Shu You Peng

Hepatic Caudate Lobe Resection

ZHEJIANG UNIVERSITY PRESS
浙江大学出版社
Springer

Shu You Peng

Hepatic Caudate Lobe Resection

Shu You Peng

Hepatic Caudate Lobe Resection

With 370 figures, mostly in color

ZHEJIANG UNIVERSITY PRESS
浙江大学出版社

Springer

Author
Prof. Shu You Peng
Second Affiliated Hospital
Sir Run Run Shaw Hospital
Zhejiang University
Hangzhou 310009, China
E mail: zrwkpsy@zju.edu.cn

ISBN 978 7 308 06598 6
Zhejiang University Press, Hangzhou

Additional material to this book can be downloaded from http://extras.springer.com.

ISBN 978 3 642 05104 3 e ISBN 978 3 642 05105 0
Springer Heidelberg Dordrecht London New York

Library of Congress Control Number: 2009936648

Cover design: Frido Steinen Broo, EStudio Calamar, Spain

Printed on acid free paper

Springer is a part of Springer Science+Business Media (www.springer.com)

Dedication

This book is dedicated to my sisters, Dr. Lillian S.C. Pang, MD, PhD, FRCPath; Dr. Shuyi Peng, MD; Madam Shutuo Peng, MA; and my brothers, Dr. Shugan Peng, MD; Shujue Peng, MD. Without their consistent encouragement and support, I would not have undertaken my study of liver diseases and surgical career.

This book is also dedicated to all my patients whose desire for life and living well is what makes this entire effort meaningful and worthwhile.

Foreword 1

The segment I is the most secret segment of the liver. It is the deepest segment between the hilum and the inferior vena cava, independent from the right liver (segments V to VIII according to Couinaud's classification) and the left liver (segments II to IV). It is by itself a single liver, receiving its portal branches from the main left and the main right portal branches, and its hepatic branches arriving independently and directly into the inferior vena cava all along its retrohepatic part.

Prof. Peng uses the term "porta hepatis" not only for the hepatic hilum but according to the Chinese anatomy to each of all of the three groups of vessels encircling the segment I: (1) the portal branches at the hilum, (2) the main hepatic veins, and (3) the small hepatic veins going directly to the vena cava. This terminology is not usual in the western anatomy and might surprise some readers. But I agree that this gives a good image of the proximity and the complexity of the network of these veins—plus the arteries—which encircles this segment. This is to say that the approach of segment I is the most difficult of all the segments of the liver and as a consequence, its surgical extirpation.

In the usual description of the hepatectomy of segment I, precisely segmentectomy I, this segment is removed in association with other segments: usually segments II and III. It is right to say that removal of the left lobe (II and III) opens the left border of the inferior vena cava and makes easier the approach and the ligation of the small hepatic veins at the anterior face of the vena cava.

Also the hepatectomy of segments II, III and IV associated to segment I, is even easier for avoiding dissecting the parenchyma between segments I and IV. Of course we are loosing in term of economy of liver parenchyma and in several circumstances as in the surgery of cirrhotic liver or of colorectal liver metastases, it is important to save the maximum amount of liver parenchyma.

In this book, Prof. Peng describes with clarity and precision the segmentectomy I alone by several approaches, I must say all of them: anterior, left, right or combined approaches.

The description of these techniques is a real demonstration of the use of the anatomical lines of division of the liver which is an important objective—above all in the center of the liver—to avoid opening or ligating large vessels with the two harmful consequences: bleeding and devascularisation.

Prof. Peng uses to achieve the resection a tool that he created himself: the Peng's Multifunction Operative Dissector (PMOD). This is a marvelous instrument to obtain a precise and bloodless line of section associating section, aspiration of the parenchyma allowing to discover the vessels and at the same time doing the hemostasis by coagulation of the small vessels. I assisted personally Prof. Peng in his Institution in Hangzhou and I used also myself the Peng's instrument. I am convinced of the efficiency of this instrument: in addition it is very cheap and easy to use even in a non-specialized surgical unit.

The numerous pictures illustrating the smallest steps of each technique show clearly how to perform all types of resection of segment I. The videos associated to the book make even easier the understanding of the techniques and show also the efficiency of the Peng's tool.

This book, describing the most delicate hepatectomy in the center of the liver, will make easy the performance of the other hepatectomies of the left liver and right liver. It is a perfect introduction to the liver surgery.

It is like doing the Bechamel sauce: if you know it, all recipes will be easy.

Henri Bismuth

Professor of Surgery
Member of the Académie Française de Chirurgie
Founding President of the European Surgical Association
Honorary Member of the American College of Surgeons
Honorary Member of the American Surgical Association
Director of the Hepatobiliary Institute

25th August 2009

Foreword 2

In spite of the rapid development in liver surgery in the past several decades, the caudate lobe has still been considered as a "no-man's land" until very recently.

In the 1960s, liver resection was a prohibitive and highly risky endeavor, carried out by a few pioneer surgeons, with inconsistent and often-disappointing results. The field of liver surgery has since grown at a spectacular rate, and has now evolved into well-planned and safe procedures. This change has mainly been brought about by the innovative advances made by surgeons based on the better understanding of liver anatomy and physiology, appreciation of liver regeneration, and improvements in the control of haemorrhage due at least partly to modern technology. The progress of diagnostic radiology allows detection of small and asymptomatic lesions. In parallel, the rapid development of liver transplantation from the end of the 1980s has greatly enhanced the experience of surgeons and anaesthetists which enabled the boundaries of liver surgery to be extended. What was previously considered as technically impossible has now become possible. Liver surgery which was defined as 'extreme' in view of the extent or the complexity of the procedure has now been adopted as routine and carried out in many centers.

The caudate lobe is the dorsal portion of the liver lying posteriorly and embracing the retrohepatic inferior vena cava in a semi-circumferential fashion. The caudate lobe lies between the major vascular structures with the inferior vena cava posteriorly, the portal triad inferiorly, and the hepatic venous confluence superiorly. There is a series of short hepatic veins which drain blood directly from the caudate lobe into the retrohepatic inferior vena cava. Thus, the caudate lobe is surrounded by important and potentially dangerous structures deep in the center of the liver. The unique anatomical position makes caudate lobe resection, especially isolated caudate lobe resection, technically challenging.

The caudate lobe consists of three parts: the Spiegel lobe, the paracaval portion and the caudate process. In the majority of cases, the three parts receive different blood supply making partial caudate lobectomy a possibility. When resection of the caudate lobe is required for tumor clearance, the operation may be an isolated caudate lobe resection or a caudate lobe resection combined with a major hepatectomy, *e.g.* right or left hepatectomy. Thus, caudate lobectomy can be classified into four types: isolated complete caudate lobectomy, combined complete caudate lobectomy, isolated partial caudate lobectomy and combined partial caudate lobectomy.

Although caudate lobectomy has been performed combined with resection of other portions of the liver, isolated complete caudate lobectomy was not reported until in 1990 by Lerut et al. (Surg Gynaecol Obstet 1990, 171: 160-162). There have not been too many publications since this important landmark paper, especially on the technique used in isolated caudate lobectomy, probably because of the small size of the caudate lobe making resectable lesions still confined to the caudate lobe uncommon.

This book describes the surgical approaches used by Prof. Peng in caudate lobectomy: the right-sided approach, the left-sided approach, the combined right- and left-sided approach, the anterior approach, and the retrograde approach. These approaches and surgical techniques are being presented in a clear and succinct manner, illustrated with many operative photographs and diagrams to allow the readers to follow the operation in a step-by-step manner, meanwhile giving detailed accounts of the indications, possible complications, their prevention and treatment. This book has been written by a very experienced HPB surgeon whom I am sure even the mature and expert liver surgeons have much to learn from. A particular feature of this book is the inclusion of a DVD-ROM showing the key steps used in the different approaches to caudate lobectomy. It is always a joy for me to watch Prof. Peng, either directly in his operating theatre or indirectly through these video clips, in using his Peng's Multifunction Operative Dissector (PMOD) to dissect and to transect the liver. Prof. Peng always makes difficult operations to look easy to carry out! Hopefully, by showing the operations carried out by a master of surgery, the readers can learn more out of this monograph.

It is a great honour for me to be invited by Prof. Peng to write this Preface to introduce this book conceived and completed by him. I have known Prof. Peng for about twenty years, and he has always been my admired friend and respected colleague. Prof. Peng has been well-known in China to be a scholar, a pioneer in many fields of surgery and a highly skillful surgeon.

Prof. Peng has emerged as an important surgical leader in China and I hope he will continue to keep at the forefront with important contributions to make to the surgical community in the future.

The publishing of this remarkable book, I am sure will become an important landmark in Prof. Peng's distinguished surgical career. This book is a 'must' for all liver surgeons who are interested to improve their knowledge and skills in complicated liver surgery.

Wan Yee Lau

MD, FRCS (Edin, Engl, Glas), FACS, Hon FRACS
Academician of the Chinese Academy of Sciences
Professor of Surgery
The Chinese University of Hong Kong

13th August 2009

Preface

Although Couinaud's study of the anatomy of the liver in the 1950s marked the beginning of a new era in modern liver surgery; and in the 1970s, huge breakthroughs in liver transplantation and regular resection of liver were made; nevertheless, it was not until the 1990s that caudate lobe resection was first documented. In the last decade, through the efforts of both western and eastern scholars of liver surgery, reports involving resection of the caudate lobe have gradually emerged. Most of these, however, are confined to individuals and small numbers of cases. Therefore, resection of the caudate lobe is considered by many experts as the ultimate field in liver surgery.

The caudate lobe is situated in a complex anatomical position. Namely, it is covered in front by the first porta hepatis, with the inferior vena cava (IVC) at the back, and its upper end lying close to the three major hepatic veins. Therefore, resection of the caudate lobe presents huge difficulties and risks. In order to reduce the operating risks and technical difficulties, the earliest caudate lobe resections were conducted in conjunction with other types of liver resection, that is, massive liver resection that included partial or complete caudate lobe. Advances in the applied anatomy of the caudate lobe, the development of modern imaging technologies such as CT and MRI, improvements in surgical instruments and facilities, and progress in the techniques of blood flow control and liver parenchymal transection, have all given much impetus to the development of hepatic caudate lobe surgery. It was not until 1990 when Lerut et al. reported isolated complete resection of caudate lobe. The anterior approach suggested by Yamamoto et al. made it possible to perform isolated complete caudate lobe resection for extra-ordinarily difficult cases. Moreover, the counter-staining technique invented by Takayama et al. made the borders of the caudate lobe clearly recognizable. Today, resection of the caudate lobe is becoming well established. A classification of the operating methods can be made based on partial resection versus complete resection; as well as combined resection versus isolated resection. Combined resection can be divided into combined partial caudate lobe resection and combined complete caudate lobe resection; while isolated resection can be divided into isolated partial caudate lobe resection and isolated complete caudate lobe resection. The approach to caudate lobe resection can be classified into left-sided, right-sided, combined, or anterior approaches.

Since 1994, we have performed caudate lobe resections on more than 170 patients by making use of the Peng's Multifunction Operative Dissector (PMOD). Forty one of these operations were isolated complete resection of the caudate lobe. These actual experiences provided us with a deeper anatomical understanding of the caudate lobe, and made it necessary for a new anatomical nomenclature to be applied. Through these operations, we have gathered much useful experience and discovered many effective techniques which we would like to share with experts in liver surgery. These include: operative strategies developed for difficult resections; retrograde resection of the caudate lobe; effective methods of blood flow control; isolated complete resection through the midplane; application of Curettage and Aspiration Dissection Techniques (CADT) using PMOD; and proper use of liver hanging maneuvers. All these constitute measures for a safe resection of the caudate lobe. For this purpose, the present author has compiled the *Hepatic Caudate Lobe Resection.* This book is a monograph that includes text, graphics, and videos, primarily aiming at introducing operative procedures. It includes more than 350 photographs and 18 videos of operations; relevant drawings based on photographs of operations are also provided to aid the readers' understanding. With the author's experience of more than 170 cases of caudate lobe resection over a span of 15 years, this monograph further incorporates the latest national and international researches. To the best of our knowledge, this might be the first monograph systematically introducing the anatomy, operating strategies, and operating techniques of hepatic caudate lobe surgery worldwide. It is hoped that surgeons wishing to perform caudate lobe resection will, after reading this book, find the operation not so difficult and challenging as they might initially have thought, and hence, would help the development of hepatic caudate lobe surgery.

This book is a result of the hard work and dedication by many of my colleagues, friends and graduate students over the last decade or so. Whether in the research and development of the PMOD, or in the mutual cooperation during operations, the postoperative management, and the filming and editing of operation videos, they have all given an enormous amount of enthusiasm and help. For this, I would like to express my special gratitude to all of them. I would like to thank my good friend Prof. Fang Zheng for spending much of his time drawing the operation photographs. I thank, too, my wife Prof. Longhua Xie for her support in many ways, and my son Dr. Baochun Peng for travelling back to China from abroad to provide the voice for the videos. I owe very much to Ms Ying Su for her consistent efforts in improving the important instrument PMOD.

It is my great honor to have both Prof. Bismuth, a living icon in the surgical

world, and Prof. Joseph Lau, a past-president of the International Hepato-Pancreato-Biliary Association and currently the president of the Asian-Pacific Hepato-Pancreato-Biliary Association, wrote the prefaces for this book amidst their busy schedules I am extremely grateful to them.

Much study still needs to be done in hepatic caudate lobe surgery. The author hopes that the publication of this book will bring about wide discussions and debates among international experts in hepatobiliary surgery. The author also hopes that while colleagues and experts point out the shortcomings, or even possible errors in this book, they will also engage in further discussions with him concerning the potential problems in the development of hepatic caudate lobe surgery, so that we may together promote the greater and better development of hepatic caudate lobe surgery.

Shu You Peng*
Hangzhou, China
8th July

****Shu You Peng** developed a special surgical dissection technique named "Curettage and Aspiration Dissection Technique" (CADT) which enables difficult operations to be performed easily and safely, and designed "Binding Pancreaticojejunostomy" and "Binding Pancreatico gastrostomy" to minimize the occurrence of pancreatic leakage. Due to prominent achieve ments, he has received numerous awards and prizes, among them including the 2001 State Technological Invention Award, the 2004 and 2008 State Scientific and Technological Progress Award, and the Ho Leung Ho Lee Foundation Award, given to individuals who have achieved outstanding innovations or made extraordinary contributions in science or tech nology. In 2004, he was titled the Honorary Fellow of the American College of Surgeons. In 2006, he became ad eundem Fellow of the Royal College of Surgeons of Glasgow, and in 2009 an Honorary Fellow of the European Surgical Association. His bibliography includes an extensive list of 646 articles in Chinese and international medical journals, and 30 book chapters and books.

Acknowledgements

Many thanks to those persons, as follows, for their work of collecting pictures, videos as well as drawings, and helping edit the book.

Xiujun Cai, MD, FACS (Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University)

Liping Cao, MD (Second Affiliated Hospital, School of Medicine, Zhejiang University)

Li Chen, MD (Second Affiliated Hospital, School of Medicine, Zhejiang University)

Heqing Fang, MD (Second Affiliated Hospital, School of Medicine, Zhejiang University)

Defei Hong, MD (Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University)

Dongsheng Huang, MD (Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University)

Jiangtao Li, MD (Second Affiliated Hospital, School of Medicine, Zhejiang University)

Yingbin Liu, MD (Xinhua Hospital, School of Medicine, Shanghai Jiaotong University)

Yiping Mou, MD FACS (Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University)

Ying Su, MBA (Second Affiliated Hospital, School of Medicine, Zhejiang University)

Bin Xu, MD (Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University)

Fang Zheng (Second Affiliated Hospital, School of Medicine, Zhejiang University)

Libo Li, MD (Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University)

Ning Li, MD (First Affiliated Hospital, Zhejiang Chinese Medical University)

Fubao Liu, M.D. (First Affiliated Hospital of Anhui Medical University)

Haoran Qian, MD (Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University)

Feng Tao, M.D. (Shaoxing People's Hospital, Zhejiang)

Jianwei Wang, MD (Second Affiliated Hospital, School of Medicine, Zhejiang University)

Xu'an Wang, MD (Hangzhou First People's Hospital, Zhejiang)

Yifan Wang, MD (Sir Run Run Shaw Hospital, School of Medicine, Zhejiang University)

Jianjun Du, MD (Xijing Hospital, The Forth Military Medical University)

Liubin Shi, MD (Huashan Hospital, Fudan University)

Bing Li, MD (the Tumor Hospital of Harbin Medical University)

Xiaowei He, MD (the First Affiliated Hospital, Jiaxing Medical School)

Xinbao Wang, MD (Zhejiang Cancer Hospital)

Jianfeng Xue (First Affiliated Hospital of Zhengzhou University)

Ge Zhang (Zhejiang University Press)

Contents

1

Anatomy

The hepatic caudate lobe (CL) is a single anatomic segment (segment I) that is defined by the presence of portal venous and hepatic arterial branches, draining biliary ducts, and hepatic veins (HVs). It is the dorsal portion of the liver lying posteriorly and embracing the retrohepatic inferior vena cava (IVC) in a semi-circumferential fashion.

1.1 Basic Knowledge

The hepatic caudate lobe lies among major vascular structures—IVC posteriorly, the portal triads inferiorly, and the hepatic venous confluence superiorly (Blumgart and Hann, 2000) (Figs.1.1 and 1.2; Peng, et al., 2008).

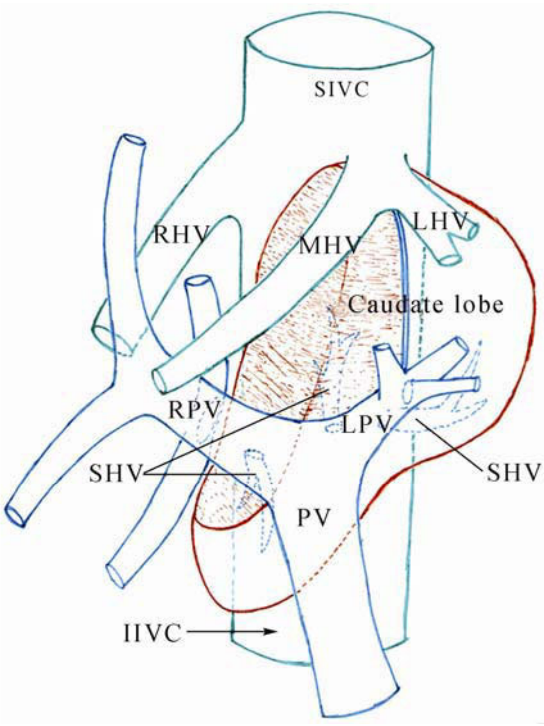
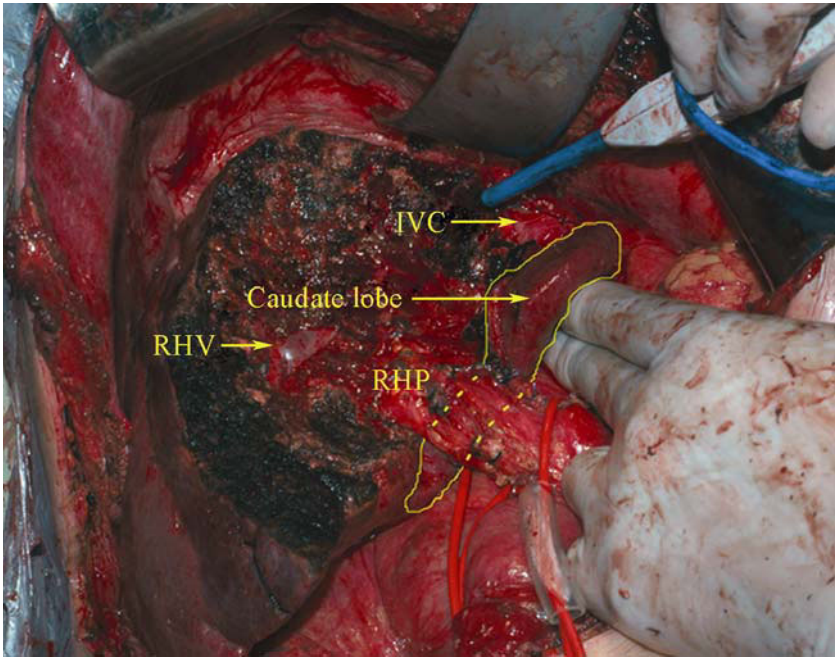
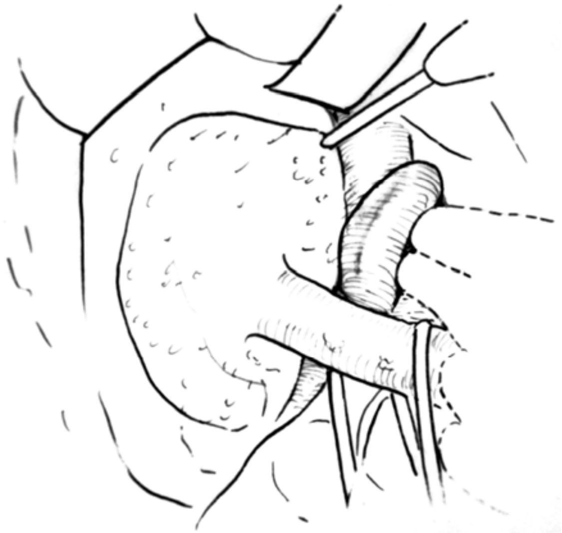


Fig.1.1. Blood vessels and biliary drainage of caudate lobe. Copyright (2008), with permission from Elsevier



(a)



(b)

Fig.1.2. Front view of the entire caudate lobe after left trisegmentectomy. (a) Photograph; (b) Drawing

Kumon (1985) considered the caudate lobe consists of three parts: (1) the Spiegel lobe, which is located behind the lesser omentum and extends to the left of the retrohepatic IVC; (2) the paracaval portion, which is in front of the retrohepatic IVC, just to the right of the Spiegel lobe, and is closely attached to the right and middle hepatic veins; (3) the caudate process (CP), which is a small projection between the IVC and the adjacent portal vein anteriorly, just to the right of the paracaval portion (Fig.1.3). However, I adopt Couinaud's division, in which the caudate lobe is subdivided into a left part (segment I) and a right part (segment IX), using the middle hepatic vein (MHV) as the landmark. The right part may be further divided into two subsegments. The caudate process is only a tongue-like projection which attaches the caudate lobe to the right liver (Fig.1.1). The border of the caudate process with the right liver is quite clear. It is where the tongue-like portion meets the thick right lobe. The ligamentum venosum lies in front of the caudate lobe and enters the IVC (Figs.1.4-1.6).

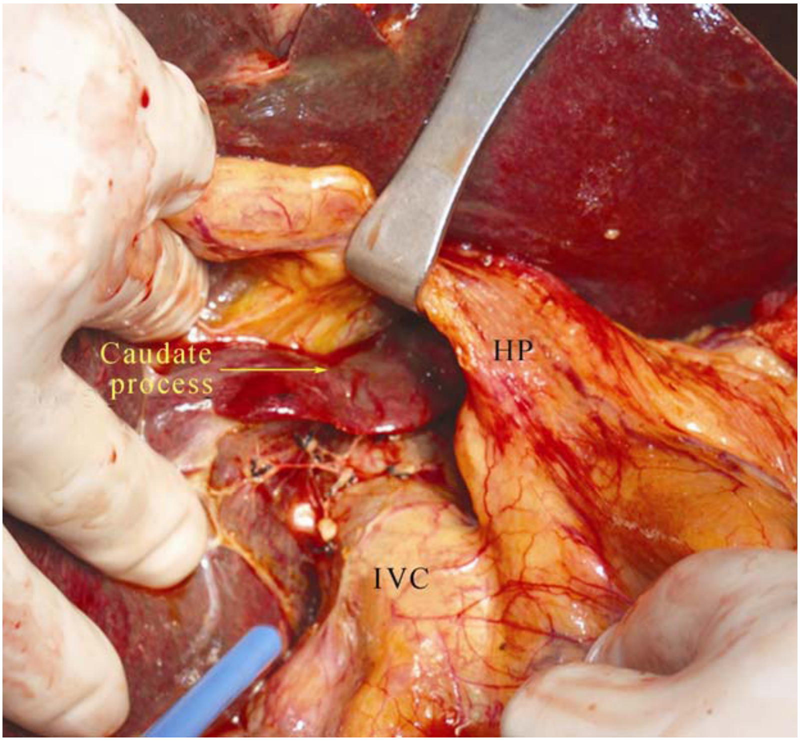
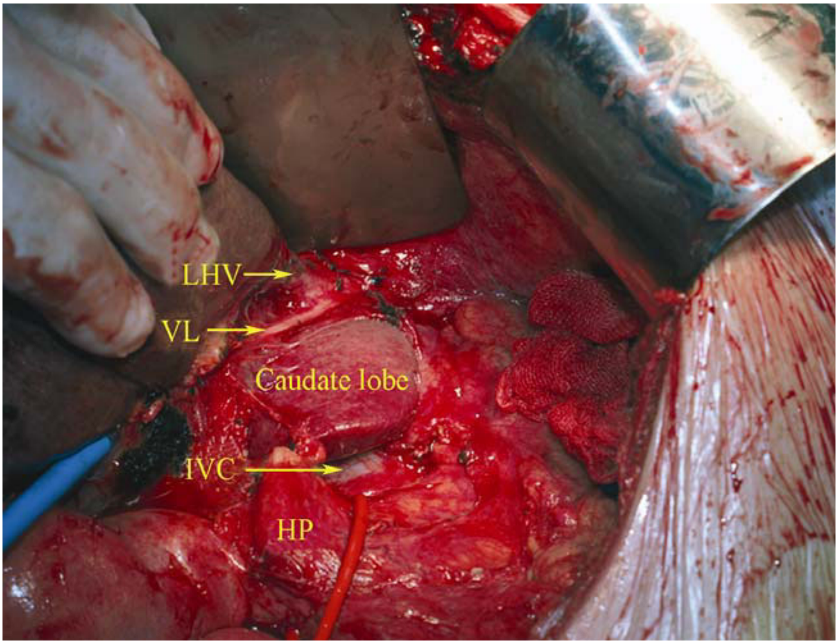


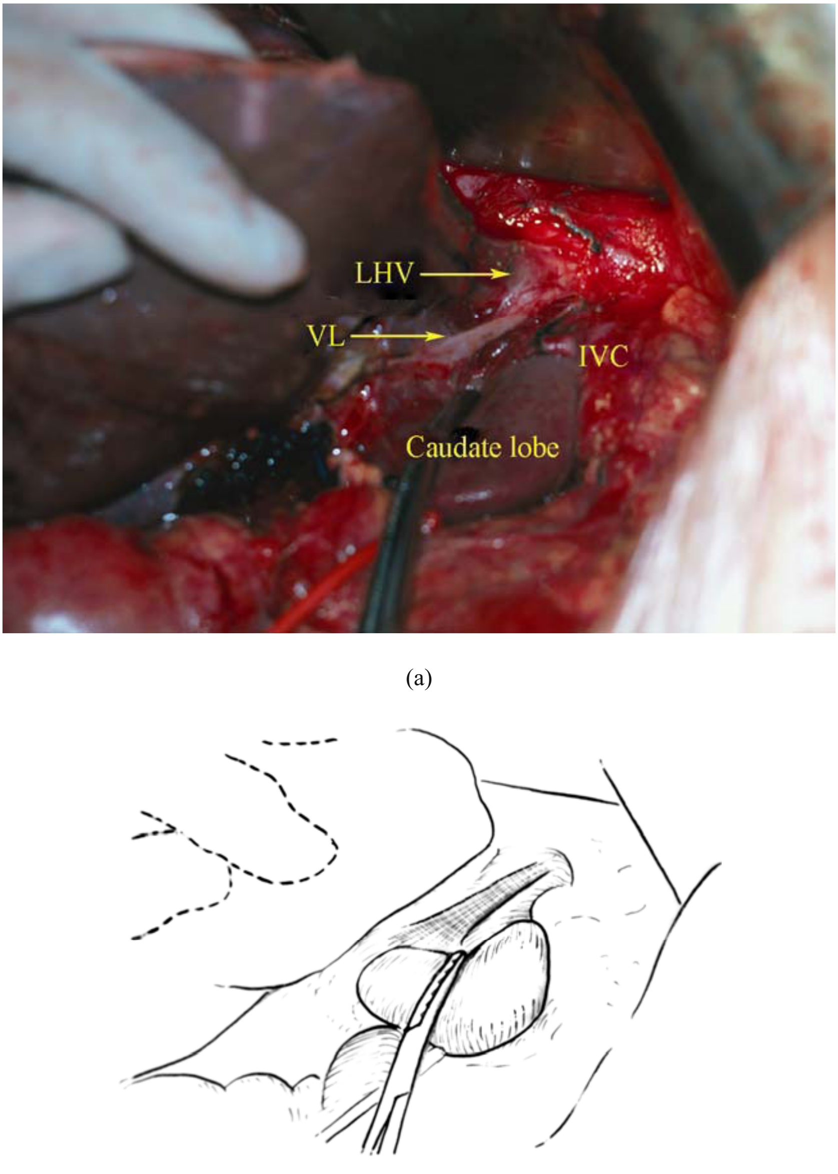
Fig.1.3. The caudate process is a small projection between the IVC and the adjacent anteriorly portal vein



(a)

(b)

Fig.1.4. The tip of caudate is located behind the venous ligament (VL) and the left hepatic vein (LHV).
(a) Photograph; (b) Drawing



(a)

(b)

Fig.1.5. The tip of caudate lobe is located at the junction between VL, LHV and IVC. (a) Photograph; (b) Drawing

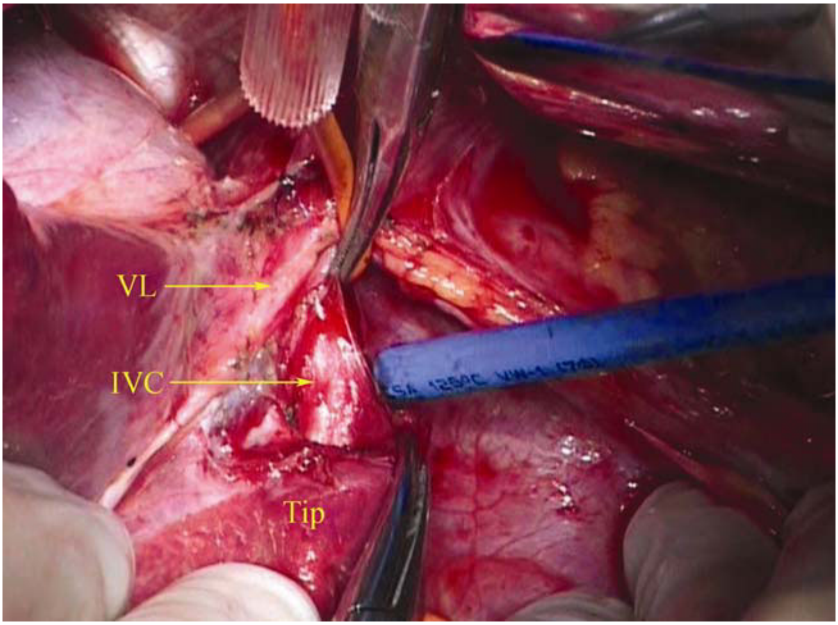


Fig.1.6. Behind the junction of the VL and IVC is the tip of the caudate lobe, which has been detached for a short distance

1.2 Portae Hepatis

Traditionally, there is only one porta hepatis. However in the Chinese literature, porta hepatis denotes not only the hepatic hilum in the general sense, but also two other locations: one being the confluence of the major HVs, and the other being the segment of retrohepatic IVC with a series of short hepatic veins (SHVs). The three different locations are named the first, second, and third portae hepatis, respectively. In other words, the first porta hepatis denotes the hilum in the general sense, the second porta hepatis denotes the confluence of the major HVs, and the third porta hepatis denotes the segment of retrohepatic IVC with a series of SHVs. Thus, the caudate lobe is surrounded by the three portae hepatis (Fig.1.7), which all consist of important and potentially dangerous structures in terms of performing operations. In view of the unique anatomical location, caudate lobe resection has been considered technically challenging, especially in isolated caudate lobectomy.

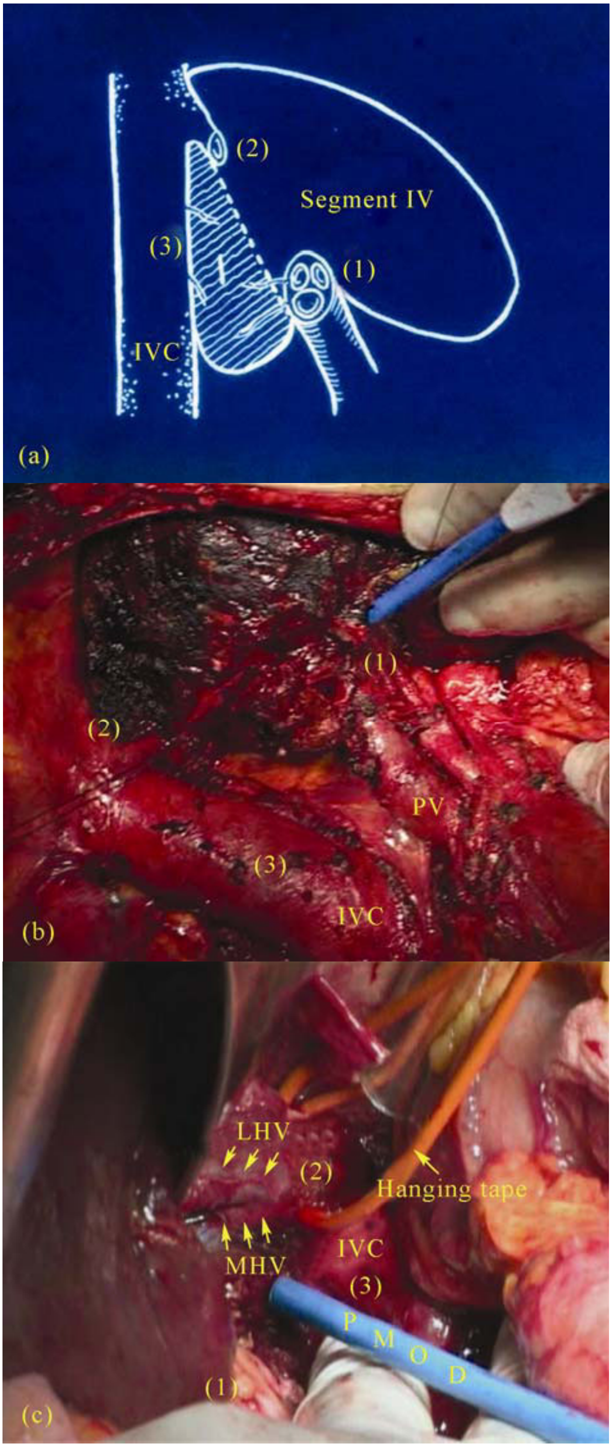


Fig.1.7. Position of three portae hepatis. (a) Sectional view, modified from Bismuth et al.,1982, used with permi ssion; (b) View from the rght side; (c) View from the left side. (1): First porta hepatis; (2): Second porta hepatis; (3): Third porta hepatis

This nomenclature of three portae hepatis is important in association with caudate lobe resection. In the course of resection, dissection is performed from 4 aspects, namely, first porta hepatis, second porta hepatis, third porta hepatis, and liver parenchyma. Usually, SHVs (in the third porta hepatis) are dissected and divided as the first step. This is followed by the dissection and division of the caudate portal triads (first porta hepatis). The third step is to dissect and divide the branches from the major HVs (in the second porta hepatis). When the tumor is not closely in contact with the major HVs, as is often the case, this step may be performed together with the fourth step, liver parenchymal transection. In the case of caudate lobe resection by the anterior approach (through the midplane), after the tumor is removed, the three portae hepatis can be seen at the same time (Fig.1.8).

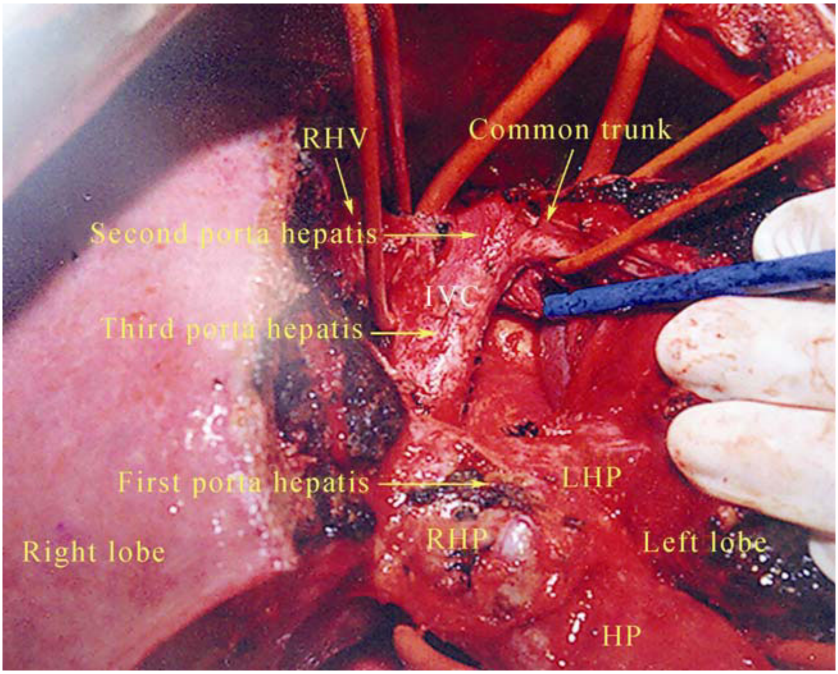


Fig.1.8. After the tumor is removed, the three portae hepatis can be seen at the same time

1.3 Pedicle of the Caudate Lobe

The caudate lobe is supplied by blood vessels and drained by biliary tributaries both from the right and left portal triads, usually two on the left side and one on the right.

However, the number may vary. Hereafter, they are called the caudate portal triad (CPT). The area where the CPT enters (or exits from) the caudate lobe is named the caudate pedicle. The right portion of the caudate lobe, including the caudate process, predominantly receives portal venous blood from the right portal vein or the bifurcation of the main portal vein, while the left portion of the caudate lobe receives portal venous blood from the left portal vein (LPV). Similarly, the arterial supply and biliary drainage of the right portion are most commonly associated with the right posterior sectoral pedicle, and the left portion with the left pedicle.

The hepatic venous drainage of the caudate lobe is unique in that it is the only hepatic segment draining directly into the IVC by a series of SHVs. However, there might be some small veins draining into the right and/or MHVs when the caudate lobe tumor is large, or when a tumor is very closely attached to the major HVs.

1.4 Peng's Transection Line

There are no well-defined landmarks between the paracaval portion and the right posterior sector.

In order to achieve a clear cut in isolated complete caudate lobe resection, Asahara et al. (1998; 2000) used the counterstaining identification technique, puncturing the portal venous branch of the posterior segment, under ultrasonic guidance, to inject indocyanine green (ICG), and staining the posterior liver segment to delineate the right border of the caudate lobe. However, this is not practical, although theoretically ideal.

I find it is very useful to use two points as landmarks, that is the tip of the caudate lobe, located at the angle between the left hepatic veins (LHVs) and IVC (Figs.1.9 and 1.10), and the point where the caudate process meets the right liver. An imaginary line joining these points can be considered as the caudate tip to boundary for liver transection.

I call this Peng's line (the tip to process transection line).

In other words, the transection line is from the tip of the caudate lobe to the right border of the caudate process, while the transection plane is oblique, slanting from the LHV to the right portal vein (RPV). Usually, there is a color change of the caudate lobe after the CPT is divided (Fig.1.11).

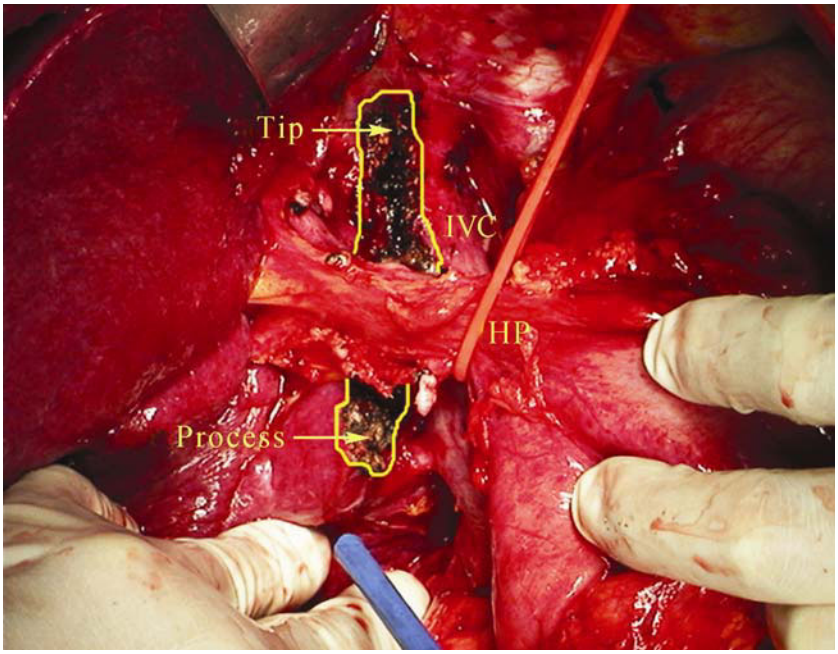


Fig.1.9. The tip and process of the caudate lobe are considered as landmarks of the caudate boundary

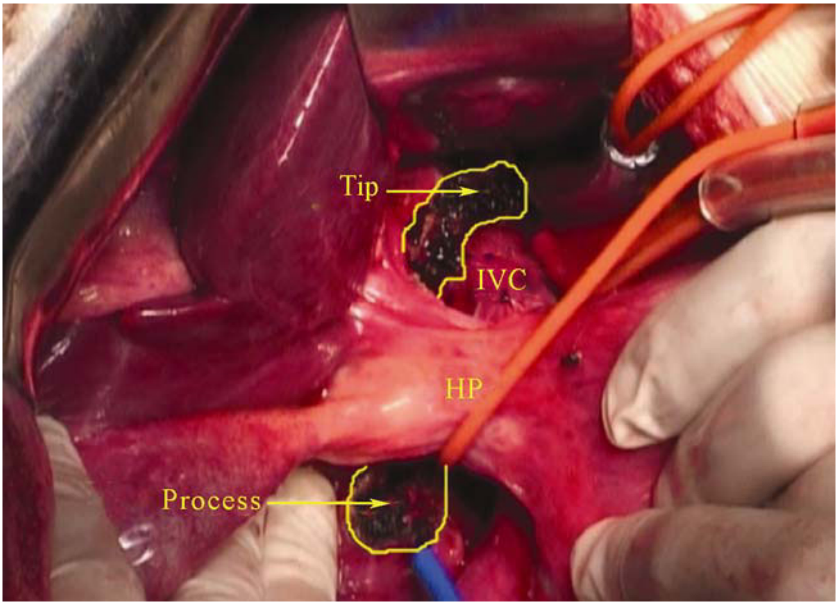


Fig.1.10. The tip and process of the caudate lobe are considered as landmarks of the caudate boundary

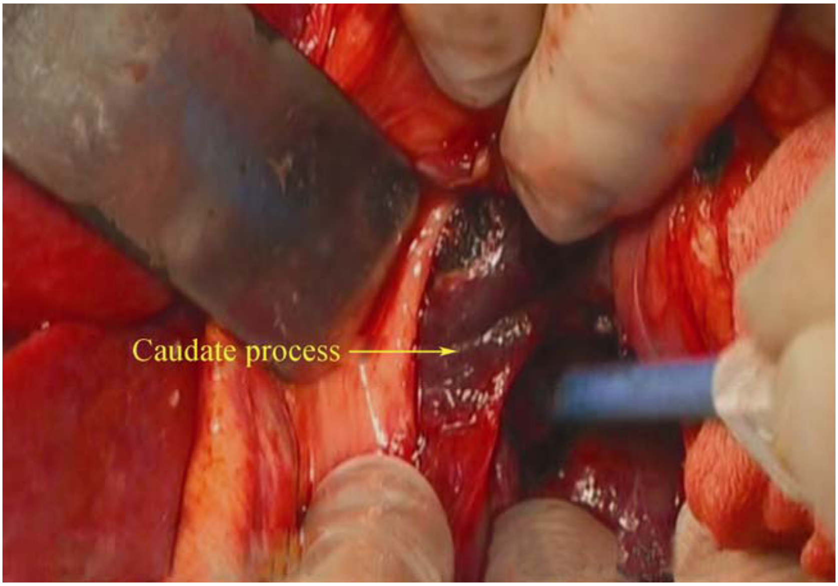


Fig.1.11. Color of the caudate lobe changes after the CPT is divided

1.5 Anatomical Bases of Caudate Lobe and Caudate Lobe Fossa

The term “caudate lobe fossa” refers to the now empty space where the caudate lobe was situated before its removal. After the caudate lobe was removed, the whole segment of the retrohepatic IVC is exposed (Fig.1.12).

The anatomical base of the caudate lobe refers to the cut liver surface after an isolated complete caudate lobe resection. Actually, it is the interface between the caudate lobe and the rest of the liver. It is an oval-shaped area, the anterior one third of which belongs to segment IV. The upper half of the posterior two thirds belongs to segment VII, while lower half belongs to segment VI (Fig.1.13).

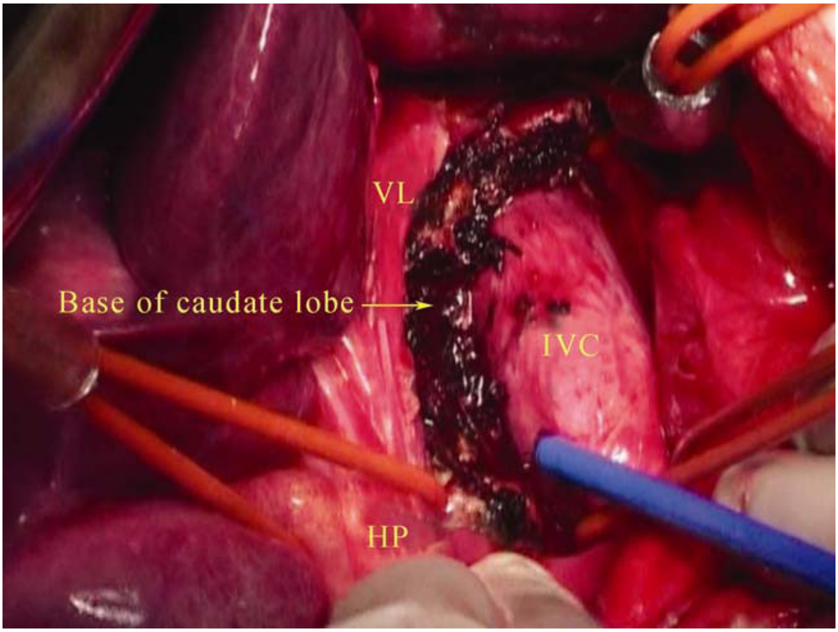
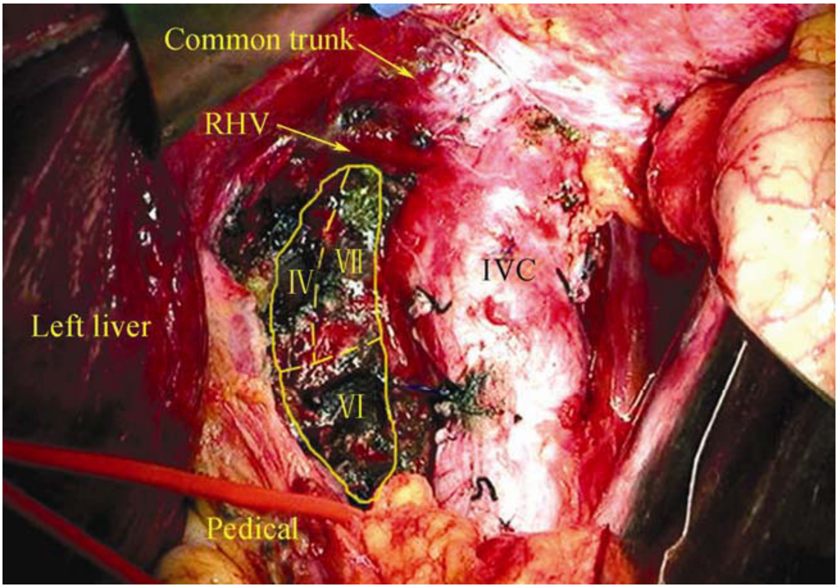
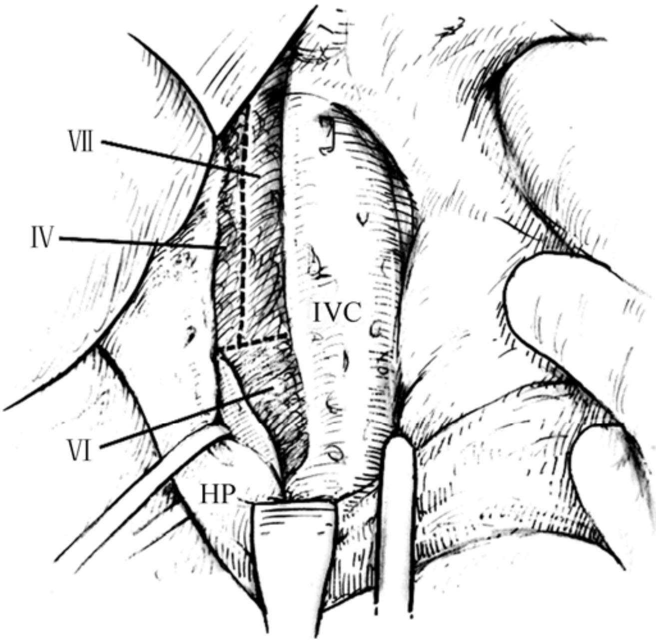


Fig.1.12. After the caudate lobe was removed, the whole segment of the retrohepatic IVC is exposed



(a)



(b)

Fig.1.13. Base of caudate lobe.
(a) Photograph; (b) Drawing

References

Blumgart LH, Hann LE (2000) Surgical and radiologic anatomy of the liver and biliary tract. In: Blumgart LH, Fong Y (eds). Surgery of the liver and biliary tract. Vol. 1, 3rd edn. WB Saunders, London, 3-33

Kumon M (1985) Anatomy of the caudate lobe with special reference to portal vein and bile duct. Acta Hepatol Jpn 26: 1193-1199

Asahara T, Dohi K, Hino H, et al. (1998) Isolated caudate lobectomy by anterior approach for hepatocellular carcinoma originating in the paracaval portion of the caudate lobe. J Hepatobiliary Pancreat Surg 5: 416-421

Asahara T, Dohi K, Katayama K, et al. (2000) Isolated caudate lobectomy for hepatocellular carcinoma: a left-sided approach. Asian J Surg 23: 115-122

Peng SY, Liu YB, Wang JW, et al. (2008) Retrograde resection of caudate lobe of liver. J Am Coll Surg 206: 1232-1238

Bismuth H, Houssin D, Castaing D (1982) Major and minor segmentectomies "réglées" in liver surgery. World J Surg 6: 10-24

2

Surgical Instrument and Dissection Technique

In liver resection, prolonged operating time and massive intraoperative hemorrhage, which are related to the level of training, skill, and surgical instruments, are associated with higher mortality and morbidity. But there seems to be a conflict between operating time and precise surgical anatomy. Classical surgical procedures must be manipulated separately by the operator and the assistant, such as cutting, coagulation, dissection, and suction. Reducing the time spent on these procedures would be of great help for the operation.

In 1990, an electrosurgical instrument for reducing operating time and bleeding, Peng's Multifunction Operative Dissector (PMOD), was developed for liver parenchymal transection (Peng and Li, 2008). The PMOD combines four functions of dissection, electro-cutting, electro-coagulation, curetting, and aspiration separately or synchronously, improving the quality of surgery (Di, 2007). Therefore, this dissection technique is named "Curettage and Aspiration Dissection Technique" (CADT).

2.1 Peng's Multifunction Operative Dissector

Peng's Multifunction Operative Dissector (PMOD) is a special instrument, with the functions of dissection, electro-cutting, electro-coagulation, curetting, and aspiration separately or synchronously, so the surgical field can be kept clear and clean (Fig.2.1). The best aspect of PMOD is that it can delineate all the vessels and ductal system so that the intrahepatic ductal structures can be identified, isolated, and treated individually.

PMOD looks like an electrosurgical pencil, but its structure is different. The main difference is that a metal pipe passes through the pencil, while the body of the pipe is coated with an insulating material and the tip of the pipe is made oblique, forming a bevelled end (Fig.2.2). A removable blade is attached to the tip of the tube for electro-cutting. The special design gives PMOD the four different functions. The pipe is connected to a vacuum apparatus through a tube. PMOD also has a wire to connect with a regular electrosurgical generator.

Both the aspiration tube and wire are anchored to the operating tube by the right side of the surgeon with a length of 60-80 cm free, so the surgeon can manipulate PMOD conveniently. PMOD is held in the hand in the same way as holding a pen. By using the thumb or index finger to control the "on" or "off" button, the tissue can be dissected with the bevelled edge of the tip; during curetting and dissecting, the tip is not electrified. Blood, fluid, and oddments in the operative field can be aspirated continually to make the field clear and clean. Operation safety is thus enhanced.

Fig.2.1. PMOD

Fig.2.2. Tip of PMOD

2.2 Curettage and Aspiration Dissection Technique

Curettage and Aspiration Dissection Technique (CADT) is a maneuver composed of four principal surgical actions: electro-cutting, electro-coagulation, curetting, and aspiration. PMOD allows the operator to perform all operative manipulations: cutting, hemostasis, suction, and dissection. These manipulations can be performed simultaneously or sequentially.

During liver transection, intermittent inflow occlusion is routinely used, and the limit is 10 min each time with 2 min reperfusion. Total vascular exclusion is seldom necessary except when the tumor, such as that originating in the caudate lobe, is closely adherent to the IVC or major HVs. In some cases, the major HVs, right hepatic vein (RHV) and/or common trunk of MHV and LHV, are dissected and pre-looped with tape to substitute for IVC control.

The power setting of the electrosurgical generator is varied according to the tissue to be dissected or transected. For dissection and division of hepatic ligament, 40 to 60 Hz would be enough. For transection of liver parenchyma, maximum power at 120 Hz can be used. Usually, dissection is carried out along the transection plane, but when large vessels are encountered, the direction is altered and runs parallel to the vessel to avoid injury, so important vessels can be safely protected with this technique; sudden and massive hemorrhage occurs rarely. Hepatic vein tributaries smaller than 3 mm in diameter can be coagulated, but the Glissonian tributaries should be ligated when the diameter is over 1 mm. Tension should be kept on both sides of the tissue to be dissected to facilitate the transection process. Two PMODs can also be used separately at the same time by the operator and the assistant to expedite the process of dissection and homeostasis.

