytic antigen patterns (partially realized) as well as presence or absence of irregular antigens or antibodies. On the basis of these data, donors are notified according to their accessibility (e.g. by letter), their availability (Freiburg residents who can be reached by telephone either at home or at work), and eligibility (the minimum interval between donations).
The time intervals are automatically determined by the computer.
In the product area, the system is programmed to serially number the blood units and to print out the number on the external data sheets,

such as donor card identification, labels for the units and the tubes accompanying each unit as well as transfusion papers. In the laboratory area the daily blood donation list is printed out as a main record, on copies of which the serological and clinico-chemical results obtained in the laboratory are entered manually. In the storage and transfusion areas reliability with regard to the identity of our own products is increased by the automatic print-out of the serial unit number on identification labels and transfusion documents.
Administrative tasks are simplified by the print-out of the daily cash register balance whenever a predetermined limit is reached during a blood donation period, by the print-out of the daily statement after every blood donation period, by the print-out of the annual statement and the possibility of erasing data of donors no longer resident in the Freiburg area.

EDP has reduced the probability of errors in the donor area and in the other areas of interaction with this area and has increased reliability in the production and transfusion of units produced by our own blood bank. The search for donors with complicated antigen patterns is facilitated. Cost savings and labour reduction were not achieved; on the contrary, the recording of data before introduction of the system increases costs and labour. Cost savings and labour reduction in using the system are conceivable if a reduction in waste caused by inadequate supplies of blood units can be achieved, by means of a program for the automatic notification of blood donors at fixed intervals as well as a program for the automatic print-out of blood donor identification cards.

A full integration of all areas of the blood bank in EDP cannot be achieved with the present system.

# COMPUTER SYSTEM OF THE GERMAN RED CROSS BLOOD TRANSFUSION SERVICE RHEINLAND-PFALZ

H. Bitz, W. Castor

Description of poster

The Blood Transfusion Service of the GRC Rheinland-Pfalz is a regional blood transfusion service. Its task is to supply hospitals in Rheinland-Pfalz and Saarland with blood units and blood components.

In order to be able to maintain this service, about 180.000 blood units from 97.000 volontary donors are needed anually. About eight mobile laboratories carry out blood collections daily within the entire service area.

All blood units are analyzed in the laboratories of the blood center in Bad Kreuznach before being shipped to hospitals. For more than 80% of the collected blood a preparation of subfractions is required.

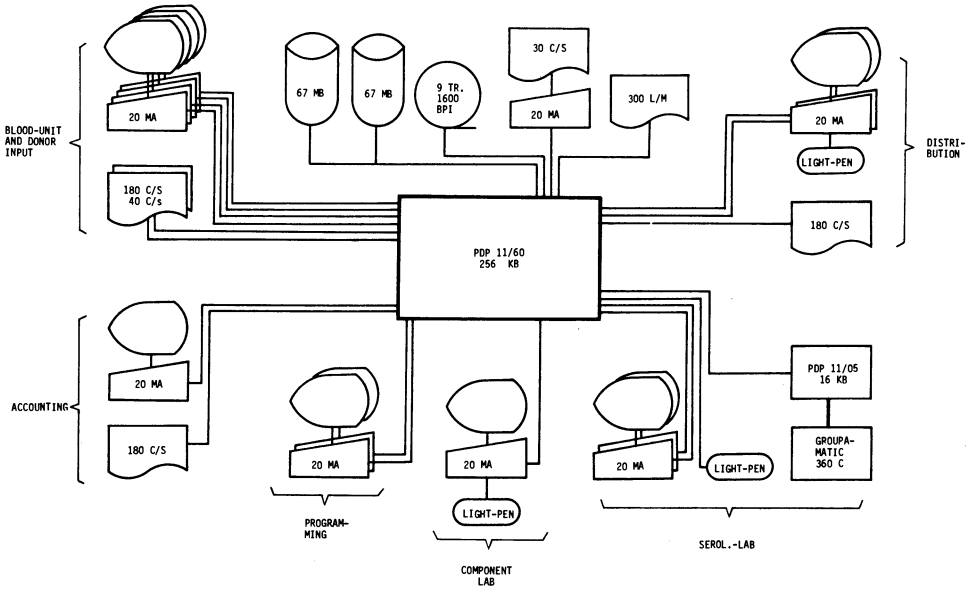
The EDP assistance of the GRC Blood Transfusion Service is supported with a PDP 11/60 computer from Digital Equipment. Digital Standard Mumps (DSM-11) is used as operating system. At present dialog-oriented input of donor, blood units and laboratory data is performed by 12 TV terminals and 2 bar code lightpens.
A Roche Groupamatic 360 C is used for blood grouping. It is equipped with a PDP 11/05 computer connected to the central computer by an opto-coupler. A bar code laser scanner serves to identify samples positively (1st poster).
The EDP system schematically represented in the second poster supports the following operation fields, specific for a regional blood transfusion service:

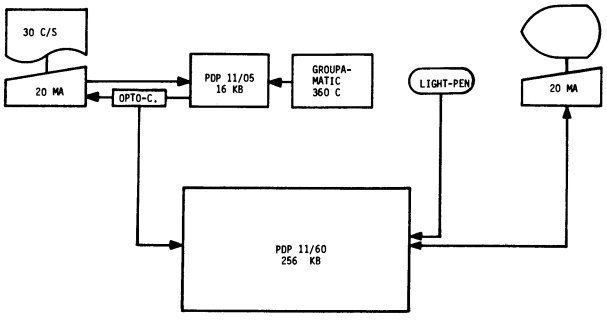
- input and administration of blood donors,
- input and analysis of laboratory results,
- processing and distribution of blood units and blood components,
- planning and completion of blood collections.

Since December 1979 it has been operating in this way.
Integration of EDP into the GRC Blood Transfusion Service Rheinland-Pfalz has brought an additional degree of security and has simplified the realization of documentary qualifications which must be fulfilled by the blood transfusion service according to "Arzneimittelgesetz" (Drug Act of the FRG) and the Good Manufacturing Practices (GMP).