After resection, the cut surface of the liver is generally electro-coagulated with PMOD (Fig.2.3), bile leaks are searched for and treated when identified. Drains are routinely placed and removed within one week unless bile leak occurs.

The advantage of PMOD is that it can dissect clean all the vessels and ductal system so that the intrahepatic ductal structures can be identified (Figs.2.4-2.6), isolated, and treated individually. The use of PMOD saves operating time and enhances the safety of the operation.

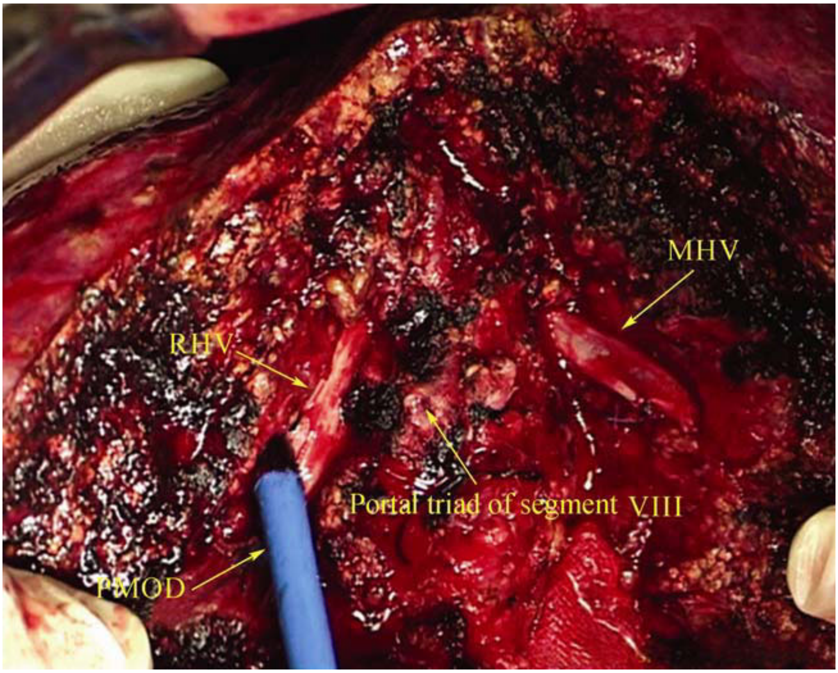


Fig.2.3. After resection of segment VIII, both RHV and MHV as well as the stump of portal triad of segment VIII are clearly seen on the raw surface

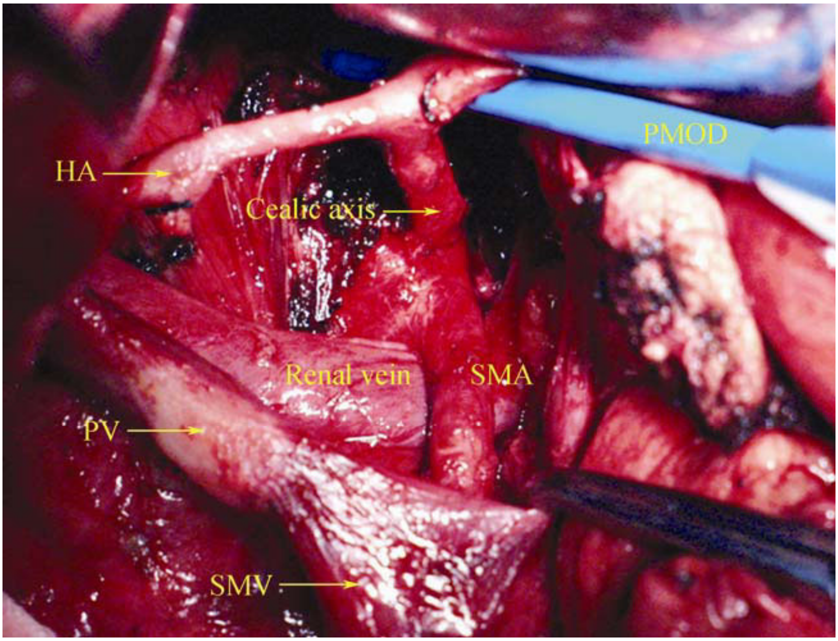


Fig.2.4. Lymphatic clearance in pancreatoduodenectomy with PMOD

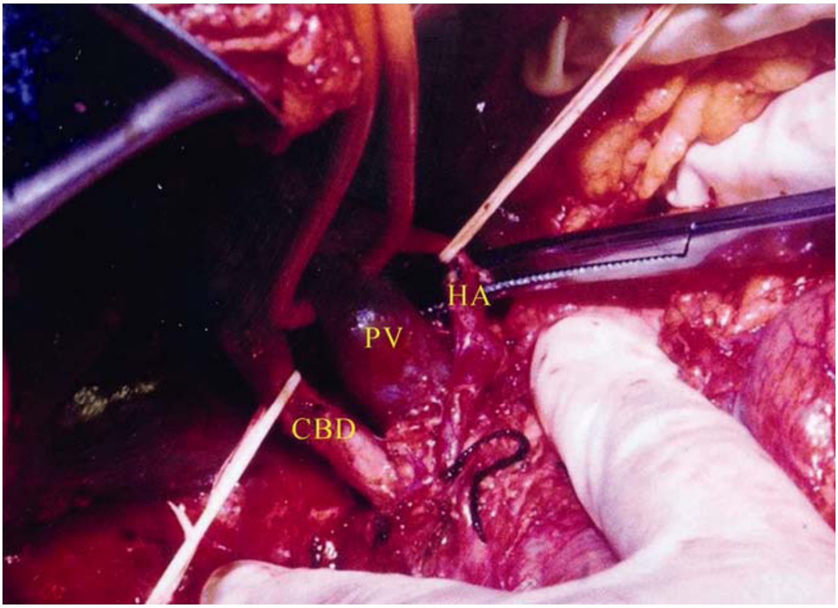


Fig.2.5. Skeletonization of hepatoduodenal ligament

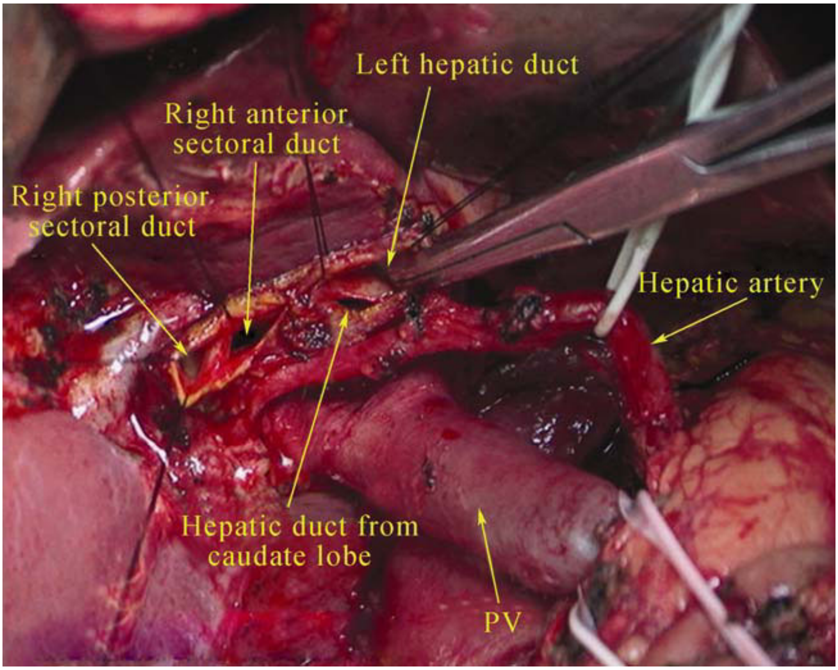


Fig.2.6. Skeletonization of hepatic duodenal ligment

References

Di Carlo I (2007) Peng's Multifunctional Operational Dissector (PMOD). In: Chirurgia Epatica: Elementi di patologia, tecnica chirurgica e trapianto. Edizioni Minerva Medica: 34-35

Peng SY, Li JT (2008) "Curettage and aspiration dissection technique" using PMOD for liver resection. HPB 10: 285-288

3

Surgical Procedures

Surgical position, incision, and the technique of mobilization of the liver, taping vessels, detachment from the surrounding structures are introduced here.

3.1 Position

The supine position is generally adopted. To improve visualization, the operating table has to be readjusted from time to time, according to the location where the dissection is being performed. For instance, when the SHVs on the right side are being dissected, the operating table is rotated to the left; when dissection is taking place in the vicinity of major HVs, the Trendelenburg position is adopted.

3.2 Incision

Several skin incisions have been reported for an isolated caudate lobectomy in the medical literature. These include a reversed L-shaped incision (Peng et al., 2006; 2007), a Mercedes incision (Asahara et al., 1998; 2000), and an inverted T-shaped incision (Yamamoto et al., 1999; Takasaki, 2007). Regardless of the incision used, an excellent exposure is of vital importance for a caudate lobectomy.

3.3 Mobilization of the Liver

Ligamentum teres need to be ligated and transected close to the umbilicus. The falciform ligament is divided up to the front of the suprahepatic inferior vena cava (SIVC), and the roots of the major HVs are anteriorly discerned and exposed. On the upper margin of the liver, the fossa between the RHV and the MHV are dissected free to the anterior surface of the IVC. Then the incision is directed to the right, dividing the right coronary, right triangular, and hepatorenal ligaments. The right liver is then turned medially and upward to expose the bare area behind the right liver. The right adrenal gland is detached from the liver. The posterior surface of the right liver is cranially dissected until the right wall of the SIVC and retrohepatic IVC are completely exposed. When a left-sided or right-sided approach is performed, only the ipsilateral liver is mobilized.

3.4 Taping Vessels

This step includes taping IVC, the common trunk of the MHV and LHV, and RHV.

3.4.1 Taping the IVC

The retroperitoneum overlying the infrahepatic inferior vena cave (IIVC) is opened at a position that is right of the IIVC and 1-2 cm above the right renal vein. Then the surgeon can pass his or her left index finger behind the IIVC to the left side and guide a tape to encircle the IIVC (Fig.3.1).

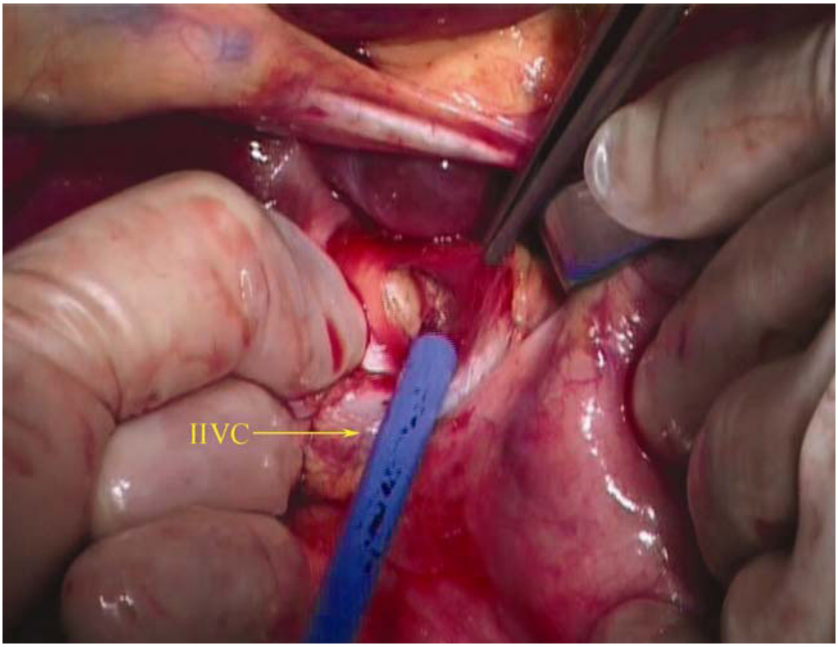


Fig.3.1. Index finger is inserted through retrohepatic IVC space to the other side to guide a tape

Dissection is now directed to the left liver. After the left coronary ligament and left triangular ligament are divided, the left liver is turned to the right. The peritoneal reflection between the Spiegel lobe and the IVC is incised from below cranially up to the left side of the SIVC. Then the SIVC is dissected posteriorly with the index finger toward the right side (Fig.3.2) until a tunnel is created and the IVC is taped.

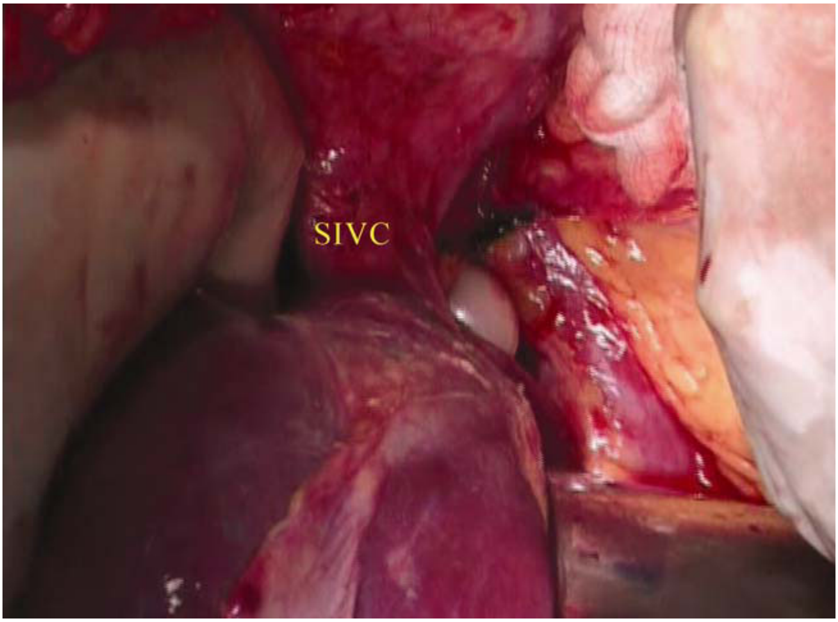


Fig.3.2. Index finger is inserted through retrohepatic IVC space to the other side to guide a tape

3.4.2 Taping the Common Trunk of the MHV and LHV

Isolation of the superior edge of the Spiegel lobe can be achieved by exposing the junction of the LHV and the IVC. If the left phrenic vein drains directly into the LHV, it should be ligated and divided. A blunt dissector is then inserted superiorly from above in the previously dissected fossa between the RHV and MHV, and the IVC anteriorly and the MHV posteriorly are carefully dissected free. The common trunk of the MHV and LHV is then encircled with a tape.

3.4.3 Taping the RHV

Dissection is now directed to the right liver again. The right liver is turned to the left. The right sides of the SIVC and the retrohepatic IVC have already been well exposed. The SHVs draining posteriorly from the posterior surface of segment I into the IVC are carefully dissected and divided, proceeding cranially to the confluence of the RHV and IVC. At this level, the hepatocaval ligament needs to be carefully divided and ligated, since it may contain a large vessel. The confluence of the RHV and the IVC is well exposed from the right side after the division of the hepatocaval ligament (Makuuchi ligament). A blunt dissector is gently passed along the anterior surface of the retrohepatic IVC to the left side of the RHV in order to meet the previously dissected fossa between the RHV and MHV. The RHV is then encircled with a tape (Fig.3.3).

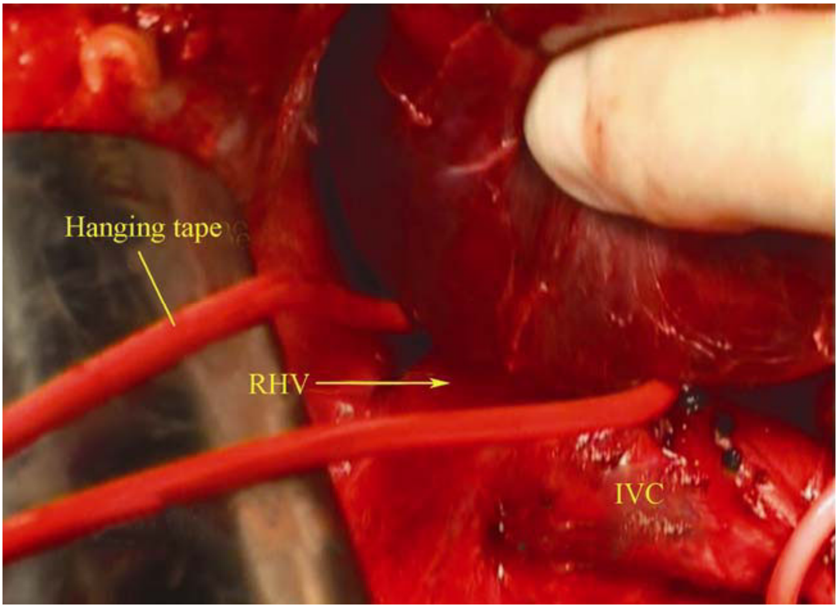


Fig.3.3. Liver hanging tape is swung round and becomes a sling for the RHV

3.5 Detachment from Surrounding Structures

To be removed, the caudate lobe has to be detached from its four boundaries: the first, second, third portae hepatis, and the neighboring liver.

3.5.1 Detachment from the IVC (the Third Porta Hepatis)

The right liver is well mobilized as mentioned above, and the posteriorly draining SHVs along the entire retrohepatic IVC are divided. The dissection proceeds along the anterior surface of the retrohepatic IVC, allowing identification and dissection of the SHVs. The remaining SHVs on the left lateral side of the IVC can be easily isolated via a left-sided approach. The left liver is turned to the right side once more.

The left lateral margin of the Spiegel lobe is freed by dividing the fibrous attachment to the IVC and the diaphragm. The remaining SHVs are exposed and can be easily ligated from the left side (Fig.3.4). The caudate lobe is now completely separated from the IVC and totally detached from the third porta hepatis.

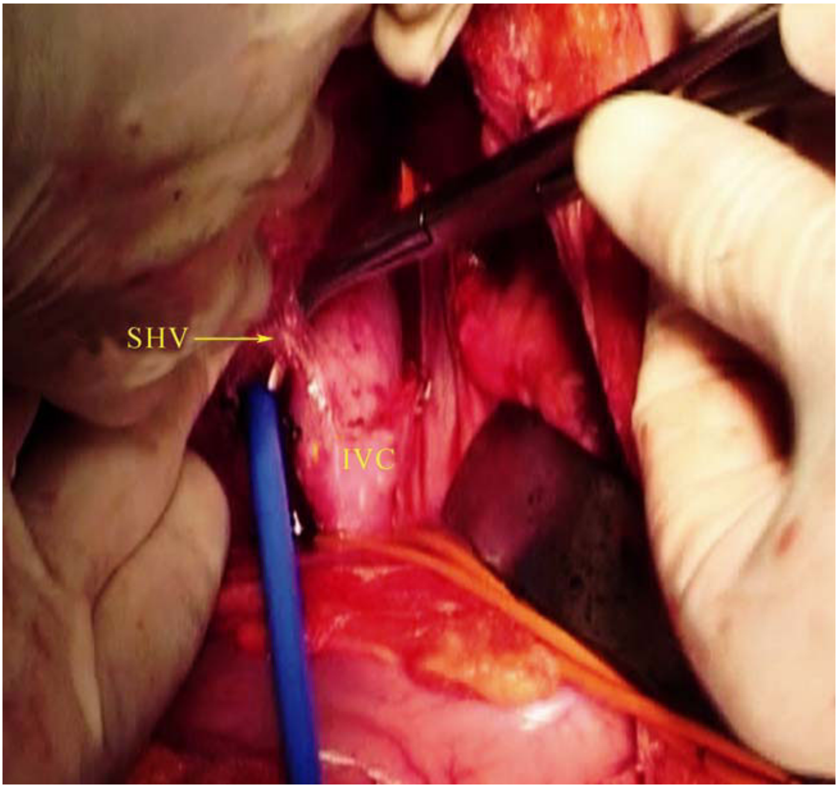


Fig.3.4. A SHV is ligated and divided from the left side

3.5.2 Detachment from the Hilum (the First Porta Hepatis)

It is advisable to start transecting the caudate process before the portal triad to the caudate process is isolated and divided. The branches to the caudate lobe (the CPTs) from the LPV and the left hepatic artery (LHA) are dissected and divided one by one, close to the base of the umbilical fissure (Figs.3.5 and 3.6).

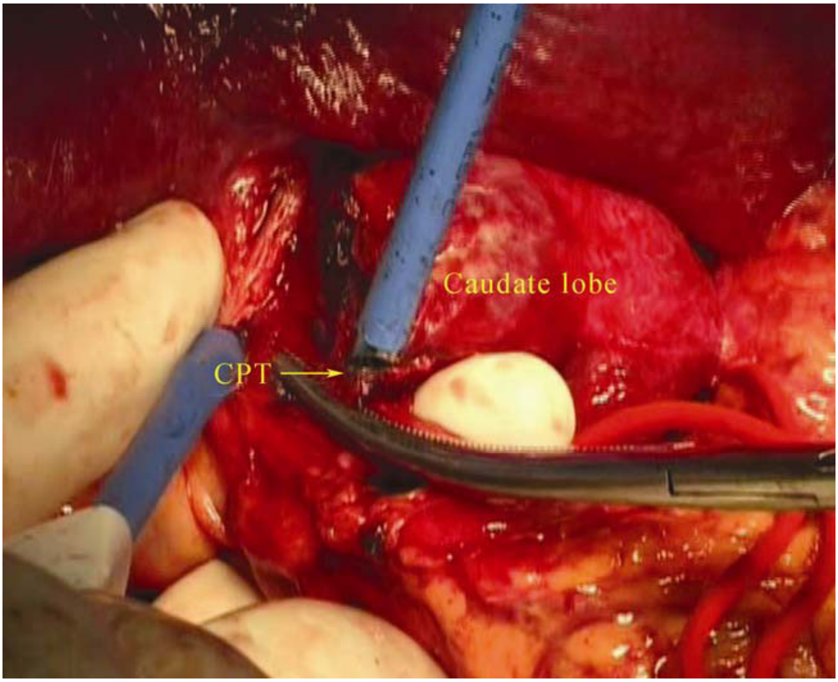


Fig.3.5. A CPT is ligated

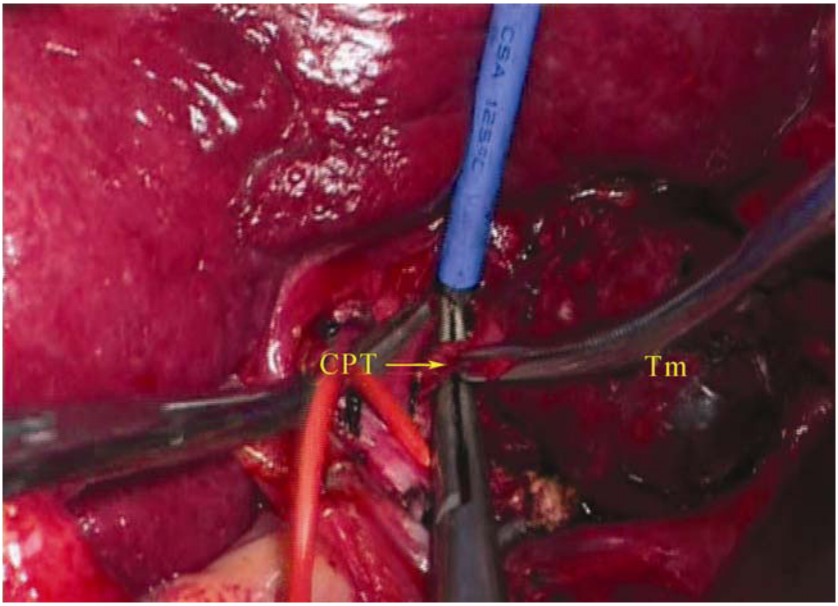


Fig.3.6. Another CPT is ligated

3.5.3 Detachment from Neighboring Liver and Hepatic Veins (the Second Porta Hepatis)

The caudate lobe is detached from the rest of the liver through the transection line which we call the tip to process line, while the transection plane is oblique, slanting from the LHV to the RPV.

Transection can be started from either end. It is easier to start from the top of the caudate lobe when the tumor is situated at the inferior part; conversely, it is easier to start inferiorly at the caudate process when the tumor (Tm) is at a more superior location. Sometimes, the transection can be started from both ends to facilitate the transaction (see videos 1 and 2).

During transection of the liver parenchyma, meticulous care should be taken not to injure the major HVs. Bleeding from these veins is very difficult to control, as the visibility is very poor. Injury to the major HVs is the major risk at this stage. If the liver parenchyma needs to be transected very close to the root of major HVs, and if these veins are inadvertently lacerated, bleeding can be controlled by temporarily excluding the HVs by pulling on the tapes which were previously positioned. Hemostasis can be achieved by suturing with 5-0 prolene.

If the tumor is closely attached to the major HVs, it is advisable to use the anterior transhepatic approach.

3.6 Isolated Resection of the Caudate Lobe by the Anterior Approach

This approach provides a better operative field than the dorsal approach by opening the midplane of the liver widely so as to expose the major HVs and the hilar plate to direct vision, thus facilitating dissection of the tumor from the major vessels, especially when there are numerous small communicating vessels among them (Peng et al., 2007).

3.6.1 Indications

When a caudate lobe tumor is larger than 6 cm, especially when it is located in the paracaval portion, or is in close contact with major HVs, the anterior transhepatic approach for an isolated caudate lobectomy is indicated.

3.6.2 Surgical Procedure

The initial steps of the operation are similar to those of isolated caudate lobectomy by the bilateral approach, as described previously. The falciform ligament is divided up to the front of the SIVC. The dissection is then directed to the right and left, dividing the coronary, triangular, and hepatorenal ligaments. The right adrenal gland is detached from the liver, and the hepatogastric ligament is completely divided. The SHVs are dissected and divided in a caudal-to-cranial direction from both the right and the left sides (Fig.3.7). In some cases where the tumor is too closely attached to the IVC, division of the SHVs has to be left until the final stage of the operation (see retrograde resection). The IIVC, SIVC, major HVs, and hepatoduodenal ligament are encircled by tapes for temporary hepatic vascular exclusion in case of need.

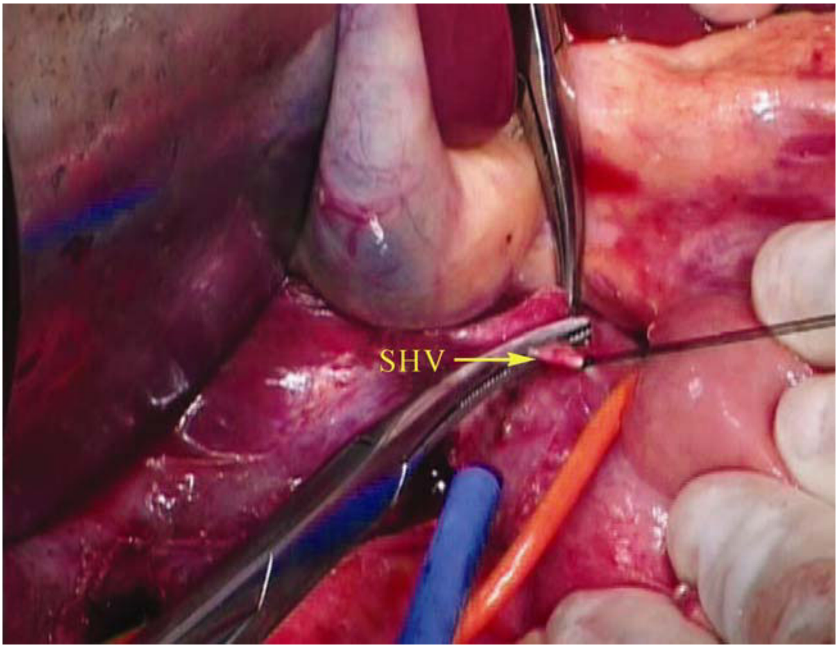


Fig.3.7. A SHV is ligated

The liver is split through the midplane. The plane of transection starts from the point between the roots of the RHV and the MHV to the fossa of the gallbladder, which should have just been removed. The transection is continued up to 1 cm from the caudate tumor as shown on intraoperative ultrasound. The transection then goes along a plane 0.5 cm from the tumor surface. The tumor capsule should be kept intact, and the major HV should be pushed away with PMOD. When the transection reaches the hilar plate at the hilum, the CPTs are isolated and divided (Fig.3.8).

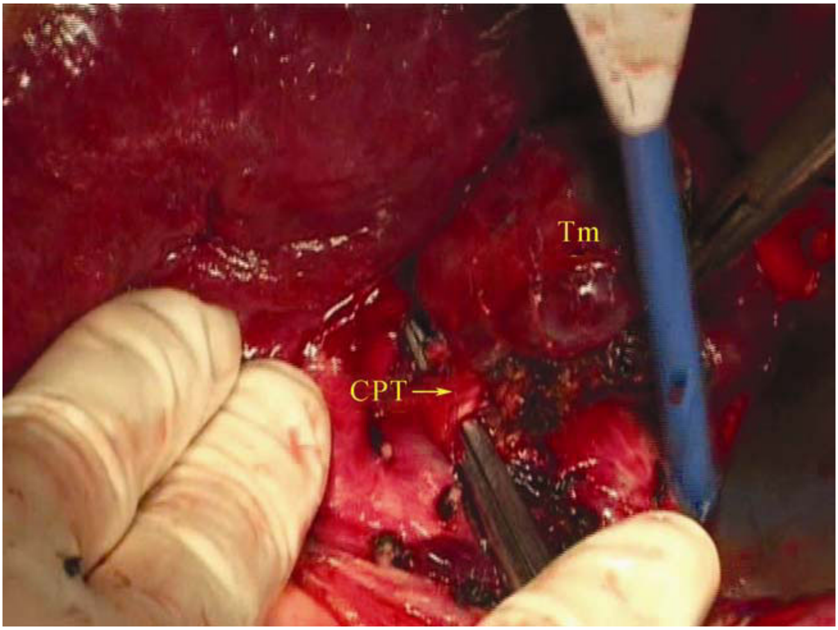


Fig.3.8. A CPT is dissected

Up to this point, the tumor has been detached from the third and first portae hepatis, *i.e.*, from the IVC and the liver pedicles. All minute vessels to the tumor are meticulously ligated and divided until the tumor is completely detached from the HVs. At this stage, the caudate lobe can be easily detached from the neighboring liver. After resection of the tumor, the MHV should be clearly seen on the cut surface of the left liver with the RHV on the right side. During parenchymal transection, Pringle's maneuver with intermittent inflow blood control should be used. When a major HV is damaged and needs to be repaired, vessel occlusion using the tapes at the roots of the major HVs is of great help to reduce blood loss. After removal of the caudate lobe, the three portae hepatis (the hilum, the confluence of the major HVs, and the retrohepatic IVC) can be clearly seen (Fig.3.9).

Any bleeding points and bile leaks on the raw liver surface are carefully controlled. The split left and right liver are sutured together to prevent internal herniation (Fig.3.10). A drain should be placed to the right side of the retrohepatic IVC. The abdomen is closed to complete the operation.

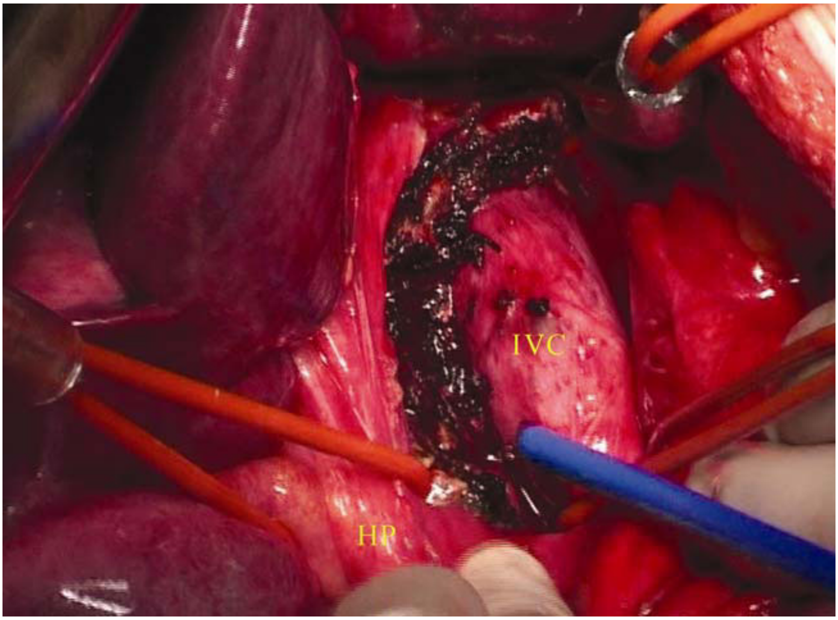


Fig.3.9. Retrohepatic IVC

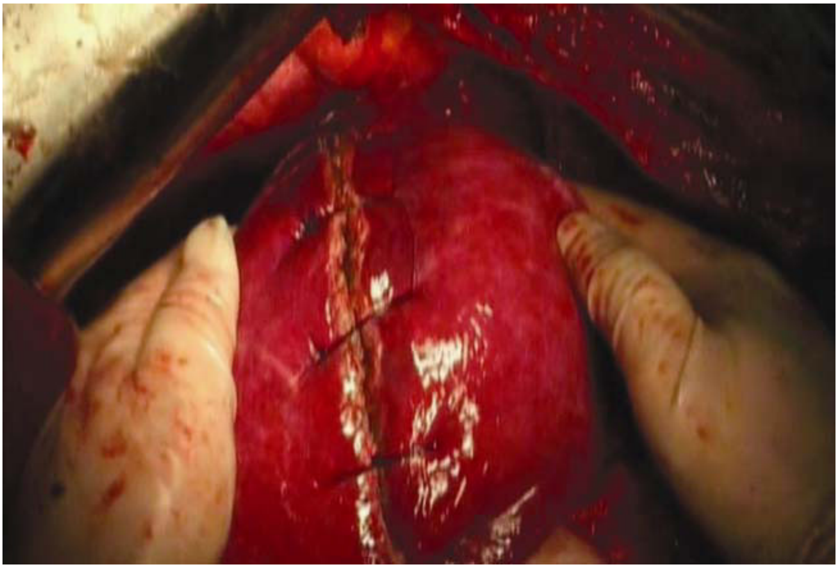


Fig.3.10. The split left and right lobes are sutured together

References

Asahara T, Dohi K, Hino H, et al. (1998) Isolated caudate lobectomy by anterior approach for hepatocellular carcinoma originating in the paracaval portion of the caudate lobe. J Hepatobiliary Pancreat Surg 5: 416-421

Asahara T, Dohi K, Katayama K, et al. (2000) Isolated caudate lobectomy for hepatocellular carcinoma: a left-sided approach. Asian J Surg 23: 115-122

K Takasaki (2007) Glissonean pedicle transection method for hepatic resection. Springer

Peng SY, Hong DF, Xu B, Wang JW, et al. (2007) The strategy of isolated complete resection of the caudate lobe of the liver through the anterior liver-splitting approach: a report of 19 cases. Zhonghua Wai Ke Za Zhi 45: 1321-1324 (In Chinese)

Peng SY, Li JT, Liu YB, et al. (2006) Surgical treatment of hepatocellular carcinoma originating from caudate lobe: a report of 39 cases. J Gastrointest Surg 10: 371-378

Yamamoto J, Kosuge T, Shimada K, et al. (1999) Anterior transhepatic approach for isolated resection of the caudate lobe of the liver. World J Surg 23: 97-101

4

Approaches to the Caudate Lobe

Hepatic caudate lobectomy is a technical challenge because of the unique anatomical location; the caudate lobe is surrounded by the first, second, and third portae hepatis, all of which consist of important and potentially dangerous structures. Recently, the surgical approach to caudate lobectomy has been gradually standardized. Approaches are mostly dependent on the size and location of the lesion as well as the severity of cirrhosis.

In the medical literature (Asahara et al., 1998; Yamamoto et al., 1999; Peng et al., 2003; Asahara et al., 2000; Shimada et al., 1994; Nagasue et al., 1997; Yang et al., 1996; Takayama and Makuuchi, 1998; Sarmiento et al., 2002), four approaches have been used for the various types of caudate lobectomy: (1) the left-sided approach, suitable for small tumors situated in the Spiegel lobe or when the caudate lobe is to be resected together with the left liver; (2) the right-sided approach, suitable for a tumor located in the caudate process or when the caudate lobe is to be resected together with the right liver; (3) the bilateral approach, a combination of the left-sided and right-sided approaches, in which the caudate lobe may be approached mainly from the right or left side, although dissection from both sides is necessary in most cases; (4) the anterior transhepatic approach, suitable only for cases when the tumor is closely in contact with the major HVs, or when the tumor is huge and especially when it is also in close contact with the IVC, thus preventing the liver from being turned from one side to the other. This operation using the anterior transhepatic approach is most suitable for patients in whom noncancerous liver parenchyma should be preserved as much as possible due to cirrhosis. In this approach, the liver is split into two halves through the midplane, thus the caudate lobe as well as the first, second, and third portae hepatis being fully exposed.

4.1 Left-sided Approach

The left-sided approach used to be suitable for small tumors situated in the Spiegel lobe or when the caudate lobe was to be resected together with the left liver. However, in recent years, it has become a frequently used approach, even when the tumor is as large as 5 cm, although Asahara et al. (1998; 2000) suggested that only if the tumor size was less than 3 cm, could the left-sided approach be performed for an isolated caudate lobectomy.

After all the SHVs on the left side are divided, the liver can be turned to the right and lifted forward, so that the SHVs on the right side can also be well dissected and divided.

4.1.1 Purely Left Approach for Metastasis from Colonic Cancer

The metastatic lesion in this case is not very large, so the isolated complete resection of the caudate lobe can be carried out purely by the left approach without disturbing the right lobe (Figs.4.1-4.15, see video 3).

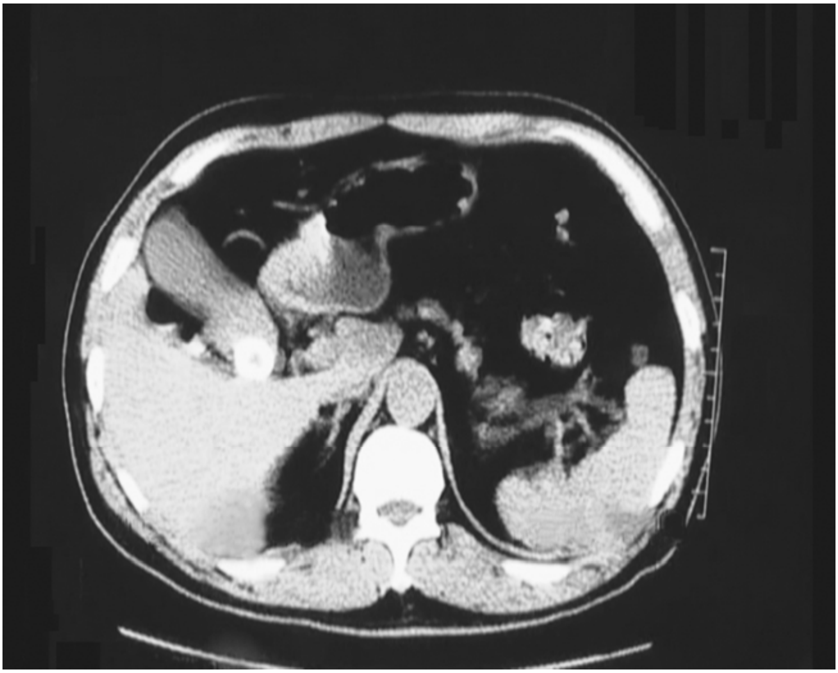
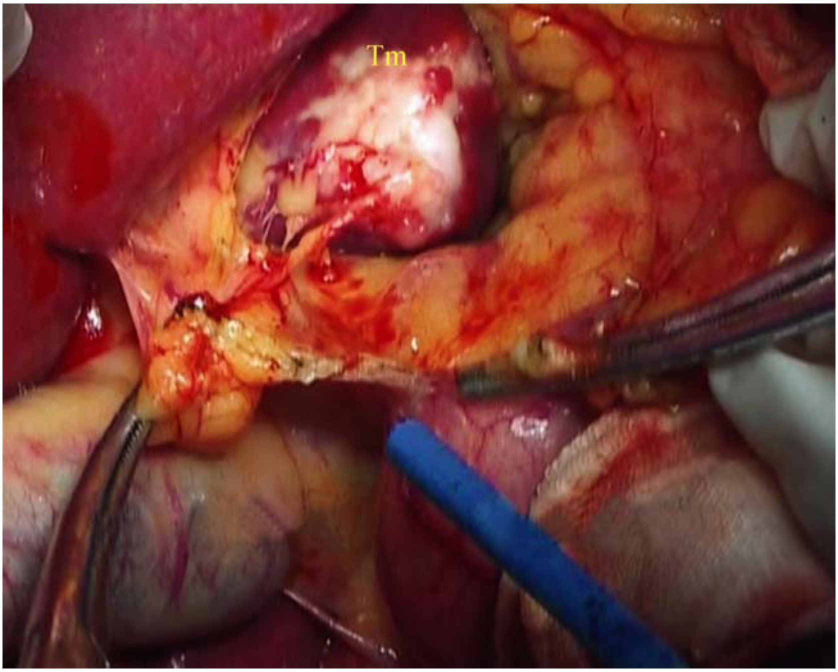
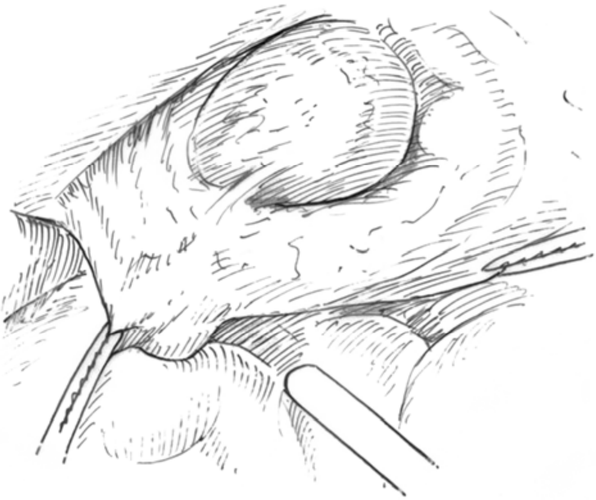


Fig.4.1. CT showing a tumor situated in the caudate lobe

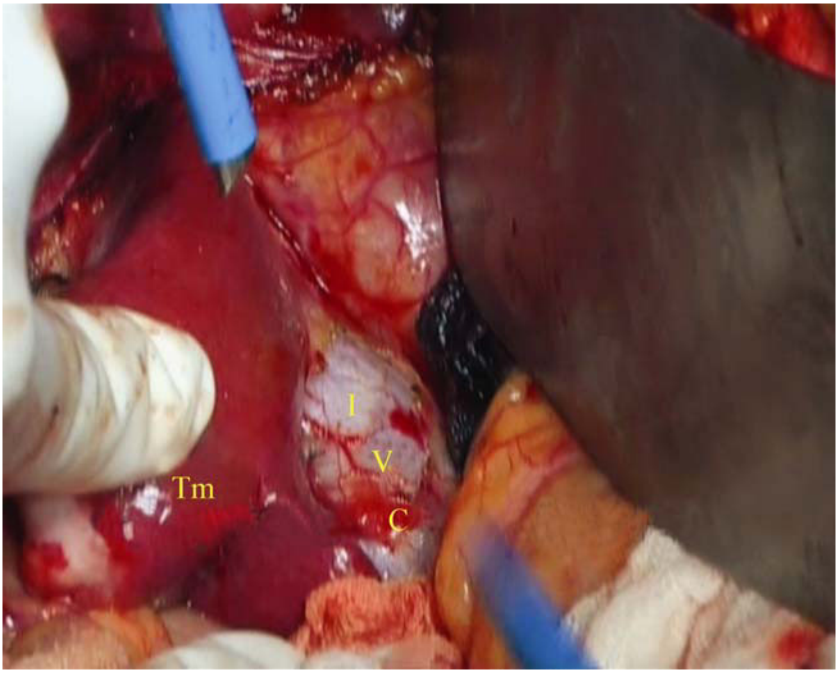


(a)

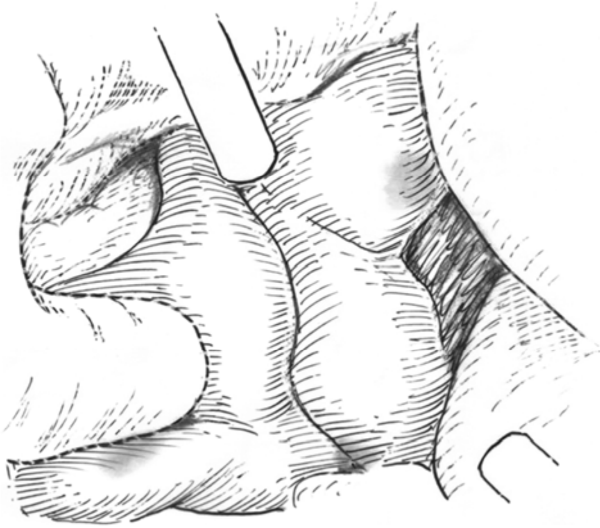


(b)

Fig.4.2. Metastatic caudate tumor in the lesser sac.
(a) Photograph; (b) Drawing



(a)



(b)

Fig.4.3. Fascia covering IVC and the caudate lobe is incised.
(a) Photograph; (b) Drawing

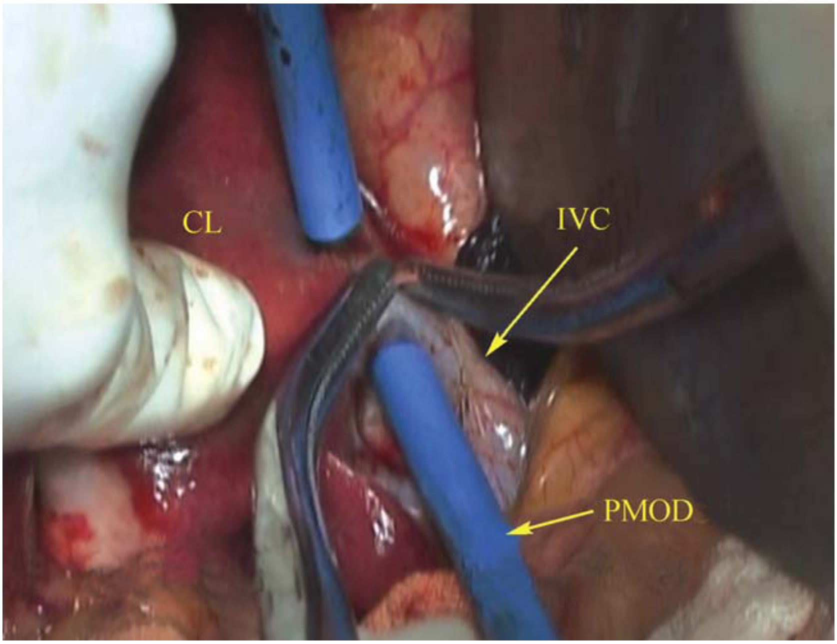


Fig.4.4. Left lower pole of the caudate lobe is raised from the IVC

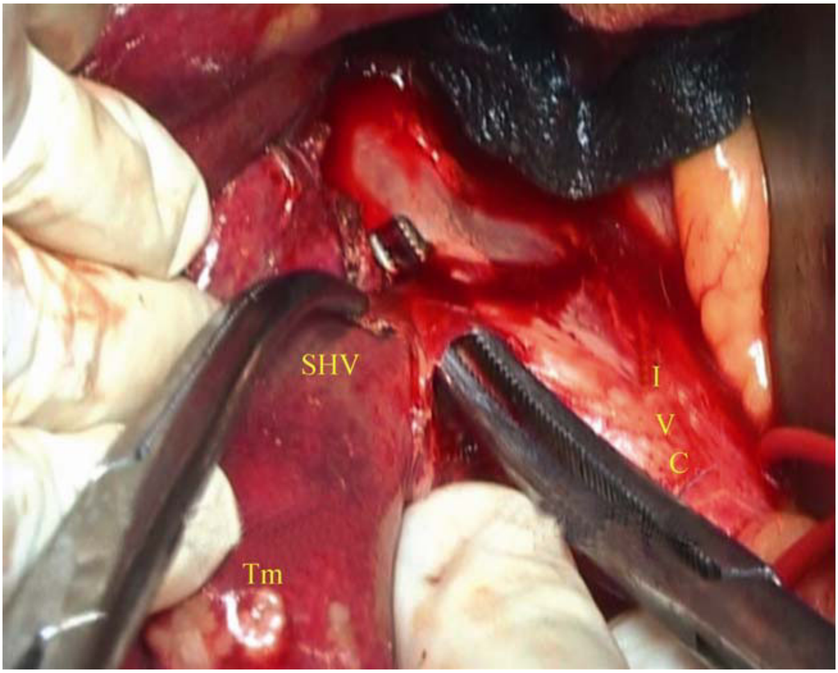
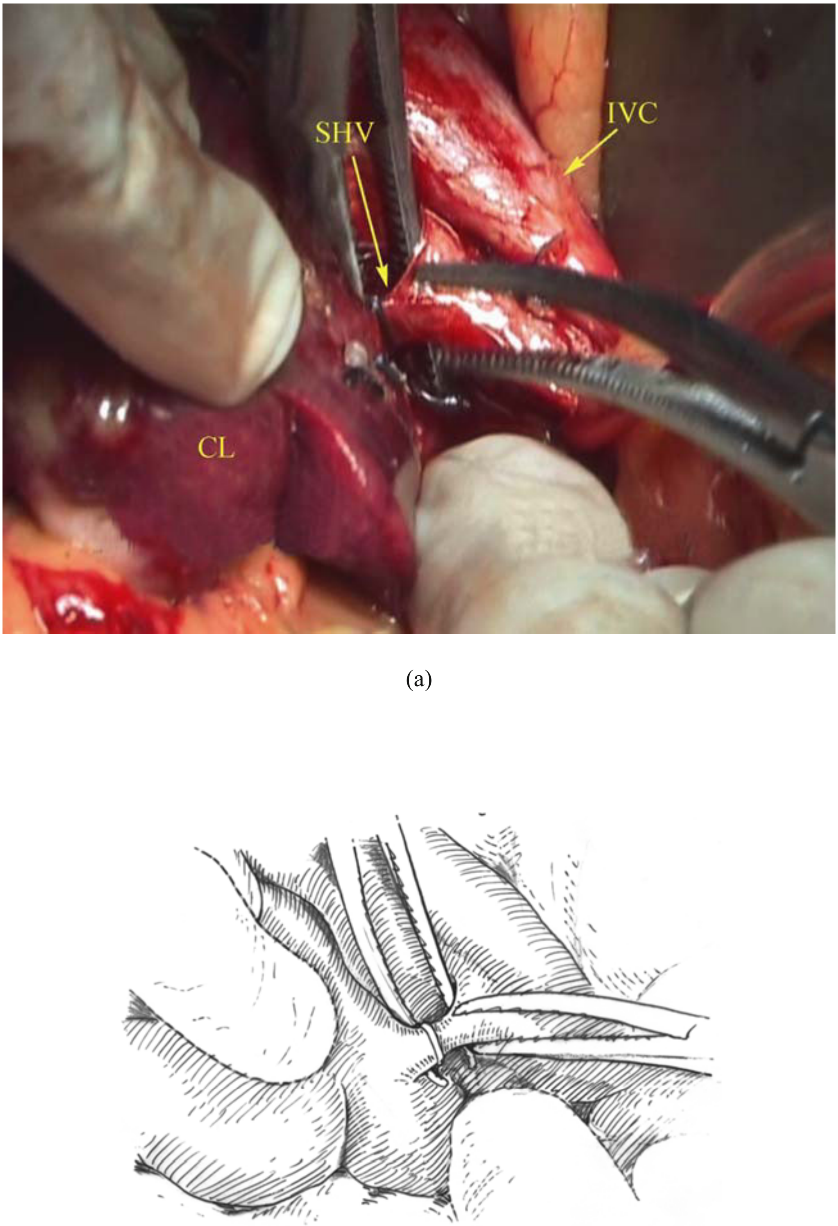


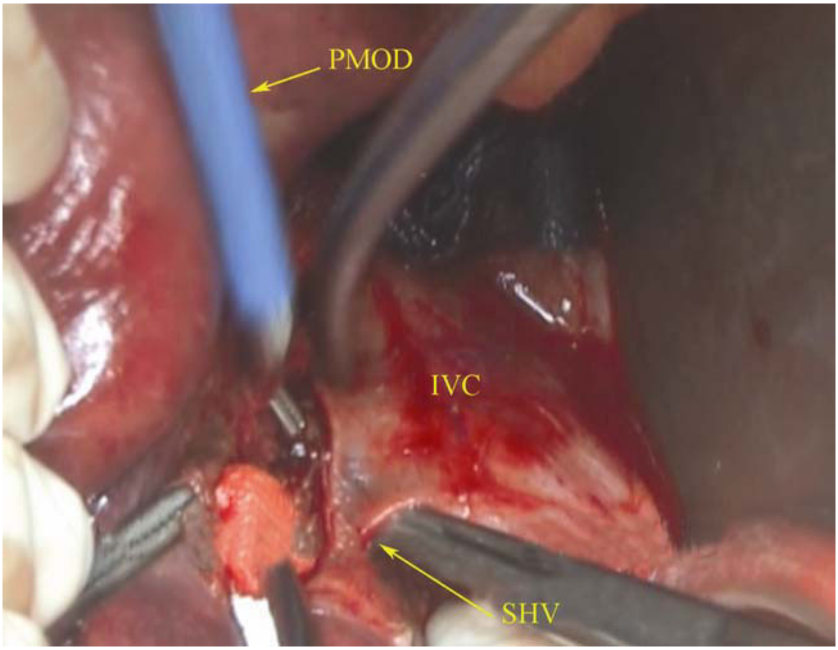
Fig.4.5. A SHV is isolated



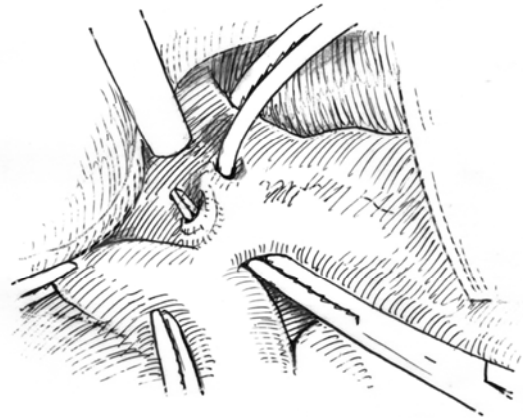
(a)

(b)

Fig.4.6. A large SHV is divided.
(a) Photograph; (b) Drawing

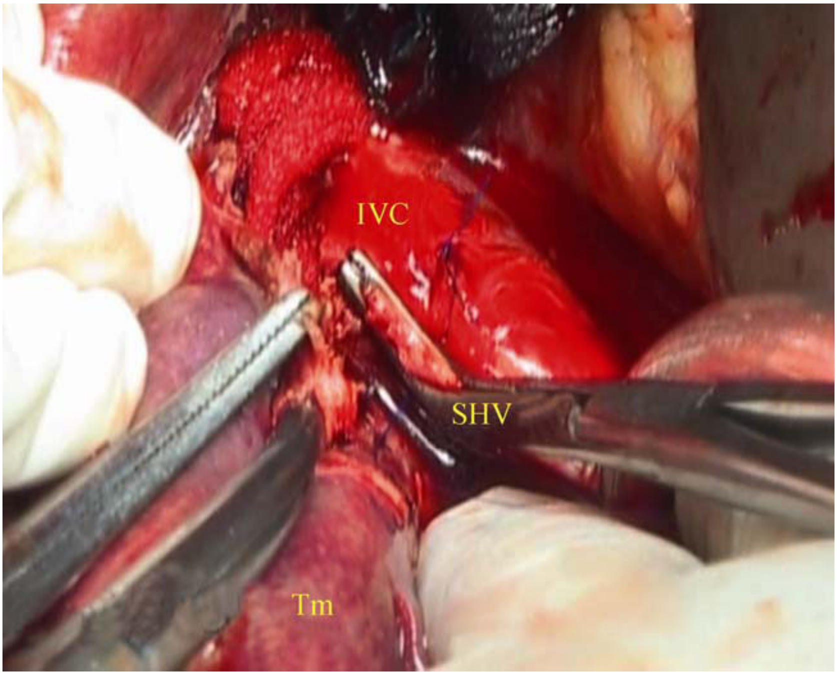


(a)

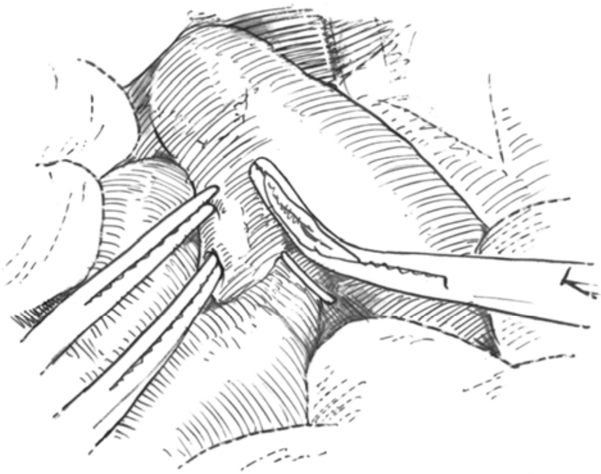


(b)

Fig.4.7. One more large SHV is ready to be divided.
(a) Photograph; (b) Drawing



(a)



(b)

Fig.4.8. The stump of a large SHV is sutured. (a) Photograph; (b) Drawing

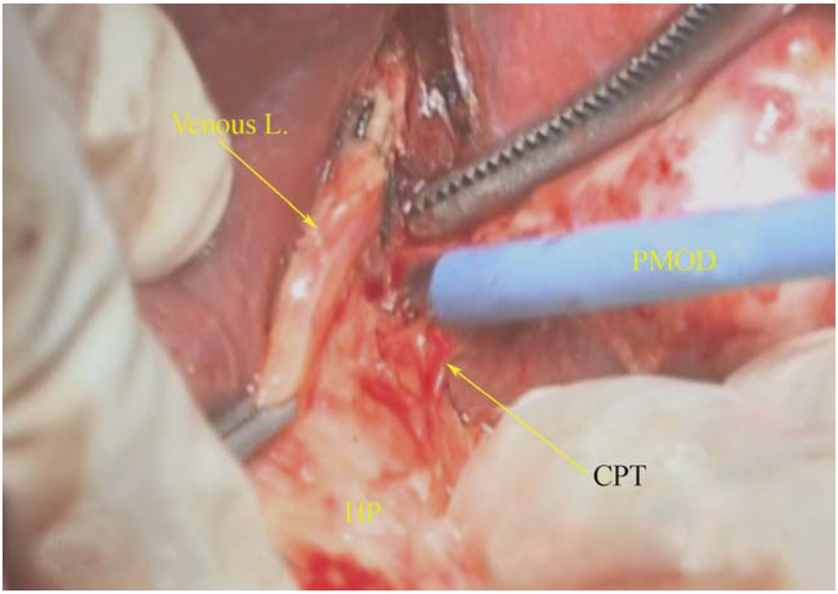


Fig.4.9. A CPT is isolated

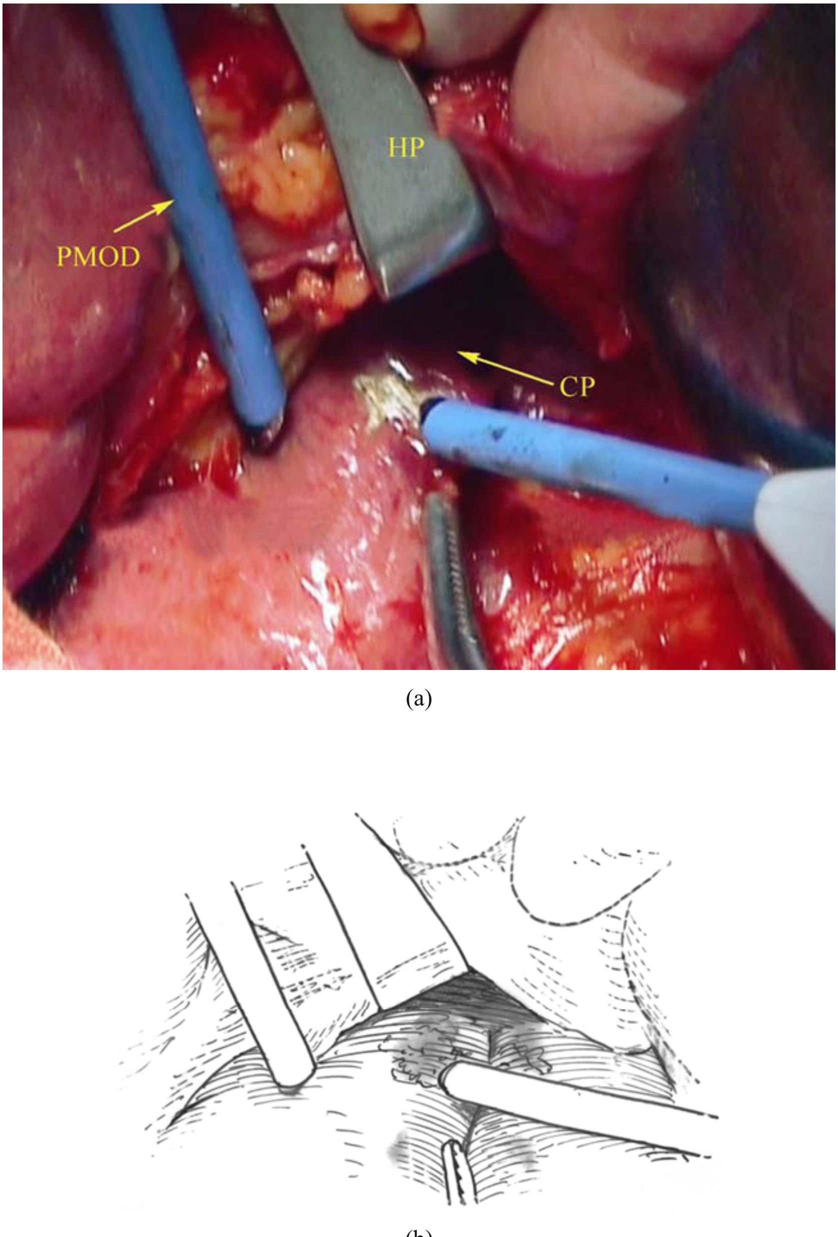
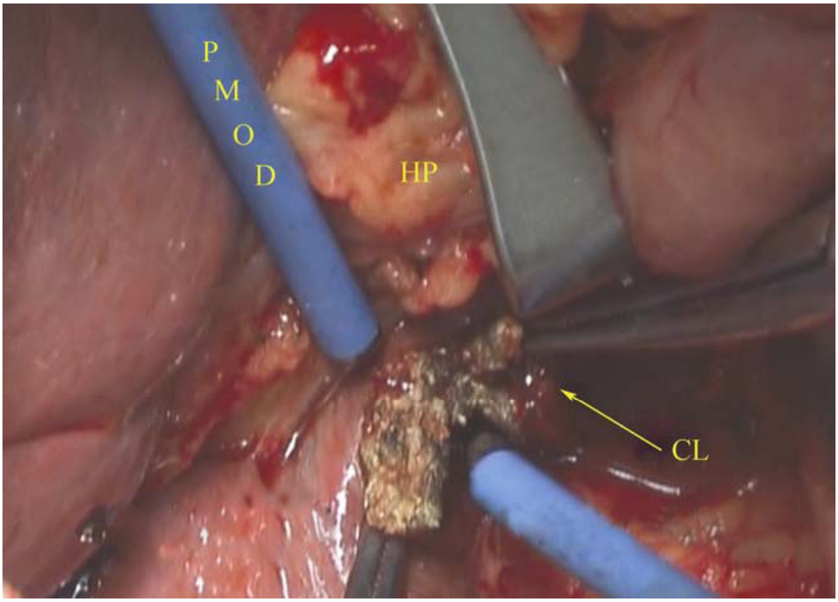
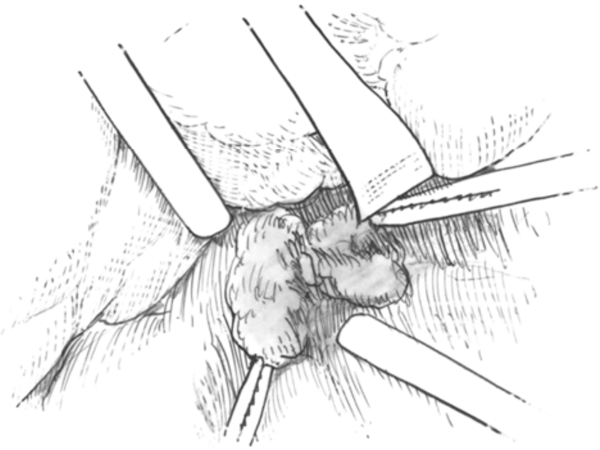


Fig.4.10. Caudate lobe transection of the caudate process is started. (a) Photograph; (b) Drawing

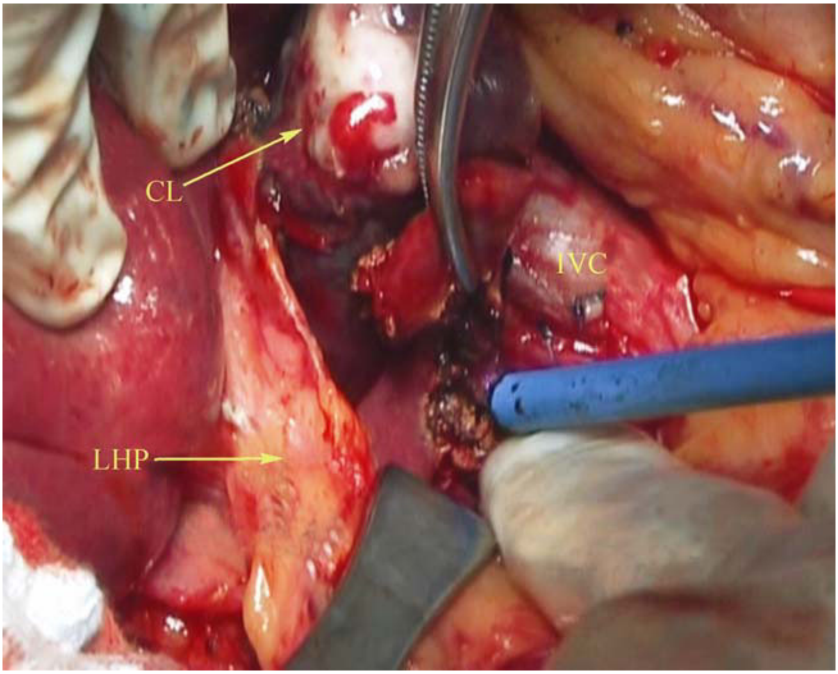


(a)

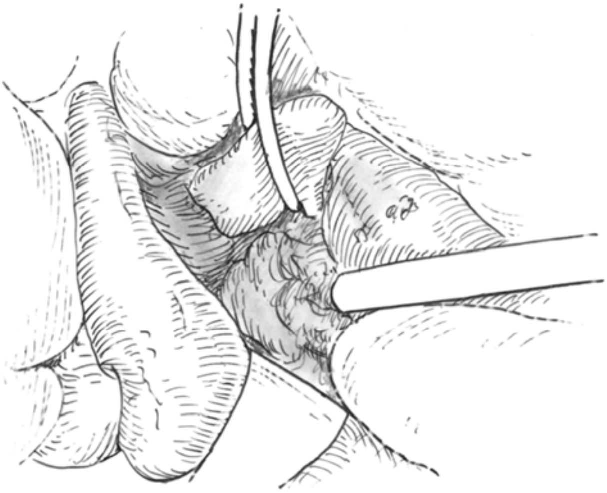


(b)

Fig.4.11. Transecting cranially until close to the RPV before the caudate is pushed to the left of the liver pedicle to continue transection.
(a) Photograph; (b) Drawing

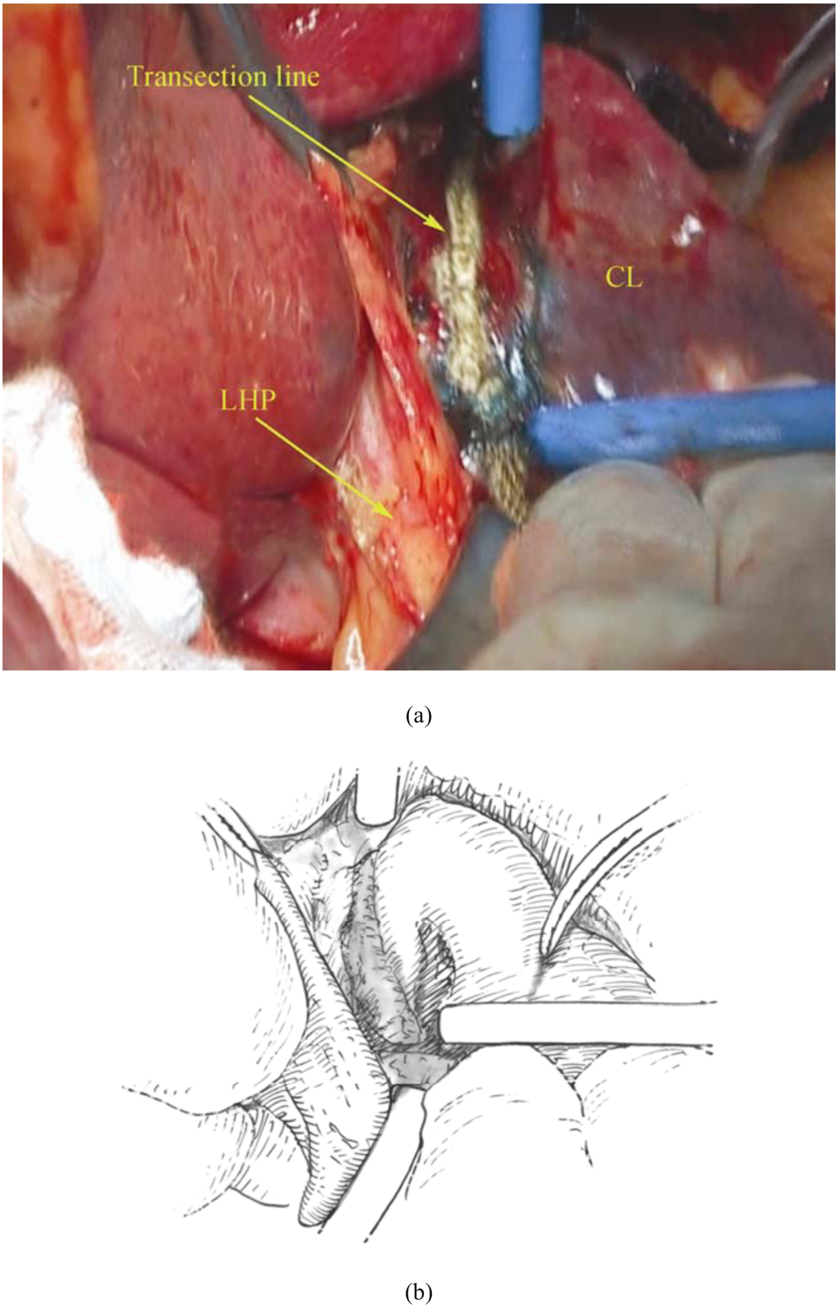


(a)



(b)

Fig.4.12. Transection is continued on the left side of the liver pedicle. (a) Photograph; (b) Drawing



(a)

(b)

Fig.4.13. Transection line from process to tip.
(a) Photograph; (b) Drawing

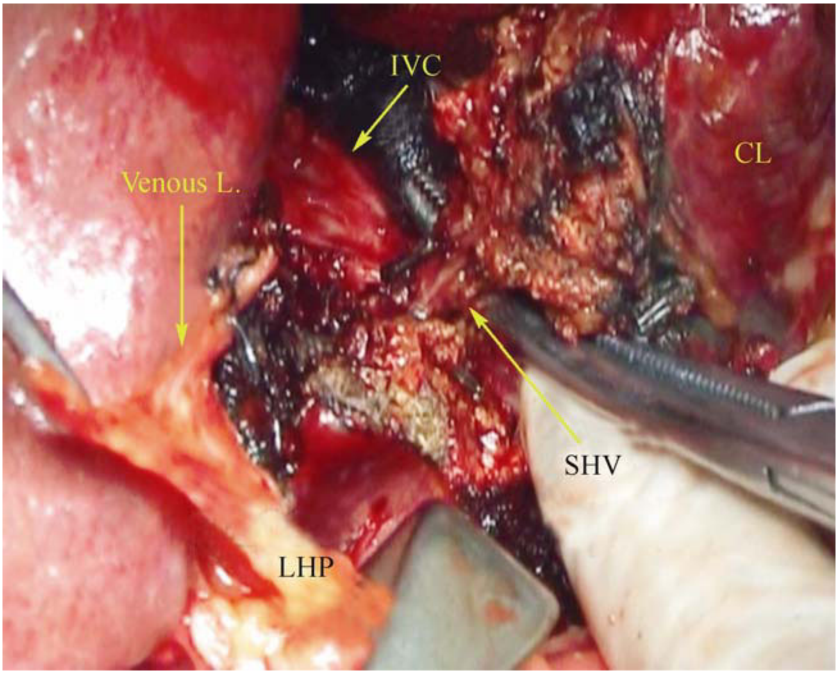


Fig.4.14. A SHV is dissected

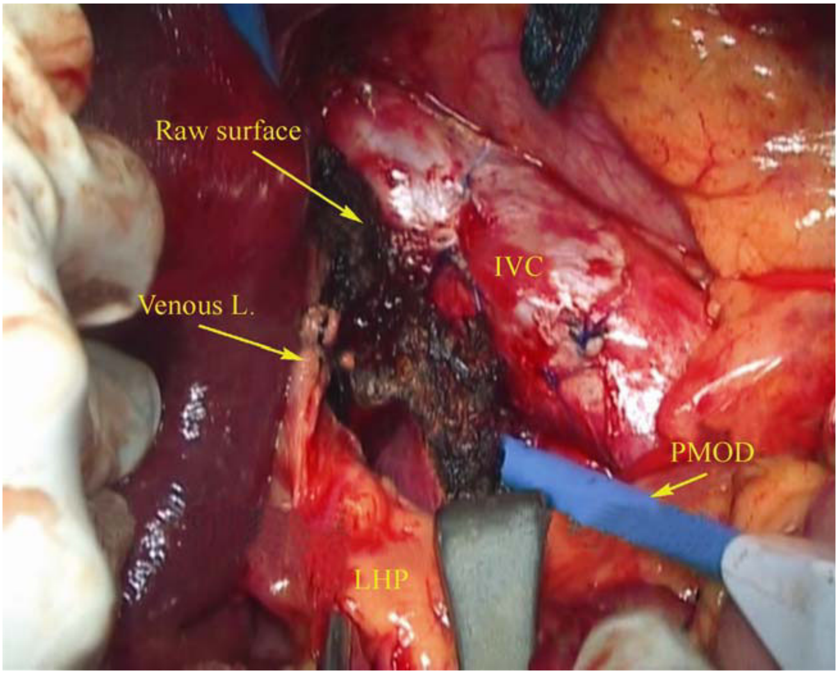


Fig.4.15. Tumor was removed, and retrohepatic IVC is fully exposed

4.2 Right-sided Approach

The right-sided approach is rarely used. Theoretically, it is suitable for a tumor located in the caudate process or when the caudate lobe is resected together with the right liver, mostly in right hemihepatectomy. However, right hemihepatectomy usually also requires mobilization of the left lobe for safe transection. While using this approach, a tumor originating in the caudate process might be difficult and risky to resect, unless the tumor is very small or is out-growing from the margin.

4.3 Bilateral (Combined) Approach

The the most frequently used bilateral approach is a combination of the left-sided and right-sided approaches. The caudate lobe may be approached mainly from the right or left side, although dissection from both sides is necessary in many cases.

4.3.1 Combined Approach for Metastasis from Gallbladder Carcinoma

This is a very difficult case. Previously the patient underwent a radical operation for gallbladder carcinoma, in which skeletonization of the hepatoduodenal ligament was carried out, resulting in the formation of dense adhesions around the hepatic pedicle including the portal vein (PV), which was damaged during isolation of the tumor. Suddenly sizable bleeding might occur. This case demonstrates how the hemorrhage is checked and stopped (Figs.4.16-4.47, see video 4).

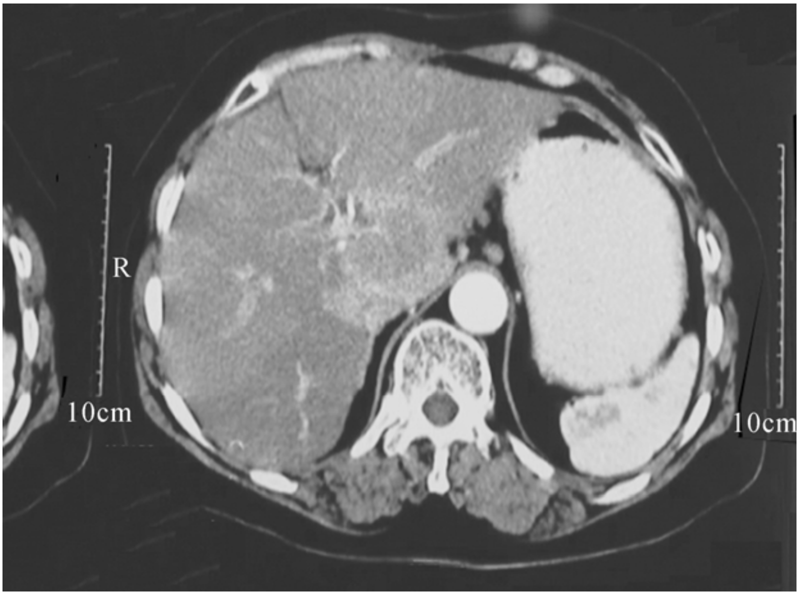
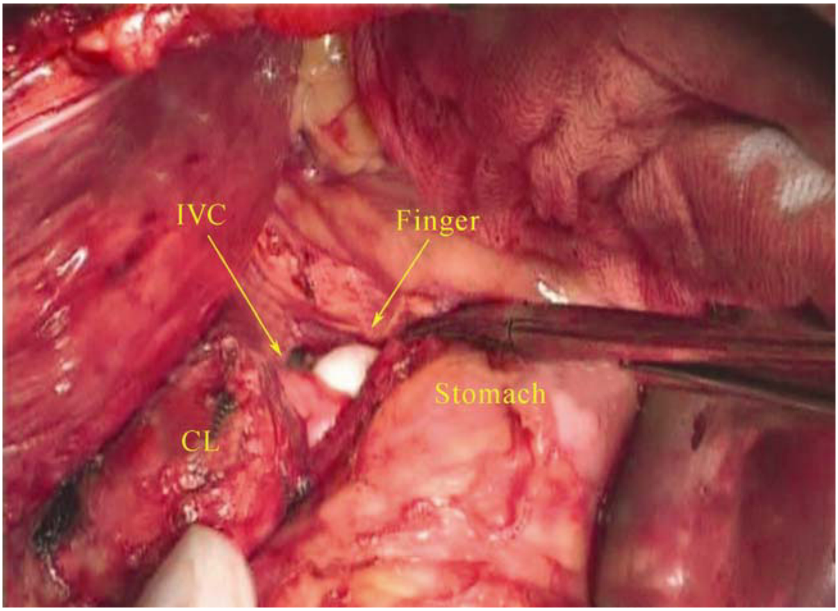
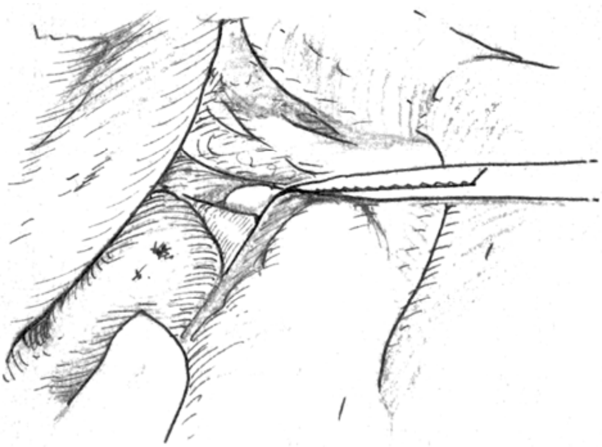


Fig.4.16. CT showing the tumor is closely attached to the PV

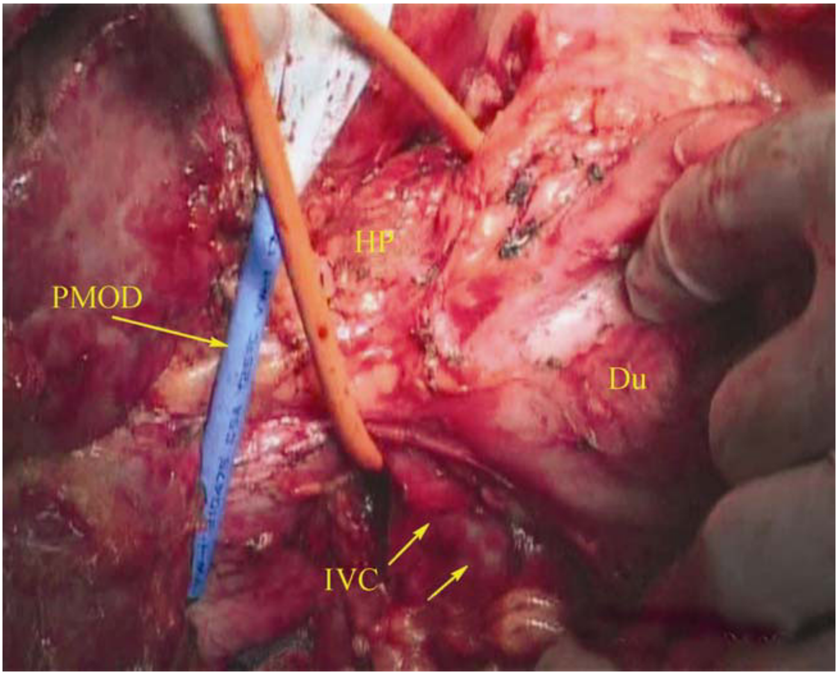


(a)

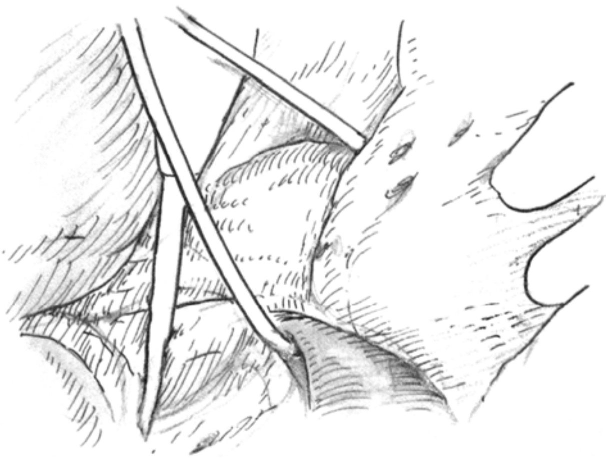


(b)

Fig.4.17. The tip of a finger through the retrohepatic IVC space appears on the left side of the IVC.
(a) Photograph; (b) Drawing

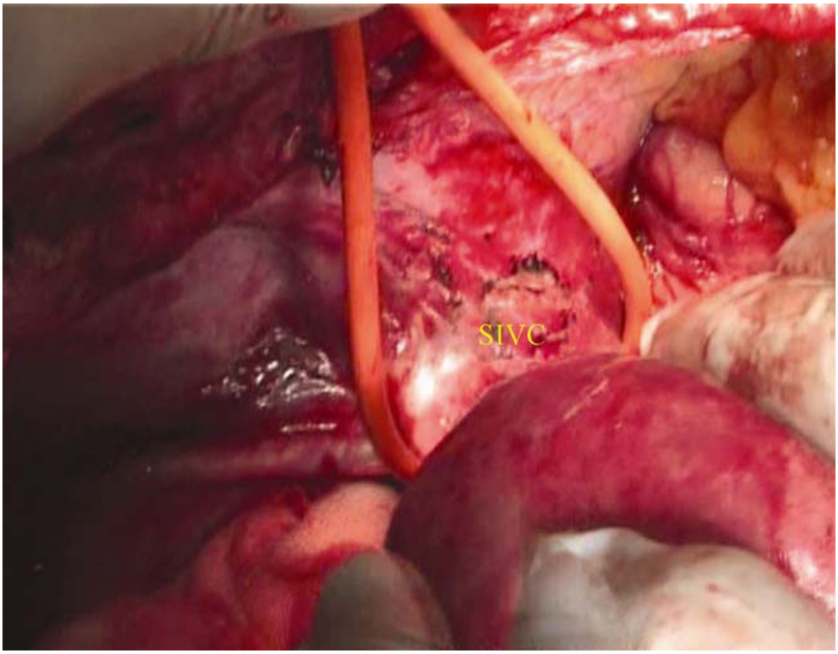


(a)

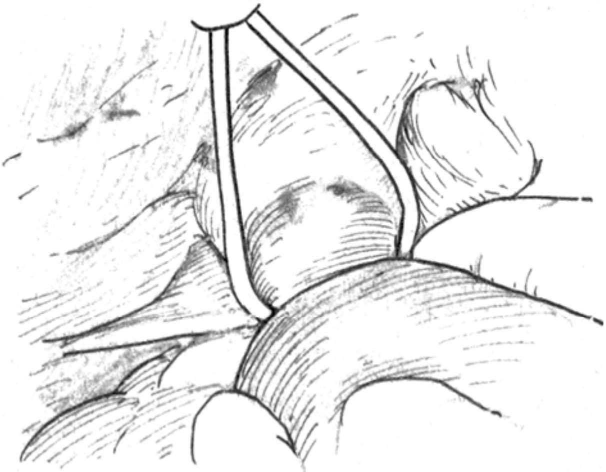


(b)

Fig.4.18. IVC is taped together with the liver pedicle. (a) Photograph; (b) Drawing

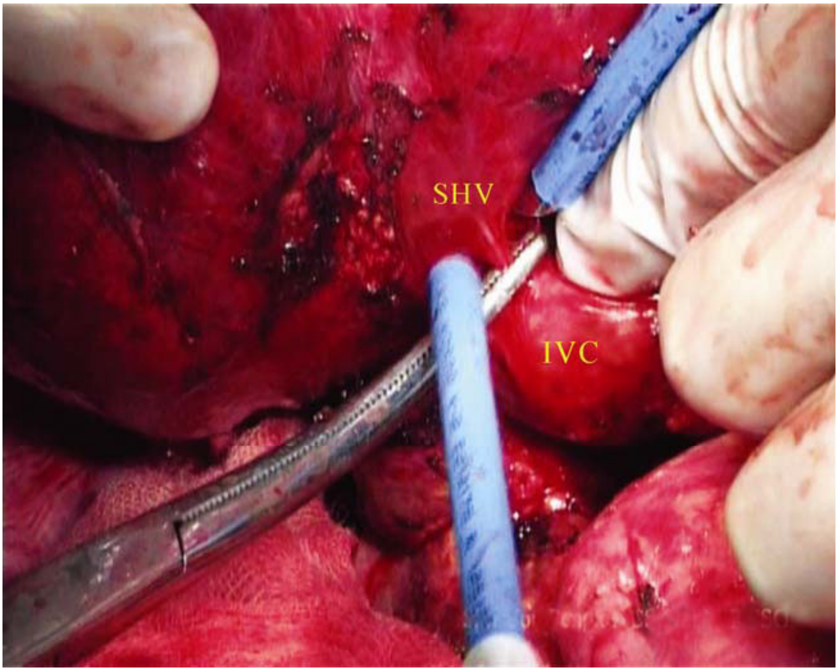


(a)

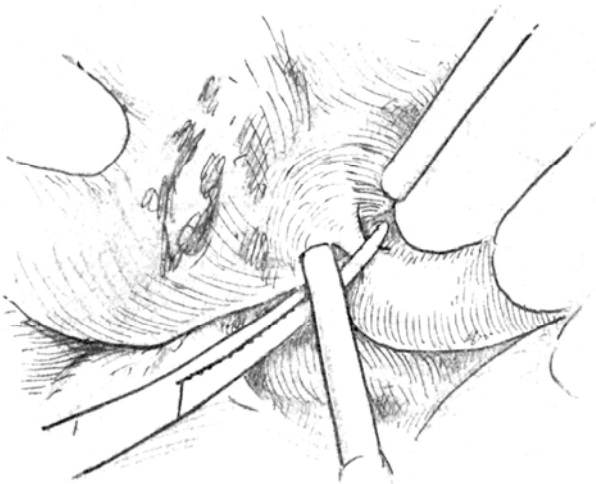


(b)

Fig.4.19. SIVC is taped.
(a) Photograph; (b) Drawing

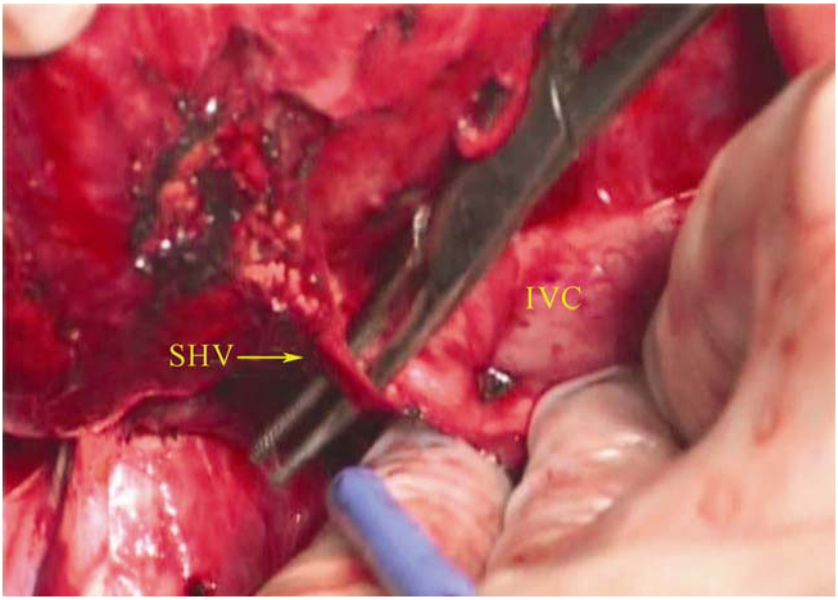


(a)

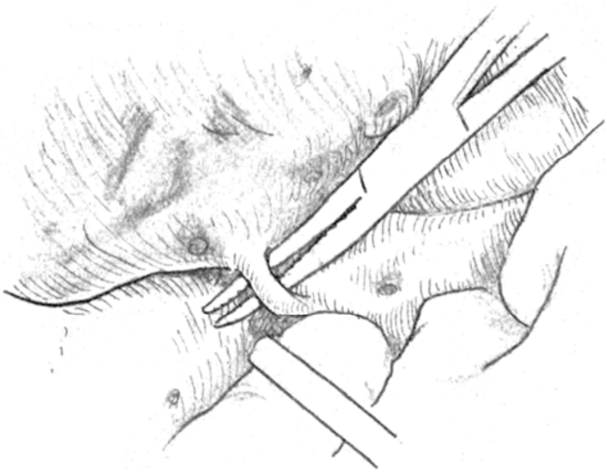


(b)

Fig.4.20. A SHV between caudate process and IVC is isolated and divided. (a) Photograph; (b) Drawing

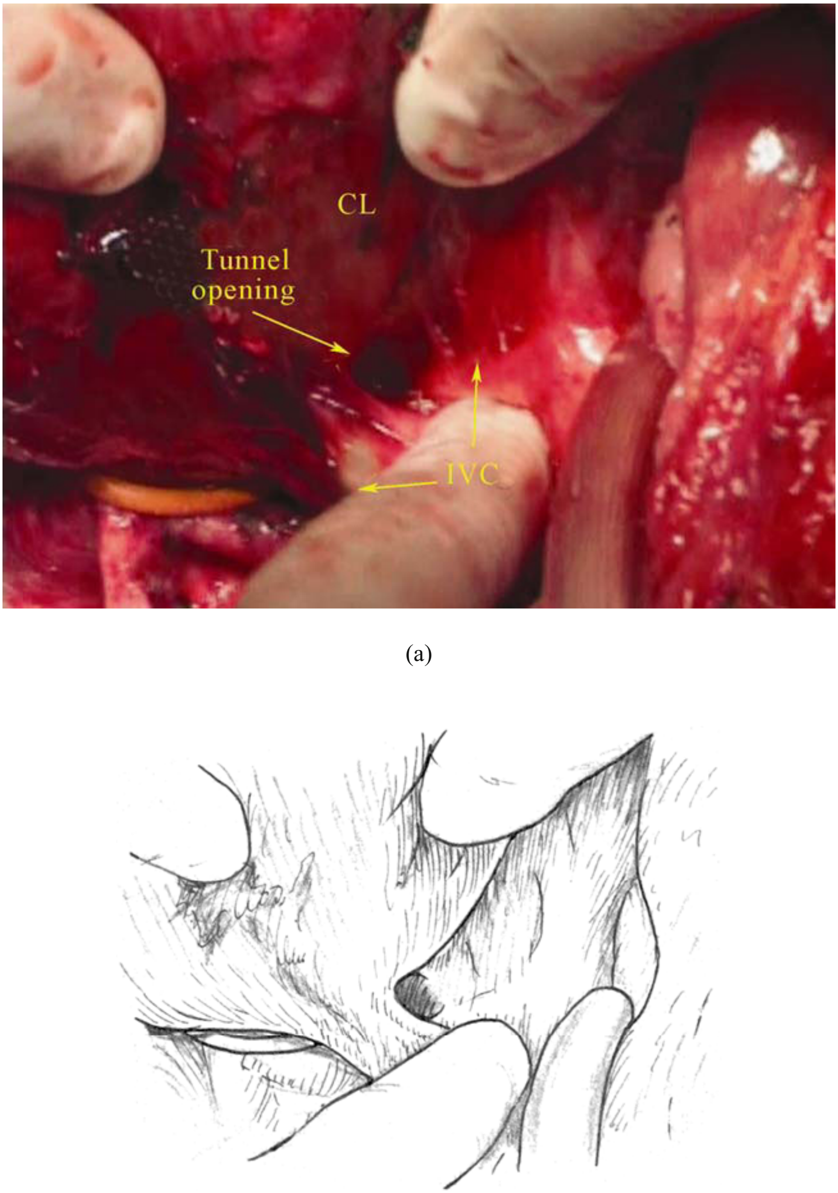


(a)



(b)

Fig.4.21. One more SHV is isolated and divided.
(a) Photograph; (b) Drawing



(a)

(b)

Fig.4.22. Lower opening of the retrohepatic tunnel. (a) Photograph; (b) Drawing

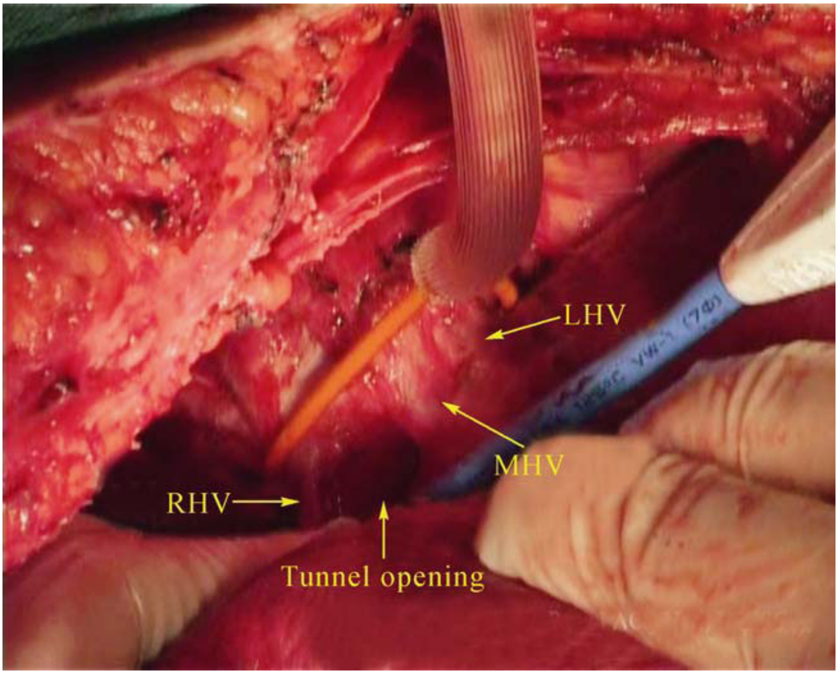
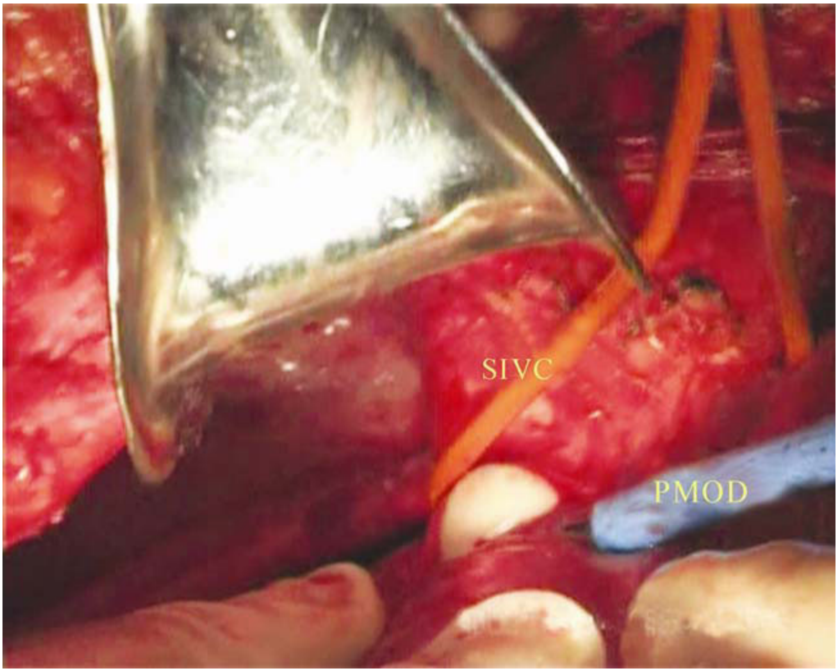
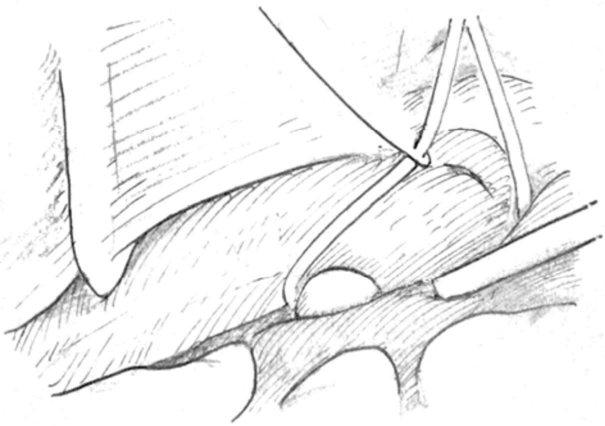


Fig.4.23. Upper opening of the retrohepatic tunnel between the RHV and MHV

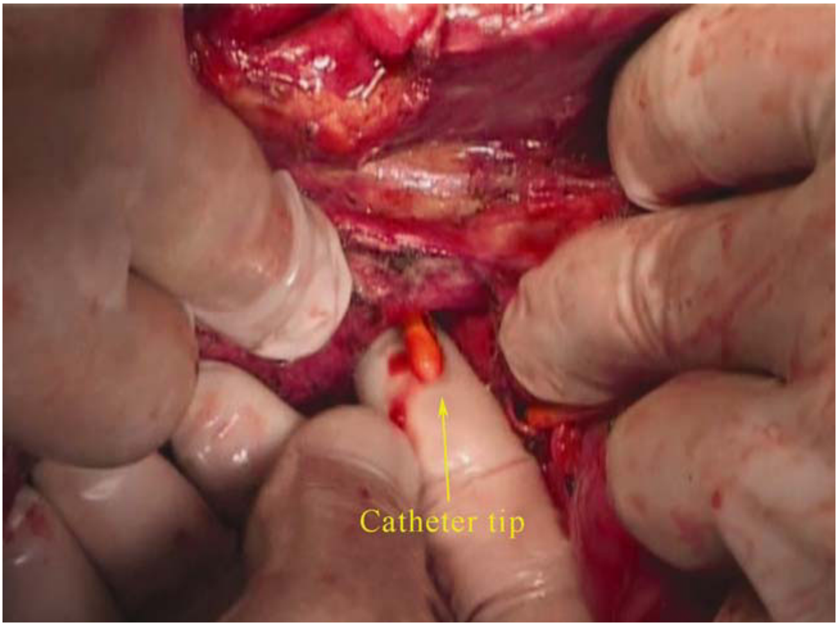


(a)



(b)

Fig.4.24. Fingertip through the tunnel appears at the upper opening. (a) Photograph; (b) Drawing



(a)

(b)

Fig.4.25. The tip of a catheter through the tunnel appears at the lower opening of the tunnel.
(a) Photograph; (b) Drawing

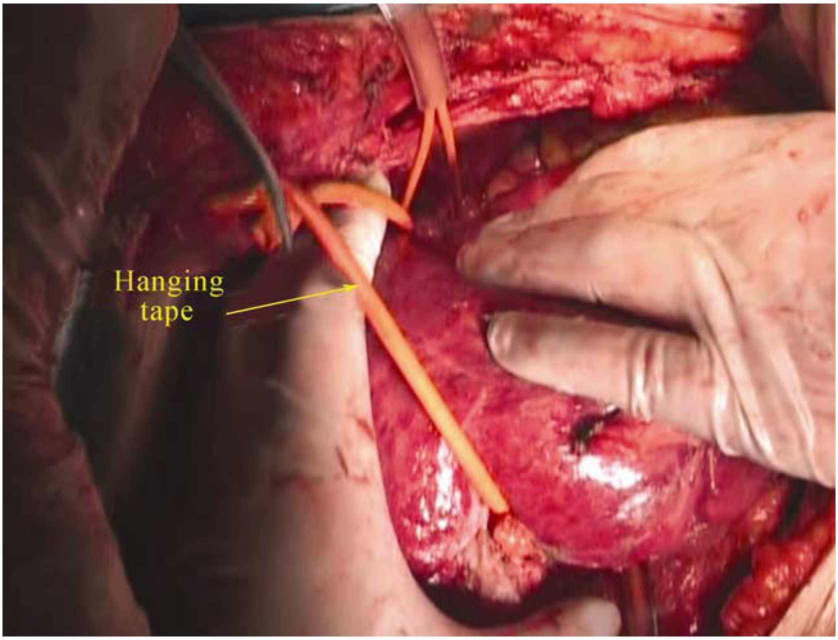
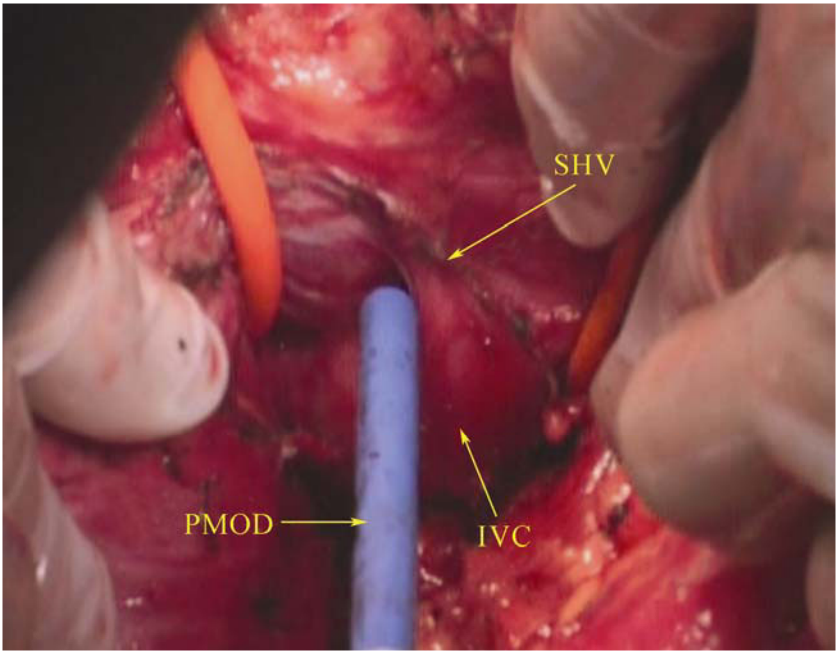
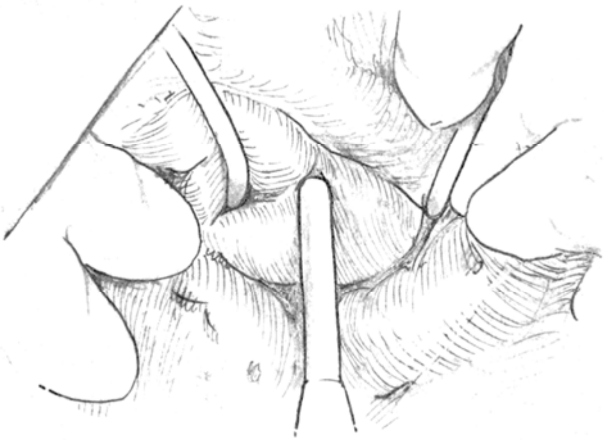


Fig.4.26. Liver hanging catheter is ready for use

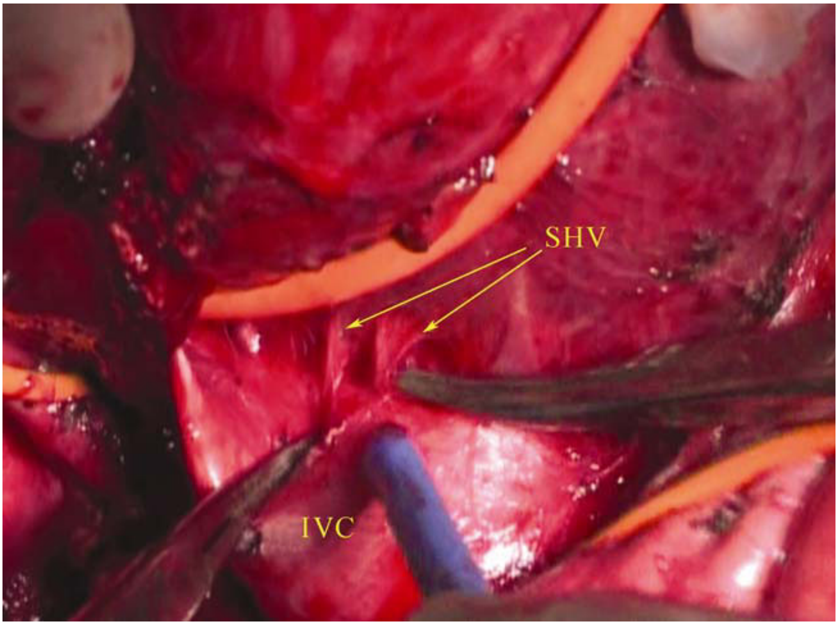


(a)

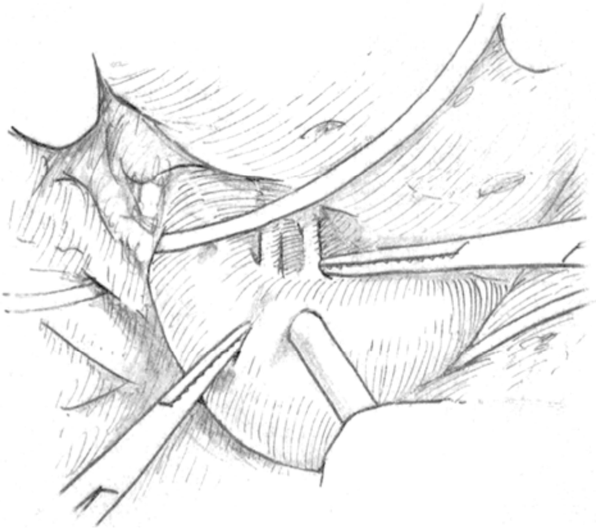


(b)

Fig.4.27. Liver is lifted forward with this hanging catheter. (a) Photograph; (b) Drawing

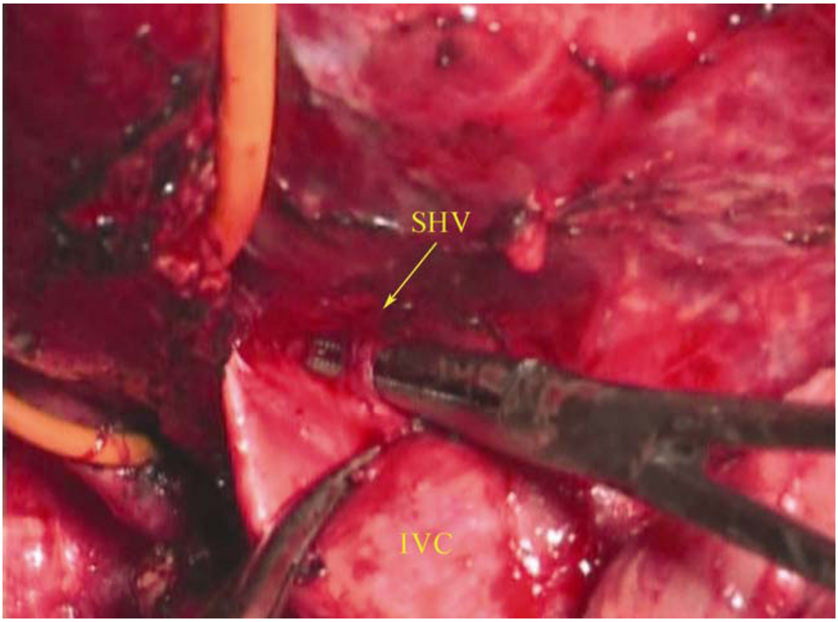


(a)