# Computer-System of the DRK-Blutspendedienst Rheinland-Pfalz

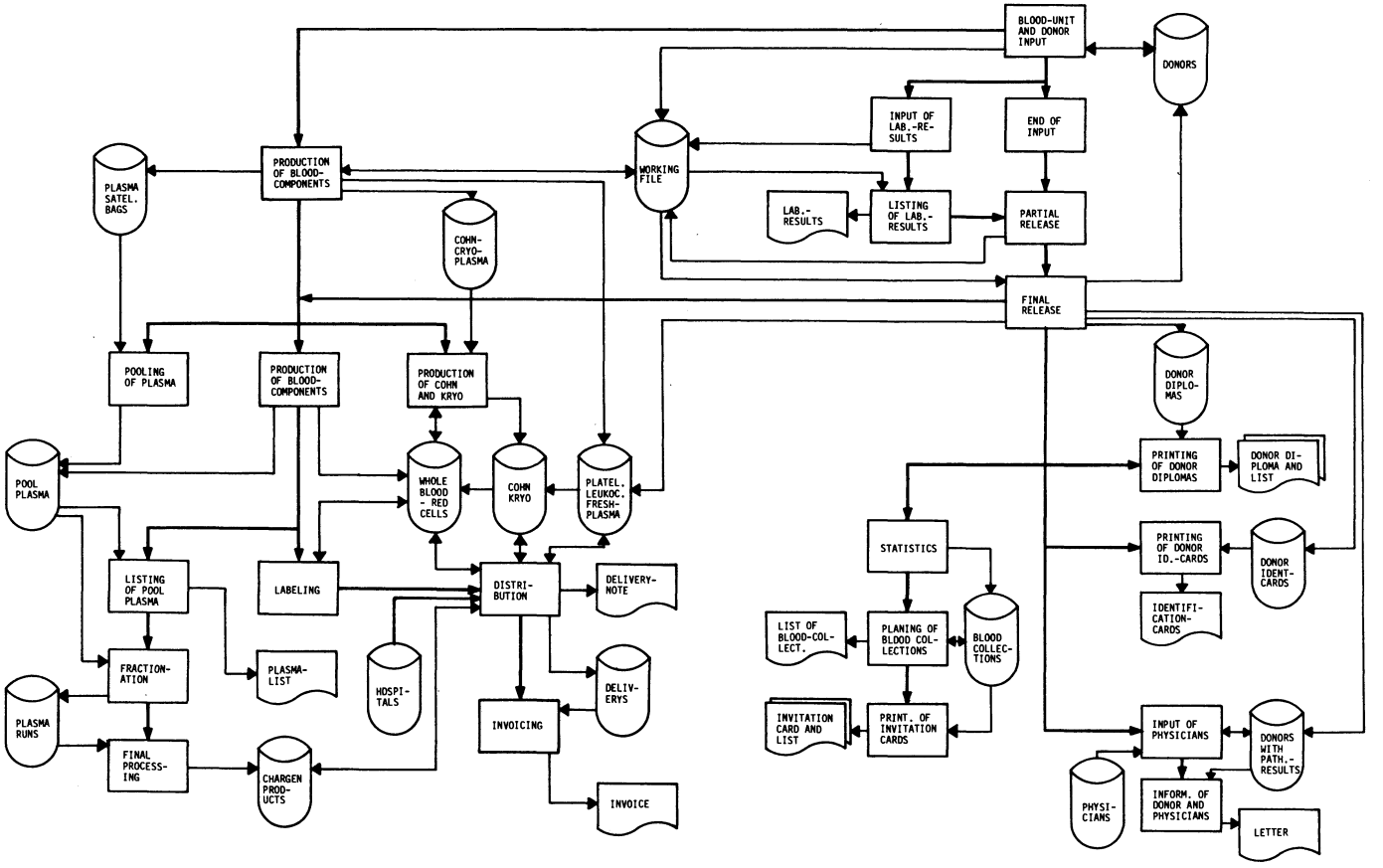
## Hardware-Configuration



# Computer-System of the DRK-Blutspendedienst Rheinland-Pfalz

## Flow-Diagram



# The EDP-System in the Blood Collection Service of the Bavarian Red Cross

G. B ü c h n e r

BLUTSPENDEDIENST DES BAYERISCHEN ROTEN KREUZES

Institut Wiesentheid

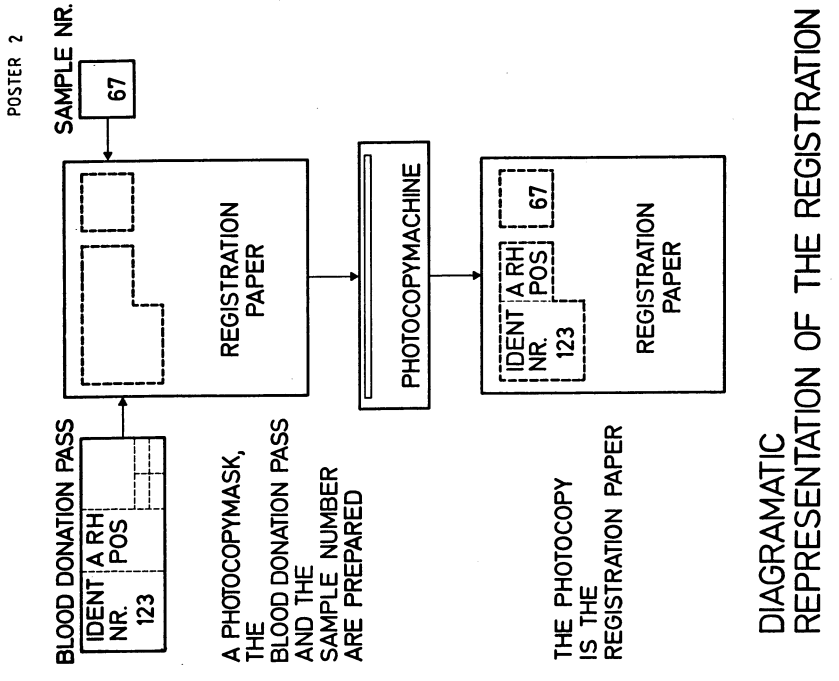
The build-up of the EDP-system within the Blood Collection Service of the Bavarian Red Cross follows the specific structure of the organisation, particularly due to the high degree of decentralisation of the institutes in Munich, Regensburg, Nürnberg, Würzburg, Wiesentheid and Augsburg.

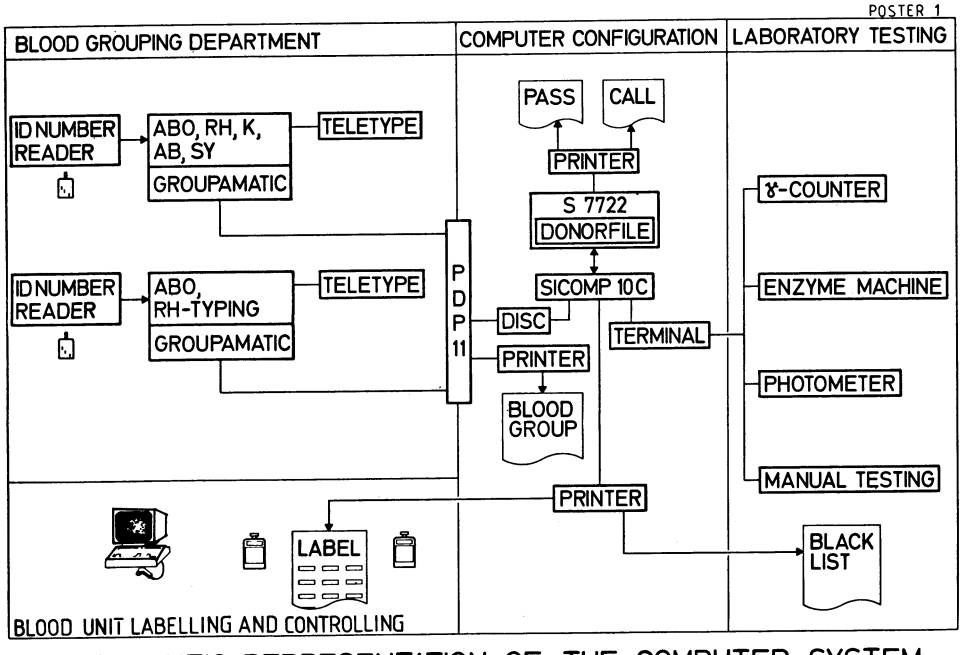
But we still consider the Bavarian BCS as a functional unit, despite the geographical dislocation of the institutes, and restrict the independence of the individual institutes to their given and limited responsibilities.

According to those circumstances, the central computer - type SIEMENS 7.722 - is installed in the Institute Wiesentheid and realized the central Donor and Unit Management, including general administrative procedures.

The processing of the blood units in the institutes, beginning with incoming donor data to the final release respectively blocking. is supported by subsystems SIEMENS SICOMP 10C. These systems are connected with the central computer by a transmission system.
The central computer supplies the donor informations, necessary for daily laboratory processing. Similarly, the laboratory informations are provided to the central computer (Poster 1).

The correct recording of the information of the each blood unit is highly important for the reliability of each unit. For collection of data (unit respectively identification number of each donor), a OCRB-hand reading system is used. The automatically readable ID-number is transferred by photostatic copy at the collection point from the donor pass to the registration form (Poster 2).




DIAGRAMATIC REPRESENTATION OF THE COMPUTER SYSTEM

# A COMPUTER-AIDED INFORMATION SYSTEM FOR THE HLA-TYPED REGULAR DONORS OF THE BAVARIAN RED CROSS BLOOD DONATION SERVICE

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The computer-aided information system, developed in cooperation with the Blood Donation Service of the Bavarian Red Cross, makes it possible to select blood donors from a computer-stored file of regular donors, on the basis of a given antigen profile.

This selection is carried out in accordance with the erythrocytic systems ABO, Rh, Kell, MNSs, P, Duffy, Lewis, Kidd, and the leucocytic HLA system.

Owing to the tremendous variety within the HLA system, the main problem encountered when performing transfusions is to find HLA-identical or compatible donors. In an attempt to limit this HLA polymorphism, the information system described here also takes into account the formerly ignored HLA-A and HLA-B cross reactions when selecting suitable donors.
An accurate testing of the agreement or tolerability of the HLA determinants between recipient and donor is necessary, since already the first administration of cells can result in the production of antibodies by the recipient.

At the same time, the program automatically checks the actual ability of the donor to donate (depending on the nature (purpose) of the donation (donation category), donation interval, donor status, medical history).

From the very beginning, the development of the selection program was undertaken with an eye to achieving a problem-free transfer to other computer systems (thus obviating extensive program modifications). The program, which uses COBOL as programming language, was produced and tested on the microcomputer KBS-Z80A. The exclusive use of ANSI (American National Standard Insitute)-COBOL commands ensures maximum transferability of the program.

In the form realized the system can, therefore, be used with other data processing hardware with only slight program modification, and can thus be taken over by other institutes.

It is intended to implement this information system in the institutes of the Blood Donation Service.

| | |
|---|---|
| Tasks: | Selection of blood donors in consideration of<br>- the erythrocytic systems: ABO, Rh, Kell, MNSs, P, Duffy, Lewis, Kidd<br>- the leucocytic HLA system |
| Particularity: | In response to the cross reaction groups in the HLA system<br>Automatic check of actual ability of the donor to donate depending on the nature of the donation, donation interval, donor status |
| Software: | Programming in ANSI-COBOL<br>Input of antigens by CRT-console<br>Integration of the selection program into other program systems with the aid of a standard program |
| Example: | Input mask |

SELECTION OF DONORS

Please give antigen profile!

| | |
|---|---|
| A B O | : A |
| RH-SYSTEM | : C c D. E e |
| KELL-SYSTEM | : kk |
| MNSs'SYSTEM | : |
| P-SYSTEM | : |
| DUFFY-SYSTEM | : |
| LEWIS-SYSTEM | : |
| KIDD-SYSTEM | : |
| HLA-SYSTEM | : |

| | |
|---|---|
| A- LOCUS: A2 | B- LOCUS: B7 BW51 |
| C- LOCUS: | D- LOCUS: |
| DR-LOCUS: | |

# EDP-ASSISTED DONOR-RECIPIENT SELECTION IN HISTOCOMPATIBILITY-MATCHED KIDNEY TRANSPLANTATION

H.M. Frauer, G. Müller, M. Dietrich, C. Müller, W. Schumann and P. Wernet

Medizinische Universitätsklinik Tübingen, Abt. II and IV

Relevant factors in sucessful kidney transplantation are the quality of the organ offered and the compatibility of donor and recipient within the major tissue types, particularly the HLA-DR alloantigens.

In order to allow as quick as possible, a recipient selection, basic data together with histocompatibility antigens (blood group, HLA-A,B, C,DR) of the patients on the waiting list of the South German cooperative study group for kidney transplantation were stored in a Diagnostik and Information System (DIS).

Following the determination of donor histocompatibility antigens, possible recipients were listed in order of matching grades on the basis of antigen number compatibility by means of the terminal.

In cooperation with Eurotransplant and within the framework of the Eigth International Histocompatibility Workshop, 67 transplants were performed. Patients having received HLA-DR-identical or -compatible kidneys showed the best results and these transplanted organs have the longest survival times.

The programs are written in FORTRAN IV and implemented on IBM 1800 and IBM Series 1.

Supported by DFG Forschergruppe WA 139/11, A III.

References

Müller, G. et al.: Höhere Erfolgsdaten bei der Nierentransplantation durch die HLA-DR-Typisierung. Deutsche Mediz. Wochenschr. 12 (1980), 396.

Müller, G., P. Wernet: HLA-DR serology in transplantation. Z. Immun.-Forschung 156 (1979), 231.