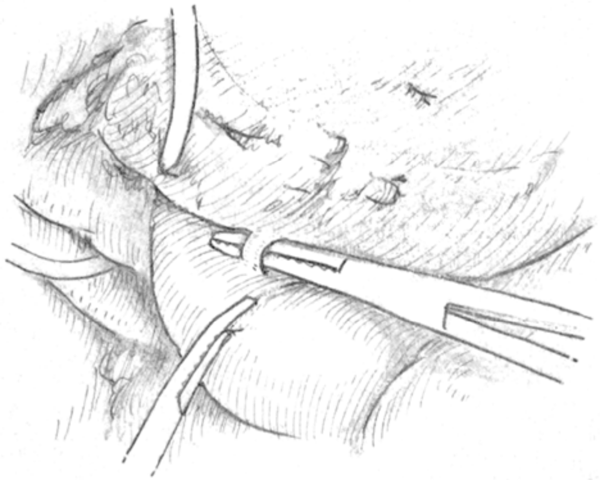


(b)

Fig.4.28. Two SHVs are visible.
(a) Photograph; (b) Drawing

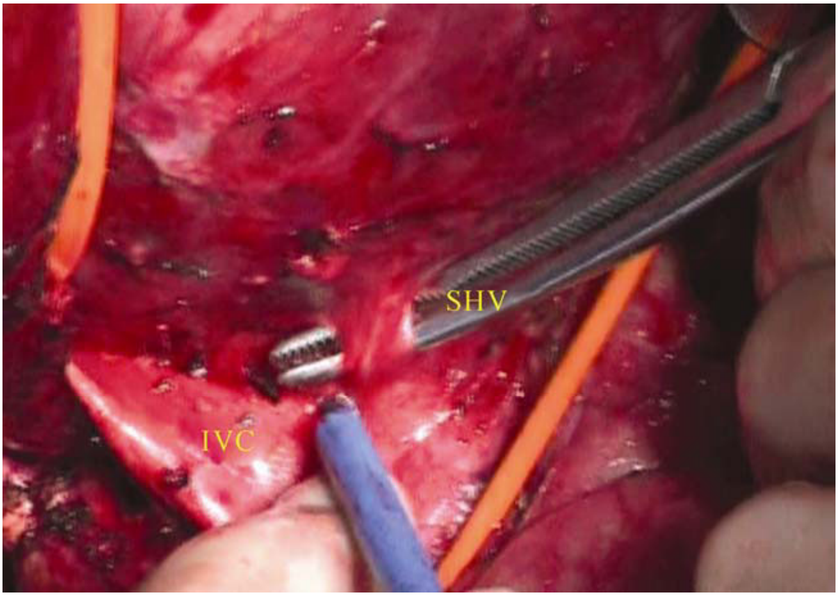


(a)

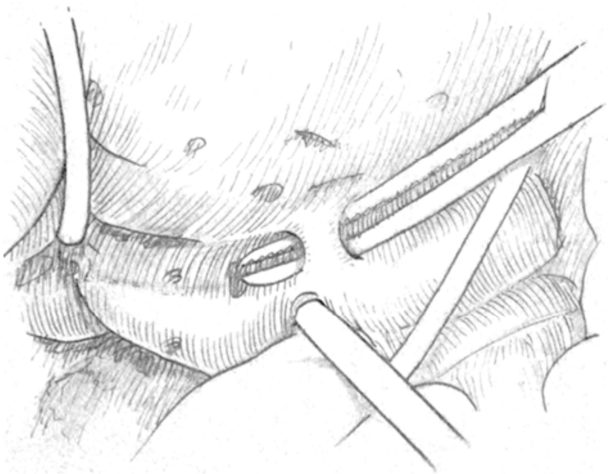


(b)

Fig.4.29. A SHV is isolated and divided.
(a) Photograph; (b) Drawing

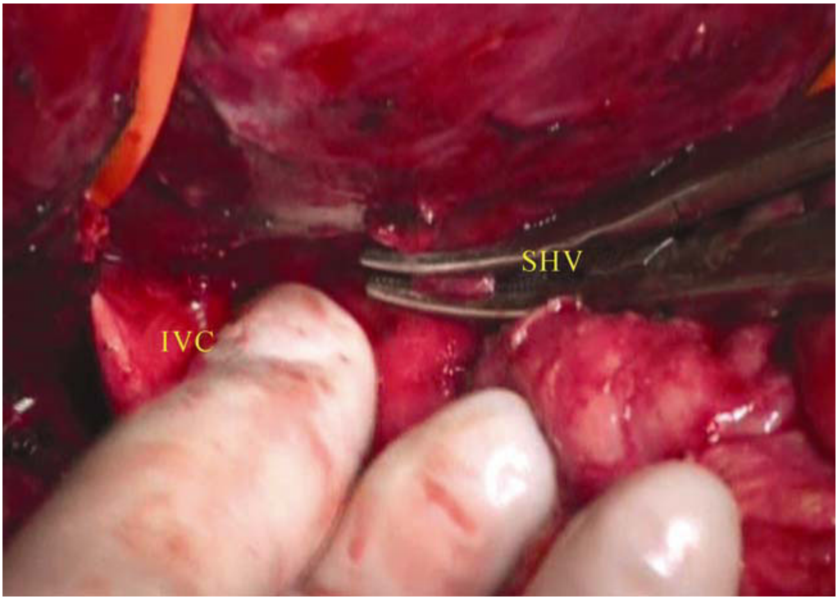


(a)

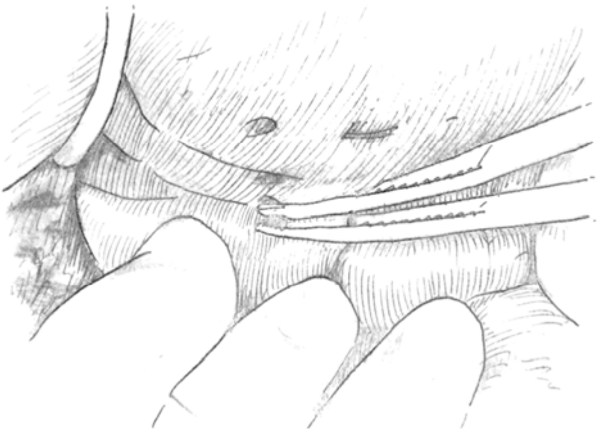


(b)

Fig.4.30. A large SHV is dissected.
(a) Photograph; (b) Drawing

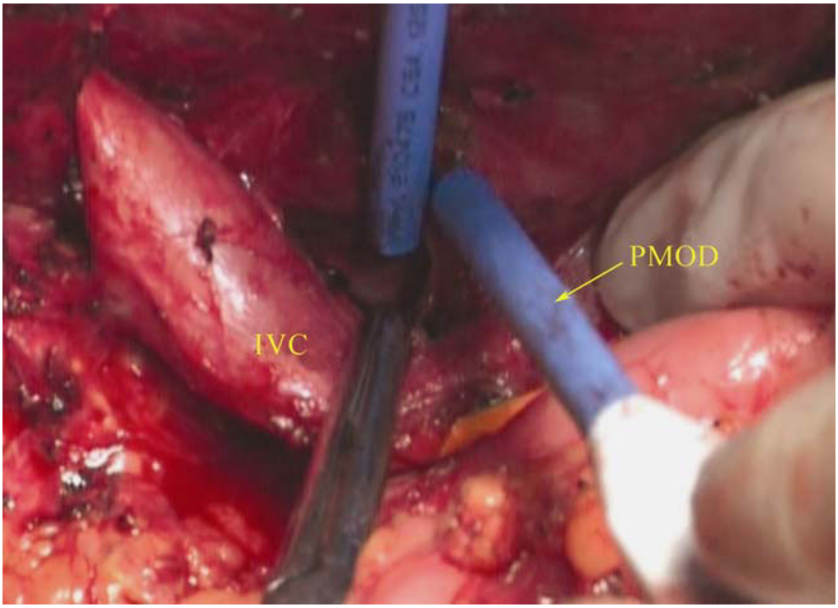


(a)

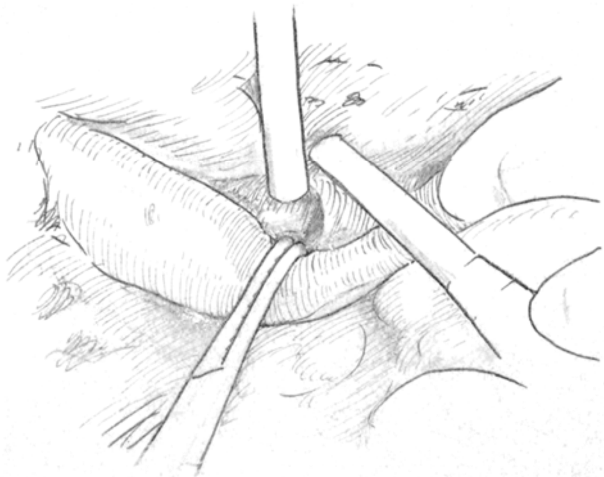


(b)

Fig.4.31. SHV is long enough to apply clamps for division.
(a) Photograph; (b) Drawing



(a)



(b)

Fig.4.32. IVC is dissected circumferentially.
(a) Photograph; (b) Drawing

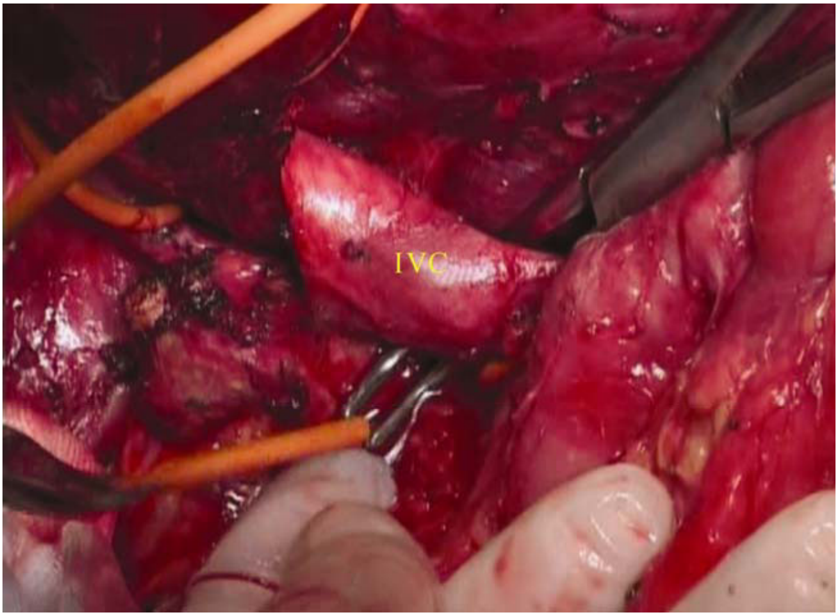
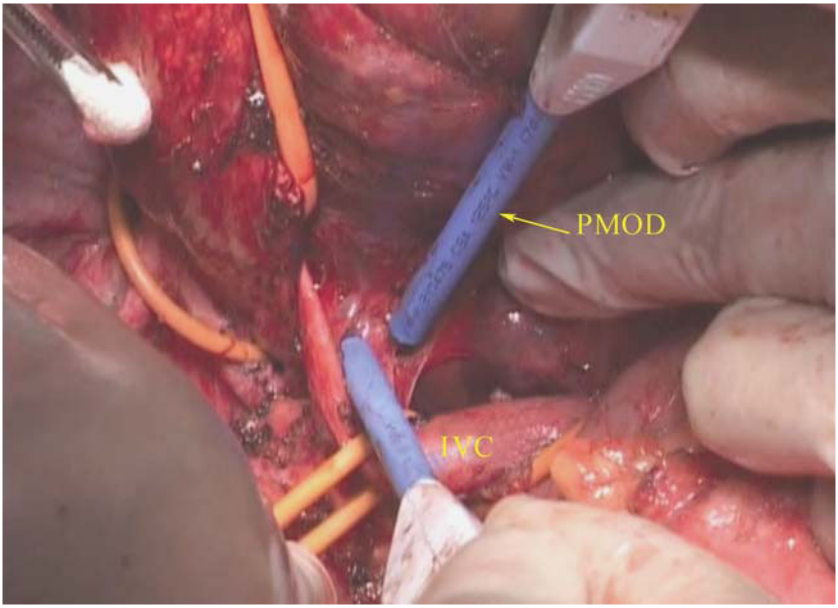
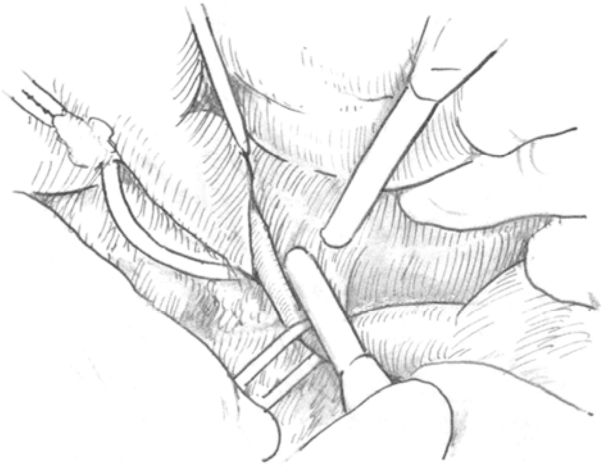


Fig.4.33. IVC is taped again at a higher position

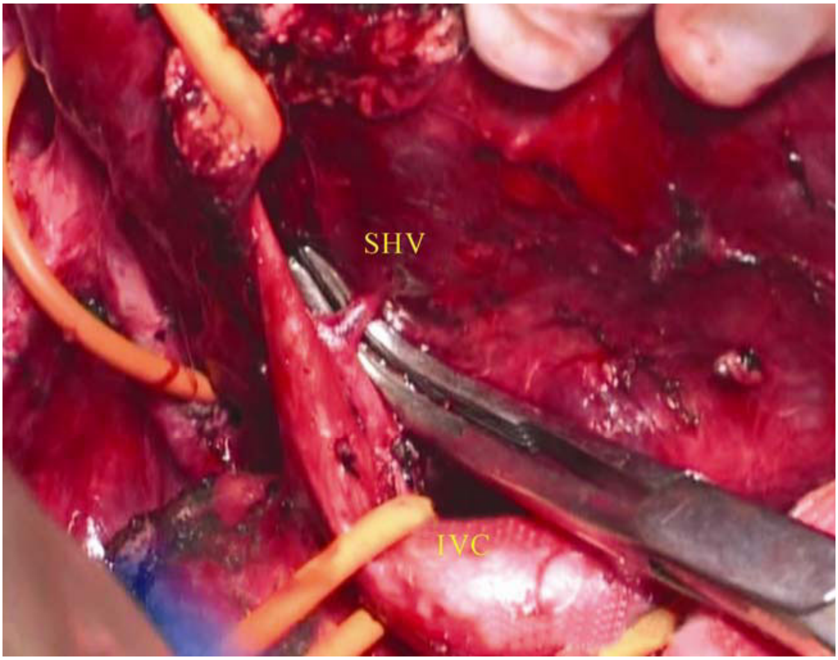


(a)

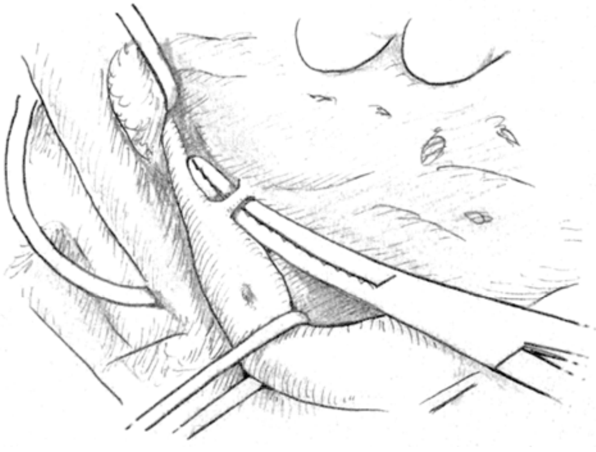


(b)

Fig.4.34. Traction on the liver tape and IVC tape elongates the SHVs. (a) Photograph; (b) Drawing



(a)



(b)

Fig.4.35. A SHV on the left side of the IVC is dissected for division. (a) Photograph; (b) Drawing

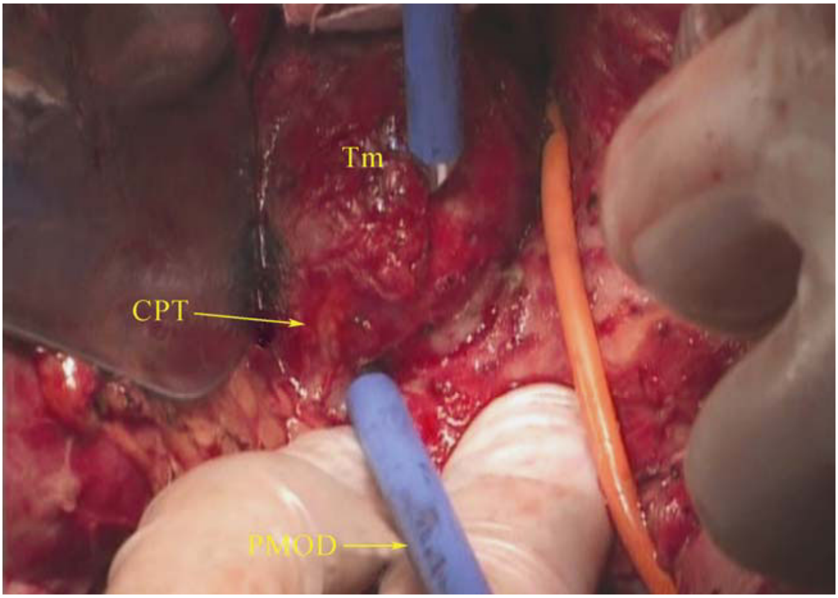
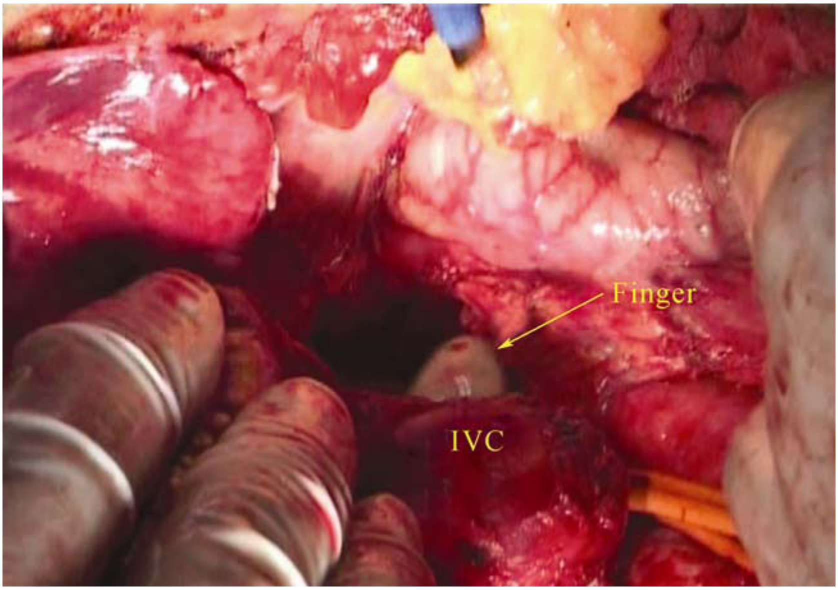
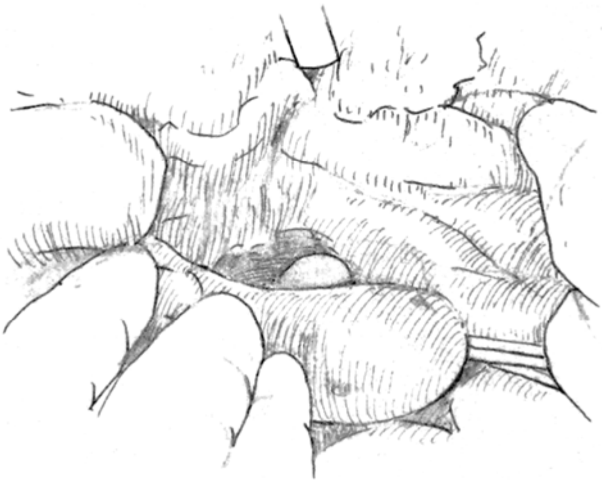


Fig.4.36. The junction between IVC and the tumor is dissected

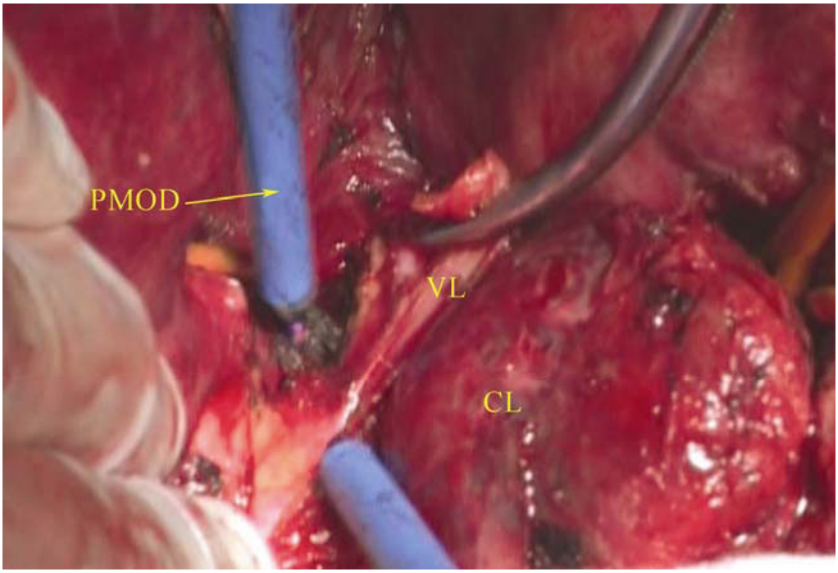


(a)

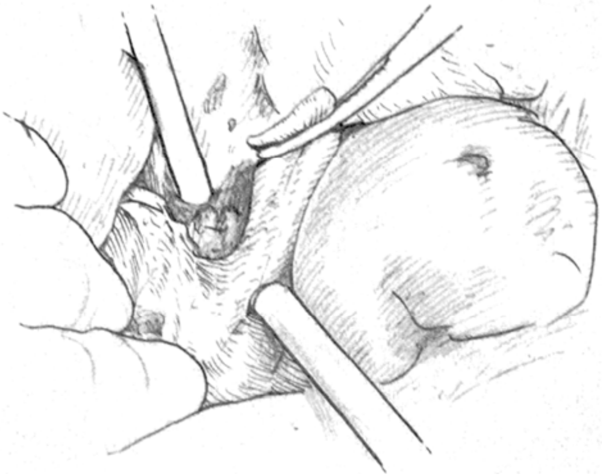


(b)

Fig.4.37. A finger behind the IVC is good for better control. (a) Photograph; (b) Drawing

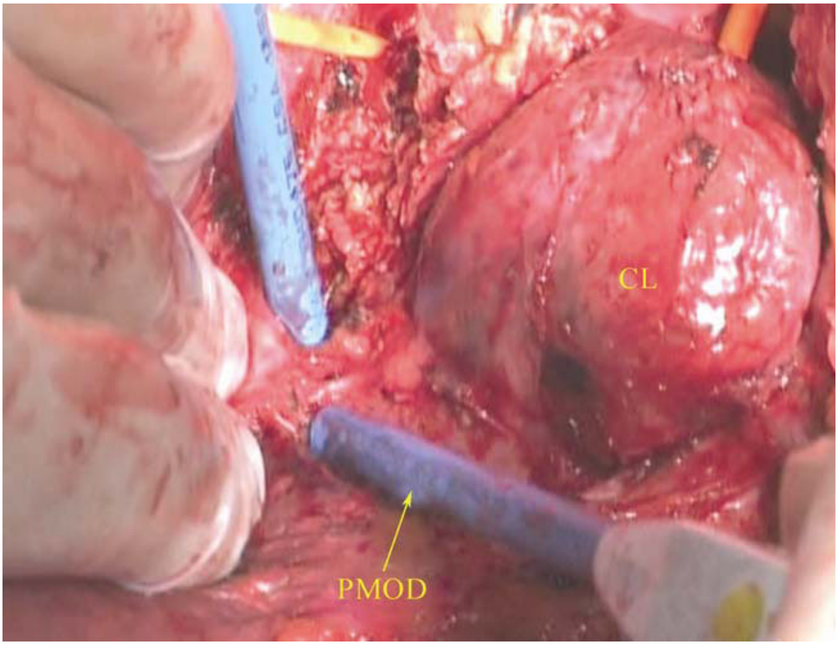


(a)

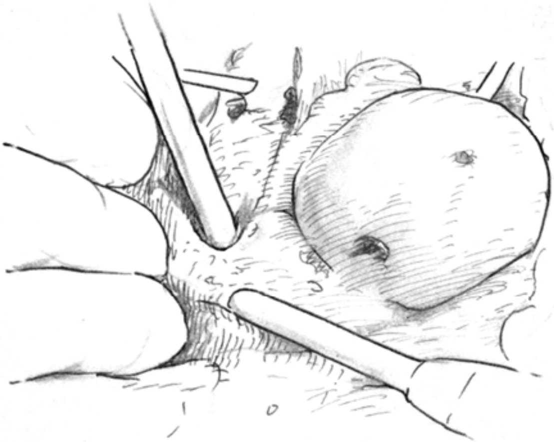


(b)

Fig.4.38. Parenchymal transection is started near the caudate tip. VL has been divided. (a) Photograph; (b) Drawing



(a)



(b)

Fig.4.39. Transection line is directed toward the caudate process. (a) Photograph; (b) Drawing

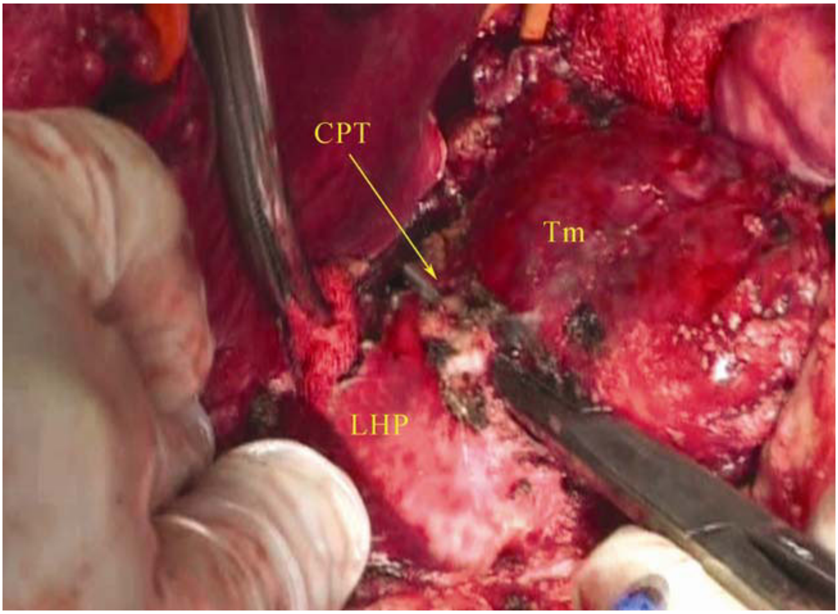


Fig.4.40. A large CPT is dissected and divided

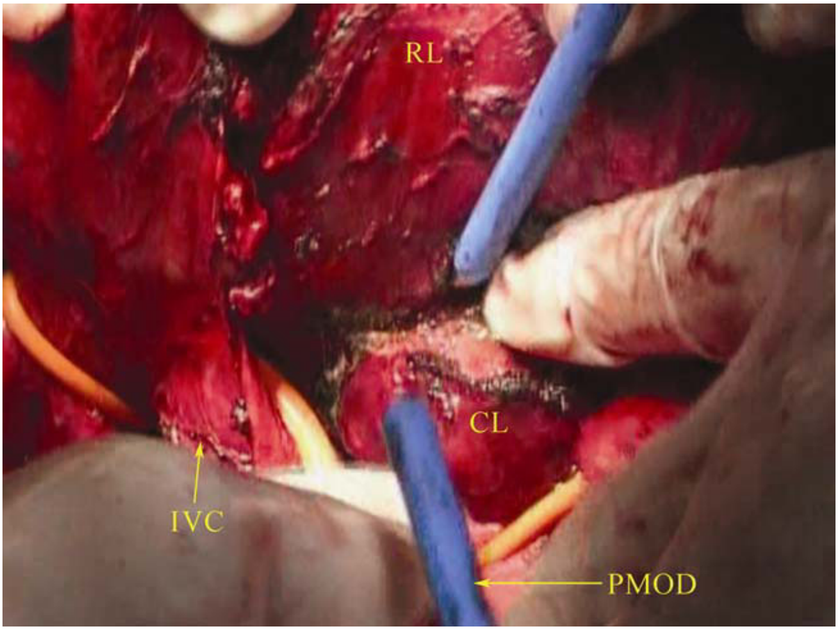


Fig.4.41. Transection toward the upper transection line

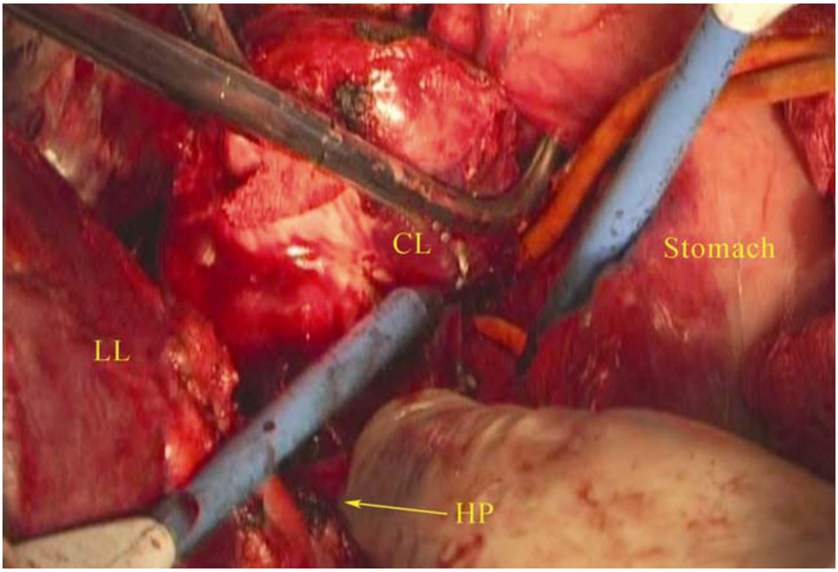


Fig.4.42. Tumor is dissected from the liver pedicle

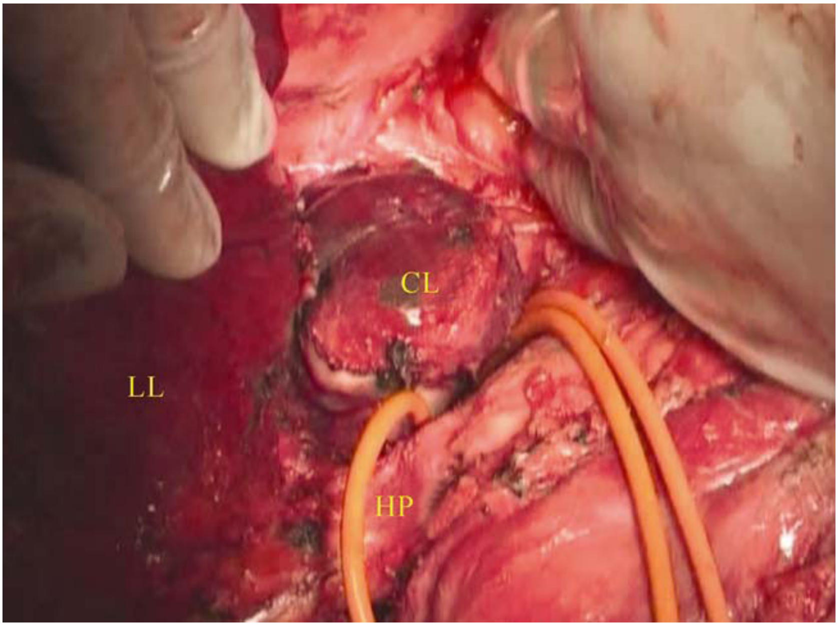


Fig.4.43. Tumor is dissected from the PV

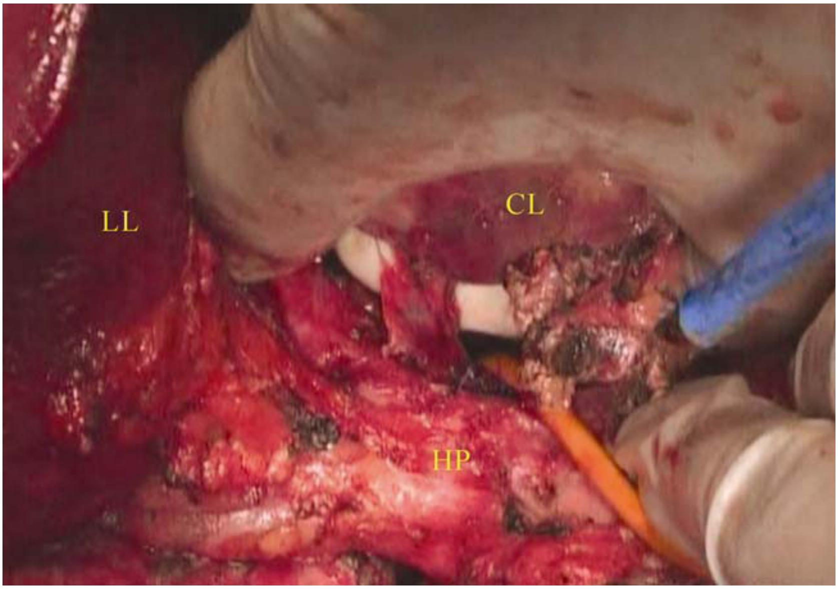


Fig.4.44. The last attachment of the tumor to the liver pedicle is dissected

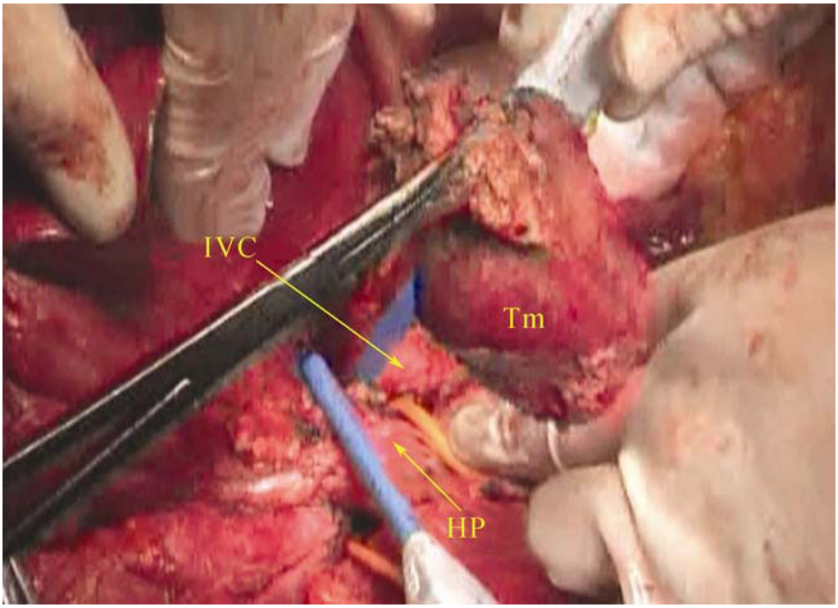


Fig.4.45. The tumor is finally removed

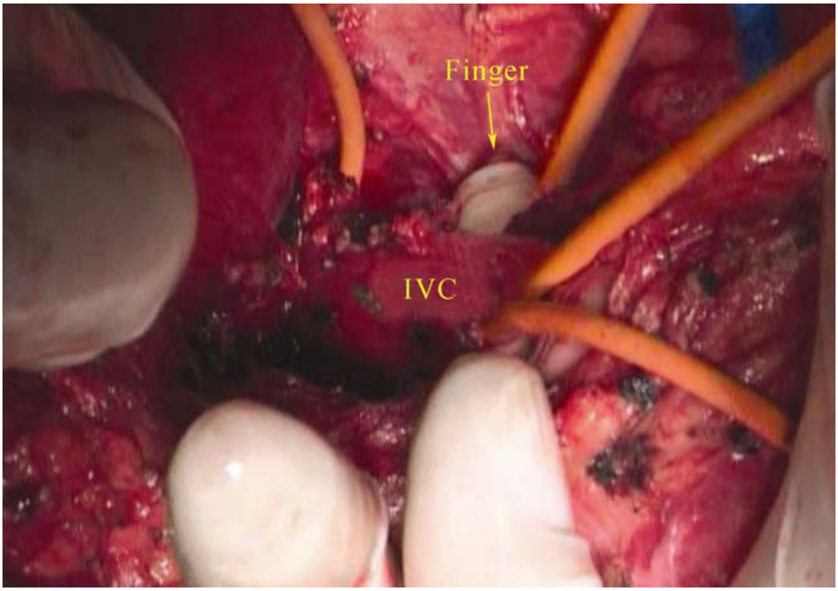


Fig.4.46. A finger behind the IVC helps control serious hemorrhage

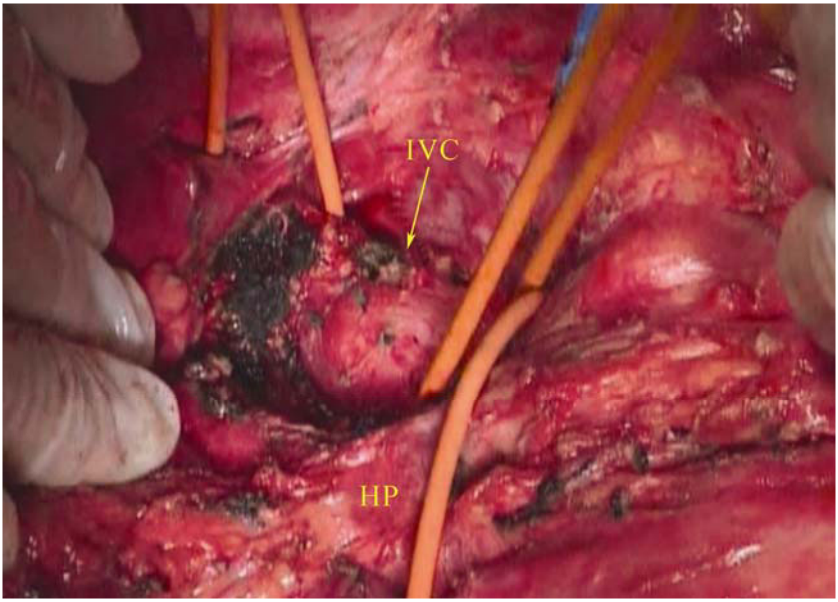


Fig.4.47. Retrohepatic IVC is completely exposed after caudate tumor removal

4.3.2 Isolated Complete Combined Resection for HCC

This is a case of hepatocellular carcinoma (HCC) which is localized in the caudate lobe. The tumor is well encapsulated and very close to the PV. The video 5 demonstrates the whole course of isolated complete resection of the caudate lobe. As the tumor is not very large, the initial step is isolation of the caudate lobe. By using PMOD, the caudate lobe is easily detached from the IVC. The maneuvers of CADT are clearly shown. A liver taping maneuver is adopted to facilitate the isolation of SHVs. After all the CPTs are divided, it is evident that the caudate color changes, becoming dusky, and the demarcation of the caudate process and the right lobe is very clear. Liver transection is started on the caudate process. Care is taken not to injure RPV. The divided caudate is pushed to the left side to continue transection toward the tip (Figs.4.48-4.75, see video 5).

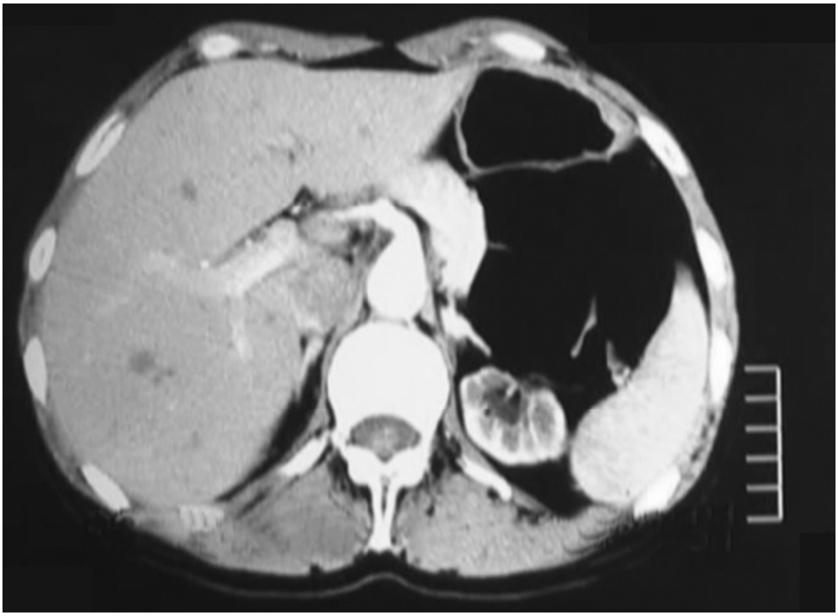


Fig.4.48. CT showing the tumor situated in the caudate lobe

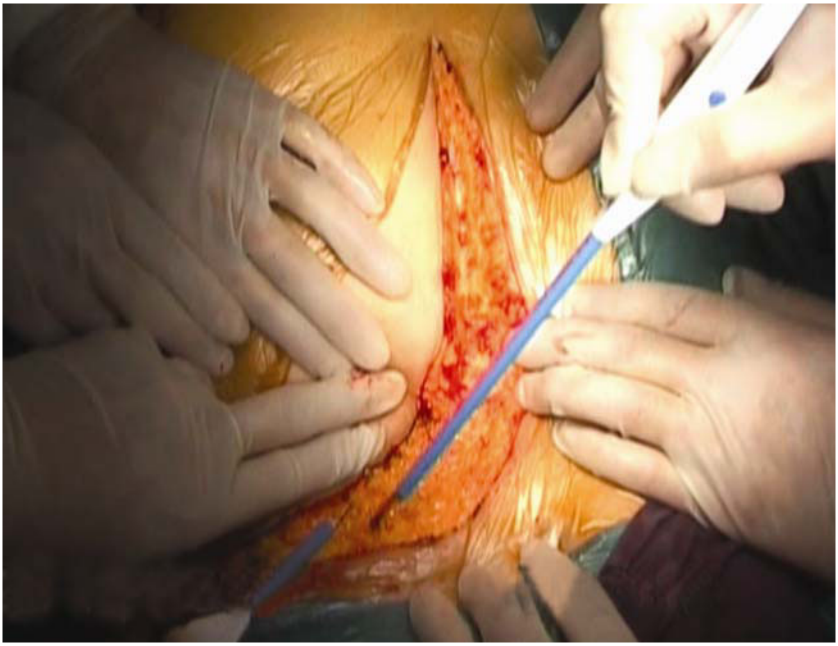


Fig.4.49. Reverse L shaped incision is performed

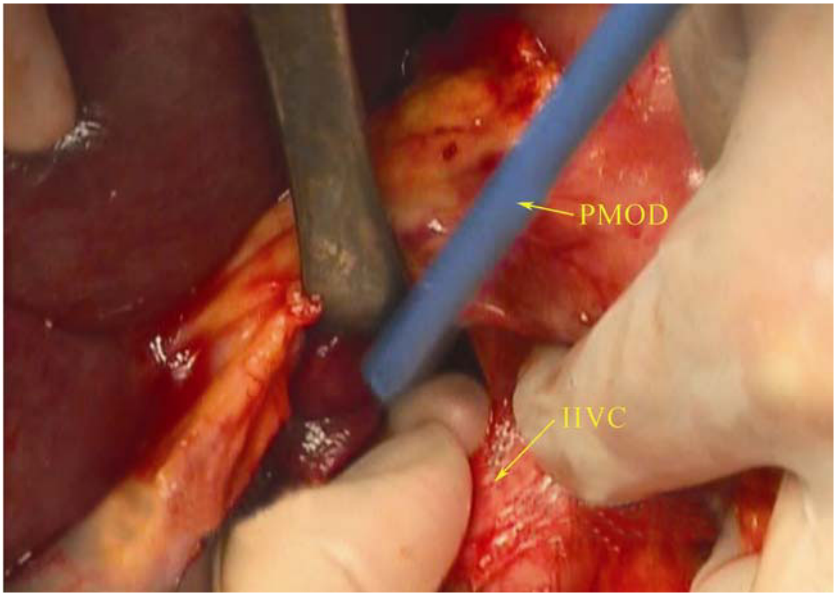
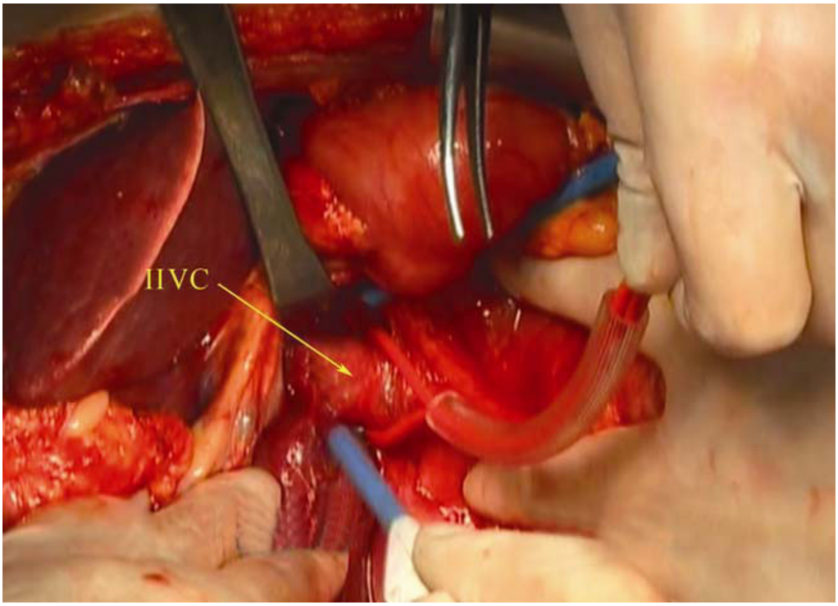
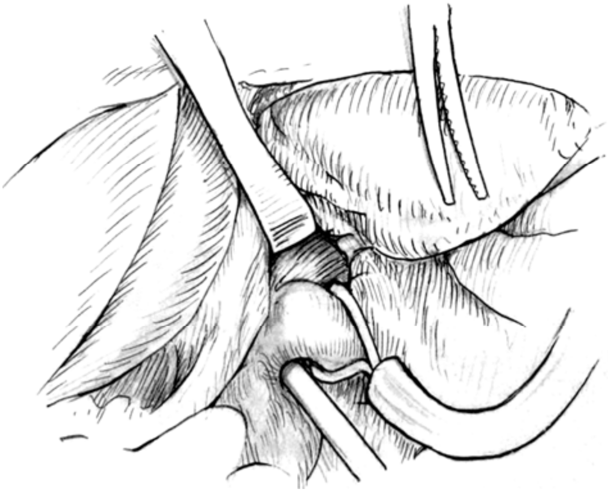


Fig.4.50. IIVC is encircled with a finger

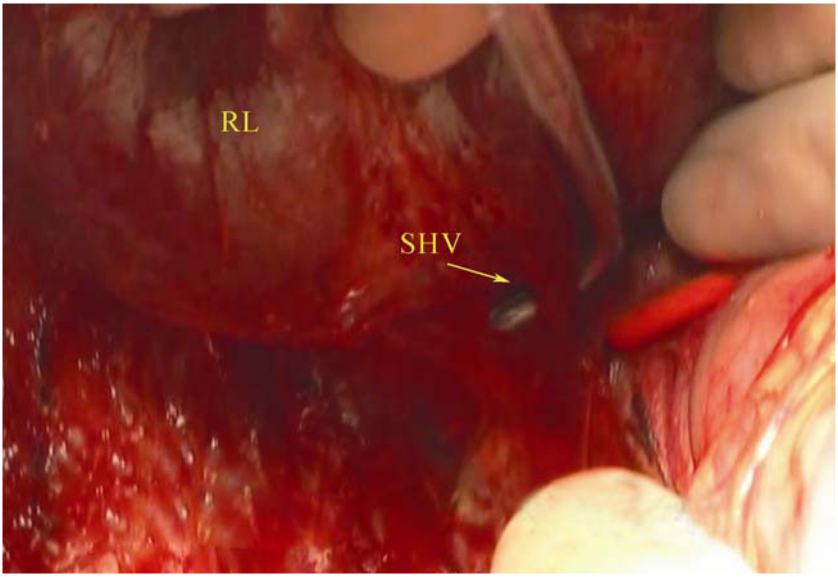


(a)

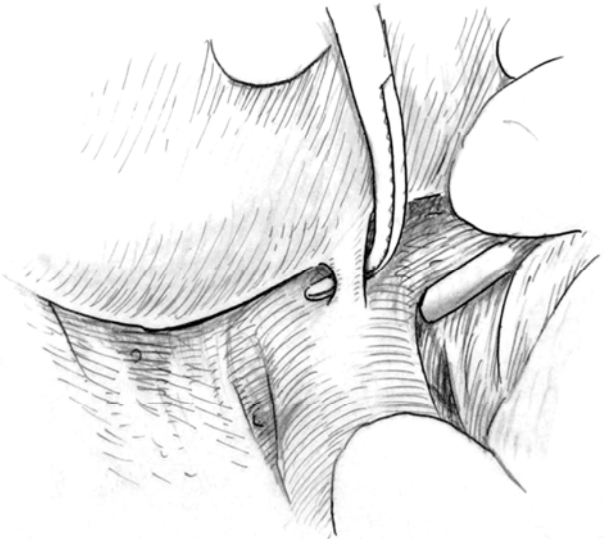


(b)

Fig.4.51. IIVC is taped.
(a) Photograph; (b) Drawing

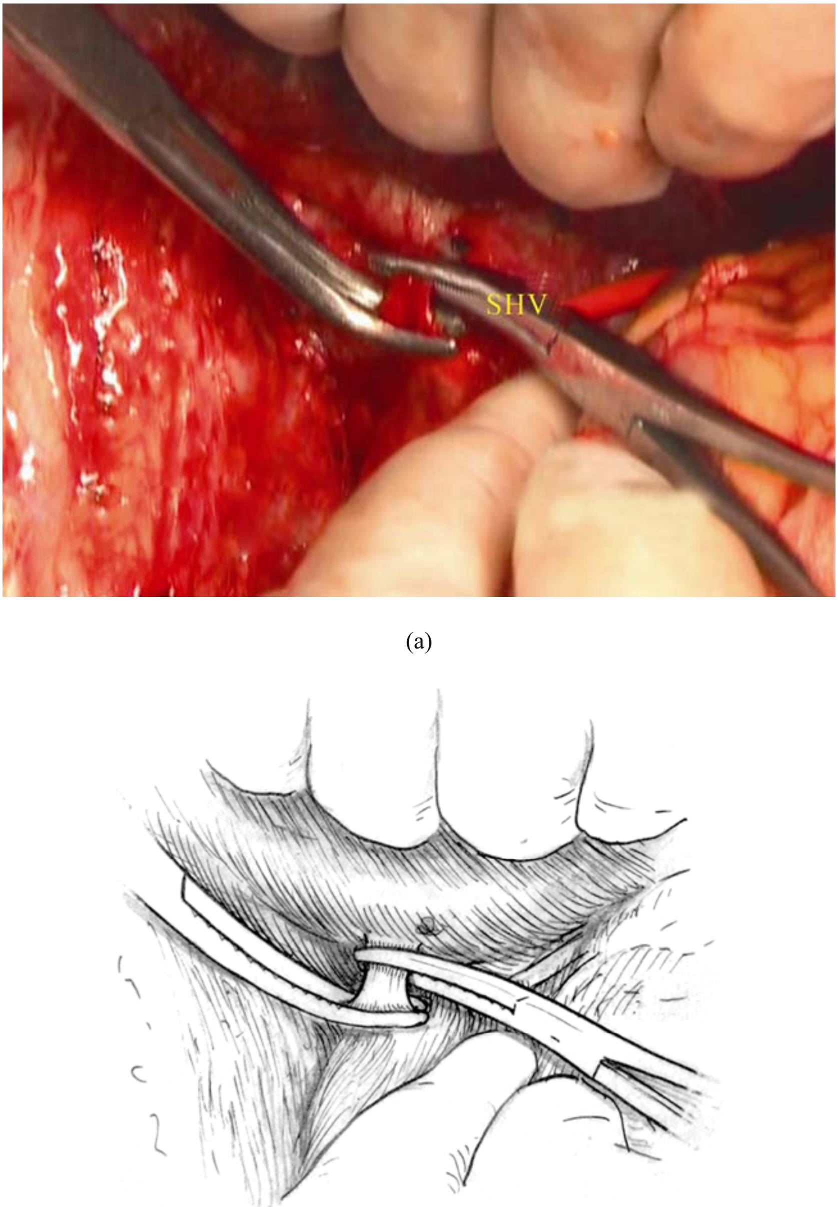


(a)



(b)

Fig.4.52. A SHV between caudate process and IVC is dissected and divided. (a) Photograph; (b) Drawing



(a)

(b)

Fig.4.53. A SHV is divided between clamps.
(a) Photograph; (b) Drawing

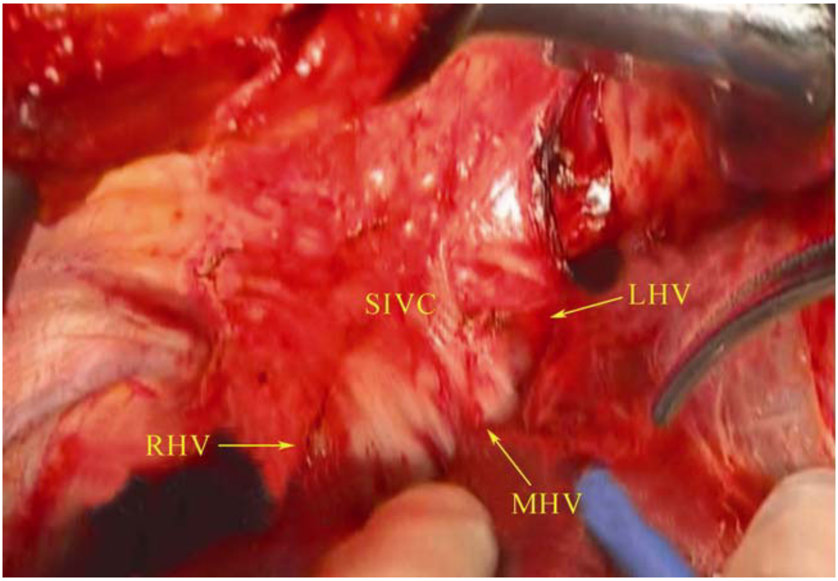
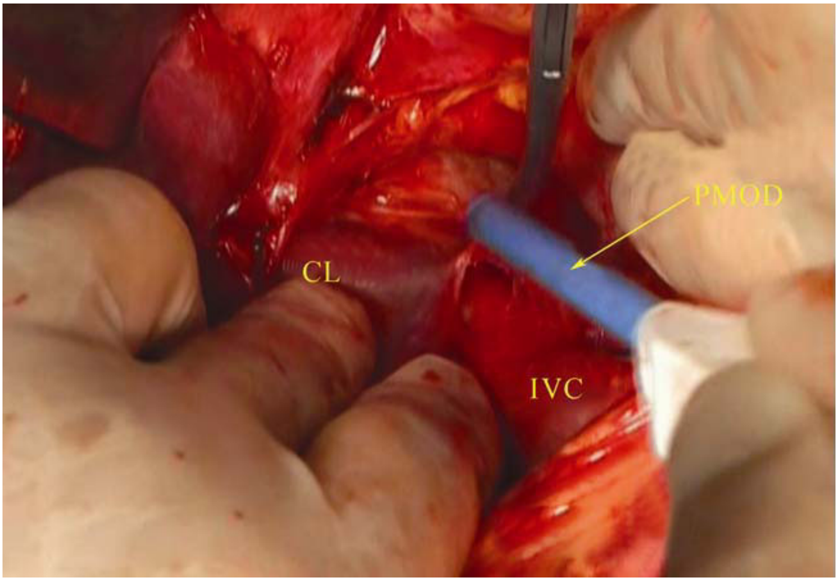
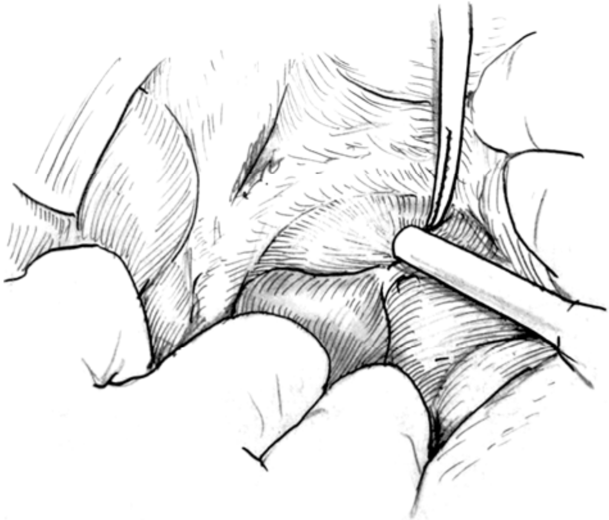


Fig.4.54. Roots of three major HVs are exposed

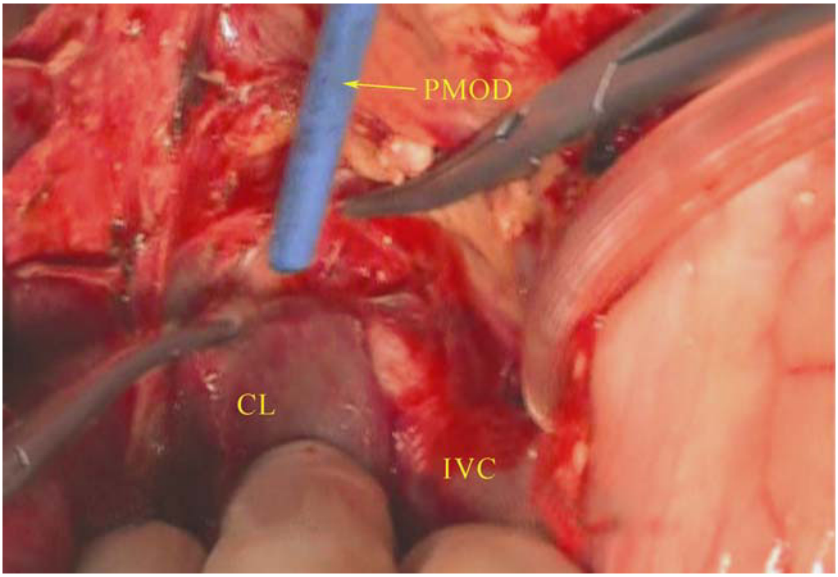


(a)

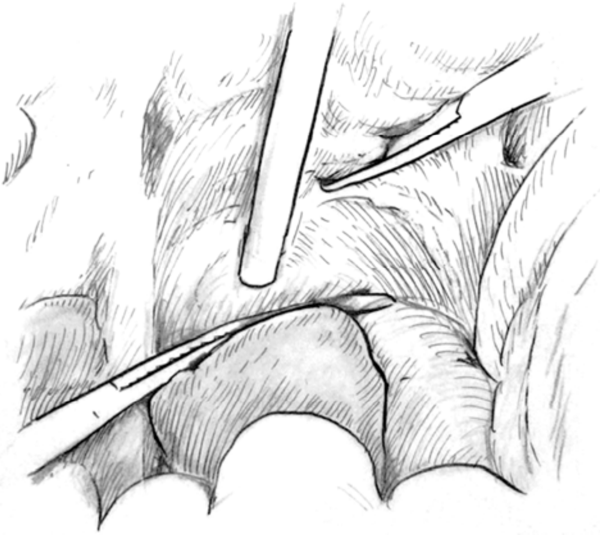


(b)

Fig.4.55. Fascia covering the CL and IVC is incised and dissected. (a) Photograph; (b) Drawing

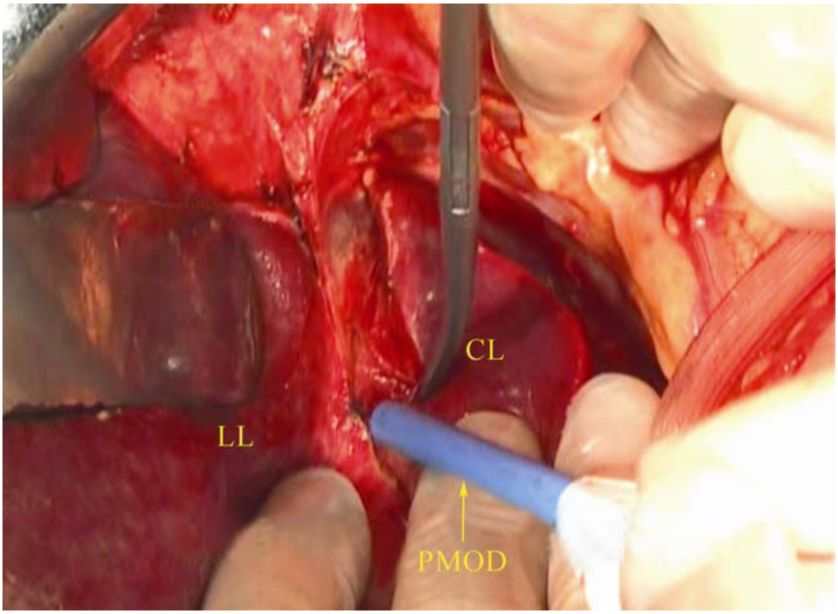


(a)

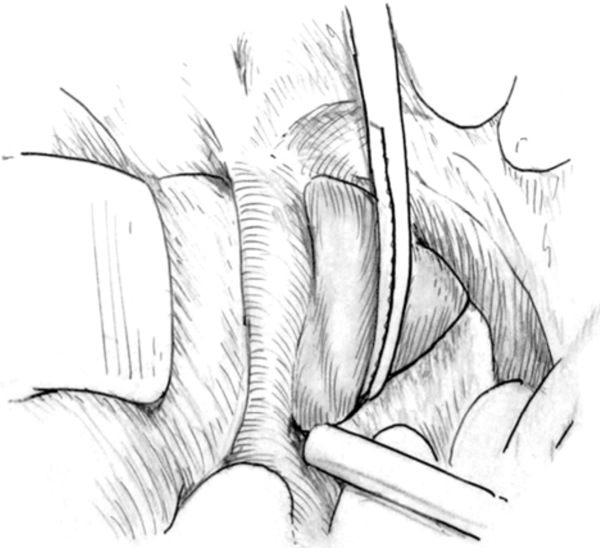


(b)

Fig.4.56. Dissection at the tip of the CL.
(a) Photograph; (b) Drawing

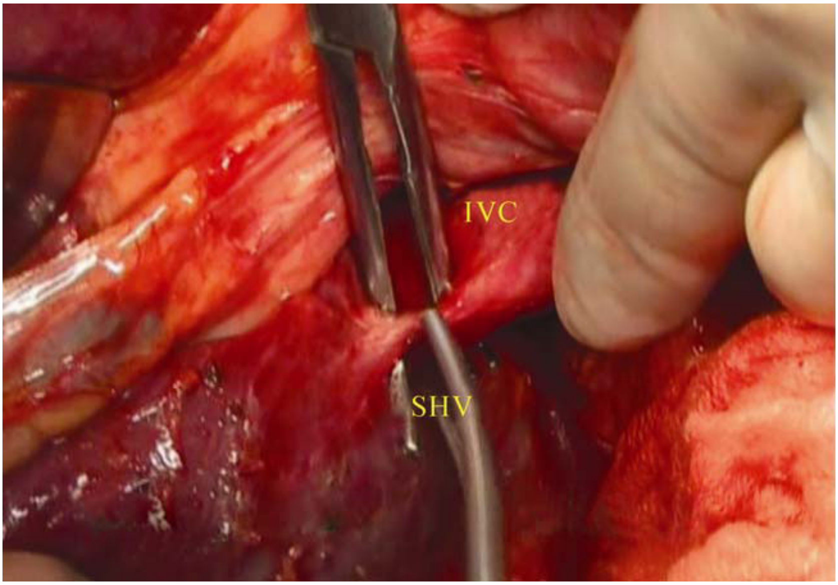


(a)

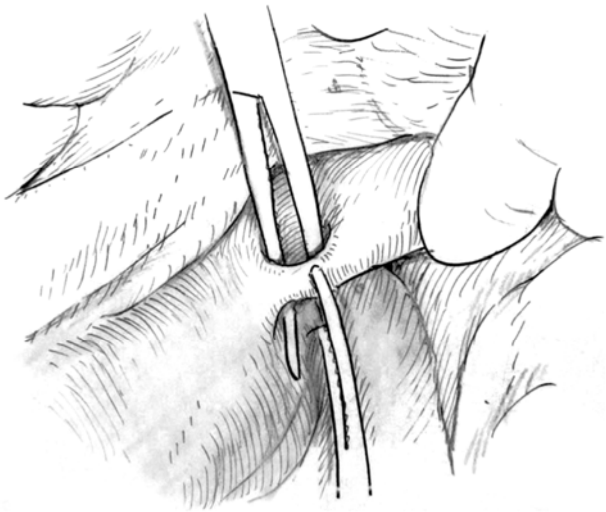


(b)

Fig.4.57. Dissection at the inner side of caudate pedicle. (a) Photograph; (b) Drawing

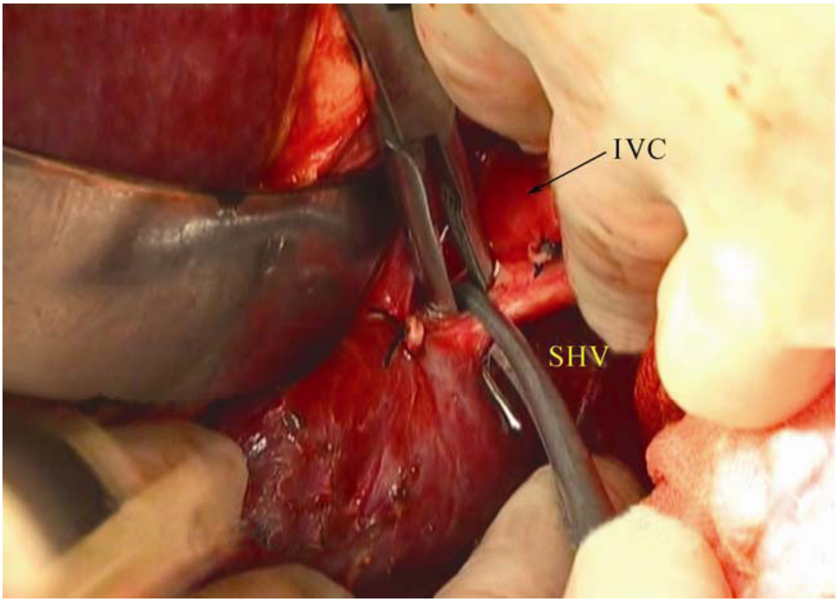


(a)

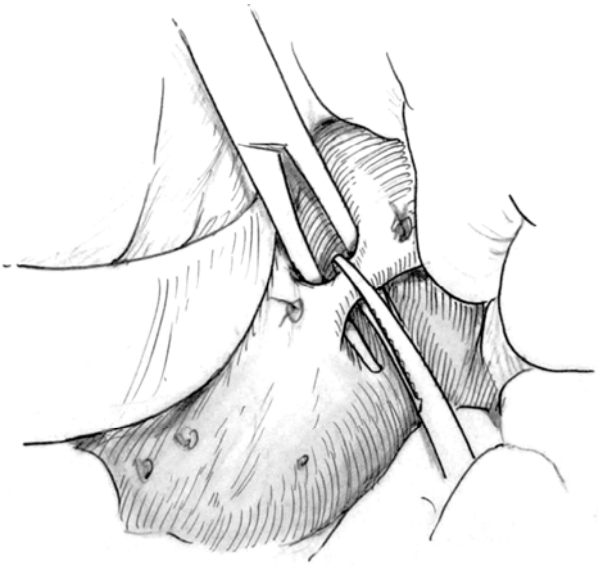


(b)

Fig.4.58. SHV between the caudate process and IVC is dissected and divided. (a) Photograph; (b) Drawing

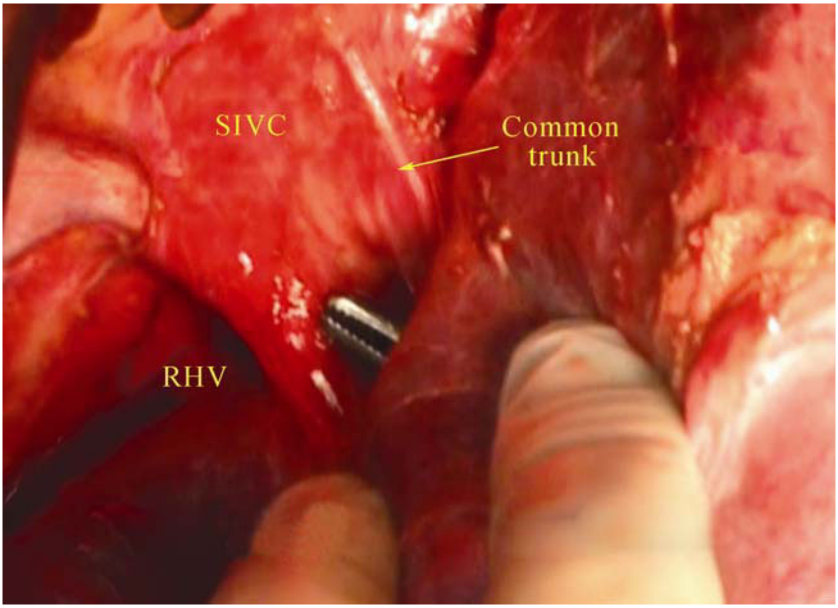


(a)

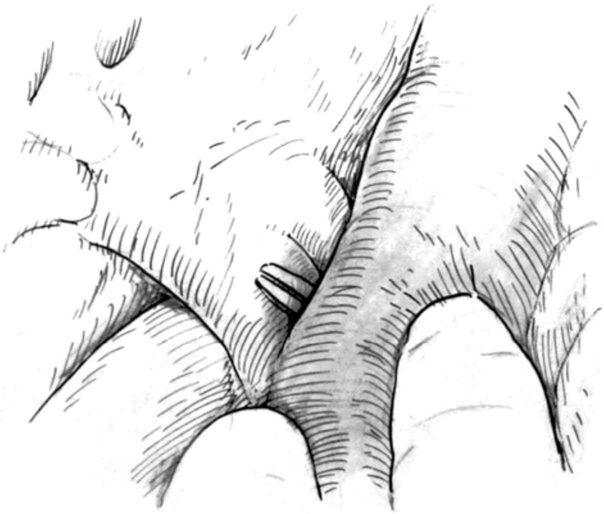


(b)

Fig.4.59. A large SHV is divided between clamps. (a) Photograph; (b) Drawing

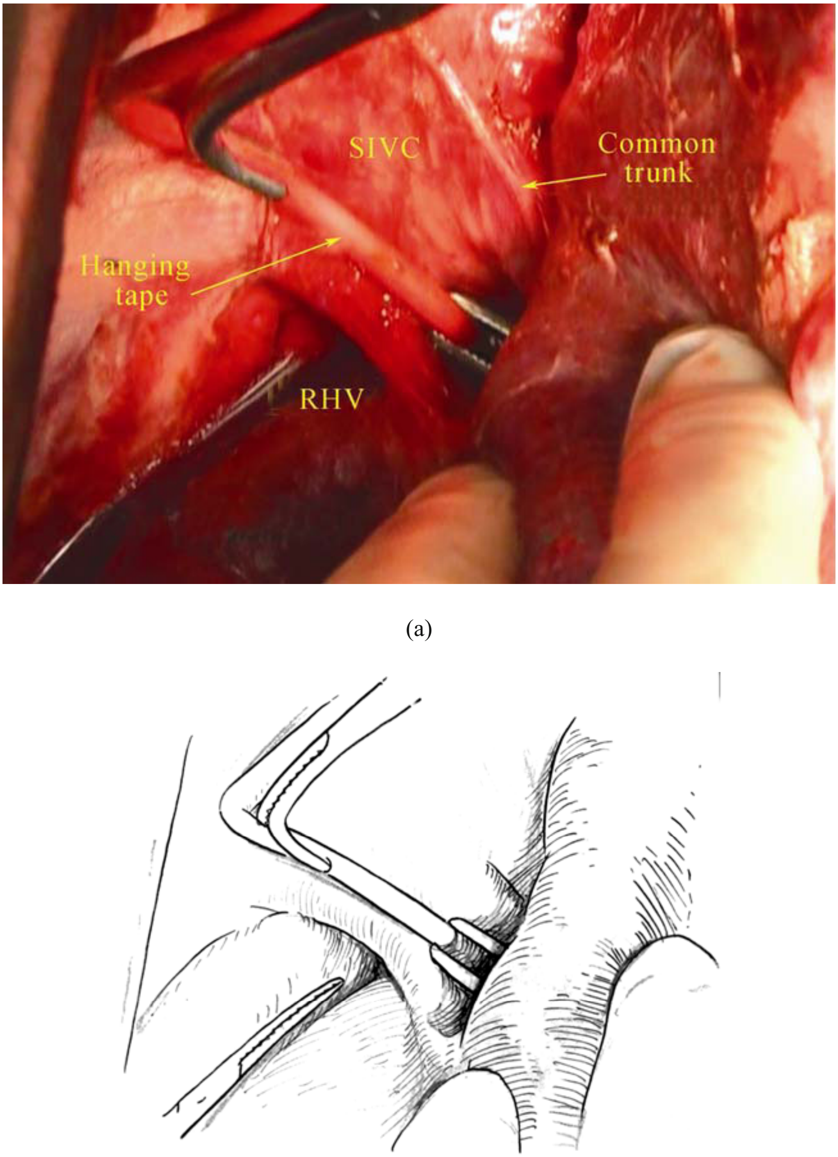


(a)



(b)

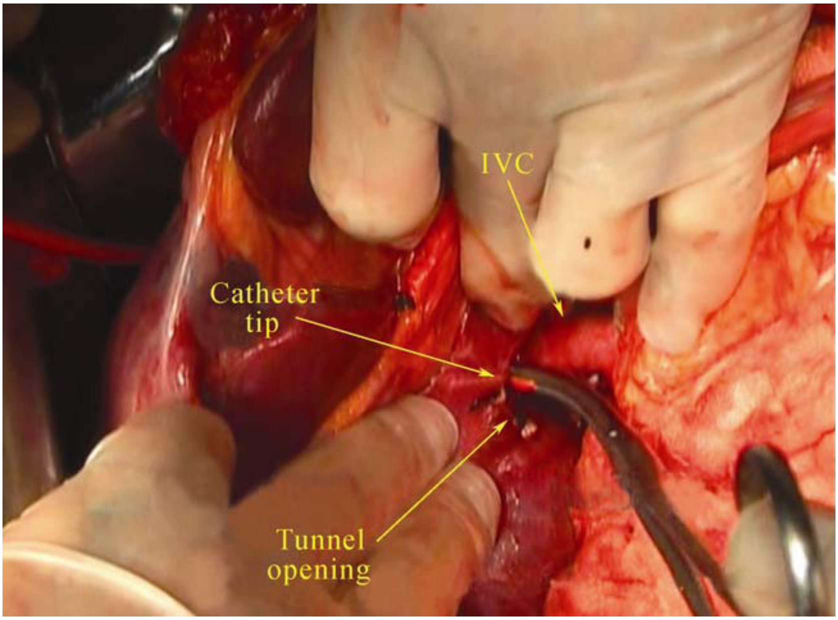
Fig.4.60. A long Kelly clamp is inserted through the retrohepatic tunnel and out from the upper opening. (a) Photograph; (b) Drawing



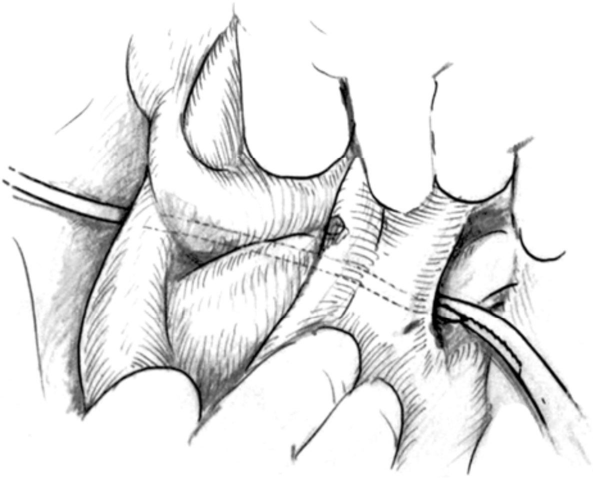
(a)

(b)

Fig.4.61. A catheter is ready to be pulled through the retrohepatic tunnel. (a) Photograph; (b) Drawing

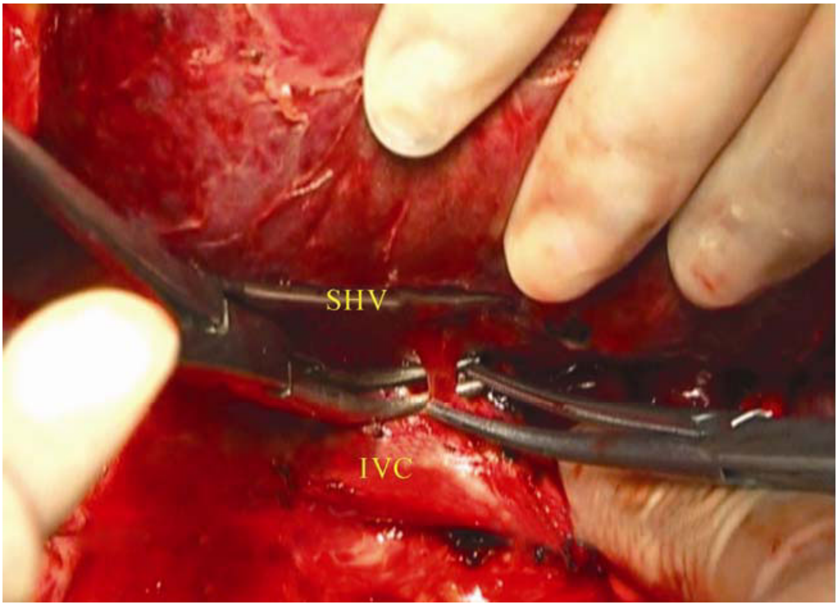


(a)



(b)

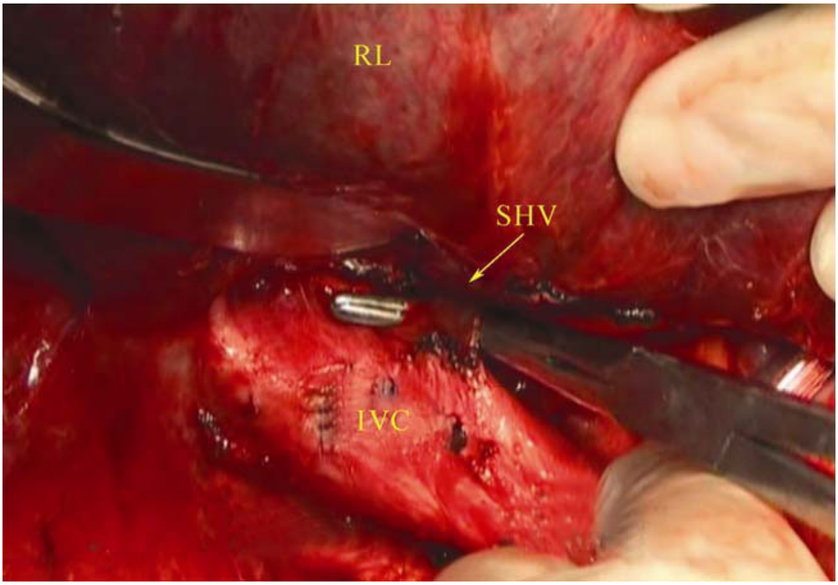
Fig.4.62. Tip of the catheter is pulled out of the lower opening of the retrohepatic tunnel. (a) Photograph; (b) Drawing



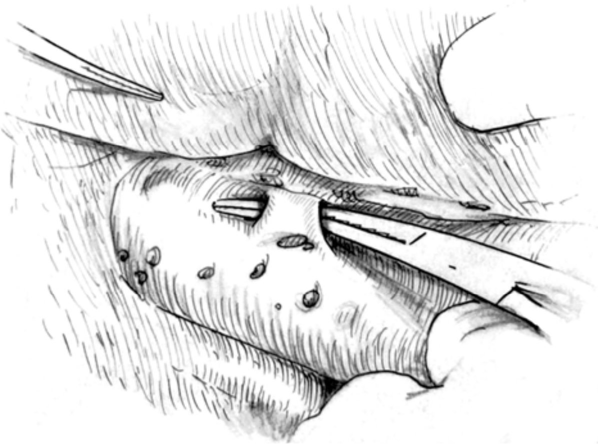
(a)

(b)

Fig.4.63. Another SHV is to be divided.
(a) Photograph; (b) Drawing

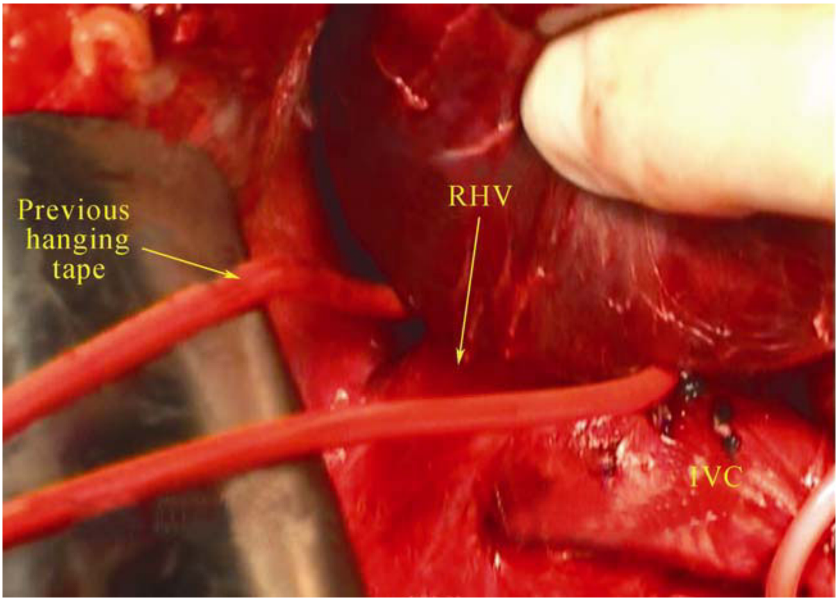


(a)

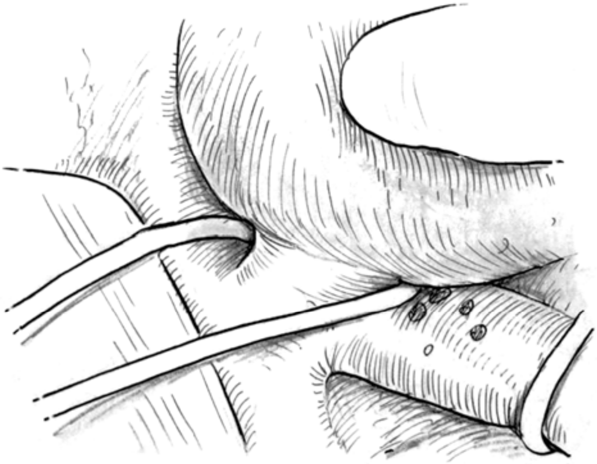


(b)

Fig.4.64. A large SHV on the left of the IVC is ready for division. (a) Photograph; (b) Drawing

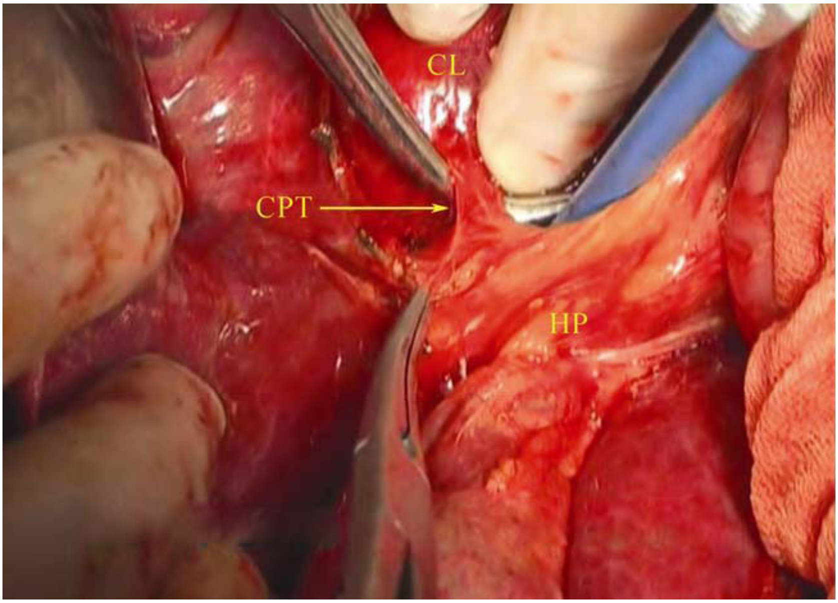


(a)

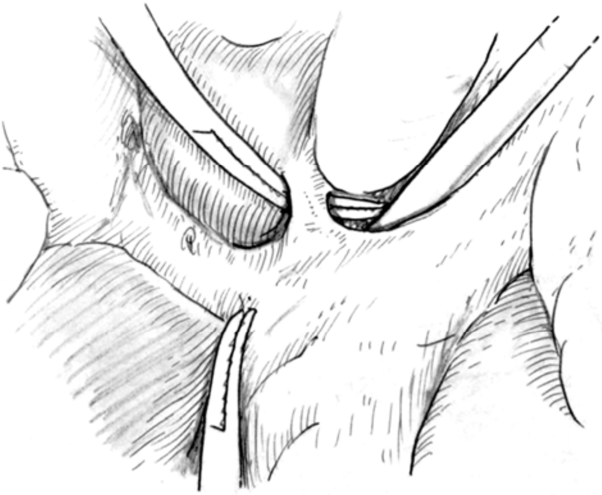


(b)

Fig.4.65. Liver hanging tape is swung round and becomes a sling on the RHV. (a) Photograph; (b) Drawing

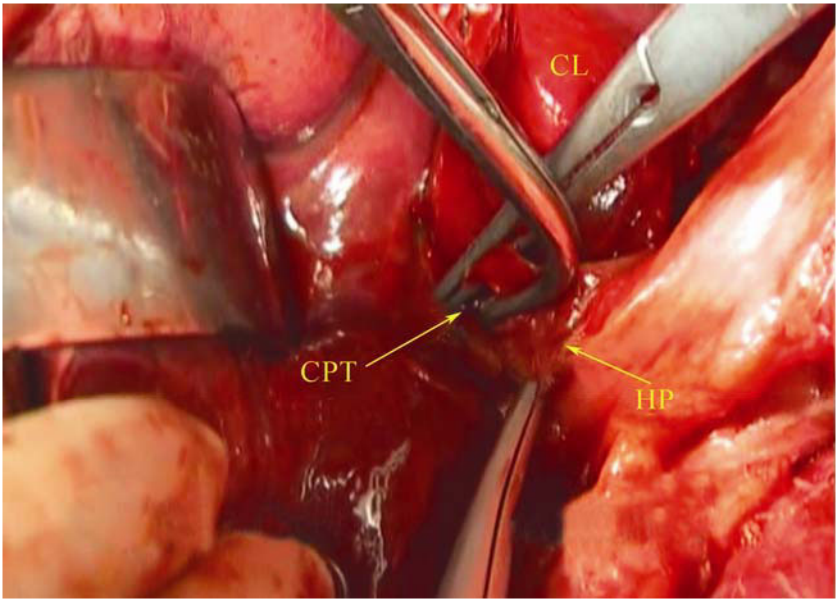


(a)

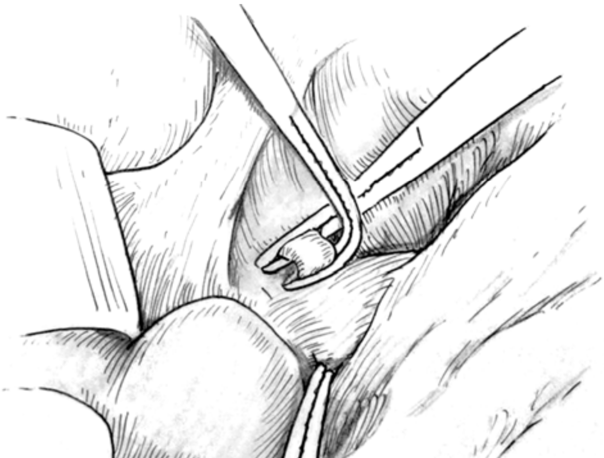


(b)

Fig.4.66. A CPT is isolated for division.
(a) Photograph; (b) Drawing

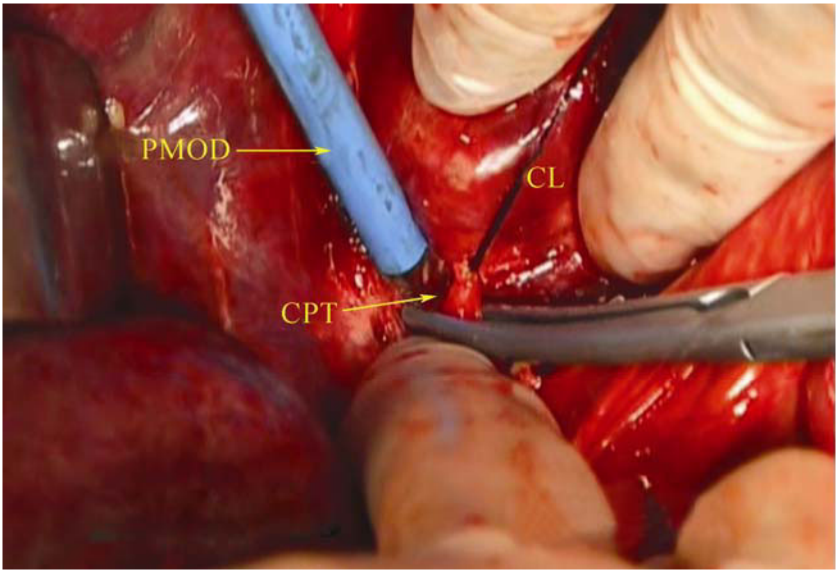


(a)

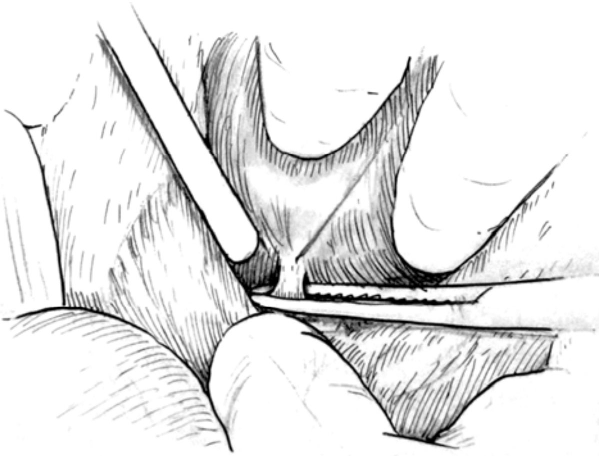


(b)

Fig.4.67. A CPT is divided between clamps.
(a) Photograph; (b) Drawing

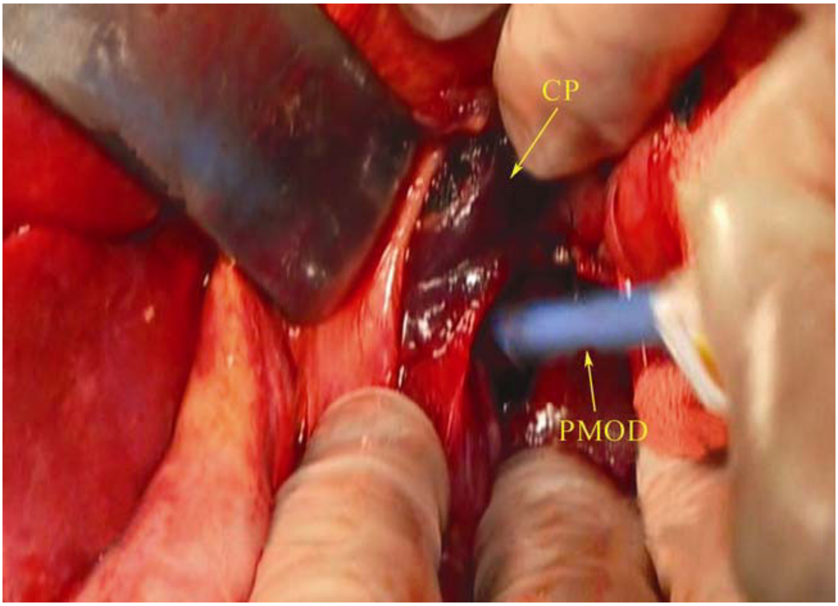


(a)

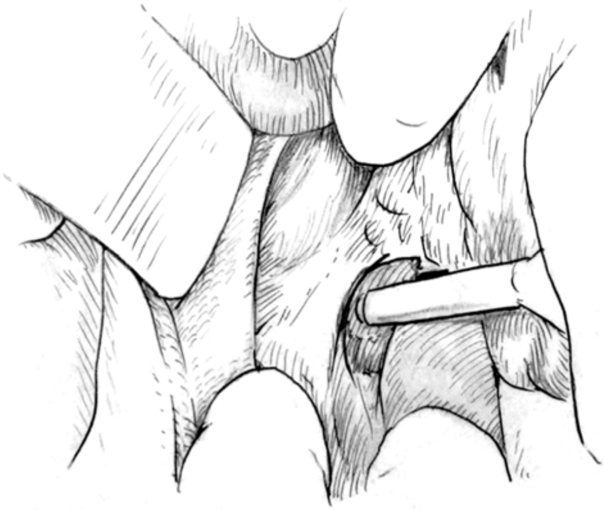


(b)

Fig.4.68. A CPT is divided.
(a) Photograph; (b) Drawing



(a)



(b)

Fig.4.69. Transection is started at the caudate process which has become dusky. (a) Photograph; (b) Drawing

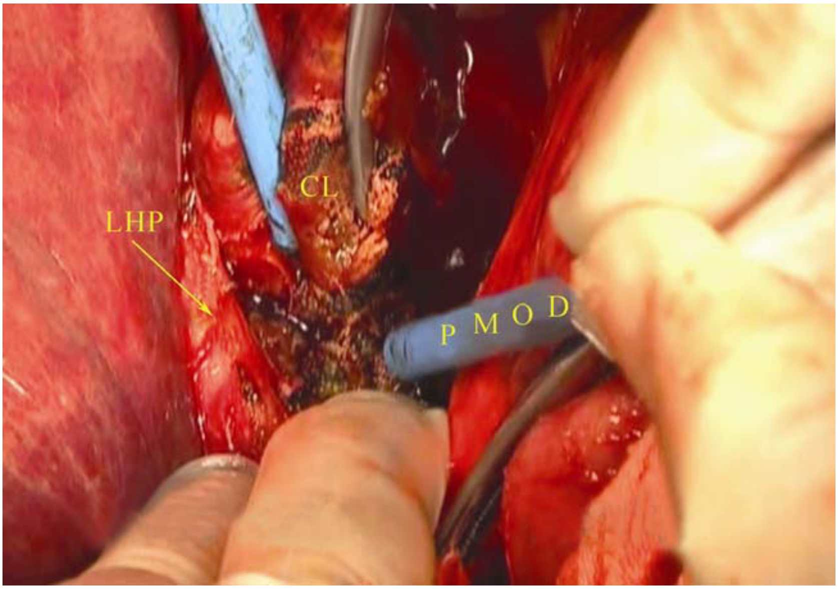
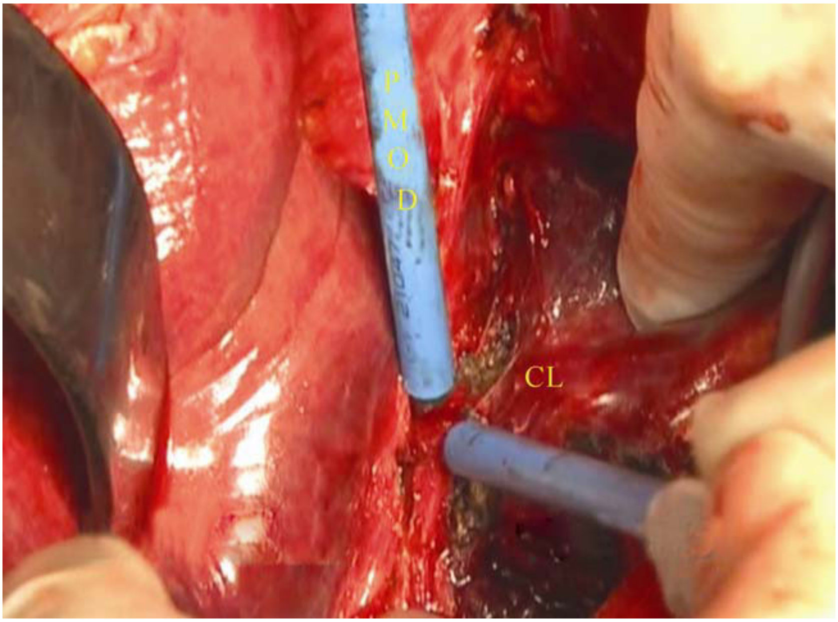
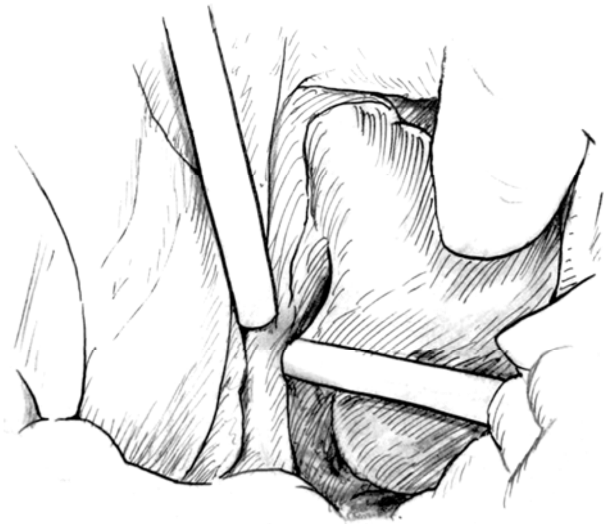


Fig.4.70. Transected caudate process is pushed to the left of the liver pedicle for further transection



(a)



(b)

Fig.4.71. Transection toward the tip of the caudate lobe. (a) Photograph; (b) Drawing

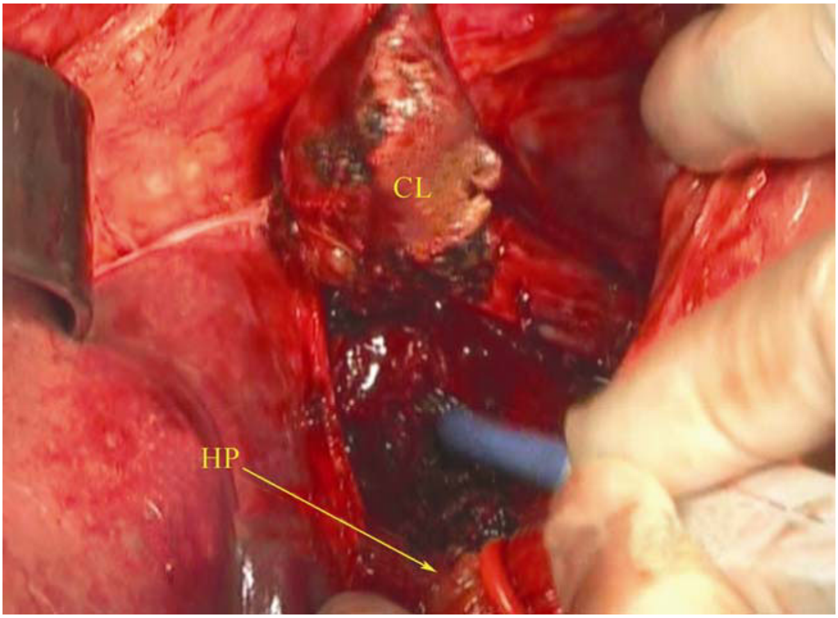


Fig.4.72. Transection is nearly completed

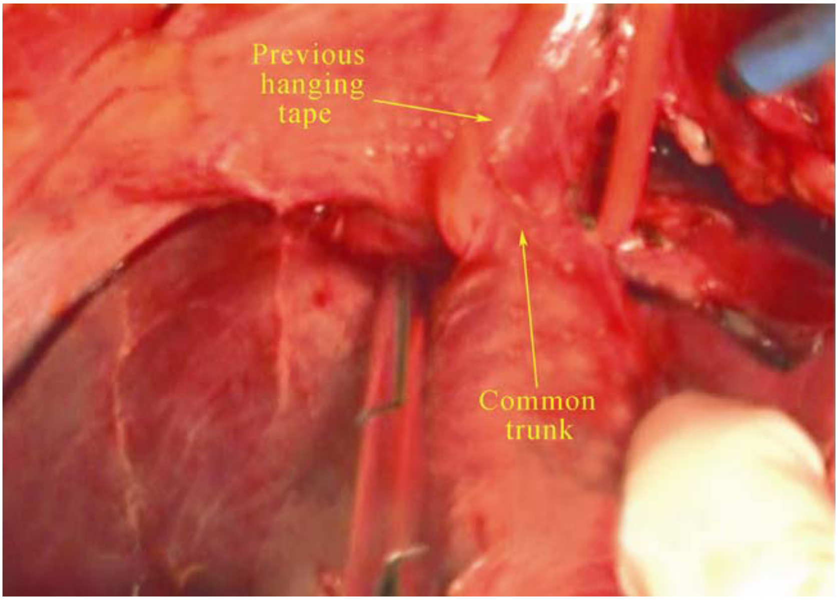
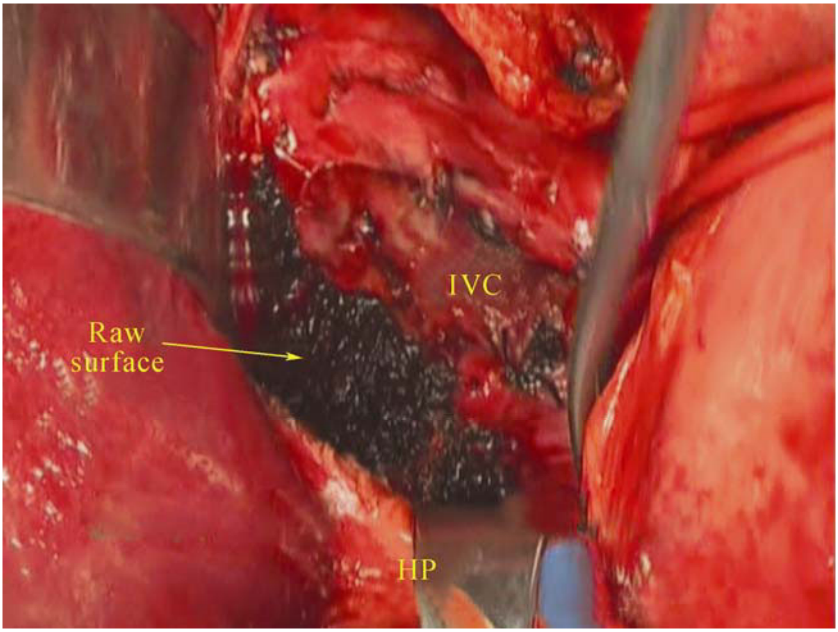
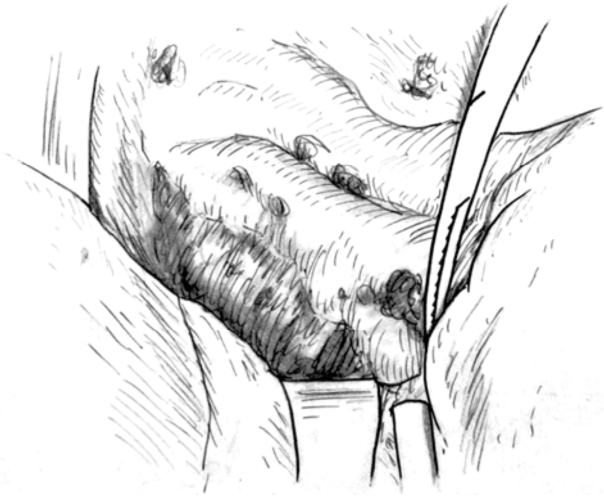


Fig.4.73. Liver hanging tape is swung round to become a sling on the common trunk

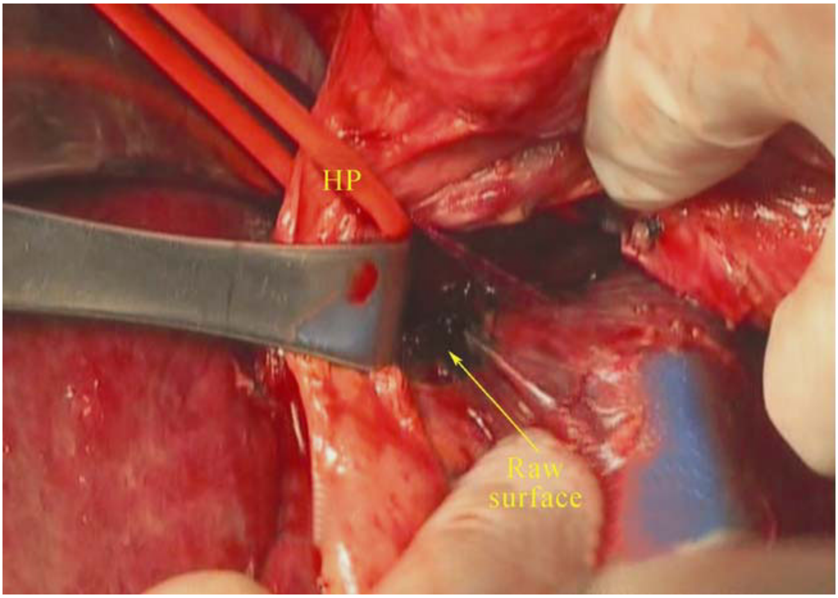


(a)

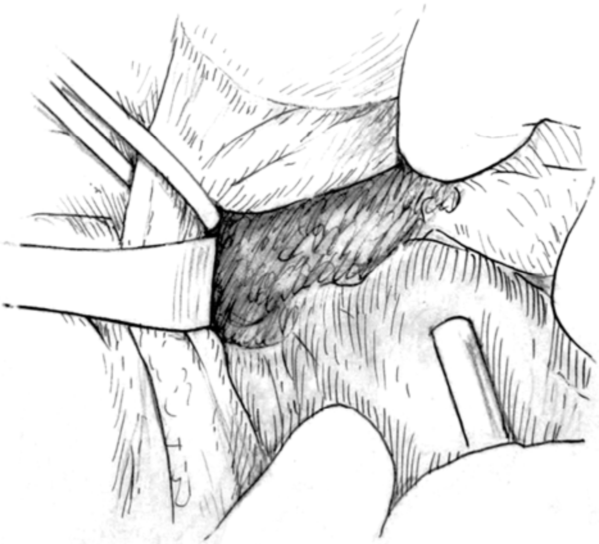


(b)

Fig.4.74. Bleeding completely stops at the raw surface.
(a) Photograph; (b) Drawing



(a)



(b)

Fig.4.75. The raw surface where the caudate process was located. (a) Photograph; (b) Drawing

4.4 Anterior Transhepatic Approach

Among the various types of caudate lobectomy, isolated complete resection of the caudate lobe is technically the most difficult operation. Some isolated caudate lobectomies can be performed through the left-sided and/or right-sided approach(es) when the tumor is small. When the tumor is large or when the major HVs are compressed by the tumor, these approaches may be not appropriate, due to the possibility of lacerating the major HVs. Under such circumstances, the first choice for isolated complete caudate lobectomy is the anterior transhepatic approach.

The anterior transhepatic approach for an isolated caudate lobectomy was first described by Yamamoto et al. (1992) for a patient with cirrhosis and a 3 cm × 3 cm HCC in the paracaval portion of the caudate lobe. It provided a safe approach for isolated complete caudate lobectomy. The separation of the hepatic parenchyma overlying the caudate lobe exposes the major HVs and the hilar plate to direct vision, thus facilitating dissection of the tumor from the major vessels, especially when there are numerous small communicating vessels among them.

The problem with the anterior transhepatic approach is that both left and right liver raw surfaces have to be dealt with. Hemostasis on both raw surfaces should be complete before the caudate tumor is isolated and removed.

4.4.1 Anterior Transhepatic Approach for HCC (1)

See Figs.4.76-4.90, and video 6.