HLA - A,B,C,DR - TYPISIERUNG  MEDIZINISCHE UNIVERSITAETSKLINIK TUEBINGEN  8 4 81
IMMUNOLOGISCHES LABOR DR. WERNET  8 17

HANNES  LABNR. 8349  KAMMER 3003  B-ZELLE  GEFR.  DIAG. 7  TYP.DAT. 12. 3.81
TYPNR. 1  PBL.  TP E1  8  MTA

| NR | SERUM | VERD | ANTI-HLA | ERG. | NR | SERUM | VERD | ANTI-HLA | ERG. |
|---|---|---|---|---|---|---|---|---|---|
| 1 | WG/32HK-MC | 1 | NEG.KONT | 2 | 31 | WER 215D/FUS | 1 | DR5 | 2 |
| 2 | AB-SER | 1 | NEG.KONT | 2 | 32 | CUR 8W670 | 1 | DR5 | 2 |
| 3 | TUE35-MC | 1 | A DR COM | 8 | 33 | GOL 8W998 | 1 | DR5 DR4W | 2 |
| 4 | NEI 811-MC | *** | A-DR-C | 8 | 34 | EWA 8353 | 225 | DR5 DR4W | 2 |
| 5 | JEA 2136 | 1 | DR1 | 8 | 35 | WER 217D/SPE | 1 | DR5 DR4 | 2 |
| 6 | GSW S37/II | 1 | DR1 | 8 | 36 | JAW 76 | 2 | DR6 | 2 |
| 7 | ROO 8W432 | 2 | DR1 | 8 | 37 | JEA1951 | 5 | DR6 | 2 |
| 8 | GAN 8W673 | 3 | DR1 | 2 | 38 | JEA 8W581 | 1 | DR6 DR3 | 2 |
| 9 | WER 214D/UGO | 1 | DR1 CW4 | 8 | 39 | WEP 8W1101 | 1 | DR6 DR2 | 8 |
| 10 | ROO 44363 | 2 | DR1 MT1W | 6 | 40 | FER 8W721 | 1 | DR7 | 2 |
| 11 | EWA 8483 | 2 | DR2 | 6 | 41 | GOL 8W999 | 1 | DR7 | 2 |
| 12 | MAL 760033 | 2 | DR2 | 8 | 42 | CUR BDS9031 | 1 | DR7 | 2 |
| 13 | WER 206D/TRU | 1 | DR2 | 6 | 43 | WER 164D/HOES | 1 | DR7 | 2 |
| 14 | WER 207D/AYD | 1 | DR2 | 6 | 44 | STA 8W462 | 1 | DR7 | 2 |
| 15 | WER 210D/END | 1 | DR2 | 6 | 45 | REE 10893 | 1 | DR7 DR4X7 | 2 |
| 16 | WER 8W1099 | 1 | DR2 | 8 | 46 | FER 8W722 | 1 | DR8 | 2 |
| 17 | BOT 8W555 | 1 | DR3 | 2 | 47 | ENG 8W507 | 2 | DR8 DR5 | 2 |
| 18 | EWA 7942 | 1 | DR3 | 2 | 48 | ROO 8W441 | 1 | DR8+ | 2 |
| 19 | JAW 35 | 1 | DR3 | 2 | 49 | WER 220D/PIT | 1 | MT1 | 8 |
| 20 | DEJ 8W766 | 4 | DR3 DR6 | 2 | 50 | STA 8W461 | 1 | MT1 | 8 |
| 21 | WER 213D/MUN | 1 | DR3 DR7 | 4 | 51 | WER 219D/SAB | 1 | MT1 | 8 |
| 22 | REE 10920 | 1 | DR4 | 2 | 52 | SFE/GRA | 1 | MT1 | 6 |
| 23 | BOD 8W963 | 1 | DR4 | 2 | 53 | SFE/PIL | 1 | MT1 DR2 | 8 |
| 24 | ENG 8W508 | 1 | DR4 | 2 | 54 | ROO DR16213 | 1 | MT1 LB12 | 8 |
| 25 | NOR BENNET | 1 | DR4 | 2 | 55 | FER 8W725 | 1 | DC1 MT1 | 8 |
| 26 | WER 137D/LAN | 1 | DR4 DR5 | 2 | 56 | ROO LW25362.5 | 1 | LB13 | 2 |
| 27 | WER 208D/SEL | 1 | DR4 DR4X7 | 2 | 57 | WER 8W1107 | 1 | MT2 | 2 |
| 28 | JAW 90M05977 | 2 | DR4 | 2 | 58 | STA 8W460 | 1 | MT2 | 2 |
| 29 | ENG 8W509 | 2 | DR5 | 2 | 59 | WER 221D/BAES | 1 | MT2 MT37 | 2 |
| 30 | FER 8W720 | 1 | DR5 | 2 | 60 | WG/32 HL-MC | 58 | POS.KONT | 8 |

Figure 1  HLA-DR typing.

08.04.81  WARTELISTEPATIENTEN FUER NIERENTRANSPLANTATIONEN  SEITE 27

BLUTGRUPPE 0  SORTIERT NACH HLA-DR

| HLA-DR | | HLA-B | | HLA-A | | RH.BGR. | DRING. | PATNR. | NAME | ALTER | ZENTRUM | EURONR. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DR1 | DR2 | B7 | B27 | A11 | AW30 | +0 | 2 | 290 | MARA | 41 | TUEBINGEN | |
| DR1 | DR3 | B14 | | A3 | AW32 | +0 | 0 | 179 | WILLI | 29 | HEIDELBERG | |
| DR1 | DR3 | B7 | B13 | A11 | AW19 | +0 | 0 | 109 | HELMUT | 42 | TUEBINGEN | |
| DR1 | DR3 | B8 | | A2 | | +0 | 0 | 265 | ROLAND | 24 | FRANKFURT | |
| DR1 | DR4 | B7 | BW35 | A3 | AW31 | +0 | 0 | 75 | ULRICH | 24 | HEIDELBERG | |
| DR1 | DR4 | B7 | BW45 | A2 | | +0 | 0 | 110 | THOMAS | 21 | HEIDELBERG | |
| DR1 | DR4 | BW15.2 | | A3 | A11 | =0 | 0 | 74 | WOLFGANG | 23 | HEIDELBERG | |
| DR1 | DR4 | B12 | BW16 | A2 | AW24 | +0 | 0 | 164 | EUGEN | 51 | TUEBINGEN | |
| DR1 | DR5 | B12 | BW35 | A9 | AW32 | +0 | 0 | 65 | LUCIA | 24 | HEIDELBERG | |
| DR1 | DR5 | B12 | BW22 | A1 | A9 | +0 | 0 | 83 | ERICH | 29 | TUEBINGEN | |
| DR1 | DR5 | B7 | BW35 | A3 | AW31 | 0 | 0 | 220 | EUGEN | 26 | ULM | |
| DR1 | DRW6 | B15 | BW38 | A26 | A28 | 0 | 0 | 234 | OTTMAR | 45 | ULM | |
| DR1 | DR7 | B7 | BW39 | A3 | AW24 | +0 | 0 | 277 | MICHAEL | 18 | HEIDELBERG | |
| DR1 | DR7 | B8 | B12 | A1 | A3 | +0 | 0 | 192 | WALTRAUD | 41 | TUEBINGEN | |
| DR1 | DR7 | B13 | B27 | AW24 | AW34 | +0 | 3 | 306 | GABRIELE | 36 | TUEBINGEN | |
| DR1 | DR7 | B12 | BW39 | A28 | AW24 | =0 | 0 | 48 | KARL | 39 | HEIDELBERG | |
| DR1 | DR7 | B12 | B37 | A1 | A29 | =0 | 0 | 39 | BERNHARD | 30 | FREIBURG | |
| DR1 | DR7 | B14 | BW35 | A2 | A11 | 0 | 0 | 238 | ALFRED | 50 | ULM | |
| DR1 | DR7 | BW22 | BW49 | A11 | A26 | +0 | 0 | 50 | IRMTRAUD | 42 | HEIDELBERG | |
| DR1 | | B5 | B14 | A2 | | +0 | 0 | 12 | ALFRED | 53 | MANNHEIM | |
| DR1 | | BW35 | | A3 | | 0 | 0 | 227 | KURT | 44 | ULM | |
| DR1 | | B13 | BW35 | A2 | AW30 | =0 | 0 | 270 | SIGRUN | 38 | FRANKFURT | |

Figure 2  Waiting list patients grouped accoording to HLA-DR match.

HLA-AB AND -DR MATCH IN 67 CADAVER KIDNEY TRANSPLANTATIONS WITHIN SOUTH GERMAN COOPERATIVE STUDY GROUP FOR KIDNEY TRANSPLANTATION.

| HLA-AB IDENTITY | HLA-DR IDENTITY 0 | 1 | 2 | TOTAL |
|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 1 |
| 1 | 2 | 7 | 0 | 10 |
| 2 | 2 | 19 | 8 | 29 |
| 3 | 4 | 13 | 3 | 20 |
| 4 | 0 | 6 | 2 | 8 |
| TOTAL | 8 | 45 | 14 | 67 |

Table 1 Number of HLA-AB and -DR match in cadaver kidney transplantations.

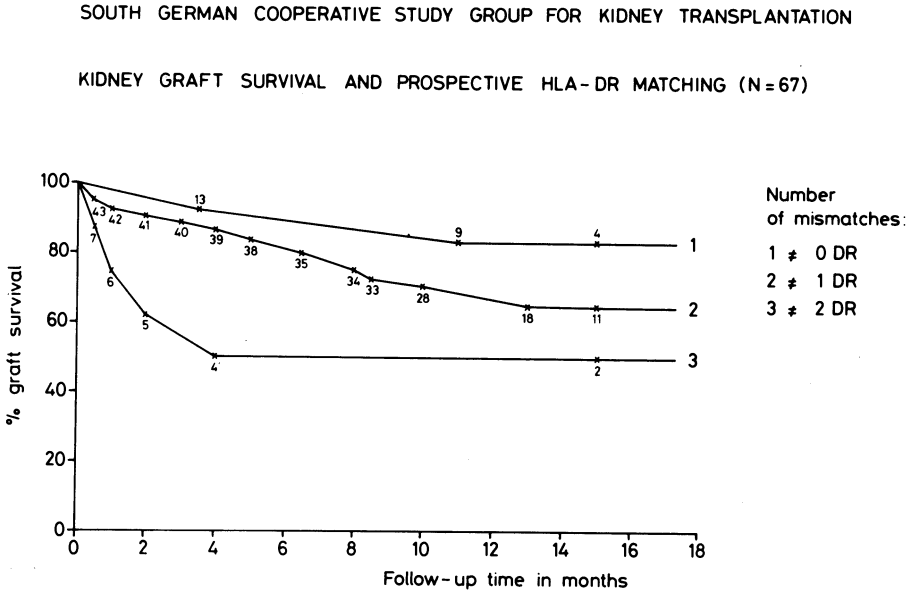


Figure 3 Kidney graft survival of 67 transplanted organs.

# Selection of Compatible Donors and Evaluation of HLA-Seroscreening Data by Computer Programs

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Blood Bank, Universitätsklinikum Charlottenburg
Free University Berlin, Spandauer Damm 130, D-1000 Berlin 19

**Supporting Programs**

Source language: Fortran IV

**Files**

Devices for permanent files: tape
Short time files: disk pack (max. 80.000 cards)
File organisation: indexed sequential

**Applications**

Computer: Control Data® Cyber model 72; access to operating system NOS/BE 1 with card reader or terminal (interactive use)
Central memory core: 50.000 x 60 bit
Disk pack core during execution: "ad lib."

- Addition or deletion of donor or patient data modification of stored data
- Storing files on tape Reading files from tape
- File protection
- Program library management

→ Donor File (Fig. 1)
→ Patient File (Fig. 1)
→ Scores of the Antibody-Reaction

→ Donor Selection Using SPSS* (Fig. 2) → raw output → List of Selected Donors (Fig. 4)
→ HLA-Antibody Screening** → List of Antigens for Each Serum Including R-Values (Fig. 3)

Further applications:
Printing of stickers
List of antigen frequencies
Sorted list of all donors/patients

Annotations:
* Statistical Package for the Social Sciences Reference: SPSS 8, Nie + Hull, Stuttgart, 1980
** Modification of the Eurotransplant Screening Programm

**Fig. 1**
**Important Donor/Patient Data:** identification number
family name
date of birth
ABO
Rhesus factor
antigens of HLA-locus: A, B, C, D, DR
clinic or blood center

**Fig. 2**
**Criteria for Donor Selection:**
Selection of HLA-A or HLA-B identical or compatible donors in consideration of cross reacting antigens.

Priority of criteria:
1. Rhesus factor
2. HLA-A, HLA-B including cross-reacting antigens
3. ABO

If the first run will not be satisfying with respect to identical donors one nonidentical or non cross-reacting antigen will be accepted.

**Example of SPSS-Statements:**

```
RUN NAME        T H O M A,LUDWIG,010199,0*,2,29,62,27,2,3, ST8A
GET FILE        BLUT
SELECT IF       (ABO EQ 0 )
IF              (HLAA1 EQ 001 OR HLAA2 EQ 001)A001=1
IF              (HLAA1 EQ 002 OR HLAA2 EQ 002)A002=1
IF              (HLAA1 EQ 003 OR HLAA2 EQ 003)A003=1
IF              (HLAA1 EQ 009 OR HLAA2 EQ 009)A009=1
IF              (HLAA1 EQ 010 OR HLAA2 EQ 010)A010=1
IF              (HLAA1 EQ 011 OR HLAA2 EQ 011)A011=1
IF              (HLAA1 EQ 019 OR HLAA2 EQ 019)A019=1
IF              (HLAA1 EQ 023 OR HLAA2 EQ 023)A023=1
IF              (HLAA1 EQ 024 OR HLAA2 EQ 024)A024=1
IF              (HLAA1 EQ 025 OR HLAA2 EQ 025)A025=1
IF              (HLAA1 EQ 026 OR HLAA2 EQ 026)A025=1
IF              (HLAA1 EQ 028 OR HLAA2 EQ 028)A028=1
IF              (HLAA1 EQ 029 OR HLAA2 EQ 029)A029=1
IF              (HLAA1 EQ 030 OR HLAA2 EQ 030)A030=1
IF              (HLAA1 EQ 031 OR HLAA2 EQ 031)A031=1
IF              (HLAA1 EQ 032 OR HLAA2 EQ 032)A032=1
IF              (HLAA1 EQ 033 OR HLAA2 EQ 033)A033=1
IF              (HLAA1 EQ 034 OR HLAA2 EQ 034)A034=1
IF              (HLAA1 EQ 000 OR HLAA2 EQ 000)AXXX=1
IF              (HLAB1 EQ 005 OR HLAB2 EQ 005)B005=1
IF              (HLAB1 EQ 051 OR HLAB2 EQ 051)B051=1
IF              (HLAB1 EQ 052 OR HLAB2 EQ 052)B052=1
IF              (HLAB1 EQ 007 OR HLAB2 EQ 007)B007=1
IF              (HLAB1 EQ 008 OR HLAB2 EQ 008)B008=1
      ETC.

COMPUTE         KORREL=A002+A029+AXXX+B015+B027+B007
*SELECT IF      (KORREL EQ 6)
WRITE CASES     (5A7,1X,2(F2.0,"-"),F2.0,1X,A1,1X,A2,   A1,6F3.0)
                NAMES,NAME1 TO NAME4,GTAG TO GJAHR,SEX,ABO,RH,HLAA1 TO HLAC2
FINISH
```

**Fig. 3**

```
********** BLOCK 6          PANEL  1-81        **********

 SERUM  SERUM DONOR          BORN      MADE      HOSPITAL
AK 22

FREQUENCY DISTRIBUTION    0   1   2   3   4   5
                         31   0   0   0   4   5

/GROUP   --  -+  +-  ++   N   T   R
A1       29   2   0   9  40  5.11  .808
B*53     31   0   7   2  40  1.82  .288
B8       27   4   5   4  40  1.61  .254
A*32     29   2   6   3  40  1.57  .249
B*40     30   1   7   2  40  1.19  .188
A25      30   1   7   2  40  1.19  .188
A*19     21  10   4   5  40   .88  .139
B*56     31   0   8   1  40   .67  .105
B*45     31   0   8   1  40   .67  .105
CW3      23   8   5   4  40   .66  .105
B12      25   6   6   3  40   .43  .068
B17      28   3   7   2  40   .43  .068
B60      28   3   7   2  40   .43  .068
CW6      28   3   7   2  40   .43  .068
CX        3  28   0   9  40   .25  .040
B*5A     30   1   8   1  40   .09  .014
B*51     30   1   8   1  40   .09  .014
B*22     30   1   8   1  40   .09  .014
```

**Fig. 4**

```
**********************************************************

        HLA-TYPISIERTE BLUTSPENDER  -  03/81   SPENDERSUCHE

**********************************************************

FUER: T H O M A,LUDWIG,010199,0*,2,29,62,27,2,3, ST8A

 23/03/81                                              SEITE   1

-------------------------------------------------------------------
ZENTRUM NAME          VORNAME        GEBURTS-  S A R !     H L A      !
                                     DATUM     E B H !               !
                                               X O   !A  A  B  B  C  C!
-------------------------------------------------------------------

  BEW   CURIE         *MARIE*        25.12.47  W O +  2 29 62 27  0  0
  RVK   SAND          *GEORGE        27. 7.44  M O +  2 29  7 27  2  0
  BEW   FISCHER       *MARIE-L*      24.12.39  W O +  2  0  7 27  2  0
  BEW   BLOCH         *ERNST         23. 4.55  M O +  2  0  7 27  2 -0
  BEW   MESSE         *HERMANN       25.20.35  M O -  2  0  7 27  2  0

PERSONEN - GESAMTZAHL :    5
```

# Clinical Documentation System for the Hemophilia Center

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Dept. of Clinical Haemostaseology and Transfusion Med., FB 4/3, Univ. of Saarland, D-6650 Homburg/Saar

The disease "hemophilia" is a congenital deficiency of the coagulation factors in blood plasma. Hemophiliacs are treated with coagulation-activating proteins (substitution therapy F VIII or F IX). These factor concentrates are made from donors' plasma and standardized by IU. On the basis of the different rates of formation and degradation of plasma protein activity in each patient, it is necessary to work out for each individual hemophiliac an in vivo recovery, characteristic of this type of hemophilia and past bleeding incidences, in order to design an effective therapy to prevent spontaneous bleedings from frequently reoccurring. Our documentation system, already in operation, has been set up to accomplish this task.

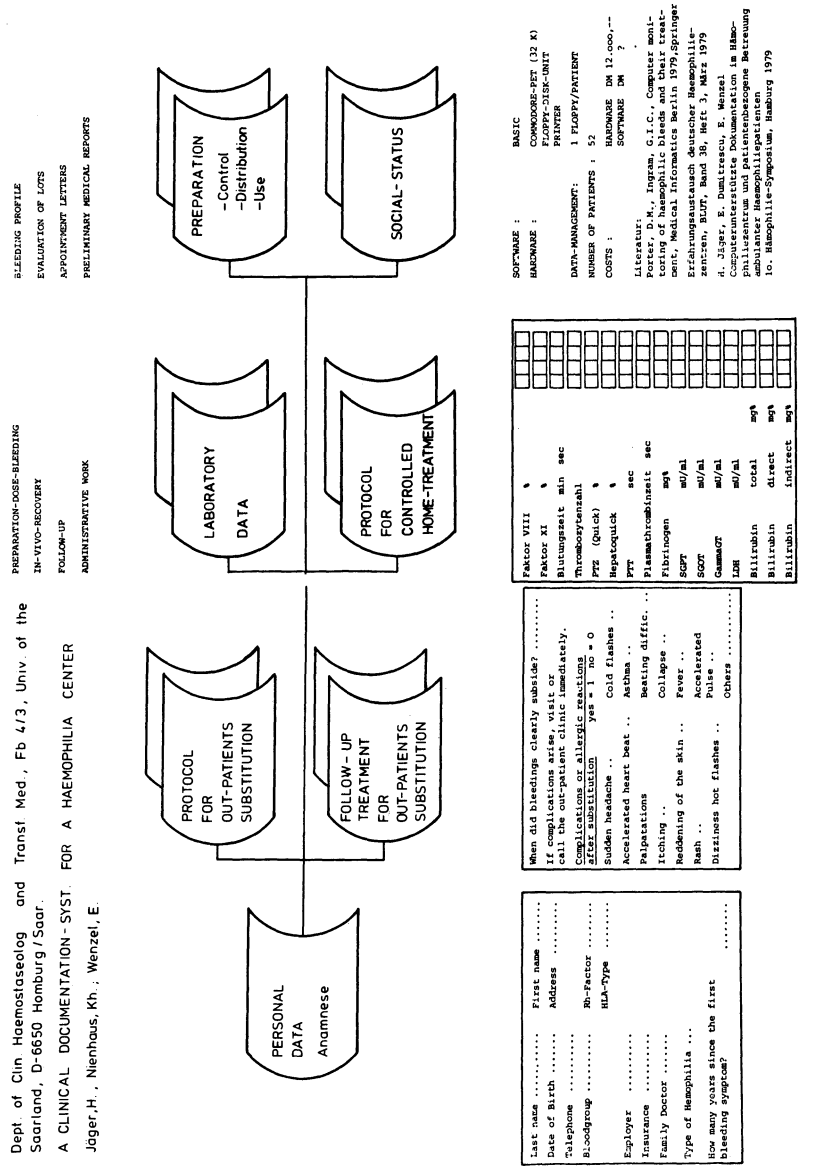
Medical care for hemophiliacs calls for a through, factual and rapid evaluation of their medical data. Obstacles, such as the abundance of data, the many possible dosage regimens, not to mention the number of additional measures possible, and the considerable expense involved, can hinder the realization of this necessary medical care. Since opinions vary from center to center as to the dosage requirement for each hemophilic case and since we are opposed to any one fixed course of treatment for every patient, we firmly decided on a computer-supported documentation system. A small data bank, which includes data form all the hemophilic patients under our care, has now been built up.