The initial steps of the operation are similar to those of isolated caudate lobectomy by the bilateral approach, as described previously. The falciform ligament is divided up to the front of the SIVC. The dissection is then directed to the right and the left, dividing the coronary, triangular, and hepatorenal ligaments. The right adrenal gland is detached from the liver, and the hepatogastric ligament is completely divided. The SHVs are dissected and divided in a caudal-to-cranial direction from both the right and the left sides (Figs.4.77 and 4.94). When the caudate lobe is completely separated from the retrohepatic IVC, SIVC, IIVC, major HVs, and hepatoduodenal ligament are encircled by tapes for temporary hepatic vascular exclusion, in case of need.

The liver is split through the midplane. The plane of liver transection starts from the point between the roots of the RHV and the MHV to the fossa of the gallbladder, which should have just been removed. The transection is continued up to the plane 1 cm from the caudate tumor as shown on intraoperative ultrasound. The transection then goes along a plane 0.5 cm from the tumor surface. The tumor capsule should be kept intact, and the major HV should be pushed away with PMOD. When the transection reaches the hilar plate at the hilum, the CPTs are isolated and divided (Fig.4.83).

Up to this point, the tumor has been detached from the third and first portae hepatis, *i.e.*, from the IVC and the liver pedicles. All minute vessels to the tumor are meticulously ligated and divided until the tumor is completely detached from the HVs (Fig.4.87). At this stage, the caudate lobe can be easily detached from the liver. After resection of the tumor, the MHV should be clearly seen on the cut surface of the left liver with the RHV on the right side. During parenchymal transection, we usually use Pringle's maneuver with intermittent control of blood inflow. When a major HV is damaged and needs to be repaired, vessel occlusion using the tapes at the roots of the major HVs is of great help to reduce blood loss. After removal of the caudate lobe, the three portae hepatis—the hilum, the confluence of the major HVs, and the retrohepatic IVC can be clearly seen (Fig.4.88).

Any bleeding points and bile leaks on the raw liver surface are carefully controlled. The split left and right livers are sutured together to prevent internal herniation (Fig.4.89). A drain should be placed to the right side of retrohepatic IVC. The abdomen is closed to complete the operation.

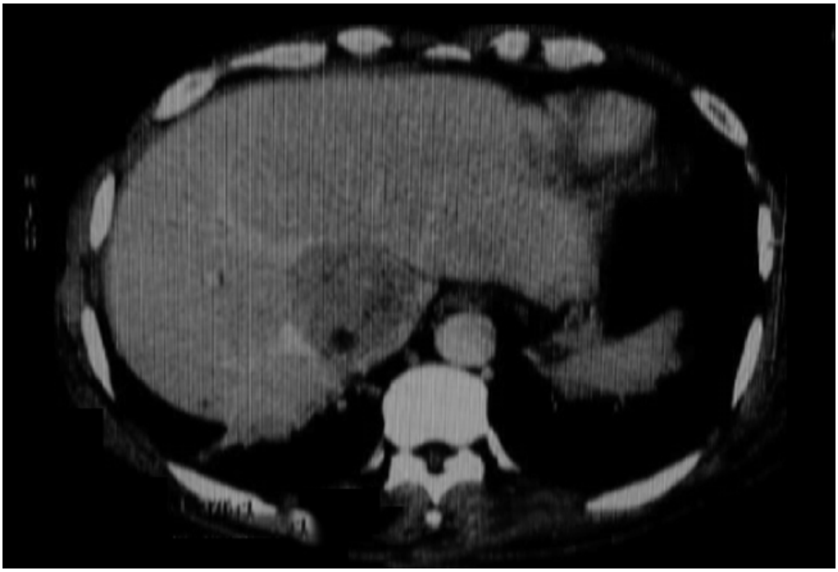


Fig.4.76. The large tumor is just at the junction of major HVs and IVC

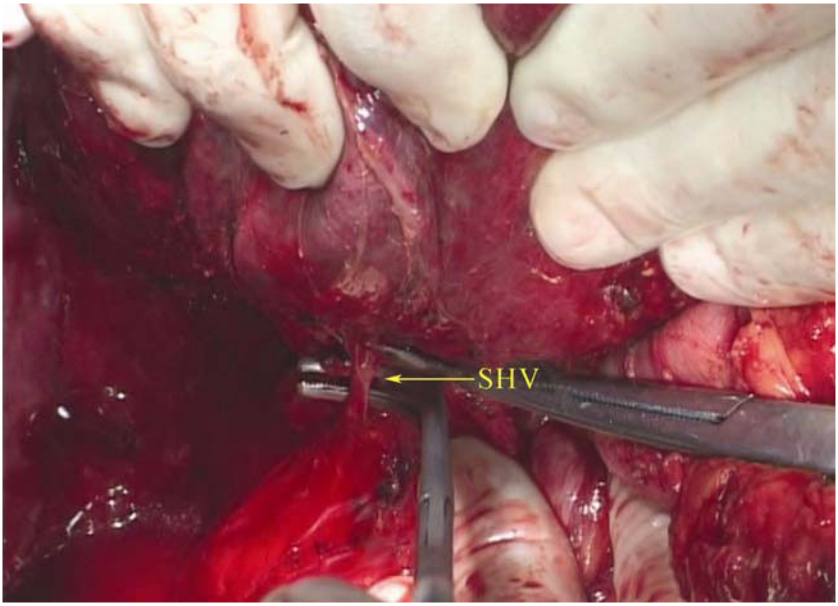


Fig.4.77. A SHV is dissected

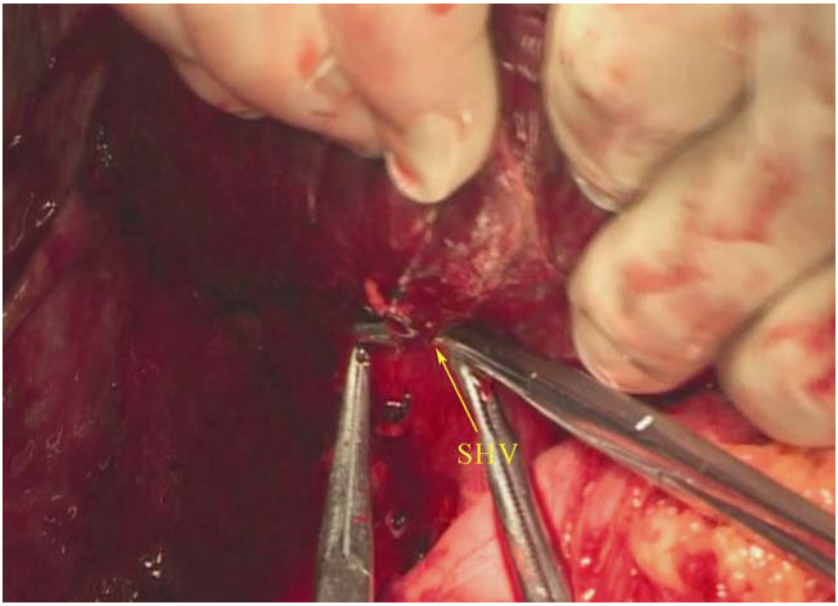


Fig.4.78. A SHV is dissected

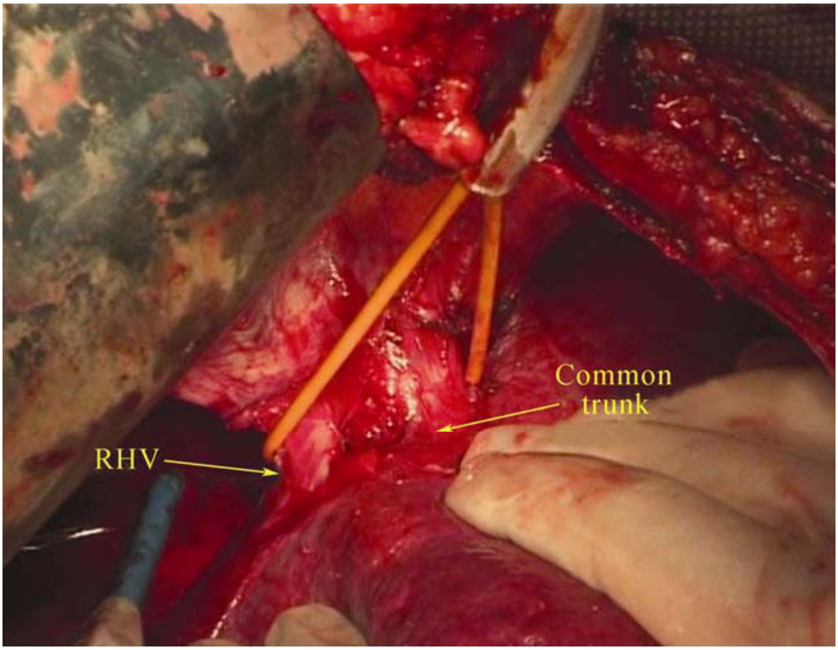


Fig.4.79. SIVC is taped

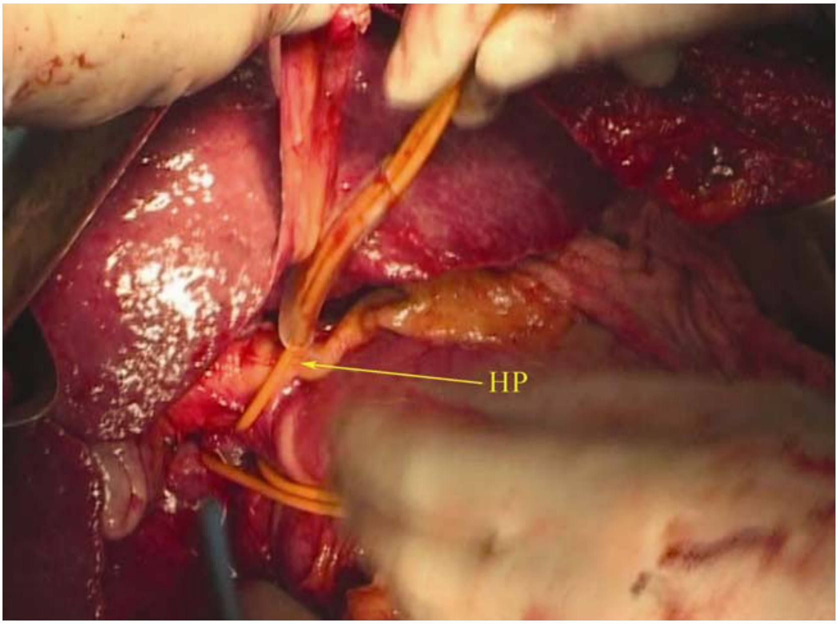


Fig.4.80. Hepatic pedicle (HP) is taped

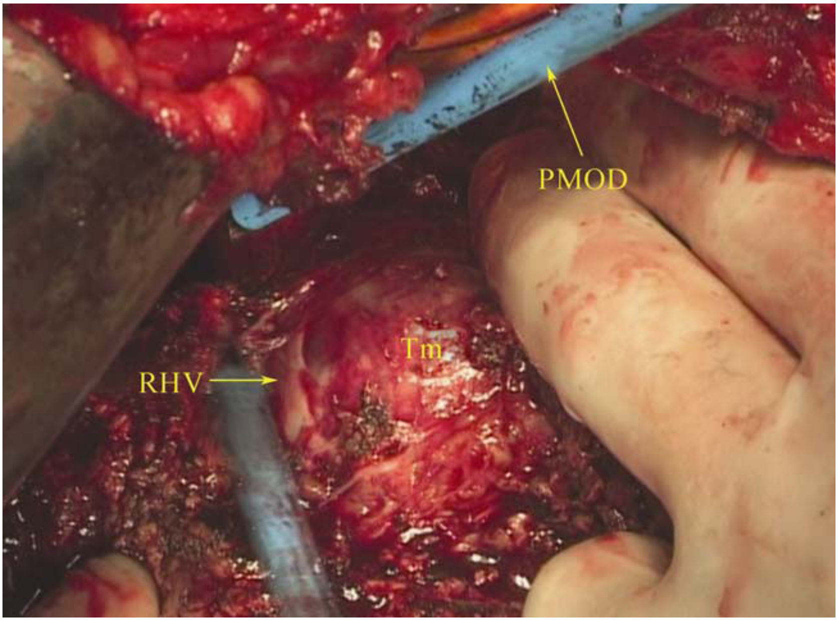


Fig.4.81. RHV is pushed outward and forward by the caudate tumor

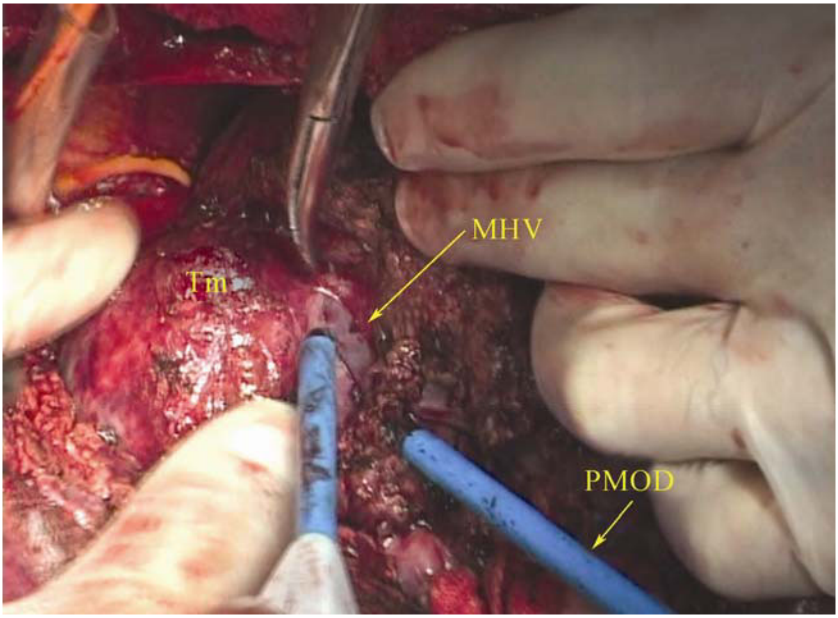


Fig.4.82. MHV is also compressed by the caudate tumor

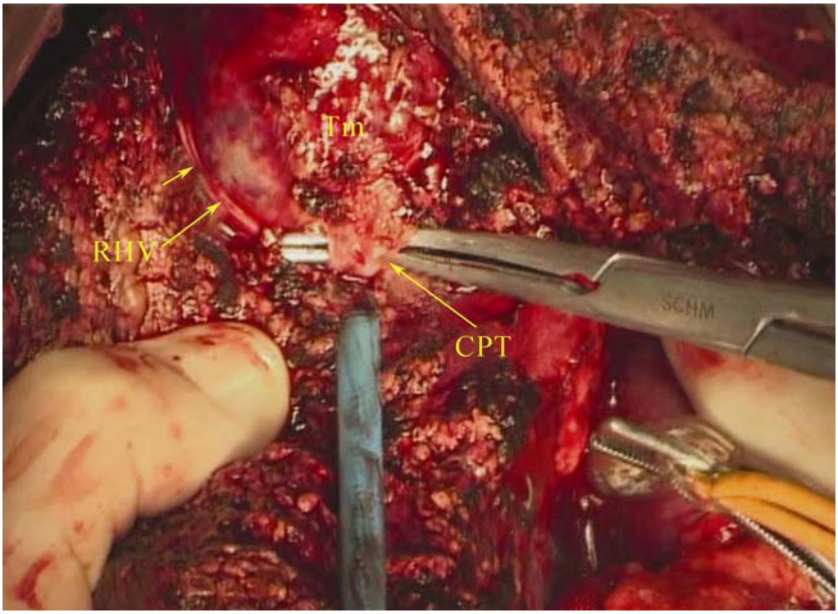


Fig.4.83. A CPT is dissected

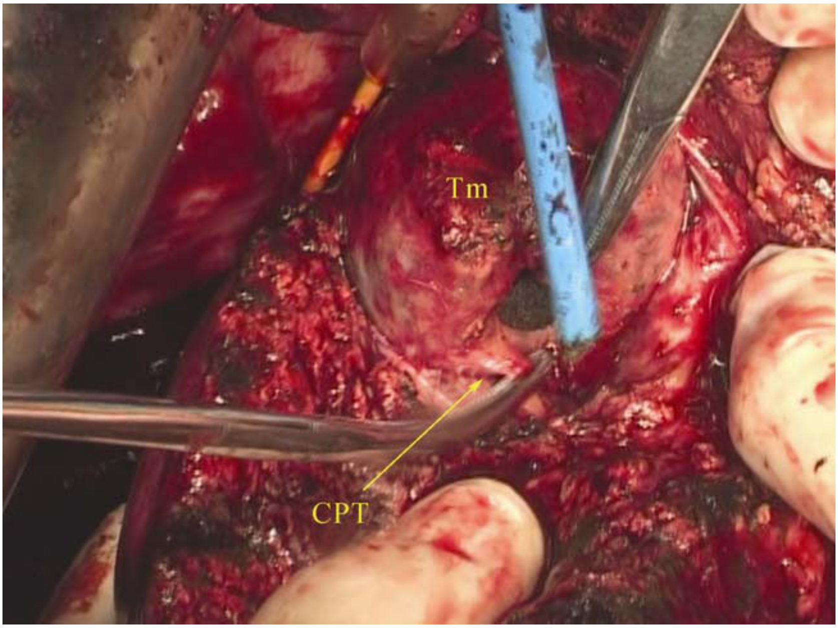


Fig.4.84. A CPT is dissected

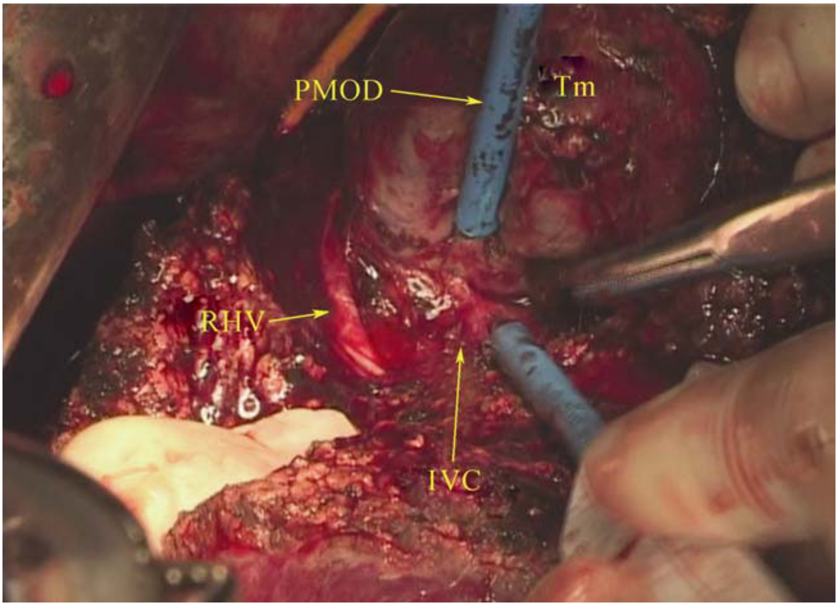


Fig.4.85. The tumor has been separated from both RHV and MHV, as well as the HP

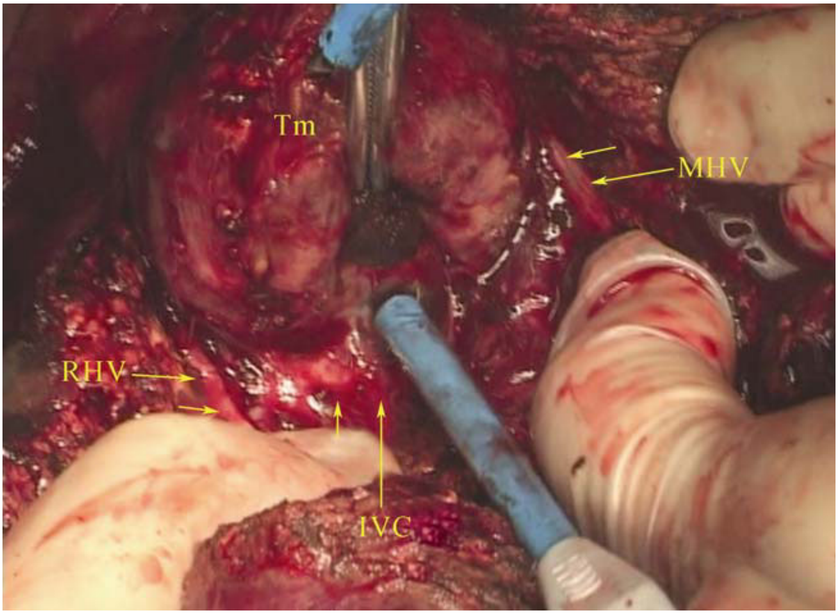


Fig.4.86. The tumor is raised from the IVC

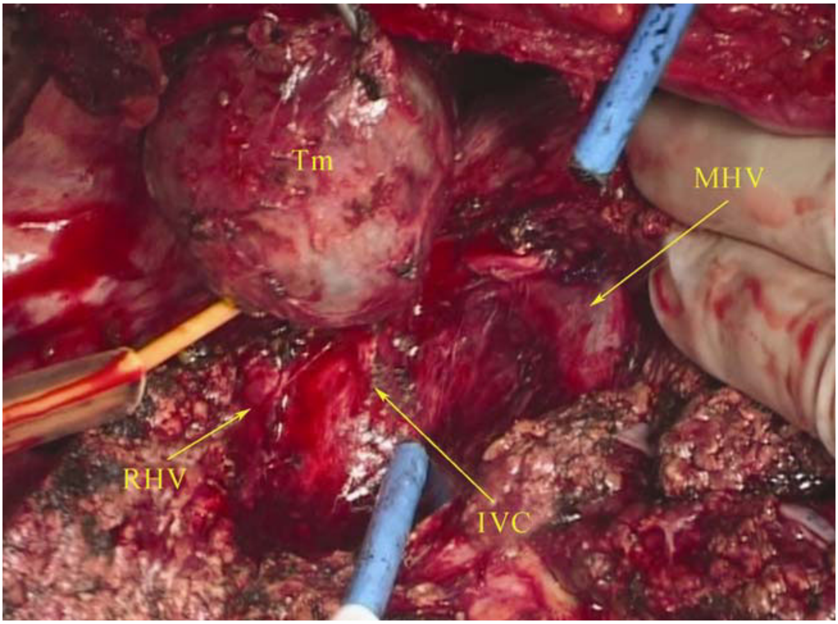


Fig.4.87. The tumor is ready to be removed, both the compressed RHV and MHV resume normal sizes

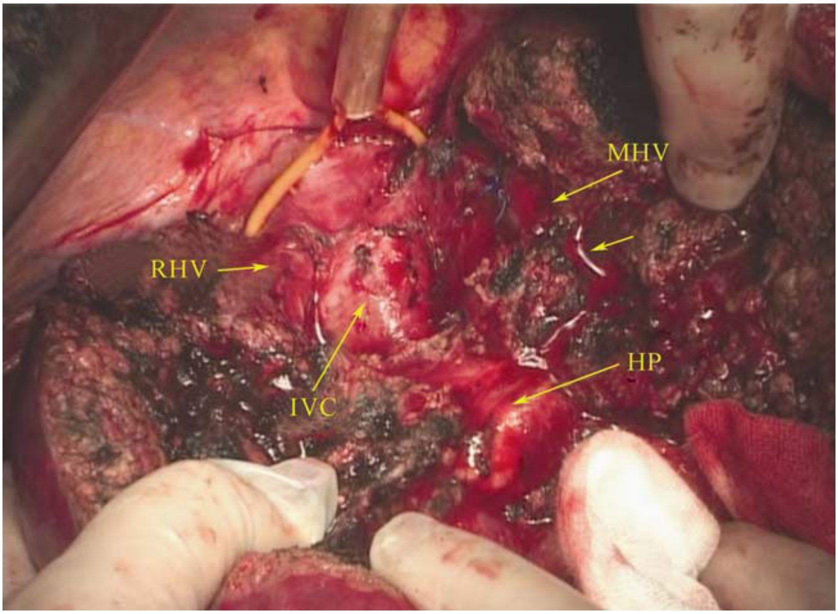


Fig.4.88. The caudate lobe fossa with surrounding important structures

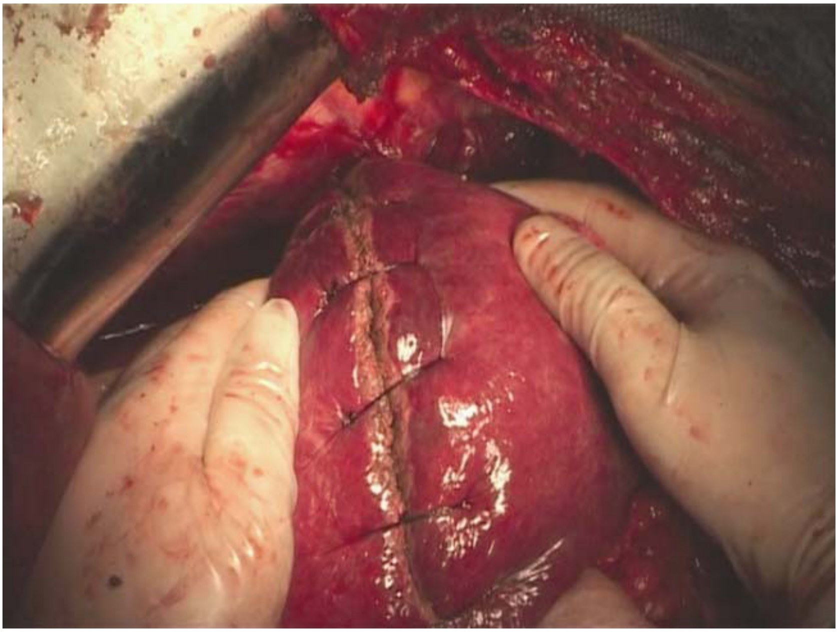


Fig.4.89. The left and right lobes are sutured together

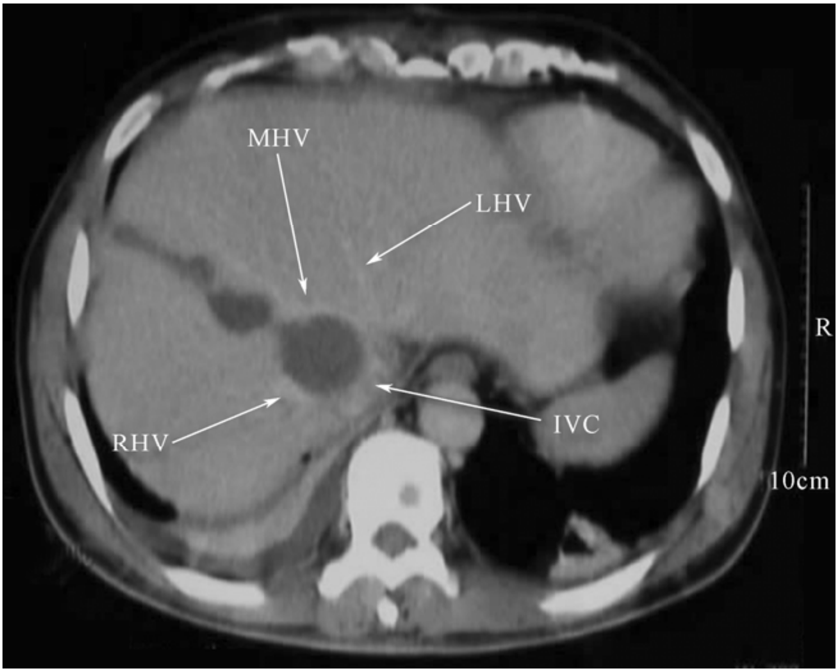


Fig.4.90. Post operative CT showing the midplane split line and the cavity situated between the LHV, MHV, RHV, and IVC where the caudate lobe was situated

4.4.2 Anterior Transhepatic Approach for HCC (2)

See Figs.4.91-4.105, and video 7.

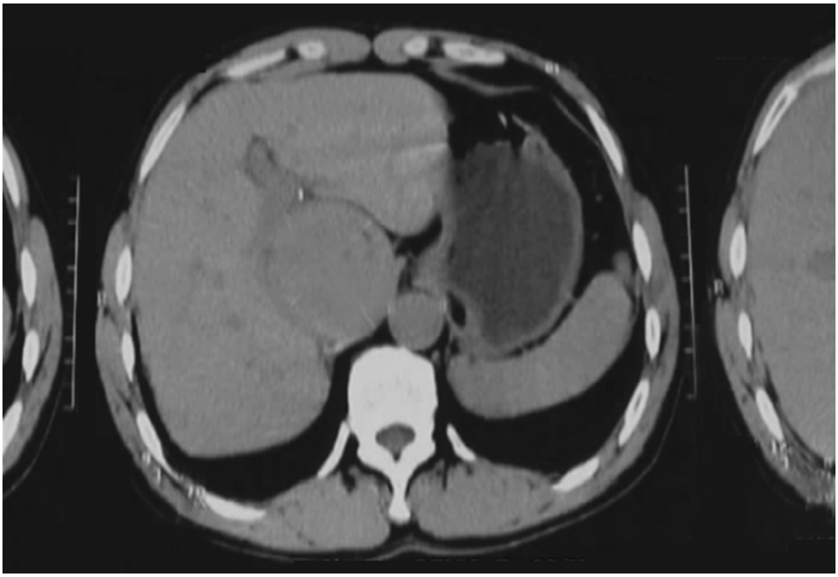


Fig.4.91. CT showing a large tumor situated in the caudate lobe

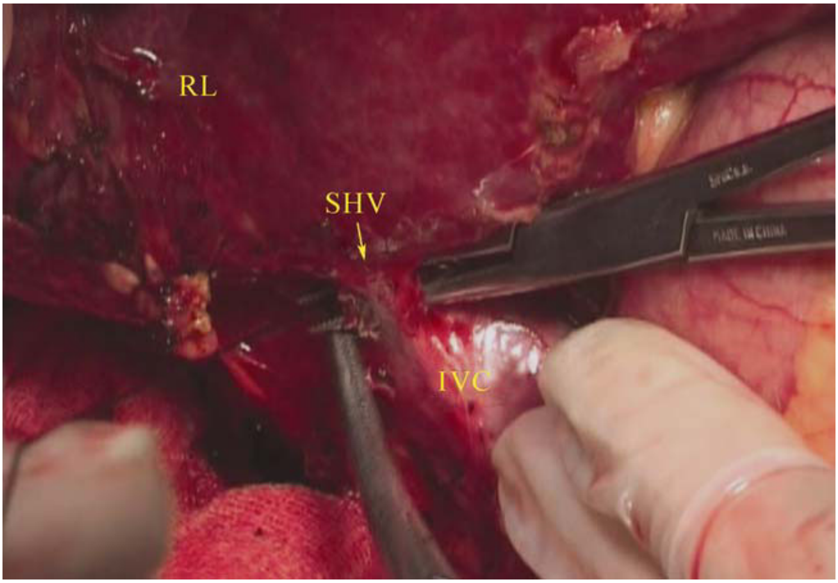


Fig.4.92. A SHV is dissected

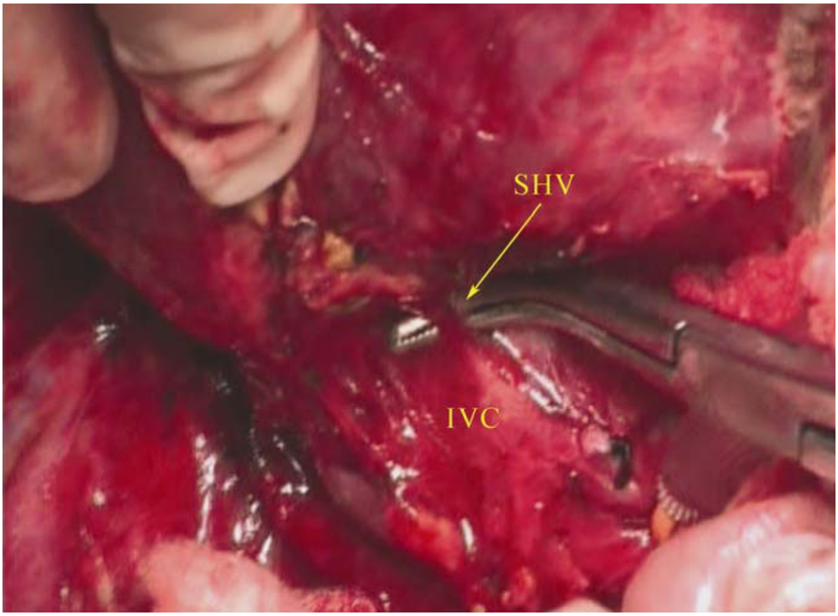


Fig.4.93. A SHV is dissected

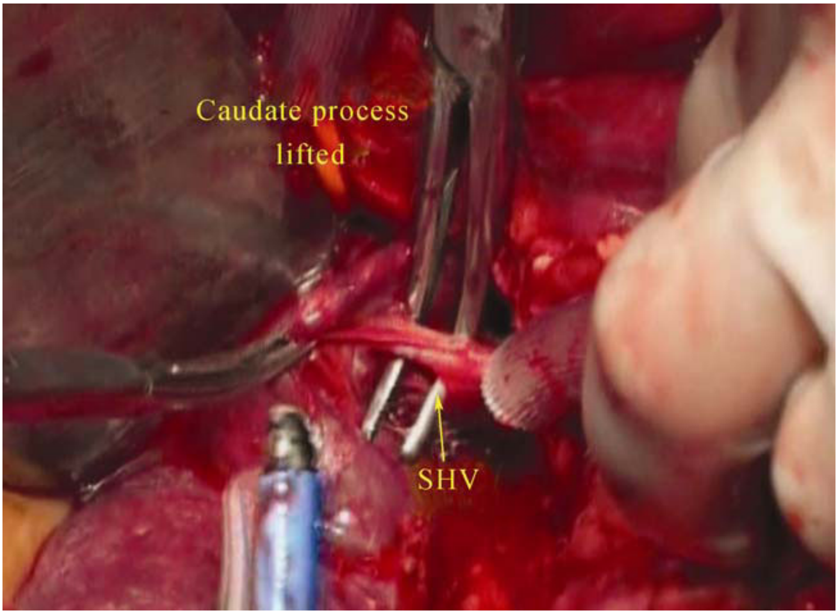


Fig.4.94. A SHV connecting the caudate process and the IVC is dissected

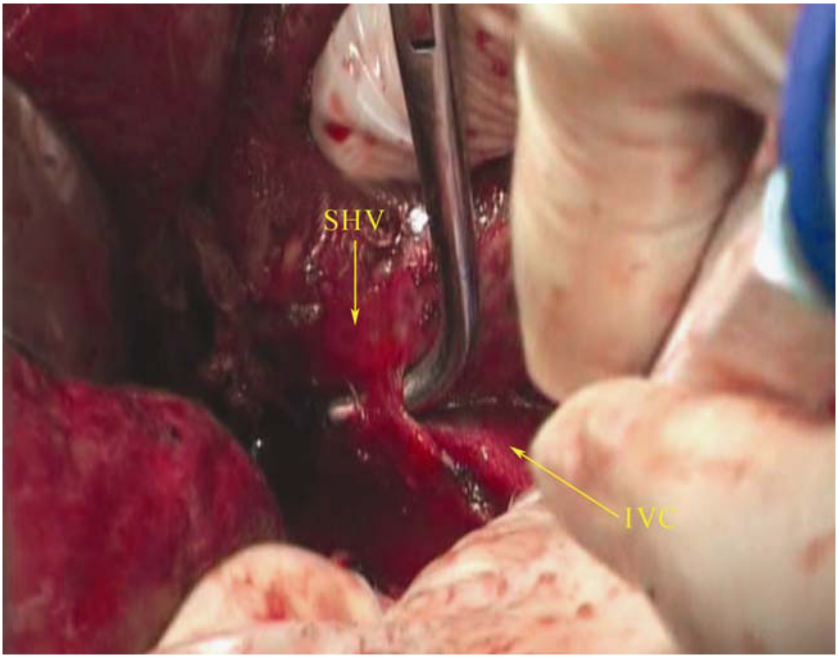


Fig.4.95. A SHV is dissected

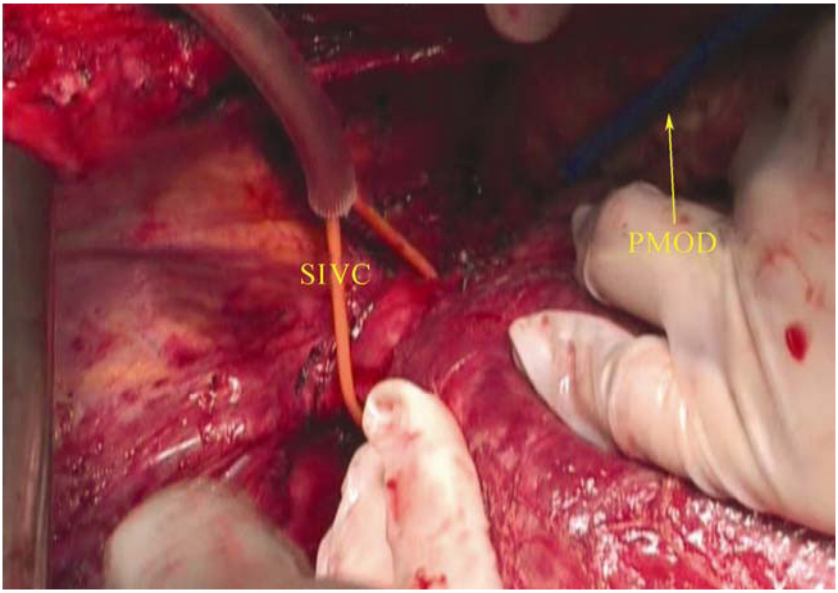


Fig.4.96. SIVC is taped

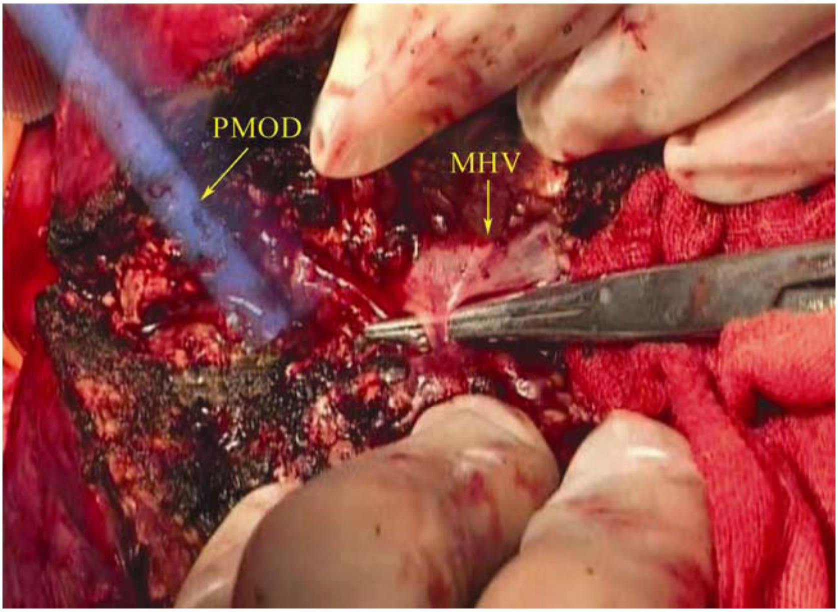


Fig.4.97. Liver is transected through the midplane, a branch of MHV is divided

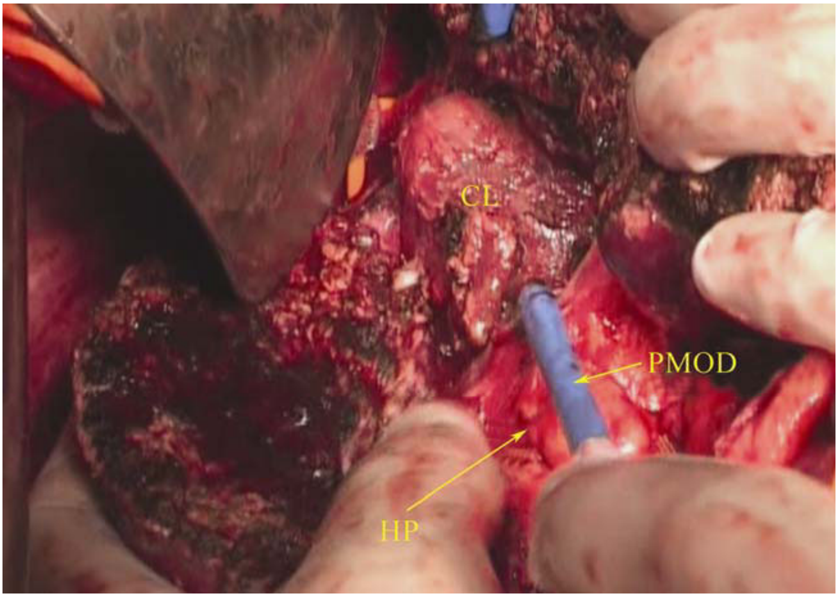


Fig.4.98. The tumor is detached from the confluence

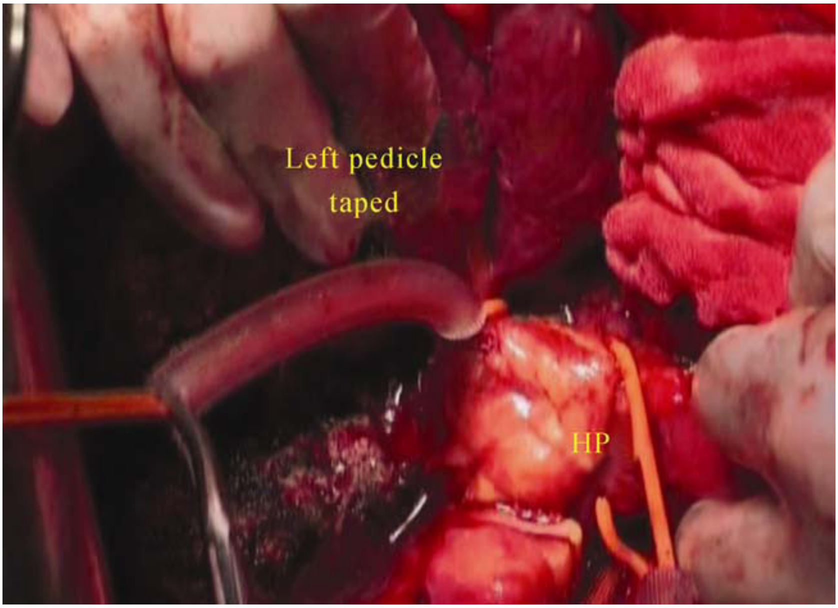


Fig.4.99. The left pedicle is occluded while occlusion of the main pedicle is released

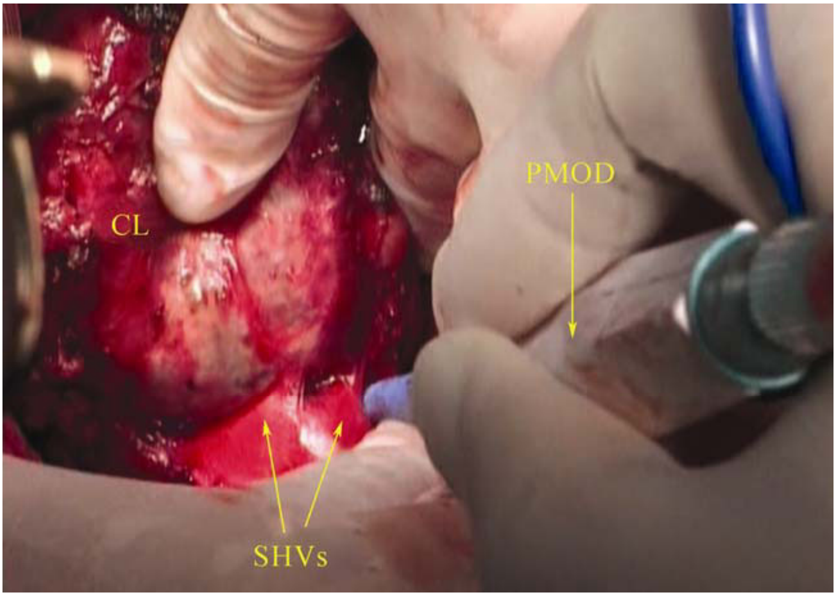


Fig.4.100. Two SHVs are dissected while the tumor is being detached from the IVC

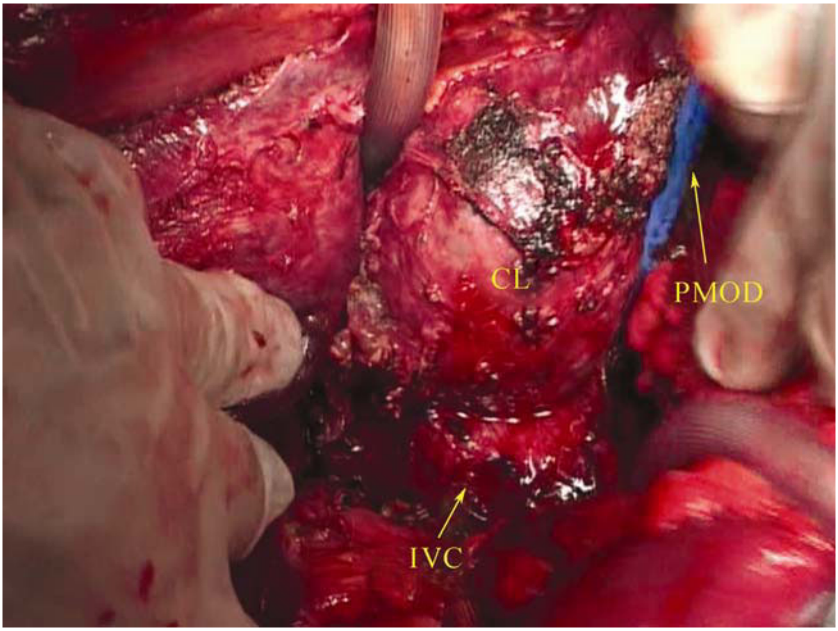


Fig.4.101. Originally the tumor was behind the midplane, after isolation it is now pushed under the common trunk to the left for further dissection

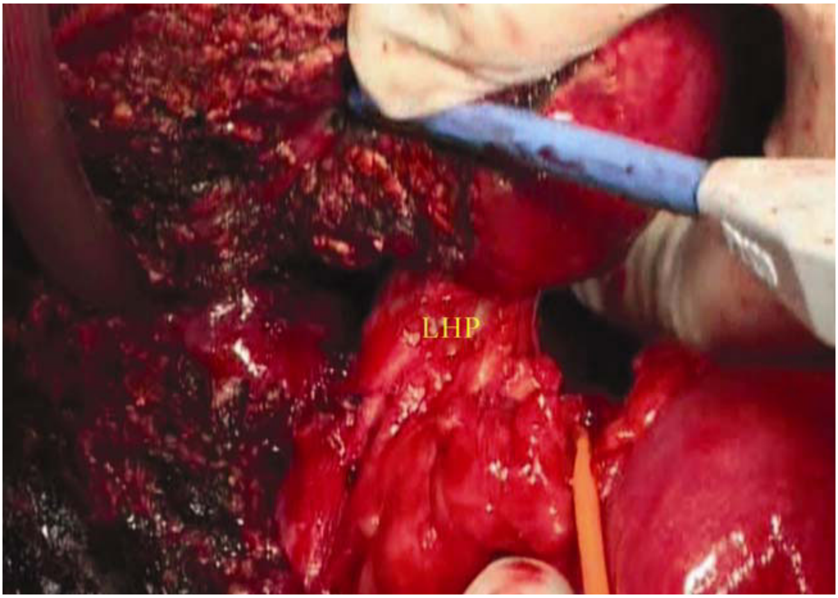


Fig.4.102. The left pedicle is completely free from surrounding tissue after the tumor was removed

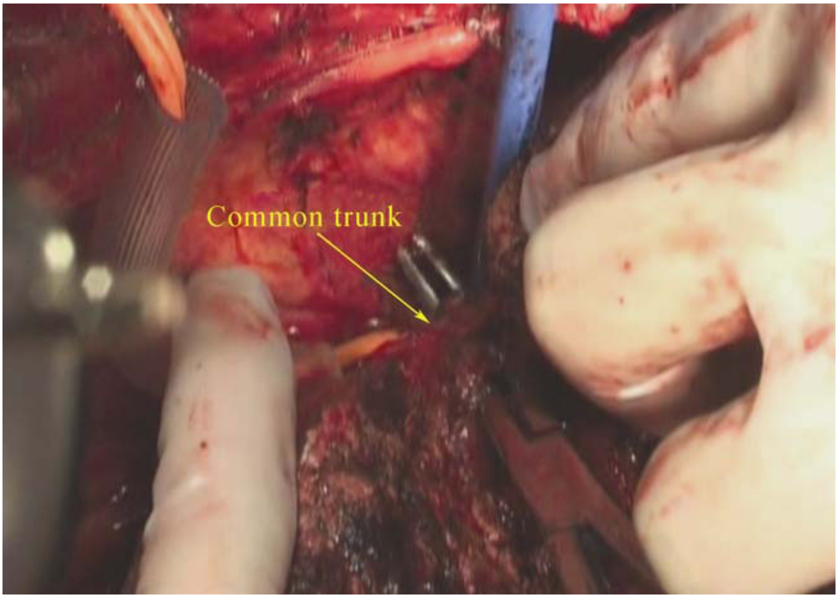


Fig.4.103. The preserved common trunk after removal of the tumor

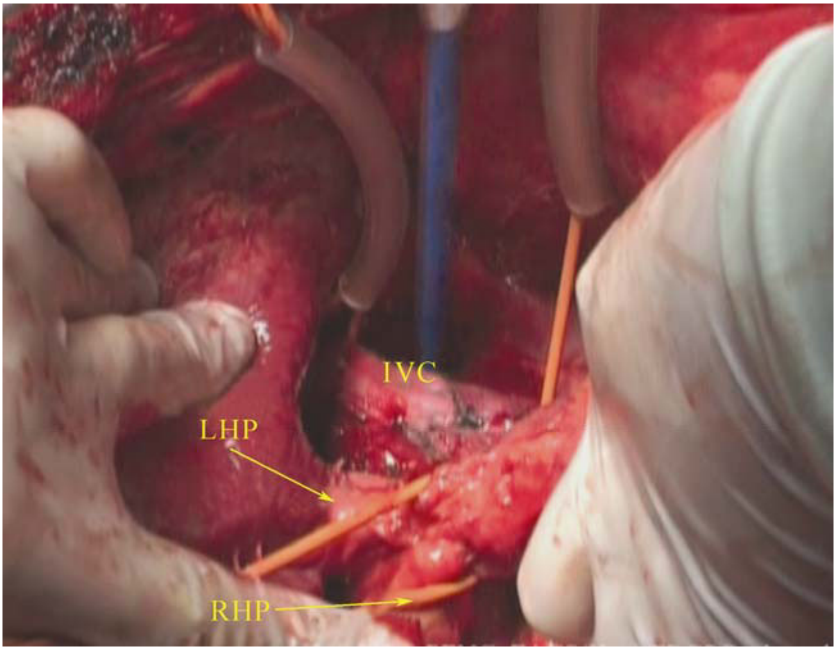


Fig.4.104. The caudate fossa. Completely exposed is the IVC, in front of which was the caudate lobe situated

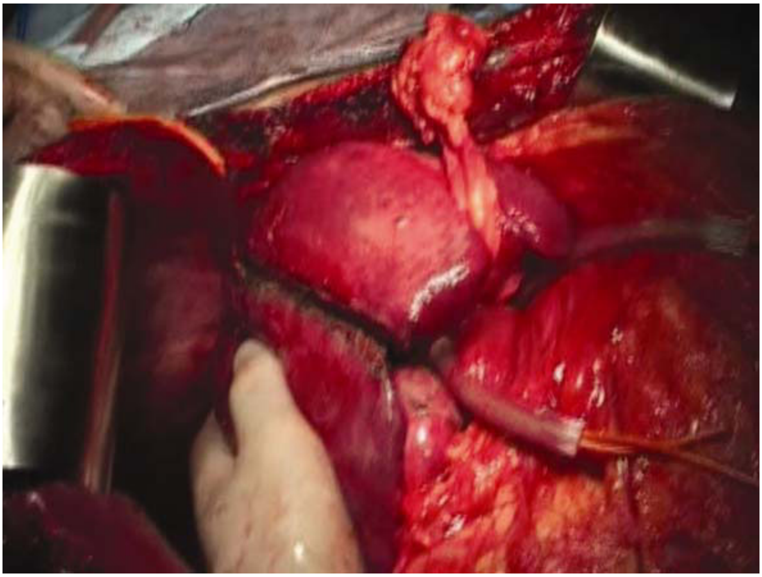


Fig.4.105. Right and left lobes are sutured together after the tumor was removed

4.4.3 Anterior Transhepatic Approach (Split of the Upper Half of the Midplane) for Hemangioma

See Figs.4.106-4.120.