The hierarchically based data structure of a patient consists of personal data (address, family doctor, type of hemophilia, self-infusion, etc.), clinical status, bleeding time (date, localization, severity, etc.), the length of therapy (date, time, dosage, manufacture of concentrate, lot, etc.) as well as laboratory analysis and a questionnaire on the patient's social status. The questionnaire and dialogue programs have been specially written and set up to be used with the computer-supported data system.

The documentation system makes it possible to make a quick evaluation of the hemophiliacs because of the speed by which the data can be extracted from this system. It additionally assists the treating physician in his routine work. Questionable lots of factor preparations

can also be more quickly eliminated. The documentation system is implemented through a Commodore-PET-Computer. Information is stored on Floppy discs - one per patient.

We expect this system to improve the care of our patients in terms of the selection of preparation, the dosage, and the time intervals of administration. Furthermore, it should help us in avoiding or reducing continual blood complications caused by therapy.



# INTERACTIVE INFORMATION SYSTEM OF SELF-TREATMENT IN HAEMOPHILIA

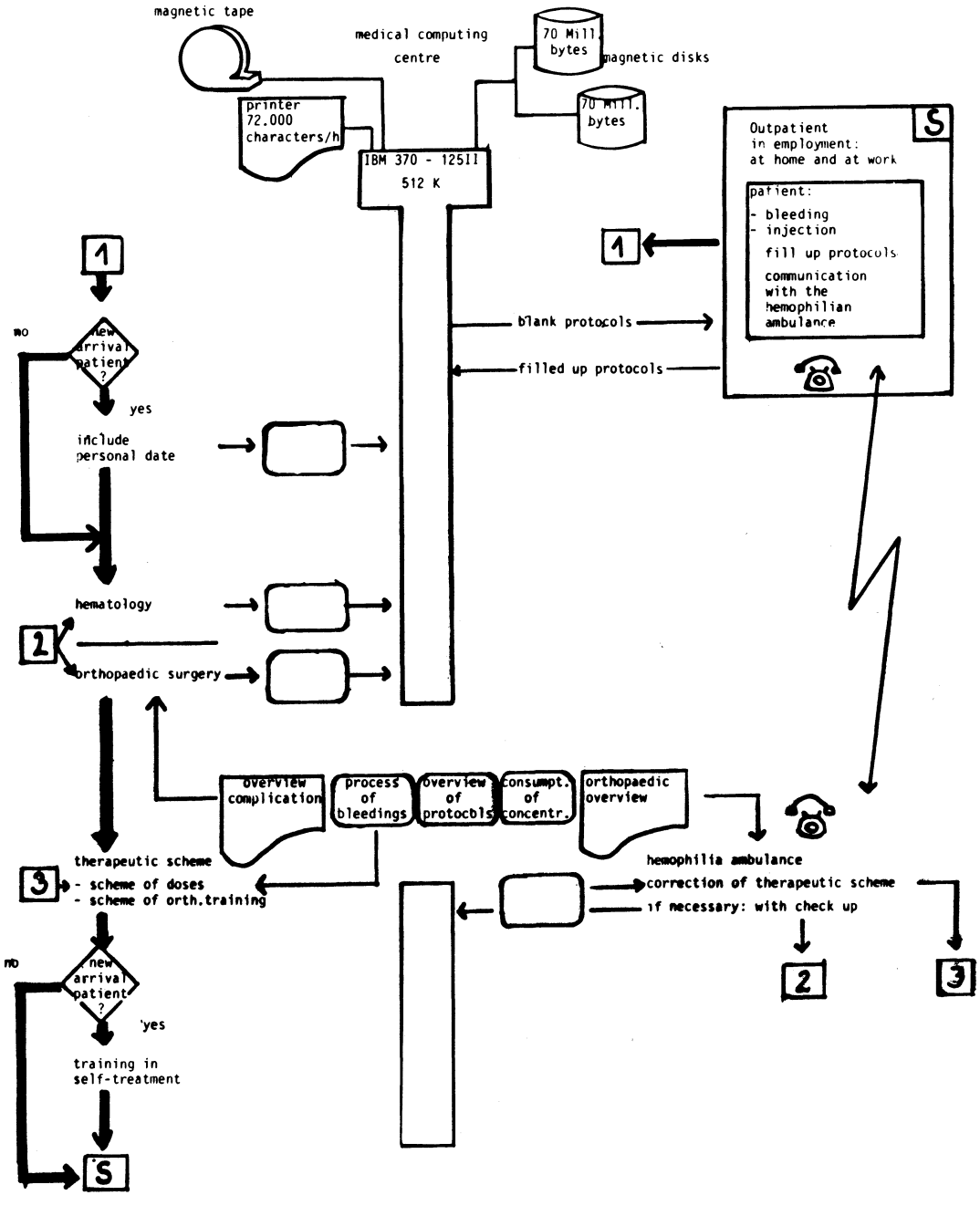
Hammerstein, U.; Voigt, U.; Lüchters, G.; Etzel, F.; Brackmann, H.H.;
Institut für Exp. Hamatologie und Bluttransfusionswesen der Univ. Bonn

Hemophilia is a congenital coagulopathy characterized by a differently marked deficiency of the coagulation factor VIII or IX. In the late sixties the development of highly purified factor VIII/IX concentrates led to a major change in the treatment of hemophilic patients. Thus, in 1971, in addition to the existing in-hospital and outpatient treatment, the Hemophilia Center Bonn introduced the controlled self-treatment. This new treatment concept enables the hemophiliac to lead a normal social life. He is no longer excluded from attending Kindergarten or school or leading a professional life.

For each hemophiliac under controlled self-treatment at our institute the treating hematologist and orthopaedist first establish an individual treatment plan based on the patient's hematologic and orthopaedic status. After the patient is put on self-treatment, he remains in contact with his doctor through regular written treatment reports and check-ups at the hematological outpatient clinic. The treatment plan is adapted to changes in the clinical paramenters.

In 1975, 384 patients were followed by our institute using this method of treatment. Now we have 637 patients under controlled self-treatment. 200 - 500 treatment records are registered every day. In addition, 200 - 270 hematological or orthopaedic clinic reports are registered per week.

In 1987, an interactive information system was developed in our institute. Actual findings collected during attendance at the hemophilia or orthopaedic clinics are directly recorded on the spot and remain available for the determination of the treatment plan. Even at home the patient remains connected with the information system. In normal cases, the patient fills in a record form after each treatment sends these record forms to the Center EDP once a week. In ermergency situations, the patient can reach his doctor at any time by telephone. The latter has, at all times, direct access to all the data in a synoptical way. The doctor checks the therapy plan and objectives, using a weekly summary of the most important therapeutical variables presented in a listing. This is the basis for controlling and modifying the treatment plan. A IBM 370/125 is used.


magnetic tape
medical computing centre
70 Mill. bytes
magnetic disks
70 Mill. bytes
printer 72.000 characters/h
IBM 370 - 12511 512 K
Outpatient in employment: at home and at work
patient:
- bleeding
- injection
fill up protocols
communication with the hemophilian ambulance
blank protocols
filled up protocols
1
2
3
5
no
new arrival patient ?
yes
include personal date
hematology
orthopaedic surgery
overview complication
process of bleedings
overview of protocols
consumpt. of concentr.
orthopaedic overview
hemophilia ambulance
therapeutic scheme
- scheme of doses
- scheme of orth.training
correction of therapeutic scheme
if necessary: with check up
training in self-treatment

# Synopsis Donor Related Data of Various EDP Systems

by

D. Roos, Hamburg

The present synopsis of donor related data is the result of an activity of the EDP working group of the Section I of the German Society for Blood Transfusion and Immuno Hematology. All members applying EDP in the area of blood banking and blood transfusion were asked to supply the data structure related to the donor. After compilation and discussion of the result every member had the opportunity to correct the overview.
The table was then extended to include data provided by H. CASSEMAR (5) concerning the Swedish system and data obtained from the data dictionary of the Office of Data Processing of the American National Red Cross, Washington D.C. (6).

The numbers of donors and donations provided reveal that two different systems are included:
The left side of the table comprises 3 systems of hospital oriented transfusion services serving university hospitals. On the right side regional blood donor services are represented.
These supply the blood unit stocks of several hospitals. The first group relies on permanent donors which are called regularly for donations. The blood is drawn within the institution. Donors have to be accessible even at night in emergency situations. These functions require larger data sets than the second kind of institutions. Here donors are not called up but are asked at larger intervals to attend external blood collections.
The Swedish system represents a mixture of both.

The different tasks result in differing data structures. Even though the workshop of our conference where this overview was presented and discussed did not allow a detailed describtion of the functions of the individual systems, a publication of the synopsis seemed reasonable to us. It should be of use as a guideline for systems to be conceived anew, and should also serve as a first step towards a uniform data structure. The results of the brief discussion have been included in the present version of the table. This discussion showed in particular that a long way remains ahead of us before international standardization, particularly in the coding and representation of blood types is achieved.

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Translation of the text by J.R. Möhr

## Synopsis of Donor Data Sets in Different Computer Systems

Hospital Transfusion Services

| | Universität Hamburg Universitätskranken-haus Eppendorf Abt.f.Transfusionsm. a. Rechenzentrum IMD | Universität Tübingen Inst.f.Anästhesie u. Transfusionsmedizin a.Abt.f.medizinische Datenverarbeitung | Universität Göttingen Blutspendedienst and Institut für medizin. Datenverarbeitung |
|---|---|---|---|
| Number of donors total / active | 15'000 / 8'500 | 12'000 / 7'000 | 19'5000 / 15'000 |
| Number of anual donations | 26'000 | 16'000 | 22'000 |
| Equipment | Siemens 7.74o | IBM / 37o - 135 | IBM / 37o - 158 |
| Data base system | A D A B A S | (Dialog w. CICS/VS) | I M S / V S |
| Files | - Main donor file (1809 Bytes) | - Main donor file (32O Bytes) | - Main donor file 'SPROOT' (2OO Bytes) |
| | - Serological file (6OO Bytes) | - Donations file (6O Bytes) | - Medical results file 'SPMEDU' (48 Bytes) |
| | - Laboratory file (15OO Bytes) | - Index file (11 Bytes) | - Telephone file 'SPBEM' (36 Bytes) |
| | | - Callüp file | - Laboratory file 'SPANG' (76 Bytes) |
| | | - Search file f. erythroc. Antigens | - Secund.index 1 'BLUTSPEDB' (29 Bytes) |
| | | - Search file f. HLA-antigens | - Secund.index 2 'SECBLUDB' (7 Bytes) |
| Direct access to donor data by: | Donor number | Sequent. donor no. | Donor number |
| | Name | ID code number | Birth name |
| | Phonetic code | Name, birthdate, sex | Birthdate and sex |
| | Birthdate and sex | ABO-Group and erythr. antigens | ABO-Group and donation ID-number |
| | Blood-type or Group of types | ABO-Group and HLA-antigens | |
| | Donor-category | | |
| | Donation interval | | |
| | Date of availability | | |
| | No. of reservation for a patient | | |
| | Special markers | | |
| | and by contents of other files (Recipients f. etc) | | |

Compiled by D. Roos, Hamburg State March 1981

Blood Centers for a greater Region

| Blutspendedienst des DRK-Landesverbandes Rheinland-Pfalz Bad Kreuznach | Blutspendedienst der DRK-Landesverbände Niedersachsen, Oldenburg und Bremen Institut Springe | Swedish National EDP System for Swedish Blood Centers | American Red Cross Data Dictionary for Donor Deferal and Retrieval State March 1977 |
|---|---|---|---|
| 300'000 / 130'000 | 700'000 / ? | 190'000 / 90'000 | - |
| 180'000 | 417'000 | ? | - |
| PDP 11 / 60 | Siemens 7.540 | IBM / 3022 (off-line) | IBM |
| M U M P S | - | ( I S A M) | - |
| - Main donor file variable record size | - Main donor file (110 Bytes) | - Donor file (360 Bytes) | - Retrieval file (157 Bytes) |
| - Family physicians file | - Index files (?) | - Unit file (180 Bytes) | - Rare donor file (70 Bytes) |
| | - Other files (?) | | - Donor deferral file (55 Bytes) |
| Sequential donor No. | Personal number (sequential access) | No. of donor IC card | |
| Donor ID code | | Donor ID code | |
| Name | | Anual no. of donations | |
| Donation place | | | |
| Unit ID number (thru unit file) | | | |

| | Hamburg | Tübingen | Göttingen |
|---|---|---|---|
| Sequential ID-no. | Donor ID-number (7 Bytes: 6 serial number 1 check) | Donor ID-number (7 Bytes) | Donor ID-number (7 Bytes: 6 serial number, 1 check |
| Public ID-number or Social security No. | - | - | - |
| Alphanumeric ID-code or searching codes | Phonetic codes (out of name : 10 x 6 Bytes) | IC-code for searching (11 Bytes) | - |
| Birthdate | Planned public ID-no (12 Bytes: birthdate 6, sex 1, serial no. 4, check no. 1) | Birthdate (6 Bytes) | Birthdate (7 Bytes) |
| Sex | | sex (1 Byte) | sex (1 Byte) |
| Name (actual) | Surname, first name, title, prefix (28 Bytes) | Surname, first name (23 Bytes) | Surname, first name (23 Bytes) |
| Names before | Last name (like actual name) | Birthname (15 Bytes) | Birthname (20 Bytes) |
| Place of birth | - | - | Place of birth (18 Bytes) |
| Other ID data | Marker for donors with the same name (1 Byte)<br>Blood service no. (3 Bytes)<br>Date when ID data are given or changed | Date of issuing of ID-code (6 Bytes) | - |
| Home address | Street, no. (28 B.)<br>Supplement (30 B.)<br>City, zip-code (30 Bytes) | Street, no. (23 B.)<br>Zip-code (4 Bytes) | Street, no. (20 B.)<br>Zip-code (4 Bytes) |
| Phone | Home phone (30 B.) Business ph (30 B.) (each: area code no. 5, phone no. 7, code 1, additional no. 2 x 4 Bytes) | Home phone (13 B.) Business ph (13 B.) | Home phone (8 B.) Business ph (8 B.) |
| Remarks | Remarks to availability (28 Bytes) | | Donor remarks ('small veins etc.) (2 x 10 Bytes) |

| Bad Kreuznach | Niedersachsen | Sweden | Am. Red Cross |
|---|---|---|---|
| Donor ID-number | Donor ID card no. | Sequential enrolling no. (optional) | ID with sequence no. (9 Bytes) |
| - | - | Public personal no. registration, no. | Social security no. |
| Donor ID-code (11 Bytes: sex 1, birthdate 6, first 4 ch. of name) | Donor ID-no. (6 B.) | - | - |
| In donor ID code | Birthdate (6 Bytes) | In personal no. | Birthdate (6 Bytes) |
| In donor ID code | Sex (1 Byte) | In personal no. | Sex 1 Byte) |
| Surname, first name | Name (35 Bytes) | Name (28 Bytes) | Name and initials including mr. and mrs (30 Bytes) |
| - | - | - | - |
| Place of birth | - | - | - |
| - | - | - | Chapter of donor's record (3 Bytes) |
| Street, no. | Street, no. (20 B.) | Street, no. (30 B.) | Street, no. (25 B.) |
| Zip-code, city | Zip-code (4 Bytes) | Zip-code, city (18 Bytes) | Zip-Code (5 Bytes) |
| | City (20 Bytes) | | City-state (15 B.) |
| Only phone and address of family address | - | Home phone (10 B.) Business ph (14 B.) | Home phone (10 B.) Business ph (10 B.) |
| - | - | - | - |

| | Hamburg | Tübingen | Göttingen |
|---|---|---|---|
| Calling data | Calling code (1 Byte) | Student ? (1 Byte) | - |
| | Distance code (1 B.) | With car ? (1 Byte) | |
| | Time of availability 2 x 2 Bytes) | Donor club code numb. (5 Bytes) | |
| | (always for home and business calls) | Calling code (1 Byte) | |
| | Days and time for donations (am/pm, 7 x 2 Bytes) | Emergency donor? (donating interval 0 days) | |
| | Donation with donor no. ... (7 Bytes) | Self advicing donors (calling interval 360 days) | drop in donors? coluntary donors? volunteers? |
| | | Special donor ? (1 Byte) | |
| Calling up items | No calls from ... till ... (2 x 8 B.) | Marker 'ready f. donation' (1 Byte) | |
| | reason (6 Bytes) | | |
| | Desired donation date (8 Bytes) | Desired donation date (6 Bytes) | |
| | Calling up date (8 Bytes) | Calling up date (6 Bytes) | Calling up date (3 Bytes) |
| | Earliest date of drawing (8 Bytes) | Marker f. 'called' (1 Byte) | |
| Donation interval | Smallest individual interval in weeks (2 Bytes) | Donation interval in days (3 Bytes) | (constant, 3 month) |
| Last donations | Last 10 donations (10 x 30 Bytes:<br>- donation date (8)<br>- donation volume (2)<br>- unit no (3 6 2)<br>- 'hold' marker (1)<br>- category of employ (3) | Last donation (12 Bytes:<br>- donation date (6)<br>- main book no. (5)<br>- donation mode (1) | Date of last donation<br><br>Last donations (each 32 Bytes:<br>- donation date<br>- unit number<br>- laboratory results) |
| | - no of in vain calls 1<br>- laboratory no. (4) | No. of donation records<br><br>Last donations<br>- donation date (6)<br>- main book no. (5)<br>- donation mode (1) | |
| | laboratory results are stored in laboratory file | - laboratory results (90 Bytes x 'number of donations' 'for every donation' | |
| | (Details of stored laboratory results see in literature) | | |
| No. of donations | Total number (5 B.) (for test-donation only 1/4 of a normal) | Total number (3 B.) | Total number (2 B.) |

| Bad Kreuznach | Niedersachsen | Sweden | Am. Red Cross |
|---|---|---|---|
| Donation place | - | Desired donation time: (23 Bytes:<br>- periods of year 8<br>- days in week 7<br>- time in day in periods of 2 hours 8) | Calling code (1 Byte)<br>Business place (15 B.)<br>Blood center donation (1 Byte) |
| - | - | Temporarly extra interval (2 Bytes)<br>Earliest date of drawing (4 Bytes) | - |
| - | - | Normally extra interval (2 Bytes) | - |
| Last donations<br>- donation date<br>- unit no.<br>- pathologic results (method code no. and result)<br>(all donations are stored) | - | Last donations<br>- donation date<br>- volume code<br>- hemoglobin rate<br>- sedimentation rate | |
| Total number | Number of donations<br>- total (2 Bytes)<br>- annual (1 Byte) | Number of donations<br>- total<br>- annual<br>(per volume code) | Number of donations<br>- total (3 Bytes)<br>- annual (1 Byte) |