Fig.4.106. CT showing a tumor very high up, very close to the root of the major HV

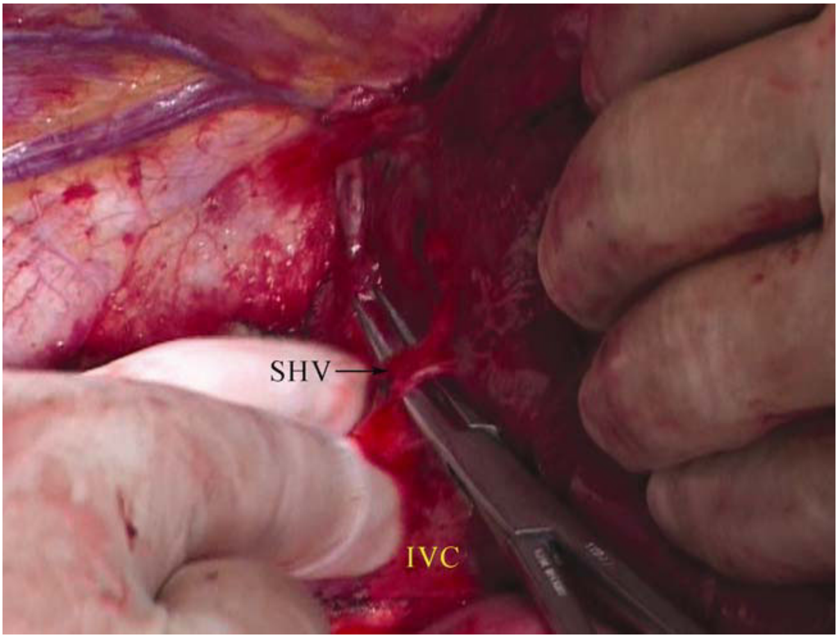


Fig.4.107. A SHV is dissected

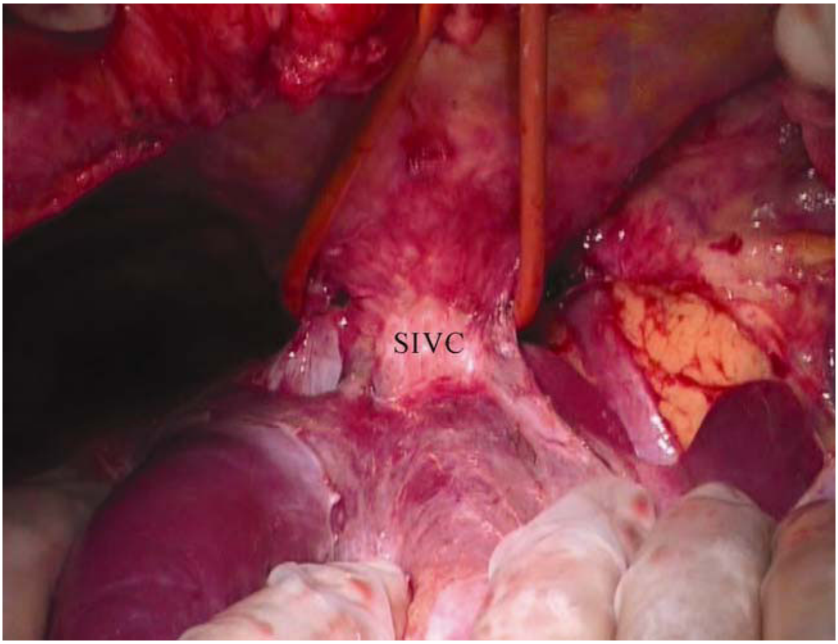


Fig.4.108. SIVC is taped

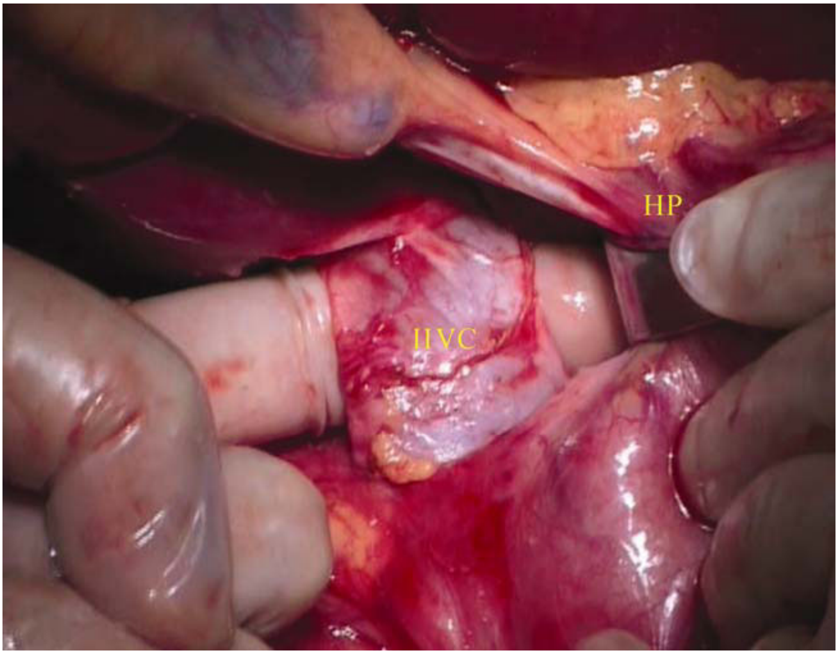


Fig.4.109. IIVC is isolated

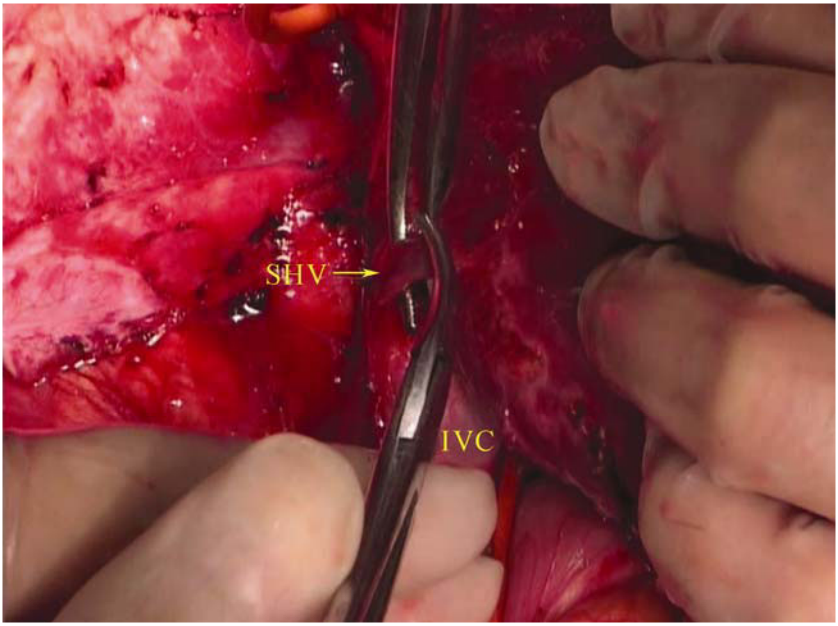


Fig.4.110. A SHV is dissected

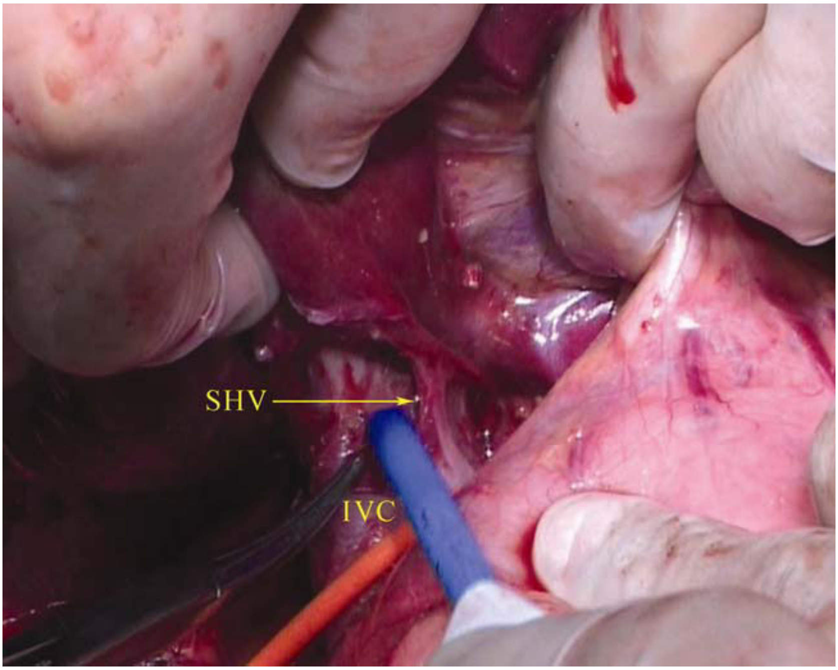


Fig.4.111. A SHV is dissected

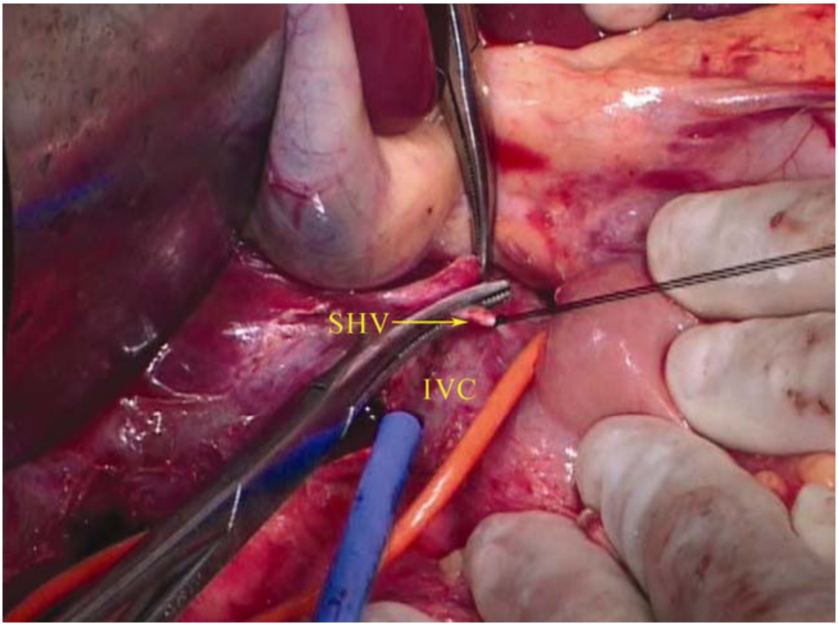


Fig.4.112. A SHV is dissected, ligated, and divided

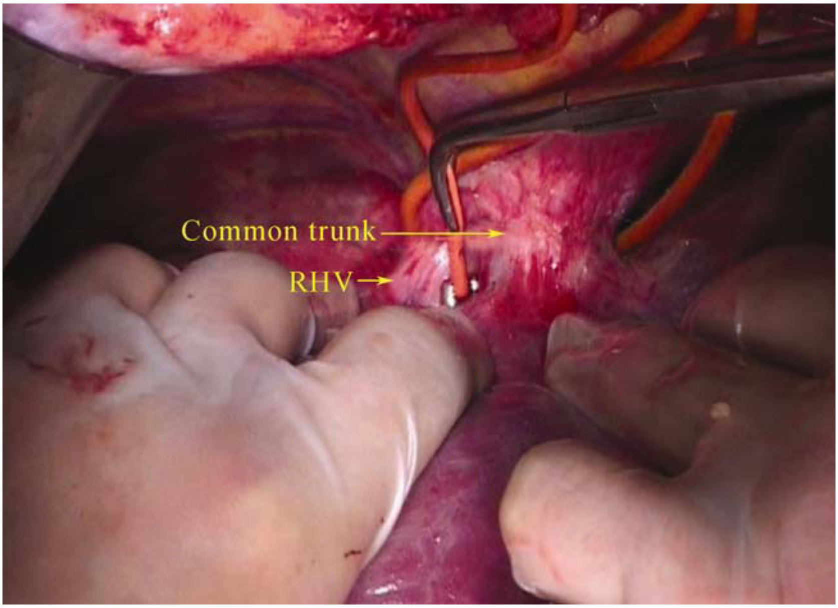


Fig.4.113. Ready to pull a catheter through the retrohepatic tunnel for hanging the liver

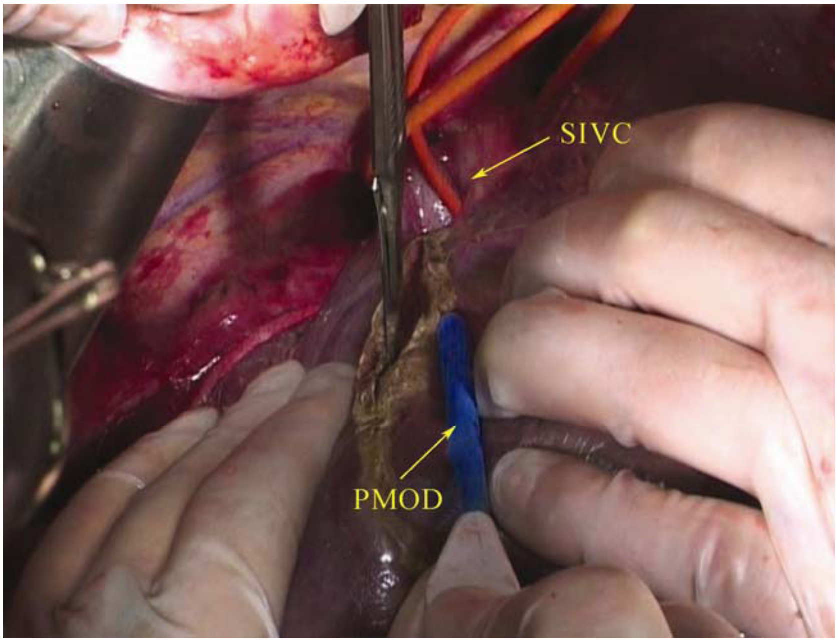


Fig.4.114. Liver transaction

Fig.4.115. A branch from the MHV is dissected

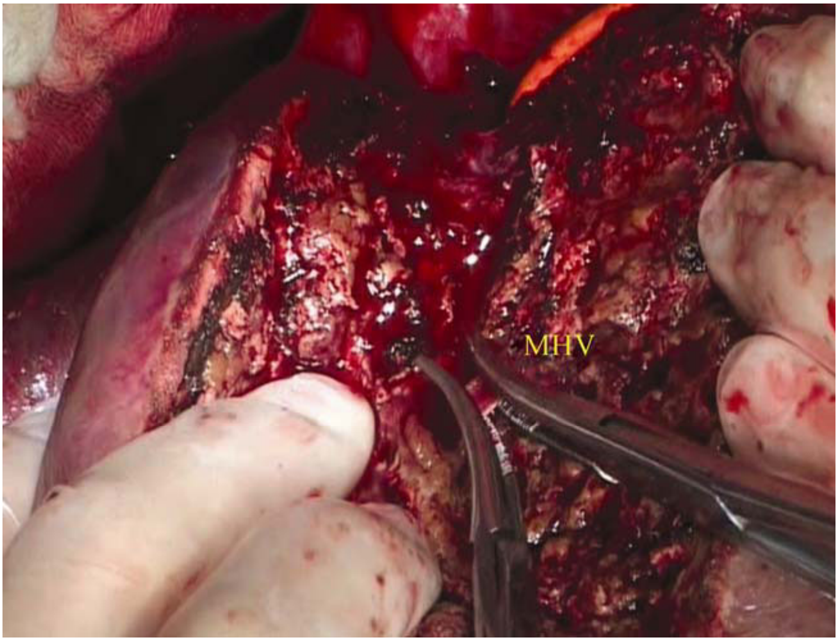


Fig.4.116. A branch of the MHV is dissected and ligated

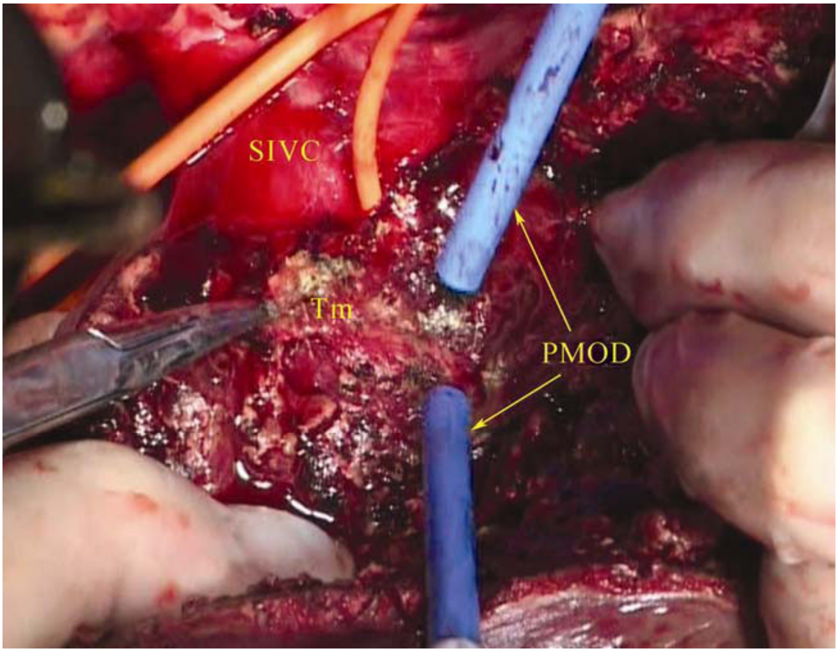


Fig.4.117. The tumor is visualized

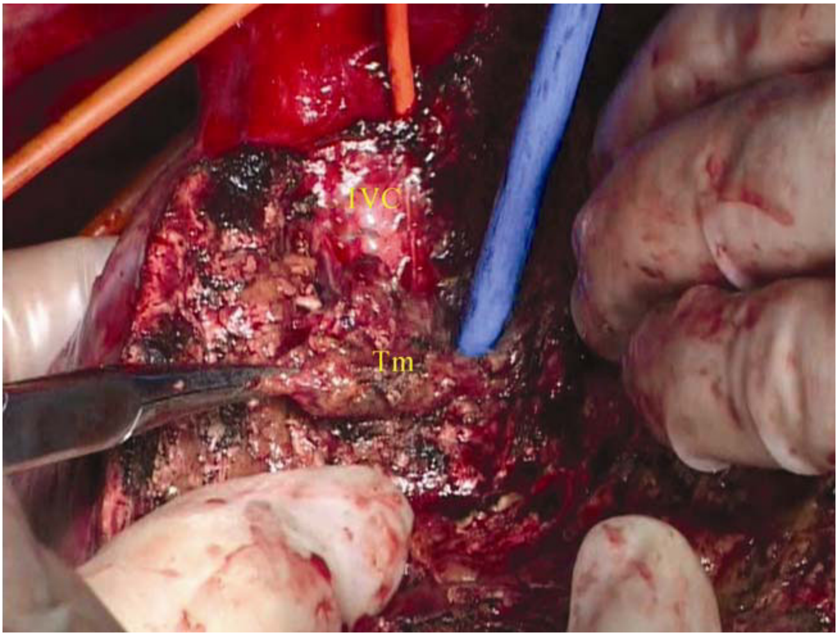


Fig.4.118. The tumor is detached from the IVC

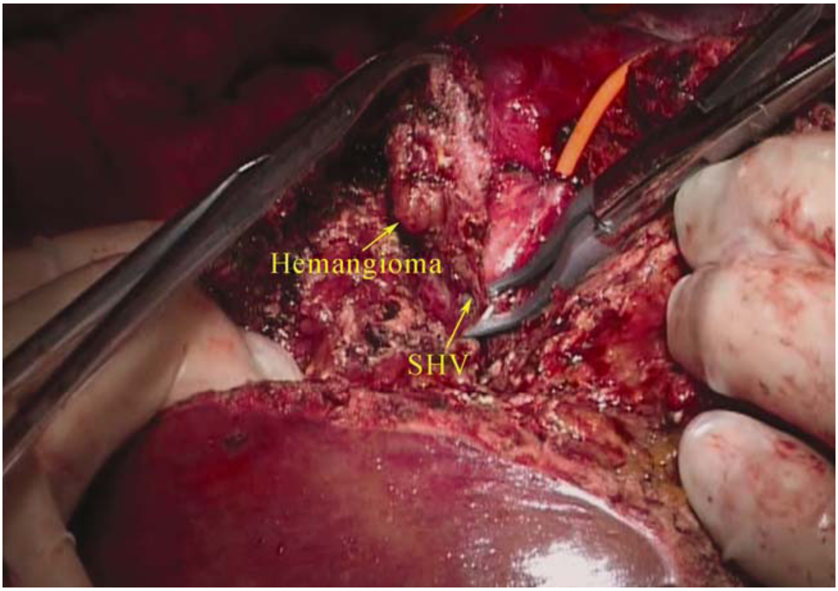


Fig.4.119. To remove the tumor, only the upper half of the midplane split is sufficient

Fig.4.120. To remove the tumor, only the upper half of the midplane split is used

4.4.4 Anterior Transhepatic Approach for HCC (3)

See Figs.4.121-4.137.

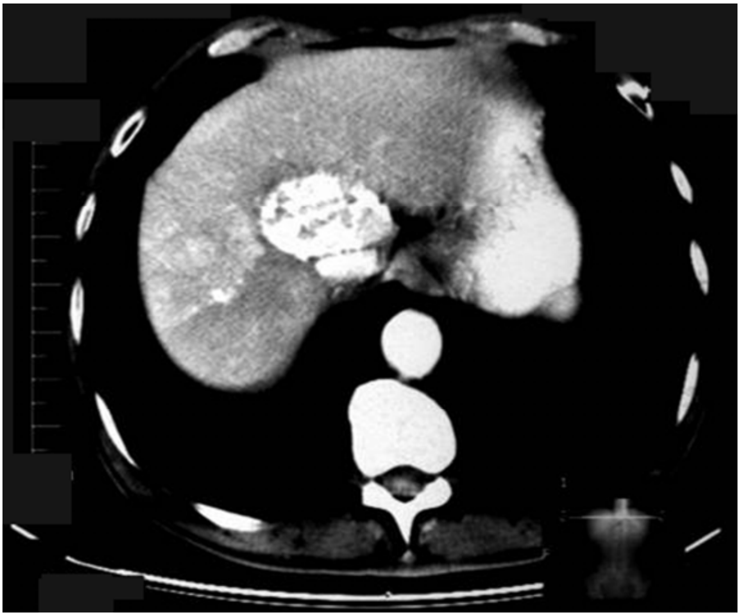
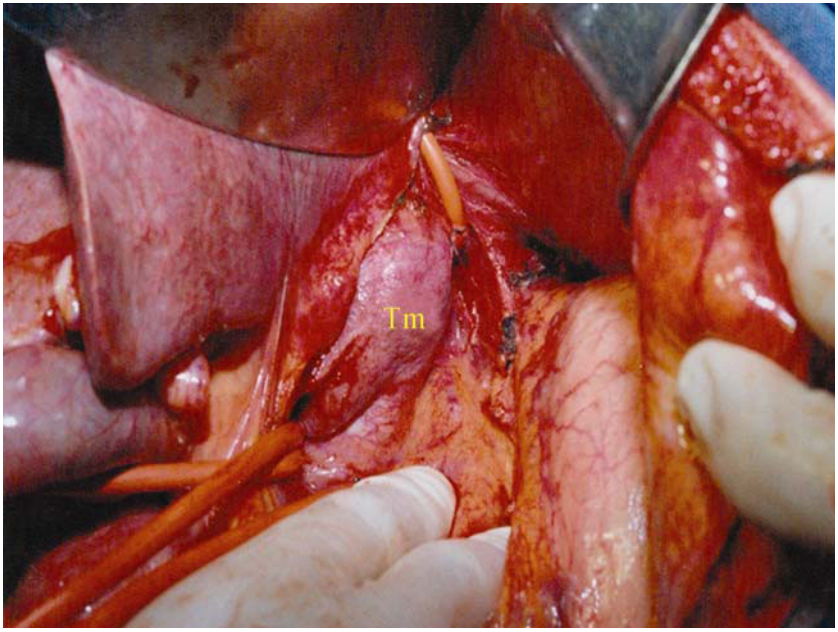
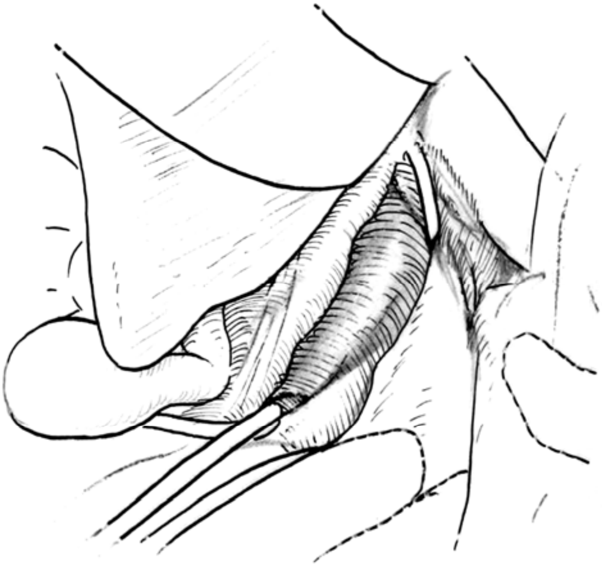


Fig.4.121. CT showing a HCC after transcatheter arterial chemoembolization (TACE) in the caudate lobe

Fig.4.122. Post operative CT showing the midplane split line and the cavity where the caudate lobe was situated

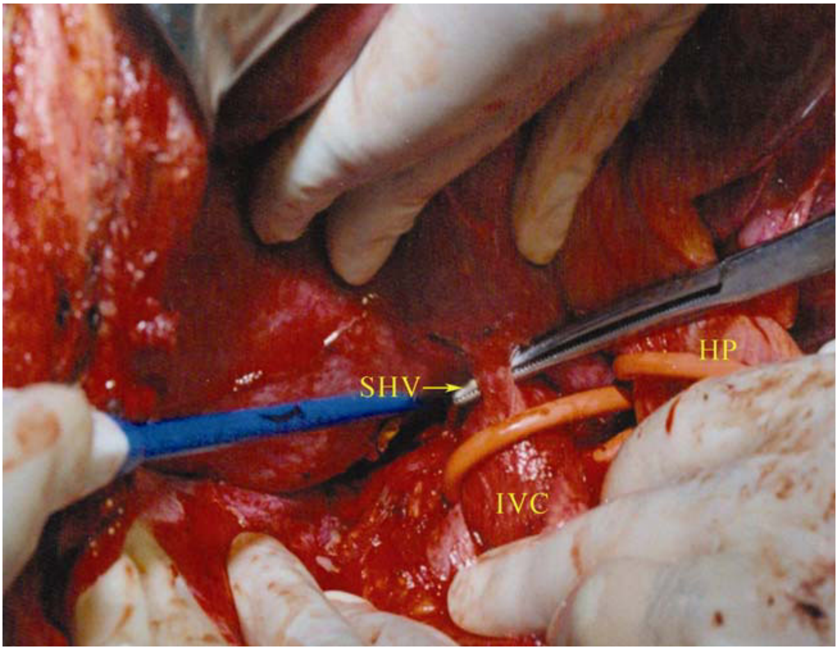


(a)

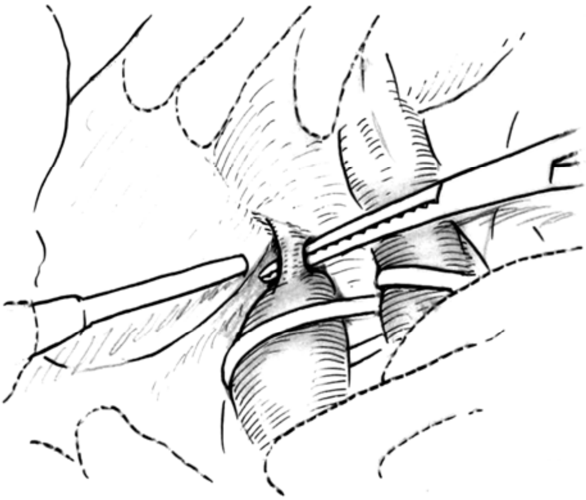


(b)

Fig.4.123. The tumor is in close contact with the tape of the SIVC. (a) Photograph; (b) Drawing

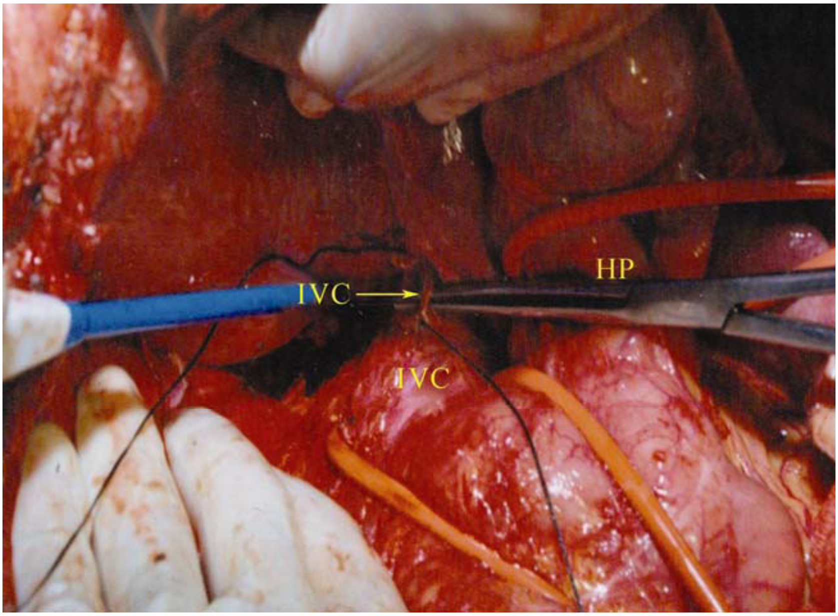


(a)

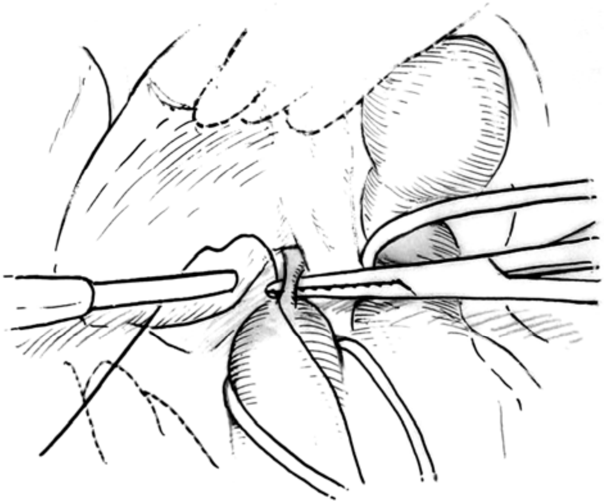


(b)

Fig.4.124. The first SHV is isolated.
(a) Photograph; (b) Drawing

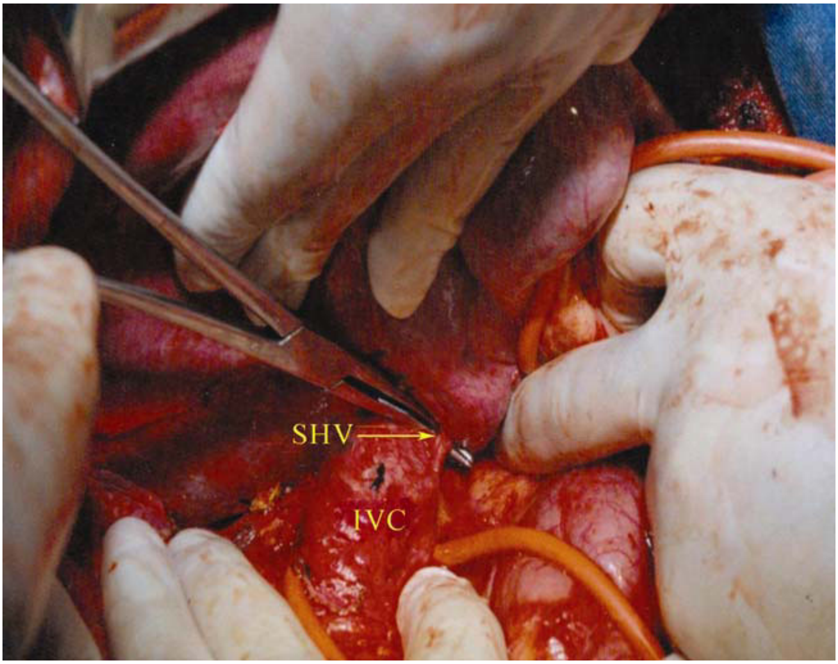


(a)

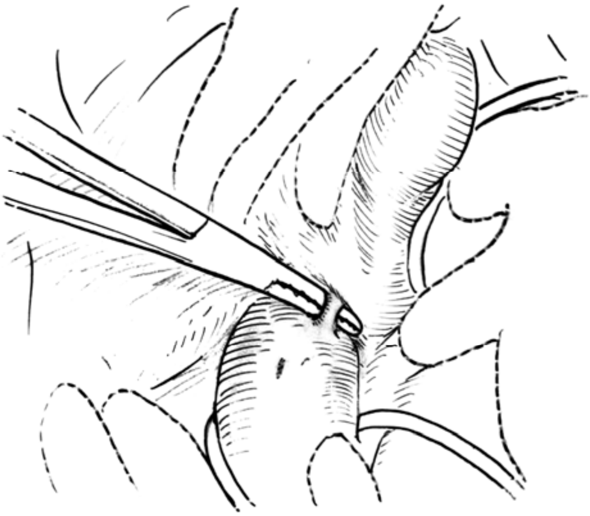


(b)

Fig.4.125. The second SHV is isolated.
(a) Photograph; (b) Drawing

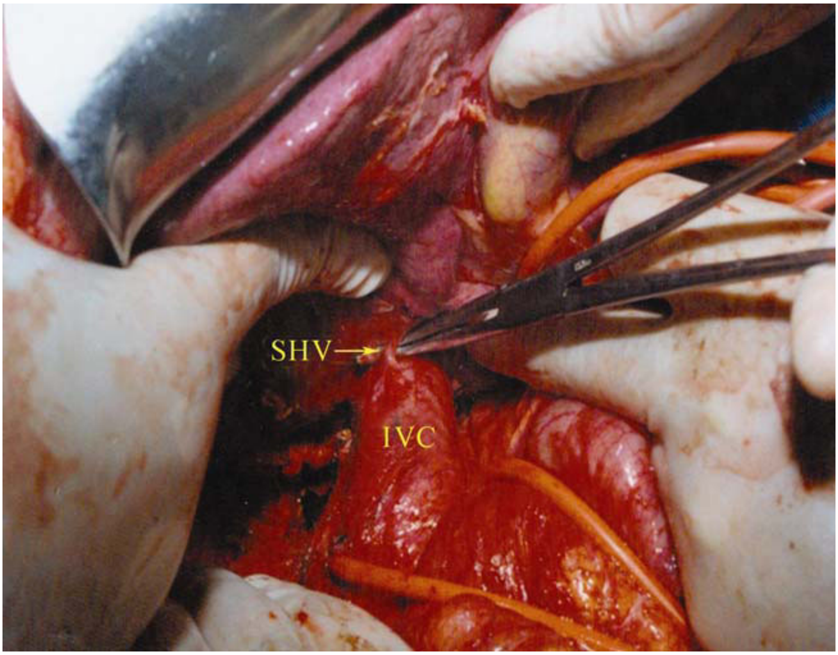


(a)

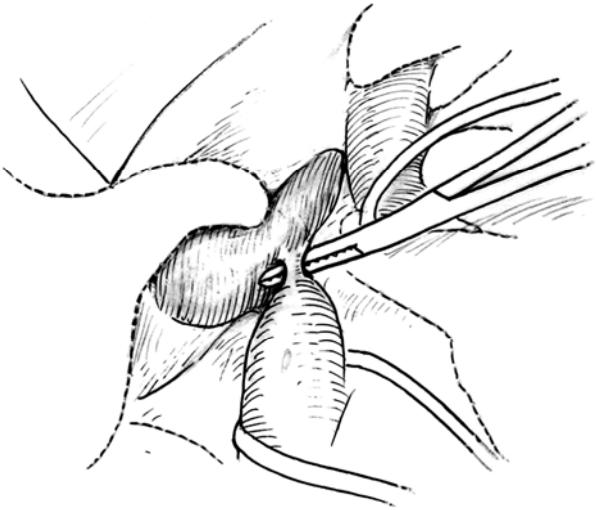


(b)

Fig.4.126. The third SHV is isolated.
(a) Photograph; (b) Drawing

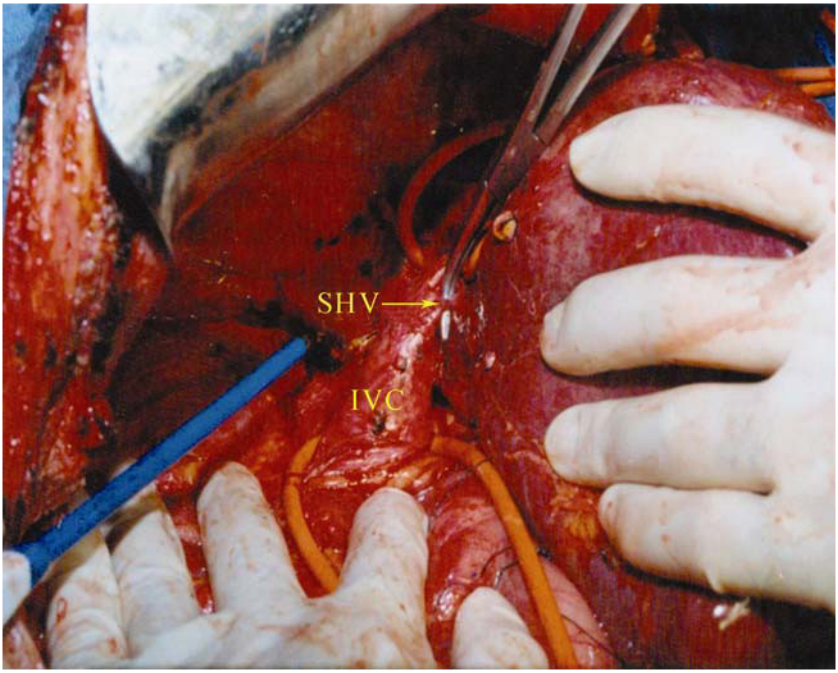


(a)

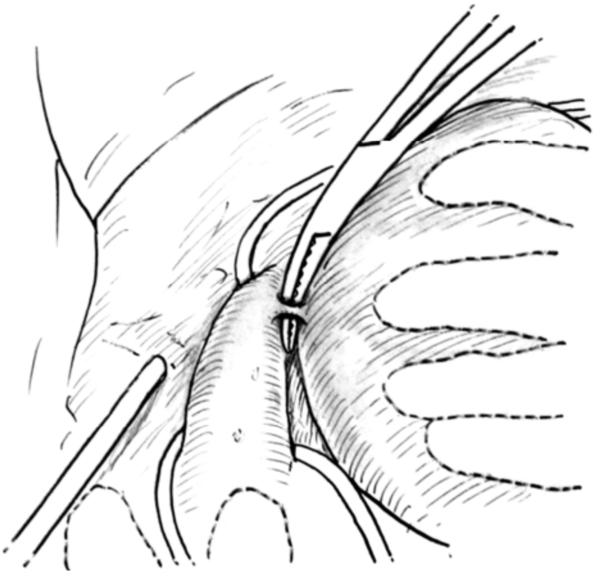


(b)

Fig.4.127. The fourth SHV is isolated.
(a) Photograph; (b) Drawing

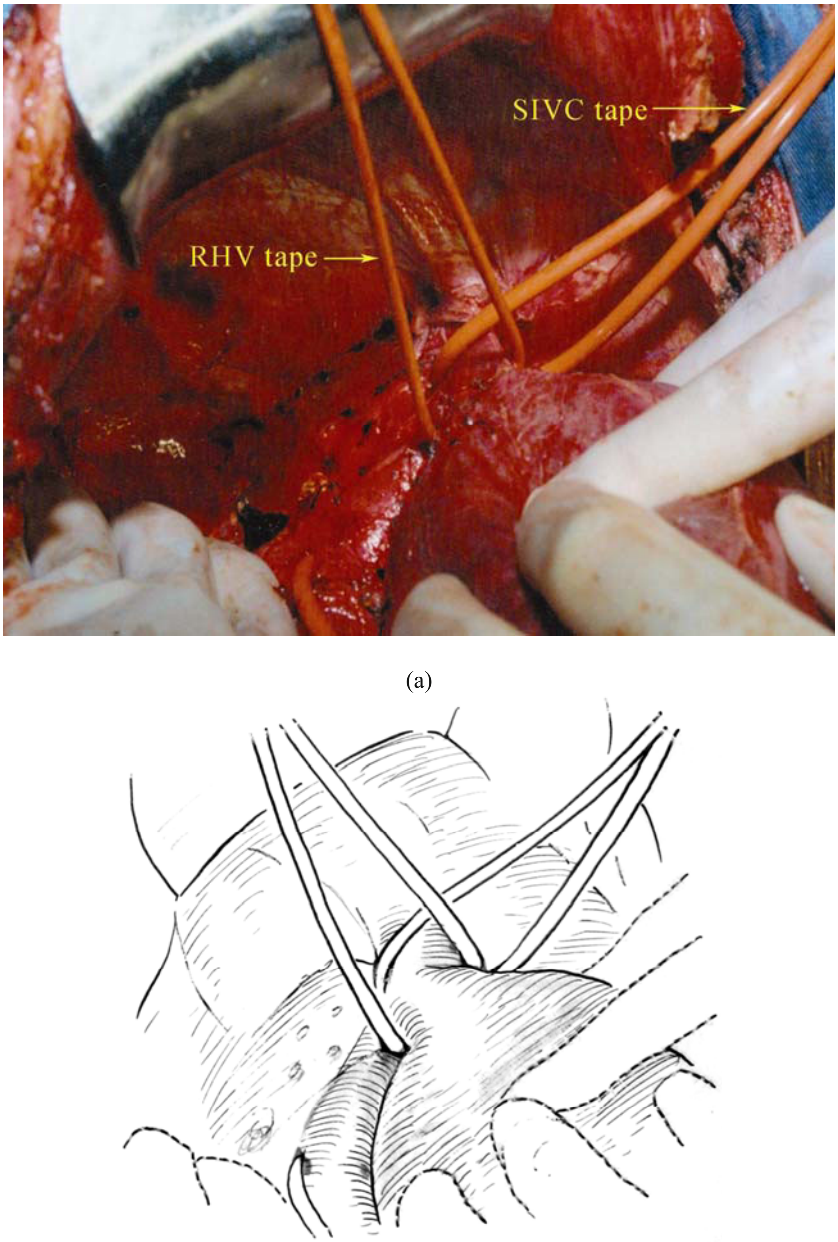


(a)



(b)

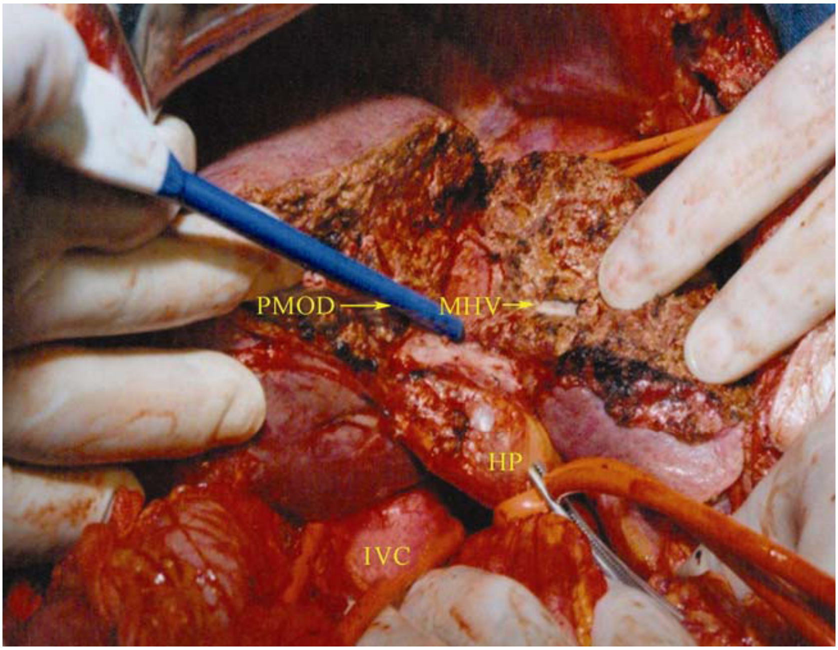
Fig.4.128. The fifth SHV is isolated.
(a) Photograph; (b) Drawing



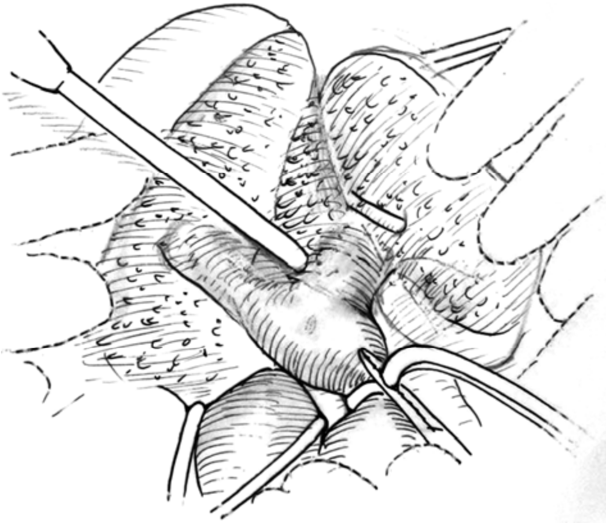
(a)

(b)

Fig.4.129. The RHV is taped.
(a) Photograph; (b) Drawing

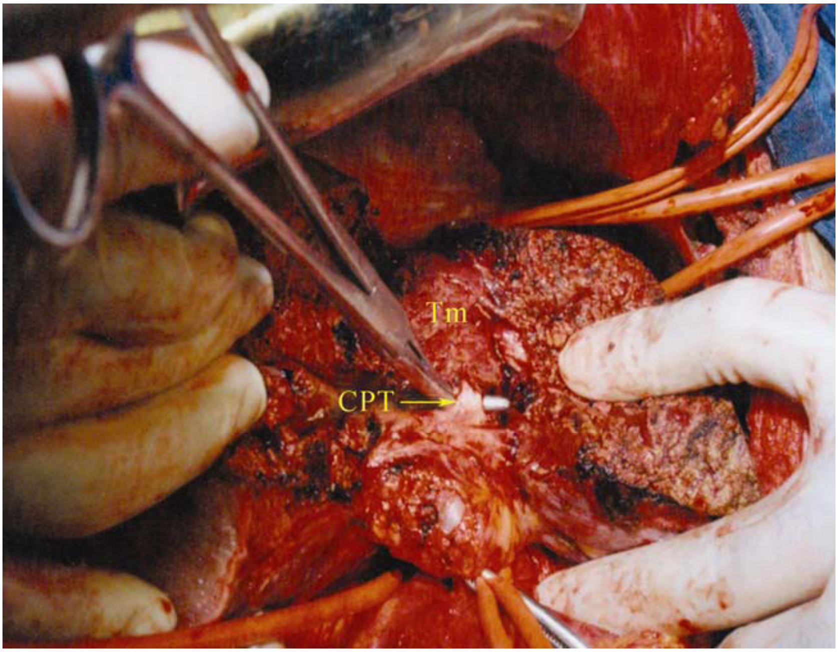


(a)

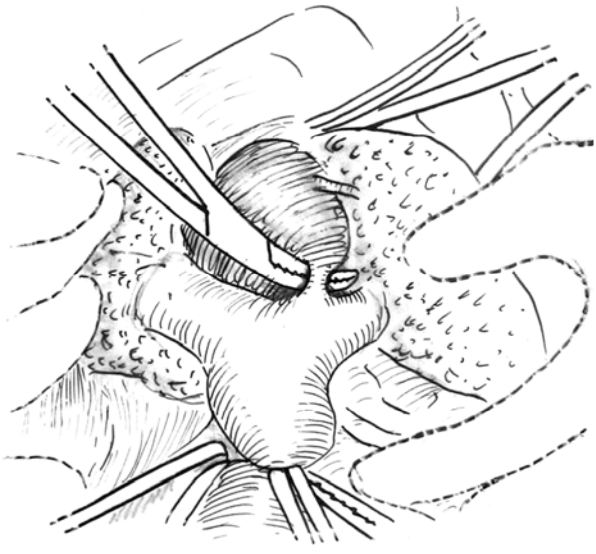


(b)

Fig.4.130. The split line is along the right side of the MHV. (a) Photograph; (b) Drawing

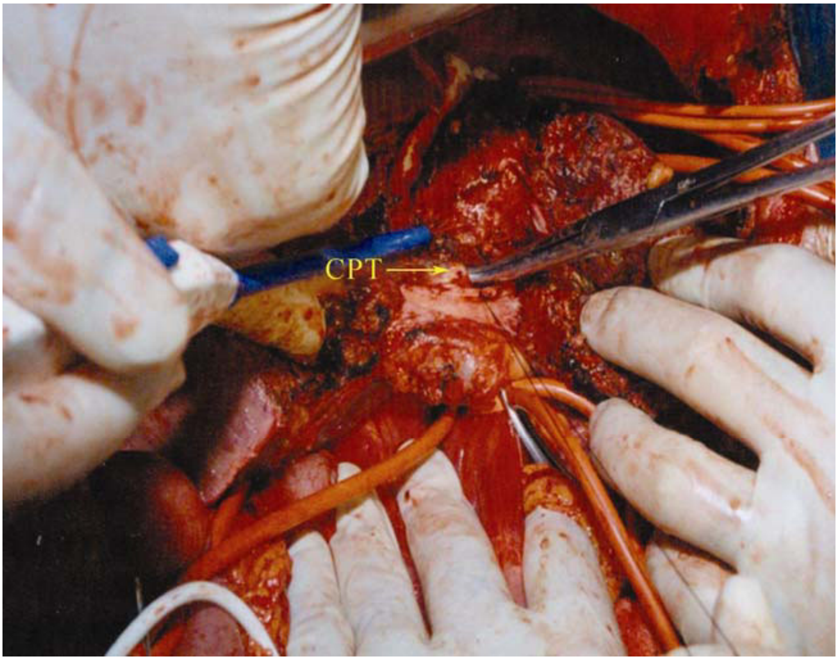


(a)

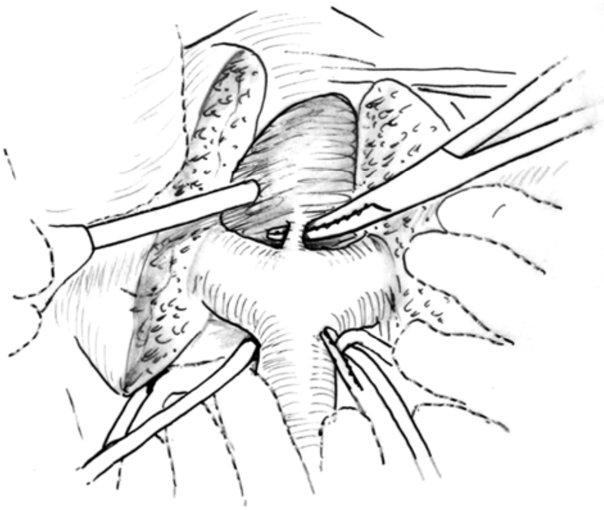


(b)

Fig.4.131. The first CPT is dissected.
(a) Photograph; (b) Drawing

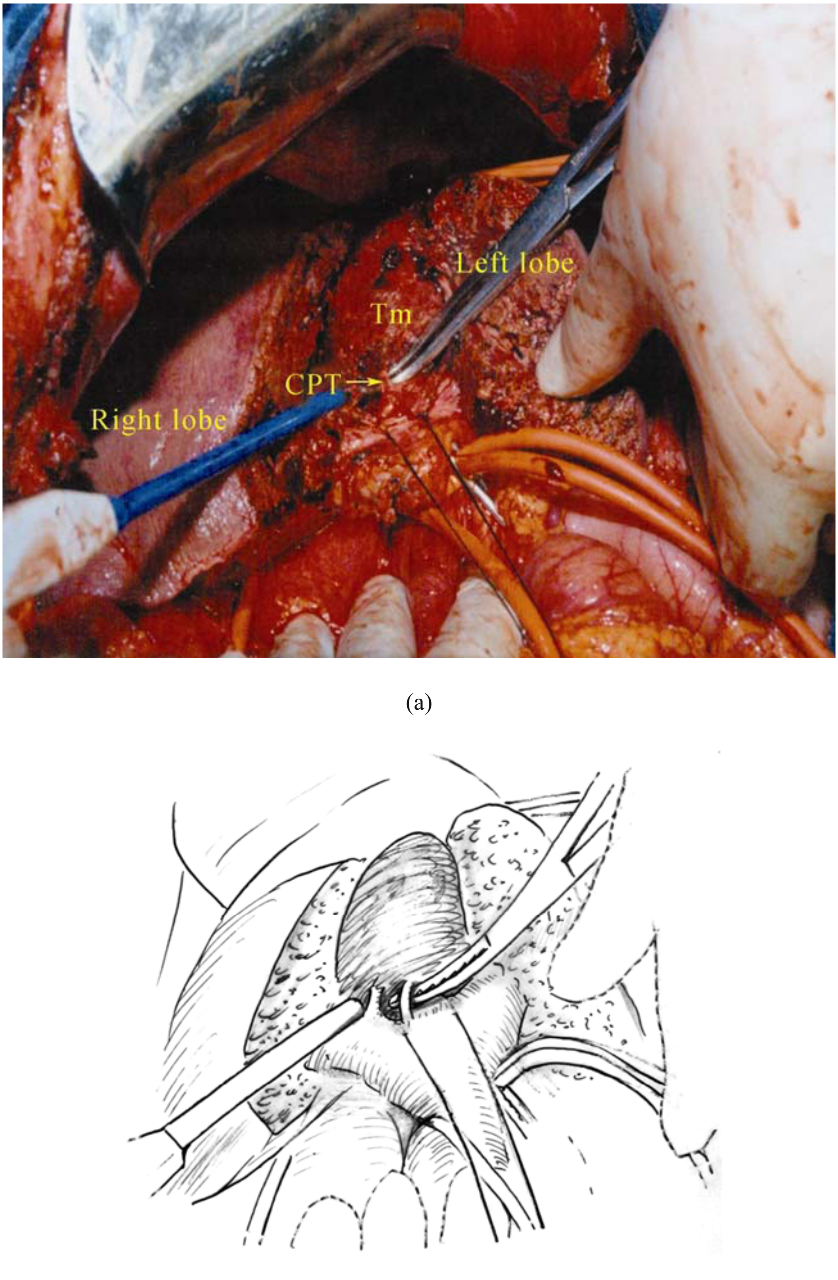


(a)



(b)

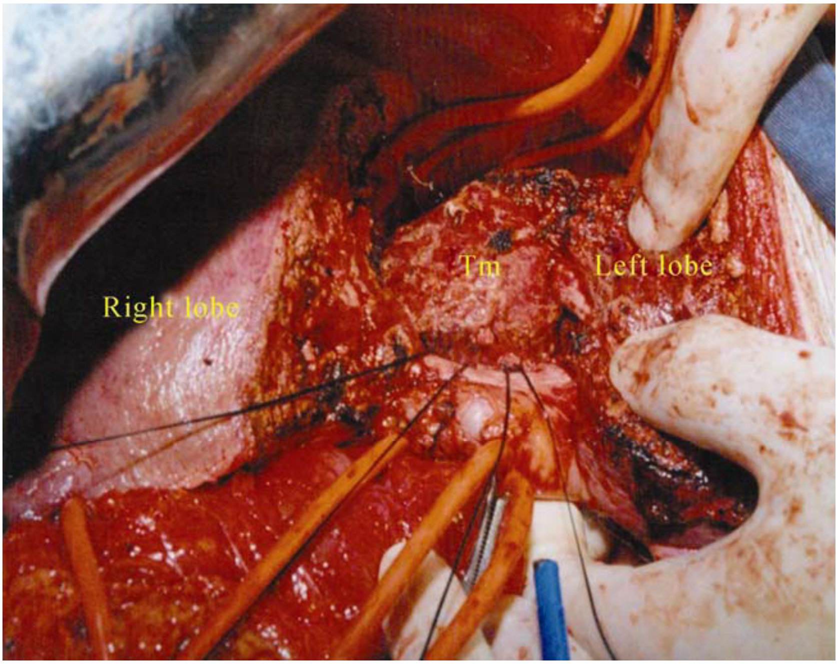
Fig.4.132. The second CPT is dissected.
(a) Photograph; (b) Drawing