| | Hamburg | Tübingen | Göttingen |
|---|---|---|---|
| BLOOD-GROUPS (red) | ABO-Rh-K code 4 Bytes | | |
| ABO - Type | 1. Position 1 Byte: 1=A,2=B,3=AB,4=O) | 'Bloodgroup' (3 alpha numeric items, p.e. A1B) | 'Main bloodgroup' (binary coded 1 Byte) |
| Rh-Factor (D) | 2. Position (1 Byte: 1=pos,2=neg,3=$D^U$, 4=else) | Rh-Factor (1 Byte: 1=pos, 2=neg) | 'Blood subtype' (1 Byte: CDE binary coded) |
| Rh-Subgroups | 3. Position (1 Byte CcEe-combination 'decimal coded, without $C^W$) | Rh-mosaic (8 Bytes: single Antigens C c D d E e $D^U$ $C^W$ +/-) | " |
| Kell-Antigen | 4. Position (1 Byte: 1=pos, 2=neg)<br>Ø=not defined | (see below) | (see below) |
| Testing date and number of investigation | Validity date for bloodtype, antigens and antibodies together (8 Bytes)<br>multiude of investigation (1 Byte: 0,1,2,F=difference) | Bloodgrouping book-number and year | - |
| Supplemental antigens | 'Antigen pattern' ($A_1$ H $C^W$ - Lea Leb $P_1$Tja K k Kpa Kpb Jka Jkb Vea Veb Xga - M N S s Lua Lub - - binary coded +/-/.: 18 Bytes) | 'Erythrocytes antigens' (1 Byte each: K k Fya Fyb Jka Jkb Lea Leb S s M n P Lua Lub value /+/-)<br>Additional antigens (free text 10 Bytes) | 'Blood-factors' (Fy-,Le-,Jk-code Mg-AG, $C^W$-fact., $C^e$-fact., Mn-Ag,Ss-Ag Kk-fact. each 1 Byte) |
| Multitude of investigations | Multitude of antigens investigation together (1 Byte: coded) | - | - |
| Results of single bloodgrouping investigations | Maximum 6 last investigations (serological file:<br>- date<br>- investig. ID no.<br>- ABO-Rh-K code<br>- antigen pattern<br>- enter code<br>- explorer code | - | - |
| Antibodies against erythrocyte antigens | Actual antibody findings (6 x 2 Bytes decimal coded) | 'Non regular antibodies' (9 Bytes) | 'Search-cyte' (result of antibody screeining coded 3 Bytes) |

| Bad Kreuznach | Niedersachsen | Sweden | Am. Red Cross |
|---|---|---|---|
| ABO / Cc / Dd / Ee and K are stored (code unknown) | ABO-Blood group and A subgroups (3 B.) | ABO and Rh-subtypes are coded stored (9 Bytes) | Blood type ABO and D (3 Bytes: AP AN BP BN OP ON ABP ABN) |
| | Rh-factor and Rh-subtype together (3 Bytes decimal co ded) | | - |
| | Kell Antigen (3 B.) | | - |
| - | Number of comparisons between stored and new made blood-group (1 Byte) | Investigation date (4 Bytes: wwdd) | - |
| Supplemental antigens (MN S P Le Jk Fy Lu, code unknown) | Marker for antigen-file (1 Byte) | | |
| - | - | - | - |
| - | - | - | - |
| - | Marker for antibody-file (1 Byte) | Antibody existence decla red in code) | - |

| | Hamburg | Tübingen | Göttingen |
|---|---|---|---|
| HLA - Type | Text for HLA typed and consent in zyta-pheresis (6 Byte free text, HLA-type only planned) | HLA locus A,B,C,D (5 x 2 Byte, alpha-numeric coded) | - |
| Marker for special functions | 'Controll groups' (10 x 24 Bytes:<br>- characteristic 4,<br>- reminding date 8,<br>- supplement infor-mation 8,<br>- No. of reminders 4 Bytes) | Organisatoric markers (realised with IO-swiches: 10 Bytes) | Binary markers with-out description (16 + 24 bit for validity and checks) |
| Instances of use | Setting up and cor-recting external documents:<br>- letter for central donor register<br>- different labels<br>- magnetic ledger donor card<br>- donor ID card<br>- donor data general card<br><br>Calling up states:<br>- elected<br>- letter written<br>- not arrived (etc)<br><br>Donating phases and hold-state (look up)<br><br>Need of revaluation<br>- antibody entry<br>- bloodtype diffe-rence<br>- unit in hold<br><br>(These groups enable to introduce new functions without changing data base structure) | - Data complet, defi-cient, missed<br>- working sheet<br>- general card of donor data<br>- address labels<br>- donor ID card<br>- new donation label sheet<br>- 3 Byte reserve | ? |

| Bad Kreuznach | Niedersachsen | Sweden | Am. Red Cross |
|---|---|---|---|
| HLA indicator planned | No. of HLA-typings (1 Byte) | HLA-code (2 x 6 B.) | - |
| Different indicators | Marker for different states (look up) | ? | ? |
| Marker 'pathologic' | - Type of donor ID-card<br>- annual no. of donations<br>(additional ?) | List of inactive donors<br>Address for letters to inactive donors | |

| | Hamburg | Tübingen | Göttingen |
|---|---|---|---|
| Reliability and Activity | Reliability quotinet (2 Bytes, not longer used)<br>No. of in vain calls since last donation | Reliability in perct: No. of donations / (No.of don. + in vain calls) | - |
| Donor state | 'Donating phase' (1 B.) enrolling - donating - inactive phase | State of deferral (1 Byte, code) | Deferral code (2 B.) |
| Holding marker | Actual donor situation 'hold' - 'free' or deferral code (1 Byte)<br>holding marker for the next blood unit (5 Bytes, reason for holding) | - | Date since donor is in 'hold' state |
| Donor qualification | Qualification code (2 Bytes:<br>- risk of infection,<br>- antibody in serum) | Suitable f. patients? (1 Byte)<br>Donor anamnesis code (2 Bytes f. lues, hepatitis etc.) | - |
| Standard use of the donors blood | Standard using code (3 Bytes:<br>- donation mode 1 normal, plasmaph., cytaph.,testdon.<br>- using category exchangetransf., normal, rare donor frozen blood etc.<br>- actual variation of blood use<br>Suitable f. cytaph.? (6 Bytes free text)<br>Date and physicians code from last assessment (2 x (8+2) Bytes) | Special donor? (1 Byte)<br>Cytapheresis donor (1 Byte) | - |
| Donor check up | Dates of last check (2 x 6 Bytes:<br>- general and laboratory investigation<br>- X-ray of thorax)<br>(results not yet stored in donor file) | Last check up<br>- date<br>- demand no.<br>- laboratory results<br>- anamnesis<br>- height, weight, blood pressure<br>(in main file, checks before in donations file) | Check up date<br>Physicians findings (35 Bytes)<br>Check up of last donations<br>- date<br>- results (look up to) |

| Bad Kreuznach | Niedersachsen | Sweden | Am. Red Cross |
|---|---|---|---|
| - | - | No. of written cards<br>- totally<br>- annually<br>- since previous donation | Inactive code (designating the time since last donation, 1 Byte) |
| - | - | Code for<br>- active, inactive or 'hold' and<br>- reasons for it | Category of deferral (1 Byte), reasons (25 Bytes) |
| Hold-code | - | | Hold-code (1 Byte)<br><br>Release date (6 Bytes) |
| Marker 'pathologic' | Markers for<br>- rised PT 1 Byte<br>- antibody file 1 B.<br>- HBs file 1 Byte<br>- lues file 1 Byte<br>- hepatitis report 1 Byte, year 2 B. | - | - |
| - | - | - | Codes for special use:<br>- freeze code 1 Byte [1]<br>- pheresis code 1 B.<br>- group code (?) 1 B.<br>- rare donor 1 B.<br><br>1) additional data in rare donor file |
| Check up of last donations:<br>- date<br>- method code and result<br>(only if pathologic)<br><br>Comments over communication to family doctor | - | - | - |

Date of expiration

1. Blood unit number

2. Blood unit number

3. Blood unit number

4. Blood unit number

5. Blood unit number

Code for preventing blood units from being used for transfusion
($HB_sAg$-reactive etc.)

Handling-code
(issue, return, expiration, scrap etc.)

Blood depot number

Date of delivery

Number of delivery note

Hospital code number

Name of data file: Poolplasma

Pool number

Blood unit number

Weight (kg)

Name of data file: Run

Run number

Quantity of plasma (kg) used in run

Plasma pool numbers

Date of manufacturing
(from - until)

Quantity of paste (kg)

Quantity of powder (kg)

# Blood Product Related Data

by

H. Bitz, Bad Kreuznach

It is essential to keep a record of all information on each blood unit and on all components and fractionation products. Different files are needed. They should have the following capabilities:

(1) Link to the donor record system.

(2) Provide record of all information on each unit of blood from the time it is collected from the donor until it is utilised for transfusion.

(3) Include basic results of all laboratory tests from which interpretations regarding blood type and suitability for transfusion can be made.

(4) Provide a record of all components and fractionation products for controlling the manufacturing processes from the source unit up to the final product.

(5) Link to patient record system.

The blood unit record system will be used as masterfile. This record system contains all essential data concerning donor, blood collection, test results, further processing, distribution to hospitals and, if necessary and possible, allocation to individual patients.

All blood products such as leucocytes, platelets and fresh-frozen plasma assigned to the source unit number should be recorded in a separate product record system. Specific data as dates of processing and expiration may be added in each file.

The data files for single-donor plasma, cryoplasma, poolplasma and run form the basis of an unprocessed and subsequently processed inventory file to facilitate control of all processing steps.
Cryoprecipitate, Fraction I (Cohn) and all lot-products (albumin, gamma-globulin etc.) are recorded in special files. Provision must be made to insure that all new numbers are added correctly.

Name of data file: Whole blood and Red blood cell concentrates

Blood unit number

Donor I.D. number

Date of blood collection

Number of blood mobile

Serological data
(ABO, Rh-factor, other antigens, HLA-system)

Product code number
(whole blood, red cell concentrates, washed red cell concentrates, red cell suspension, leucocyte deprived concentrates)

Date of processing

Time of processing

Plasma pool number

References to additional products
(platelets, white blood cells, fresh plasma, fraction I (Cohn), cryoprecipitate)

Code for preventing blood units from being used for transfusion
($HB_sAg$-reactive etc.)

Handling-code
(issue, return, expiration, scrap etc.)

Blood depot code

Date of delivery

Number of delivery note

Hospital code number

Name of data file: Platelet concentrates

Blood unit number

Donor I.D. number

Date of blood collection

Date of processing

Time of processing

Expiration date

Serological data
(ABO, Rh-factor)

Code for preventing blood units from being used for transfusion
($HB_sAg$-reactive etc.)

Handling-code
(issue, return, expiration, scrap etc.)

Date of delivery

Number of delivery note

Hospital code number

Name of data file: White blood cell concentrates

Blood unit number

Donor I.D. number

Date of blood collection

Date of processing

Time of processing

Serological data
(ABO, Rh-factor)

Code for preventing blood units from being used for transfusion

Handling-code
(issue, return, expiration, scrap etc.)

Date of delivery

Number of delivery note

Hospital code number

Name of data file: Fresh-frozen plasma

Blood unit number

Donor I.D. number

Date of blood collection

Date of processing

Time of processing

Expiration date

Serological data
(ABO, Rh-factor)

Code for preventing blood units from being used for transfusion
($HB_sAg$-reactive etc.)

Handling-code
(issue, return, expiration, scrap etc.)

Date of delivery

Number of delivery note

Hospital code number

Name of data file: Single-donor plasma

Blood unit number

Name of data file: Fraction I (Cohn)

Cohn number

Date of processing

Date of expiration

Product code
(1 = Cohn plasma, 2 = Final product)

1. Blood unit number

2. Blood unit number

Code for preventing blood units from being used for transfusion
($HB_sAg$-reactive etc.)

Handling-code
(issue, return, expiration, scrap etc.)

Blood depot number

Date of delivery

Number of delivery note

Hospital code number

Name of data file: Cryoplasma

Blood unit number

Donor I.D. number

Code for preventing blood units from being used for transfusion
($HB_sAg$-reactive etc.)

Name of data file: Cryoprecipitate

Cryo-number

Date of processing

Name of data file: Lot-products

Product number

Lot number

Produced quantity

Date of processing

Date of expiry

Run number

Quantity (kg/liters)

Scrap (quantity)

Blood depot number

Stock per blood depot

Serial delivery number

Date of delivery

Number of delivery note

Hospital code number

Quantity delivered

Blood Recipient Related date

by

A. Kluge, Heidelberg

After considering the data sets of the blood donor and of the product, derived from his donation, the next member of the chain of data sets is that one of the blood recipient. There are only few EDP-systems published in the English or German literature dealing with the recipients' part in transfusion medicine. SCHNEIDER (1) made a comparison in the following way (Tab. 1).

EDP-supported systems in blood banking and their tasks

| Country | number | donor | stock | laborat. | recipient |
|---|---|---|---|---|---|
| USA | 10 | 3 | 10 | - | 1 |
| UK | 1 | 1 | - | - | - |
| Sweden | 2 | 1 | 1 | 2 | 1 |
| Switzerland | 1 | 1 | - | 1 | - |
| FRG | 5 | 4 | 2 | 2 | 1 |
| | 19 | 10 | 13 | 5 | 3 |

Tab. 1

A request for data structures from pertinent groups did only in two cases include data on the recipient. Dr. Roos and W. Müller, Homburg, supplied material on the data structure of the recipient. Therefore the data structure of the blood recipient s exemplified on the basis of the data structure used in Heidelberg.
This was supplemented in Pos. 7-9 with concepts from the TRAMIDIS system.

A blood bank receives an order and/or a blood sample belonging to a single case. The order will be met by assigning one or more blood units to one. In the latter case there may be none of that type available, the order resp. sample is held on call, or the sample has been sent for diagnostic purposes only. The supporting EDP-System has to link the order to a single case. One case may have many related orders. Few data suffice for identification of a case. Some additional data are needed for accounting purposes. Only rarely the account has to be

divided among several cost carriers. If a hospital EDP is installed for patient administration, the blood bank subsystem work receive a subset of the patient data from the host computer.
Upon the suggestion of Prof. STUCKY a small group (A. Kluge, H.G. Wolf, W. Mannes) provided a compact summary of the relations that have to be supported by the system:

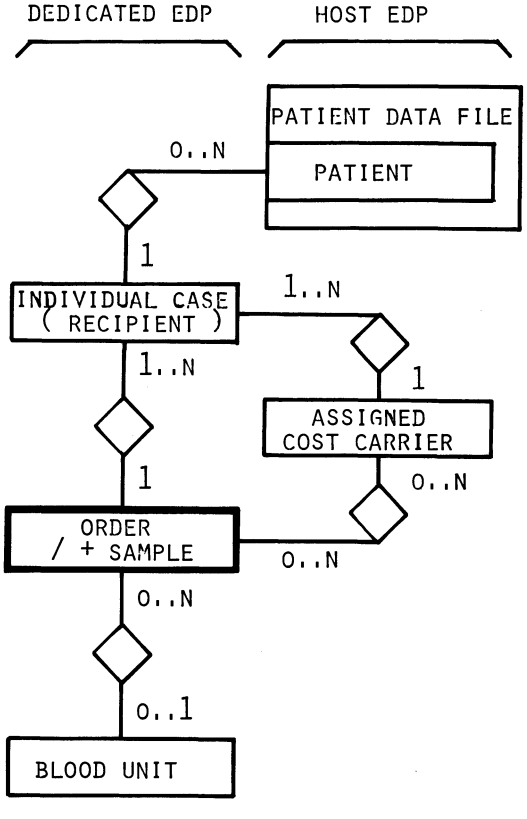


FIG. 1 MODEL OF THE RANGE OF RELATIONS BETWEEN BLOOD RECIPIENT AND ORDER(S)

| Recipient Data Set | I/D | Example 'input'/related value (Remarks) |
|---|---|---|
| 1. Personal Identification Data | | |
| 1.1. Birth date | I | DDMMYY, D.M.YY |
| 1.2. Sex | I | 'F','M','U'=unknown |
| 1.3. Name | I | |
| 1.4. Birth-name | D | default: name |
| 1.5. Christian name(s), title(s) | D | (line of free text) |
| 1.6. Sequential number for multiple occurrence of codes for 1.1. - 1.5. | I | |
| 1.7. Id-Number with 1 check digit | I | automaticly generated from:<br>- birth date<br>- birth name (using a distribution table)<br>- Sequential number for multiple occurrence of codes for 1.1. - 1.5. |
| 2. Medical Identification Data | | |
| 2.1. ABO blood group | I | 'A','B','O','AB','..' |
| 2.2. Rh(D) factor | I | 'pos','neg','..' |
| 2.3. Rh formula | D | '0' .. '36' (numerical coded)/ 1='CcD.Ee', 36='.....' (using amenue card) |
| 2.4. Rh system factor CW | D | '-','-','.' |
| 2.5. Kell-Cellano factors | D | K-, K-, .. |
| 2.6. A-subgroup | D | A1, A2, .. |
| 2.7. Additional bloodgroup systems incl. HLA-System | D | (free text) 1 line characters |
| 3. Transfusion Risk Data | | |
| 3.1. Antibody - type, - detectability, - specificity (- quantity) | D | |
| 4. Remarks concerning Recipient's Physician | D | up to 3 codes for defined meaning (using a menue card) |
| 5. Number of Data Modification (1.-4.) | | |
| 5.1. Sequential number | D | N modulo 10 |
| 5.2. References: responsible for | D | 2 characters |
| 6. Number of blood units assigned to Recipient | | |
| 6.1. number of 'red' units: | | |
| 6.1.1. "assigned" | I | |
| 6.1.2. "reserved" | I | |
| 6.1.3. "delivered" | I | |
| 6.2. number of 'white' units: | | |
| 6.2.1. "assigned" | I | |
| 6.2.2. "reserved" | I | |
| 6.2.3. "delivered" | I | |

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| Recipient Data Set | I/D | Example 'input'/related value (Remarks) |
|---|---|---|
| 7. Cost Carrier Data | | |
| 7.1. Type of medical treatment | I | Preventive case/ Scientific/ inpatient -/ outpatient treatment |
| 7.2. Type of cost carrier | I | insured patient/ private patient/ self-payment/ consultation |
| 7.2.1. Insurance company | D | national code |
| 7.2.1.1. State of membership | D | insured person/ famicy member/ retired person |
| 7.2.1.2. Birth date of the insured person | D | |
| 7.2.1.3. Membership number | D | |
| 7.2.2. Recipient for the bill | D | in case of self-treatment |
| 7.2.2.1. Name | D | default: name (1.3.) |
| 7.2.2.2. Christian name(s), title(s) | D | |
| 7.2.2.3. Street, number | D | |
| 7.2.2.4. Postale code, place | D | |
| 8. Order Data | | |
| 8.1. Order number | I | machine-readable (OCR-B light pen) |
| 8.2. Date of sample | I | |
| 8.3. Adress of referring physician/ institution | I | (code number, using a menue card) |
| 8.3.1. Ward/ physician within referring institution | D | 4 characters (free text) |
| 8.4. Confirmation of identity of sample | D | no/yes. signed ... |
| 8.5. Remarks concerning the sample | D | 'Sample or request form are following'/ ... code, using a menue card) |
| 8.6. Number of modifications of order data (8.1. - 8.5.) | | |
| 8.6.1. Sequential number | I | N modulo 10 |
| 8.6.2. Reference: responsible for last modification | I | 2 characters |
| 8.7. Additional order data diagnosis(es)/ therapy/ transfusion indications/ transfusion reactions/ evaluation | | (not yet implemented) |
| 9. Order Set (related units) | | |
| 9.1. State of sample | I | key number |
| 9.2. Unit counter | I | integer |
| 9.3. Unit set | D | |
| 9.3.1. Unit number | | (machine readable |
| 9.3.2. Mode of relation | | assigned/ reserved/ delivered |
| 9.3.3. Date -/ time of relation | | |
| 9.3.4. Remarks to the relation | | code |
| 9.3.5. Reference: responsible technician | | 2 characters |

Subject index

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# E r r a t a

page, line

7,7 temperature of +4°C for at .....

7,9 which is to comply with the requirements by appropriate and ....

8,15 - ER red blood cells/erythrocyte ......

8,16 - TC platelet/thrombocyte .....

9,30 One can imagine that in future it ......

9,31 be treated at cell separators by one .....

11,12 transfusion (see pg. 220).

11,21 and therapy of bleeding disorders (see pg. 239f) are .....

13,4 ratory tests on patient blood samples were carried out .....

57,1 The Laboratory Data System as an Integral Part

154, 1 Editors' comment: Vox Sang. 41:50-55 (1981)

206,8 and donors from the sections of immunochemistry,.....

206,32 to -.95 DM per test in 1979 for laboratory EDP (including forms) and ....

263,1 Blood Recipient Related Data

263,20 cases include data on the recipient. Dr. Roos and W. Müller, Hamburg,

263,22 the data structure of the blood recipient is exemplified on ....

263,27 or none. In the latter case there may be none of that ...

272, Jansen, A.M.Dr.med., Blutspendedienst der Univ.Kliniken Hugstetter ..

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