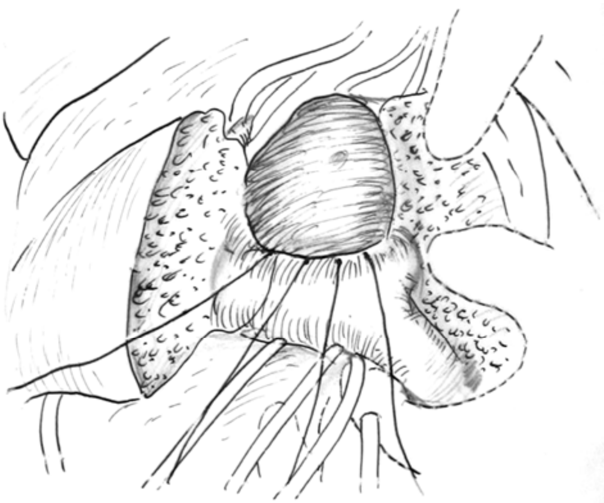
(a)

(b)

Fig.4.133. The third CPT is dissected.
(a) Photograph; (b) Drawing

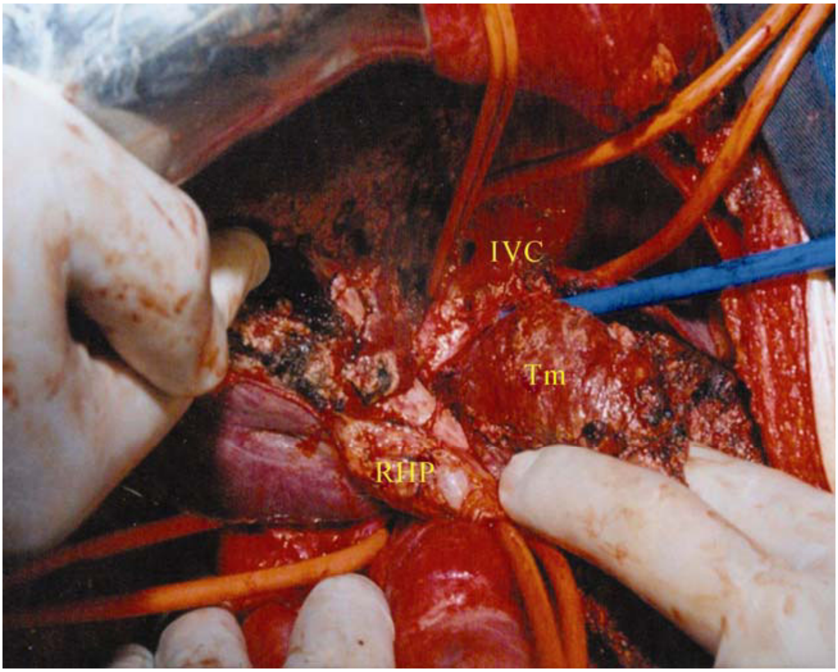


(a)

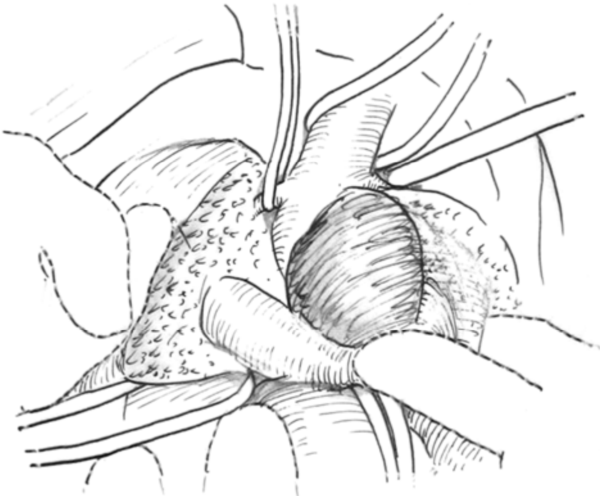


(b)

Fig.4.134. Four CPTs are ligated and divided.
(a) Photograph; (b) Drawing

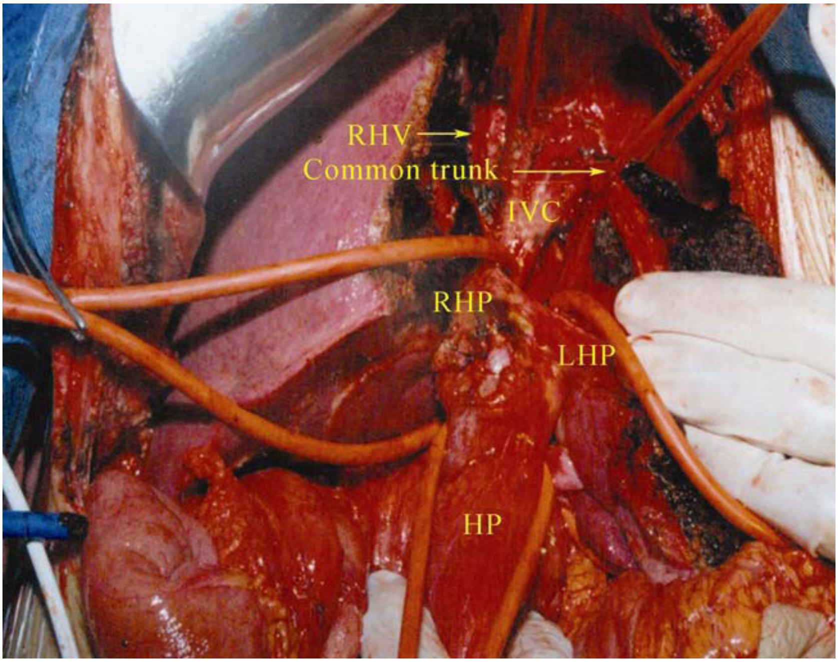


(a)

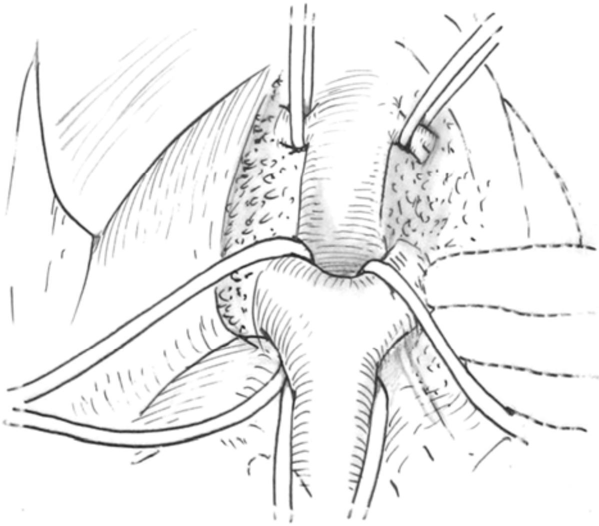


(b)

Fig.4.135. The tumor is to be detached from the MHV.
(a) Photograph; (b) Drawing



(a)



(b)

Fig.4.136. After tumor removal, the first, second, and third portae hepatis can be seen at the same time. (a) Photograph; (b) Drawing

Fig.4.137. The splitted left and right lobe are sutured together

References

Asahara T, Dohi K, Hino H, et al. (1998) Isolated caudate lobectomy by anterior approach for hepatocellular carcinoma originating in the paracaval portion of the caudate lobe. J Hepatobiliary Pancreat Surg 5: 416-421

Asahara T, Dohi K, Katayama K, et al. (2000) Isolated caudate lobectomy for hepatocellular carcinoma: a left-sided approach. Asian J Surg 23: 115-122

Nagasue N, Kohno H, Yamanoi A, et al. (1997) Resection of the caudate lobe of the liver for primary and recurrent hepatocellular carcinomas. J Am Coll Surg 184: 1-8

Peng SY, Li JT, Mou YP, et al. (2003) Different approaches to caudate lobectomy with "curettage and aspiration" technique using a special instrument PMOD: a report of 76 cases. World J Gastroenterol 19: 2169-2173

Sarmiento JM, Que FG, Nagorney DM (2002) Surgical outcomes of isolated caudate lobe resection: a single series of 19 patients. Surgery 132: 697-708

Shimada M, Matsumata T, Maeda T, et al. (1994) Characteristics of hepatocellular carcinoma originating in the caudate lobe. Hepatology 19: 911-915

Takayama T, Makuuchi M (1998) Segmental liver resections, present and future: caudate lobe resection for liver tumors. Hepatogastroenterology 45: 20-23

Yamamoto J, Kosuge T, Shimada K, et al. (1999) Anterior transhepatic approach for isolated resection of the caudate lobe of the liver. World J Surg 23: 97-101

Yamamoto J, Takayama T, Kosuge T, et al. (1992) An isolated caudate lobectomy by the transhepatic approach for hepatocellular carcinoma in cirrhotic liver. Surgery 111: 699-702

Yang MC, Lee PH, Sheu JC, et al. (1996) Surgical treatment of hepatocellular carcinoma originating from the caudate lobe. World J Surg 20: 562-565

5

Classification of Caudate Lobe Resection

With the steady improvement in diagnostic modalities and increasing numbers of hepatic malignancies, tumors originating in caudate lobe can be detected while at a respectable stage, when resection of the caudate lobe is required for tumor clearance. The operation may be an isolated caudate lobe resection or a caudate lobe resection combined with a major hepatectomy; caudate lobectomy is thus classified into isolated and combined resections. It is also classified into complete and partial resections. Thus, caudate lobectomy can be classified into four types: isolated complete resection, combined complete resection, isolated partial resection, and combined partial resection.

5.1 Isolated Complete Resection of the Caudate Lobe

For patients with fair to excellent liver functions, most surgeons prefer to carry out caudate lobectomy combined with another hepatic resection (so-called preparatory hepatectomy), because this operation is technically less demanding. However, hepatic malignancies arising in the caudate lobe of a cirrhotic liver present surgeons with some difficulty in choosing the best therapeutic strategy. A cirrhotic hepatectomy (even a limited resection) sometimes ends up in patients' death because of the loss of functional hepatic parenchyma. In this situation, an isolated caudate lobe resection, despite its technical difficulty and perioperative risks, may be the first choice of treatment because the operation achieves complete removal of the tumor, and preserves the maximum amount of nontumorous hepatic parenchyma at the same time.

5.1.1 Isolated Complete Resection of the Caudate Lobe for Angioleiomyolipoma (1)

See Figs.5.1-5.12, and video 8.

Fig.5.1. CT showing the caudate lobe mass situated between the PV, IVC, and the abdominal aorta

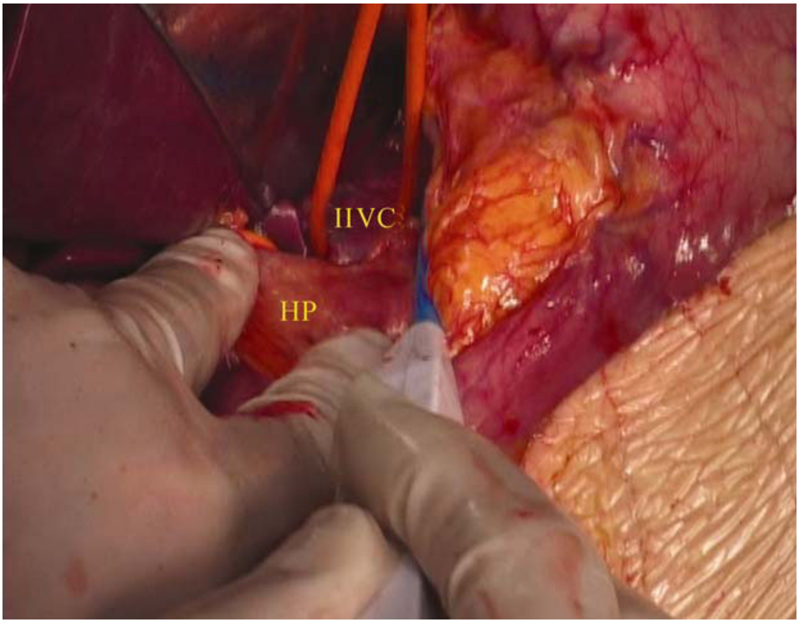


Fig.5.2. IIVC is taped

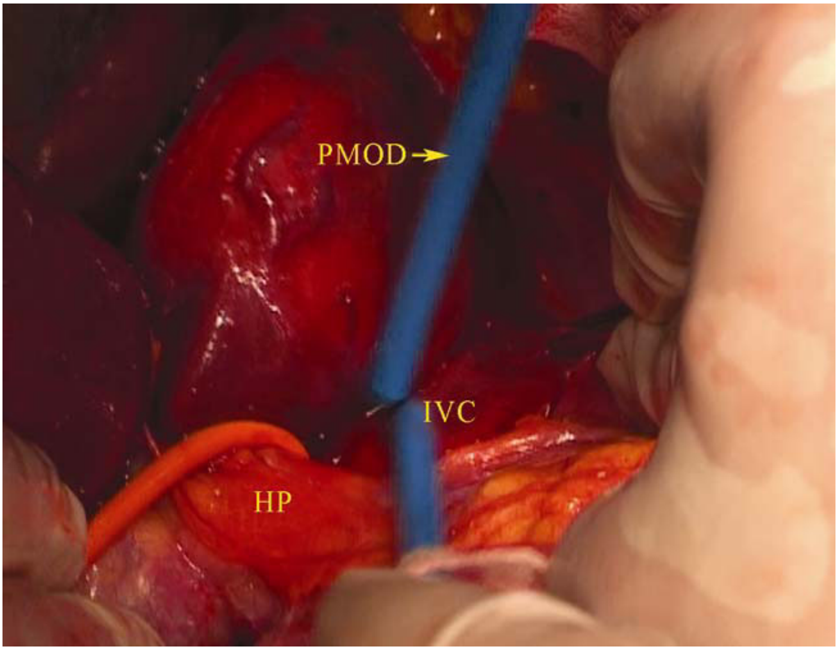


Fig.5.3. The tumor is situated between the IVC and the HP

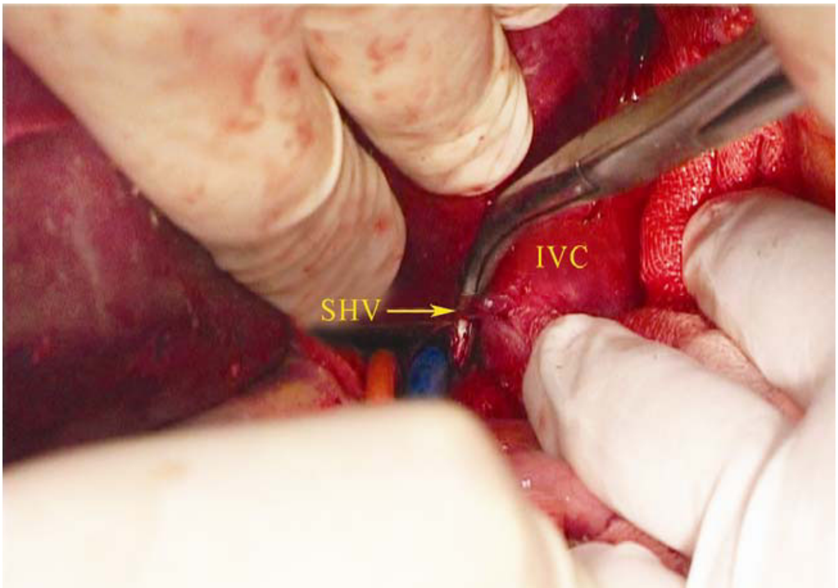


Fig.5.4. A SHV is dissected

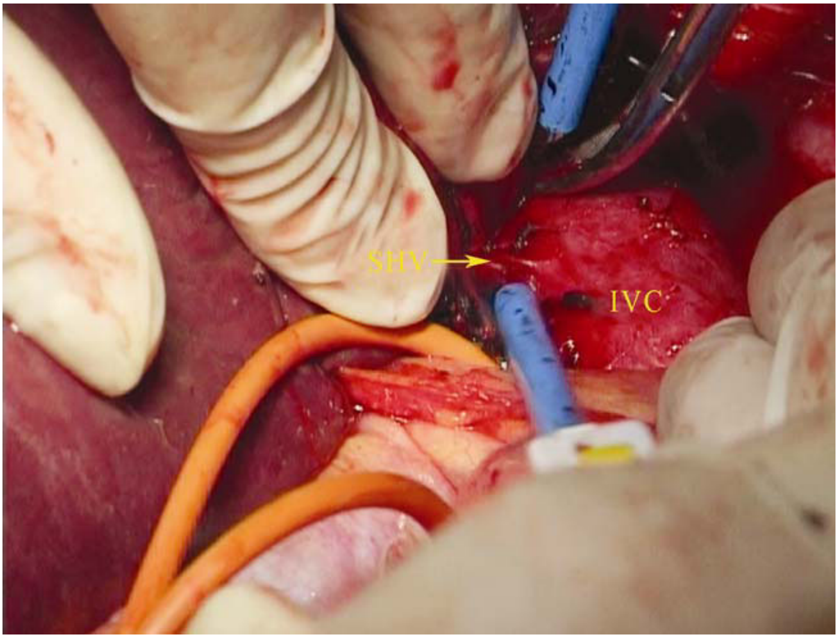


Fig.5.5. A SHV is dissected

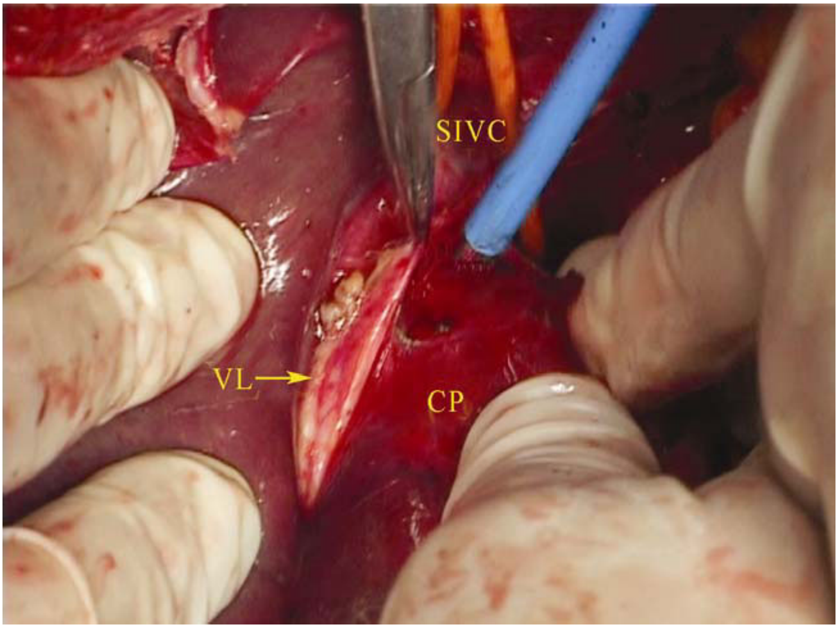


Fig.5.6. Dissection is started at the tip of the caudate lobe

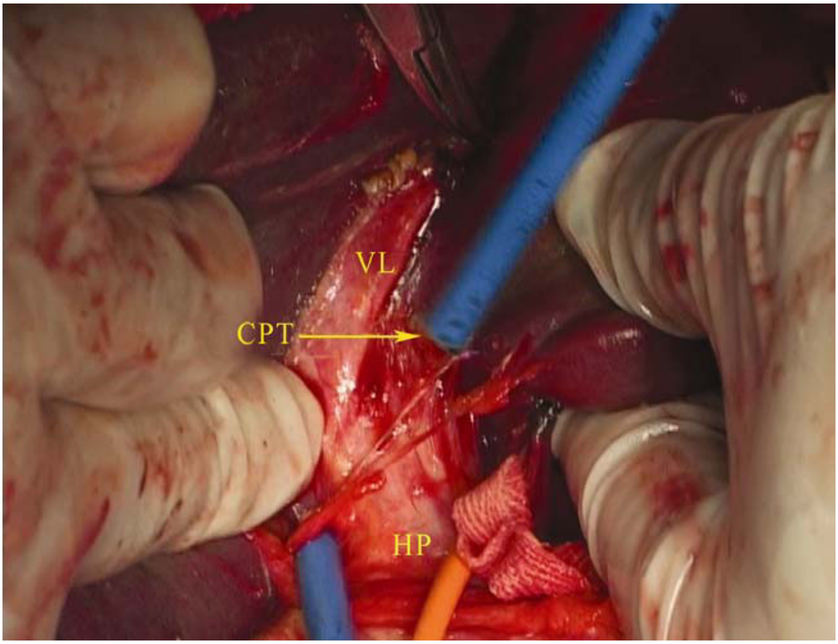


Fig.5.7. A CPT is dissected

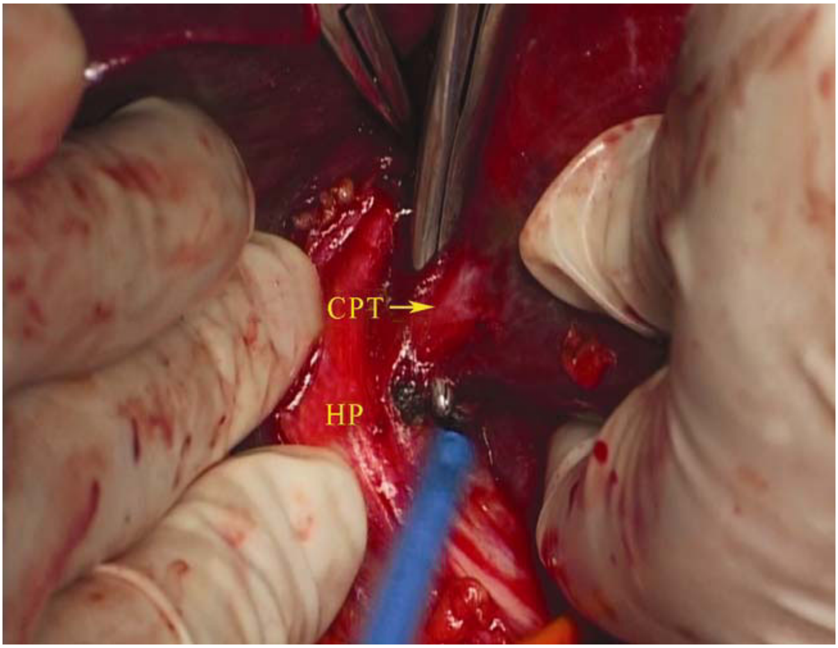


Fig.5.8. A CPT is dissected

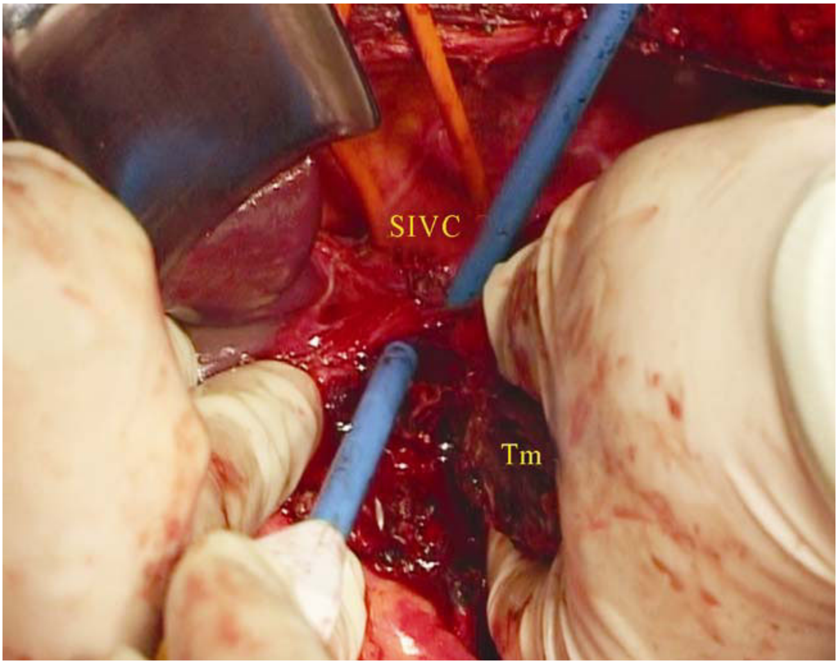


Fig.5.9. The tumor is dissected from the LHV

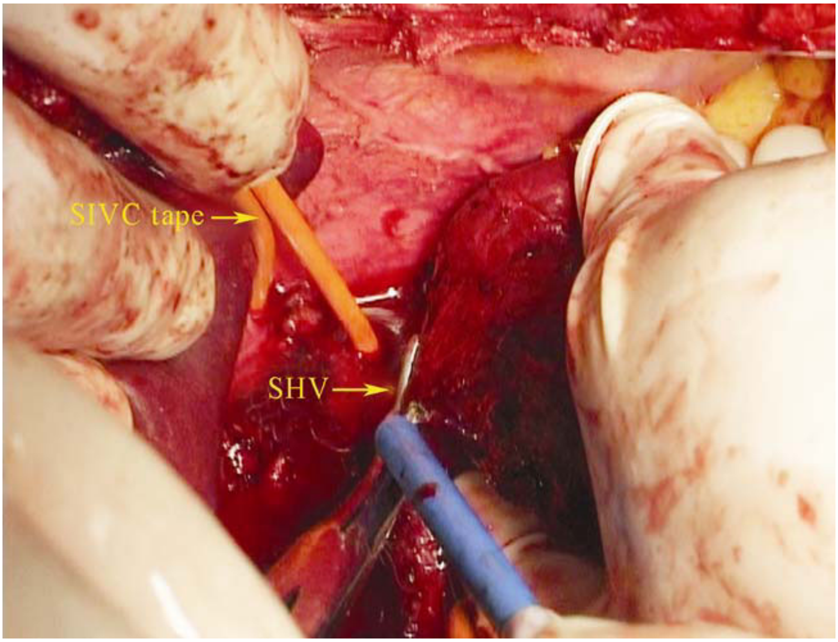


Fig.5.10. A SHV is clamped

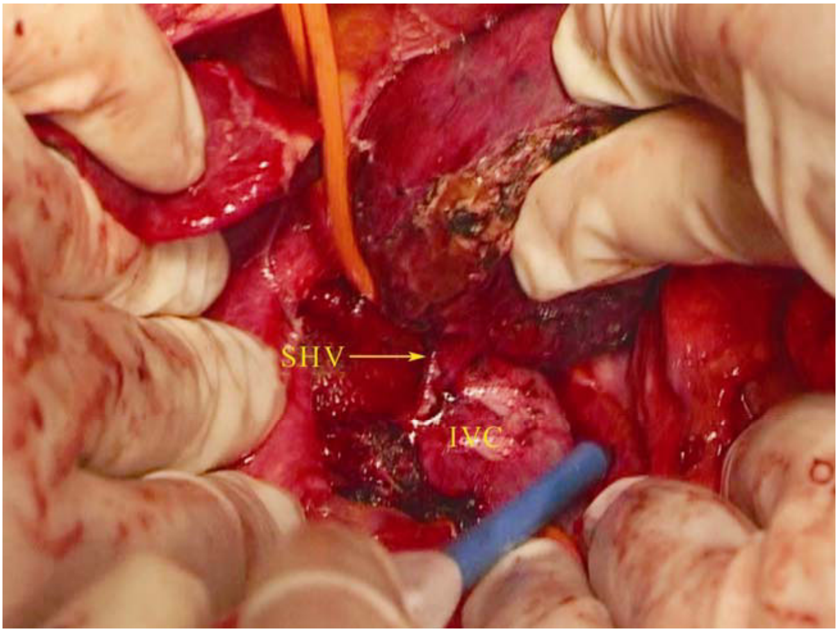


Fig.5.11. The last SHV is exposed and divided

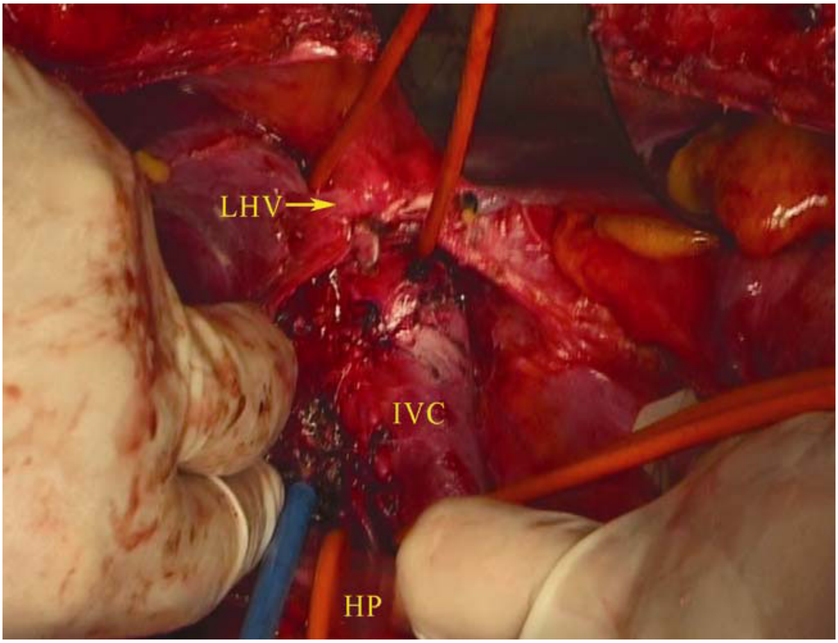


Fig.5.12. After the tumor was removed, IVC is fully exposed

5.1.2 Isolated Complete Resection of the Caudate Lobe for Angioleiomyolipoma (2)

See Figs.5.13-5.27, and video 9.

Fig.5.13. CT showing a large tumor in the caudate lobe

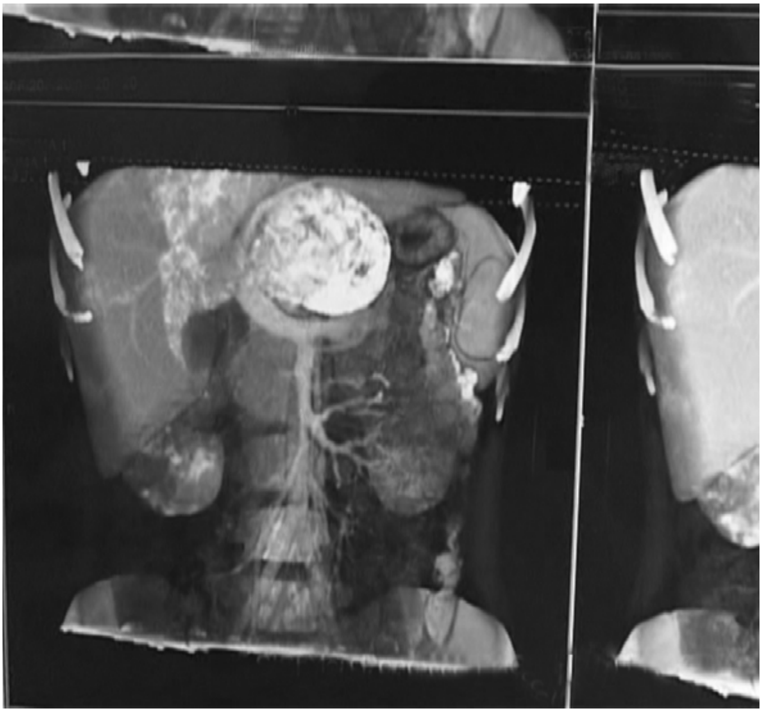


Fig.5.14. CT showing the tumor is embraced by the PV

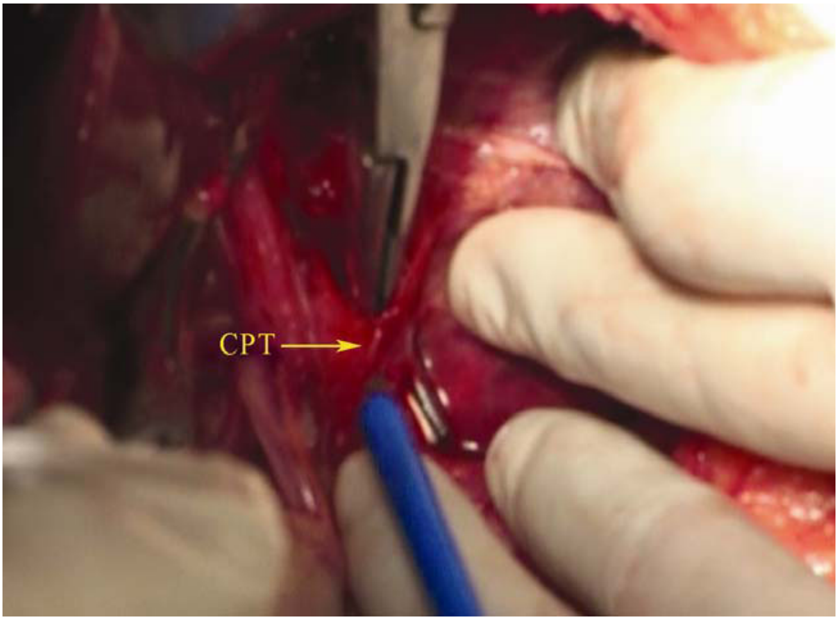


Fig.5.15. A CPT is isolated

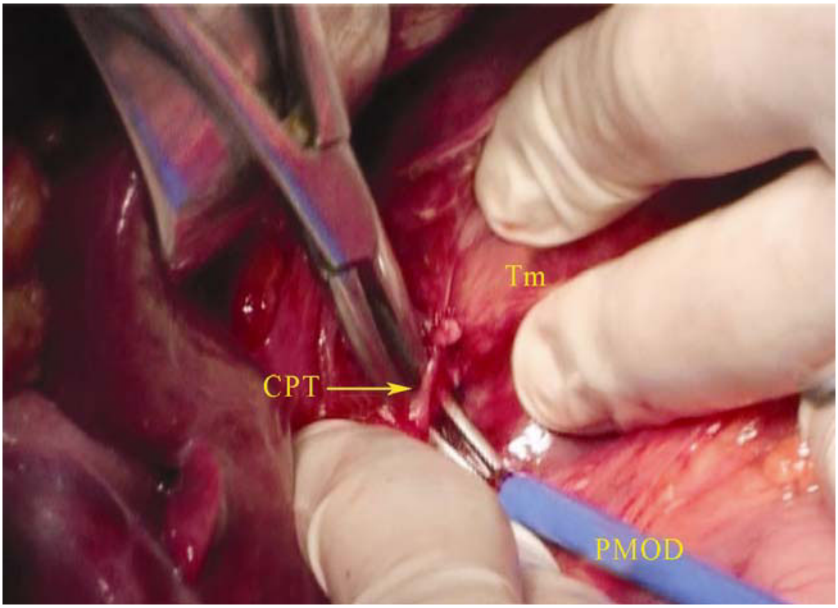


Fig.5.16. A CPT is isolated

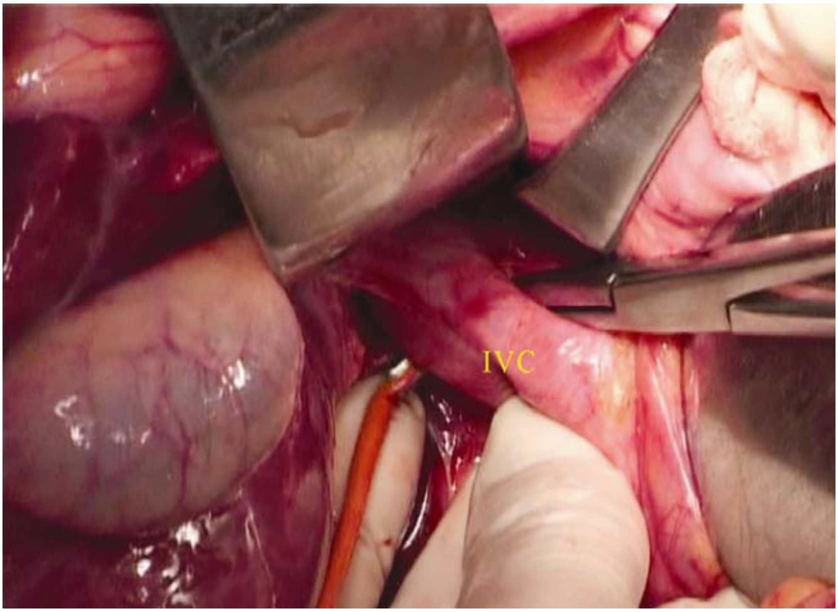


Fig.5.17. A catheter is pulled through the space behind the IVC for control

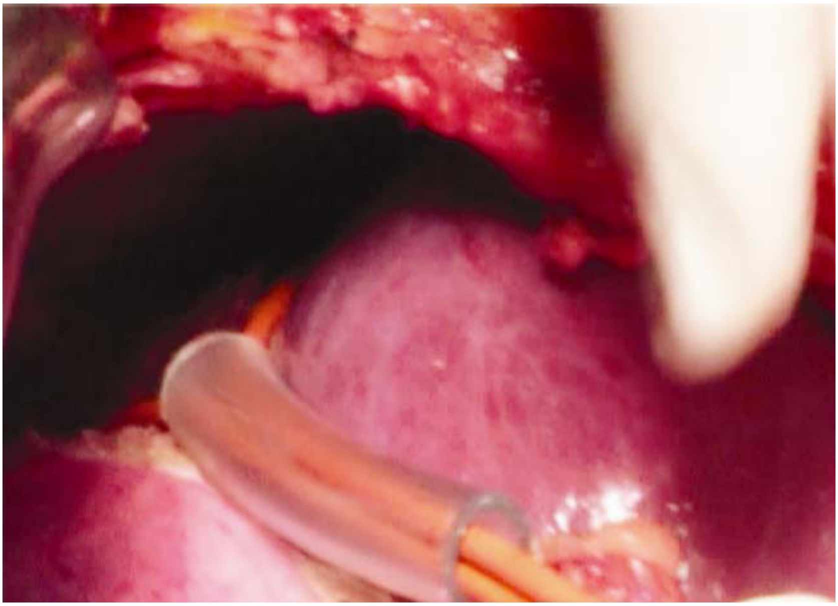


Fig.5.18. The SIVC is taped

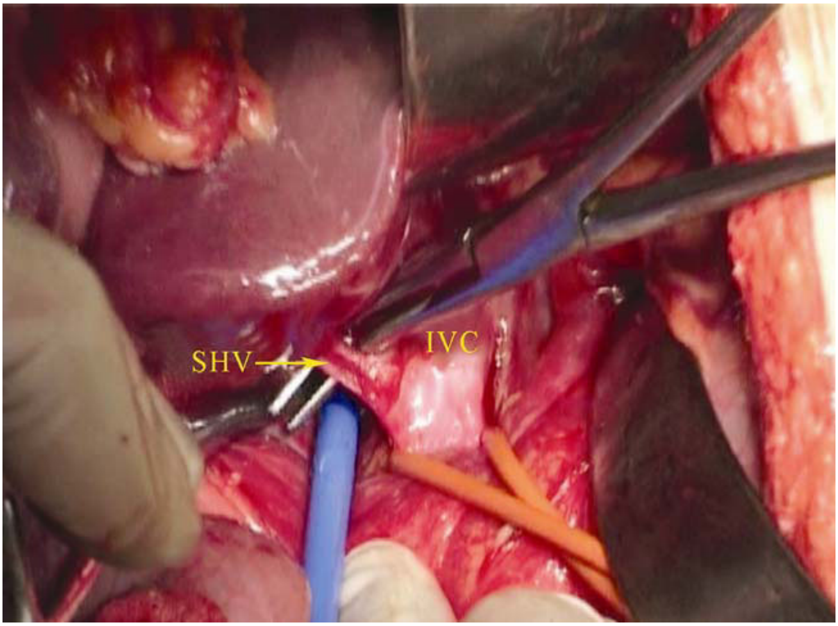


Fig.5.19. A SHV is isolated

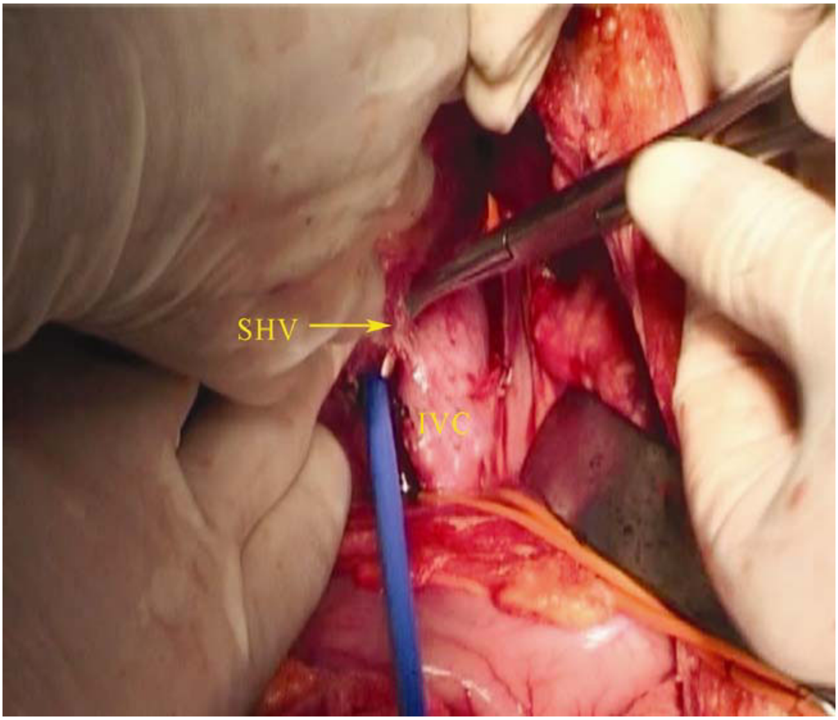


Fig.5.20. A SHV is isolated

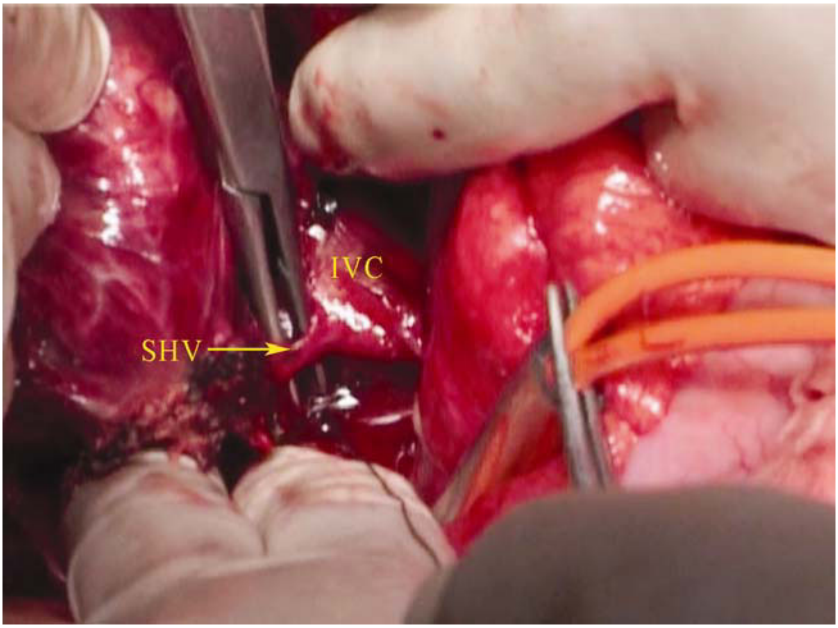


Fig.5.21. A SHV is isolated

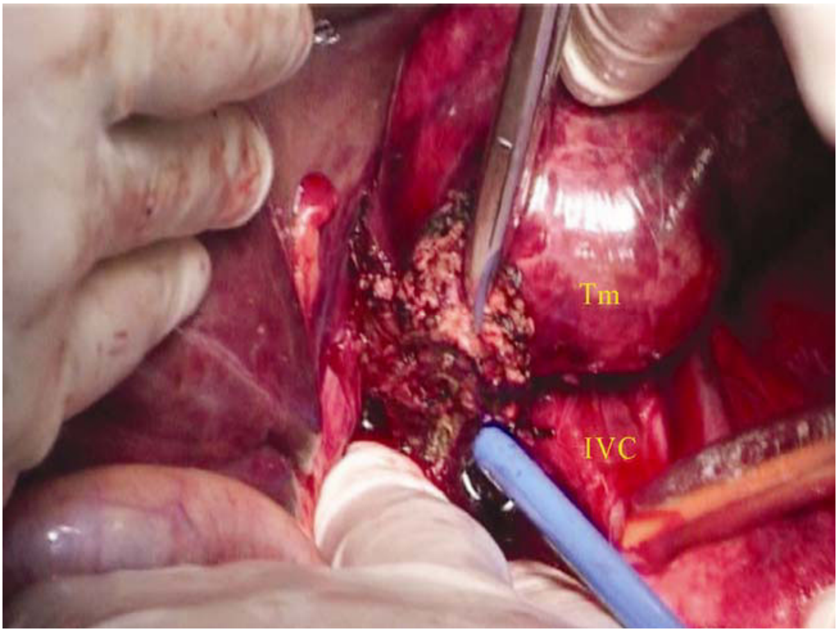


Fig.5.22. Parenchymal transection is started at the caudate process and proceeds upward

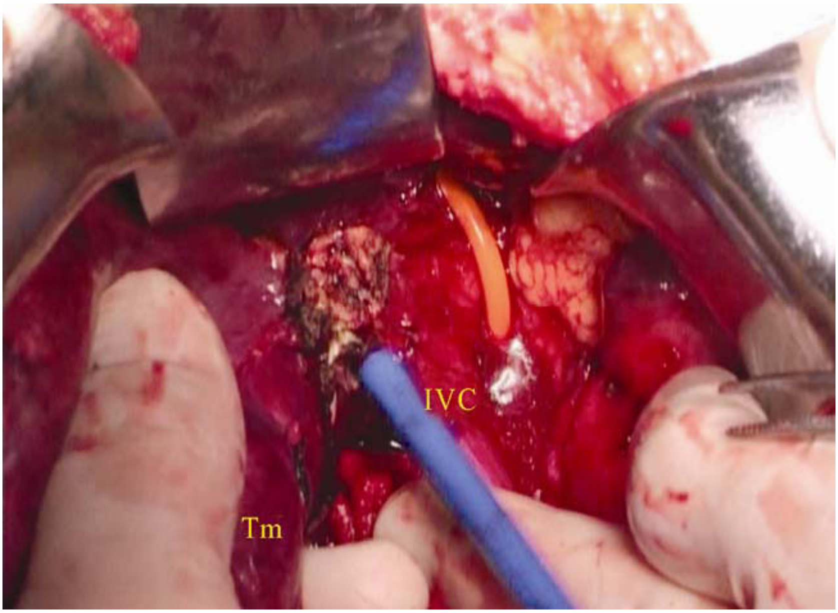


Fig.5.23. Transection at the caudate tip near the SIVC tape

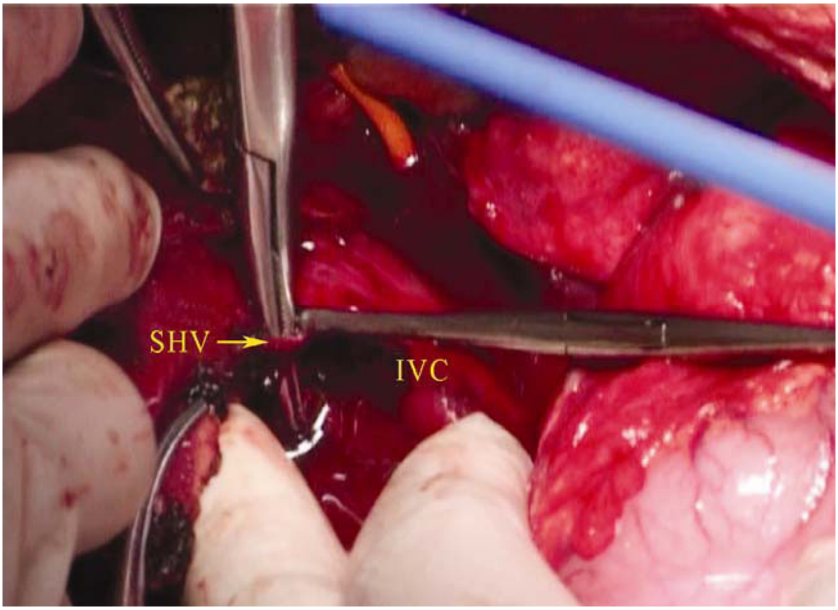


Fig.5.24. During transection, a SHV is encountered and divided

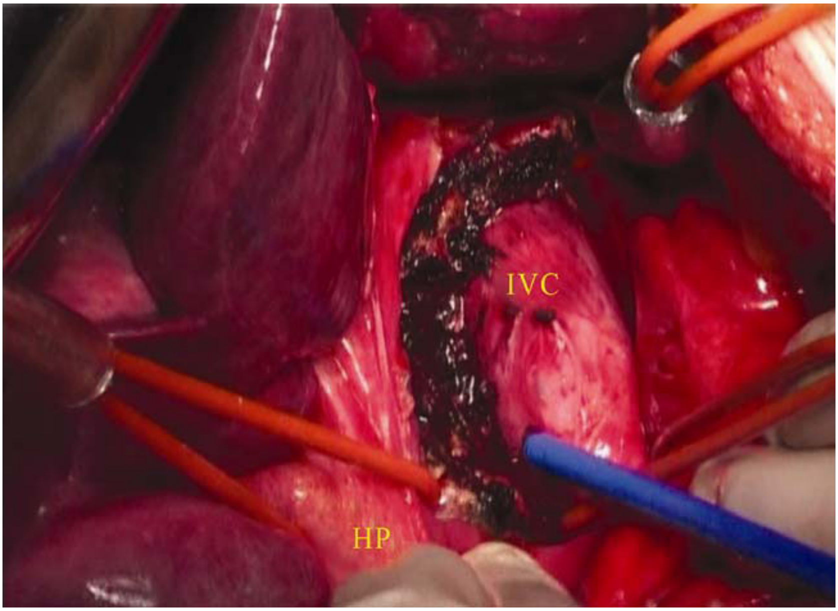


Fig.5.25. The whole segment of the retrohepatic IVC is exposed and the raw surface is dry without oozing

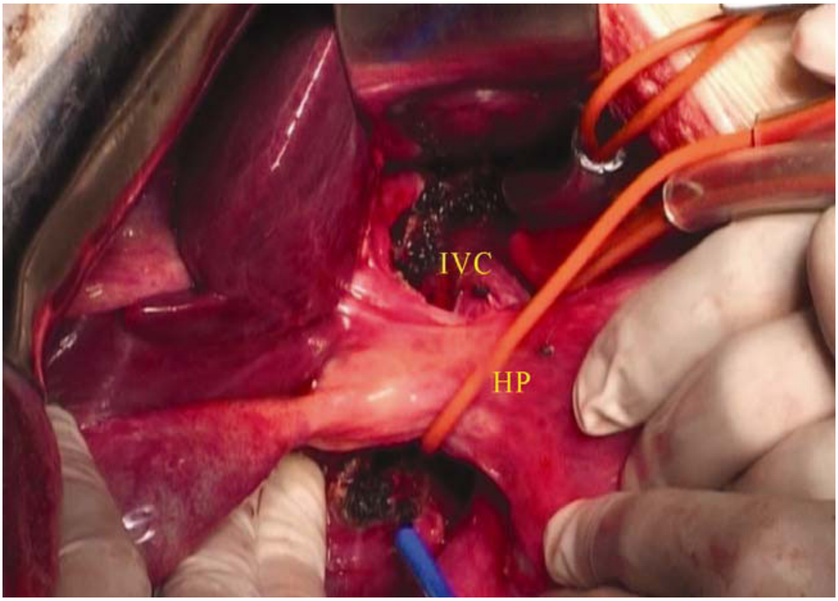


Fig.5.26. Transection line from the caudate tip to the caudate process

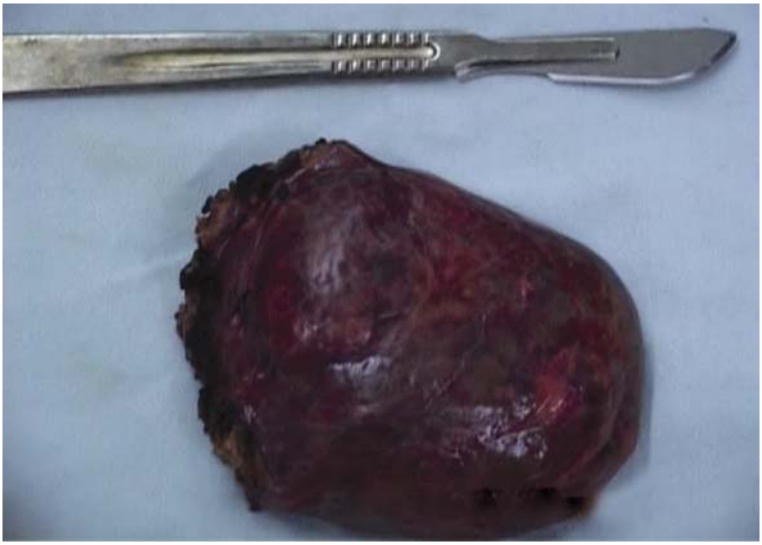


Fig.5.27. A huge angioleiomyolipoma from the caudate lobe

5.1.3 Isolated Complete Resection of the Caudate Lobe for Hemangioma Mainly by Left Approach

See Figs.5.28-5.42, and video 10.

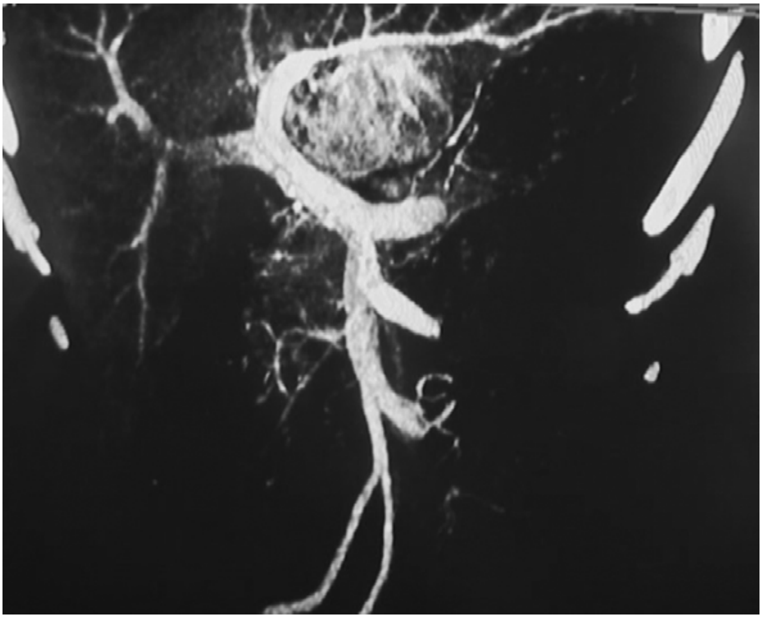
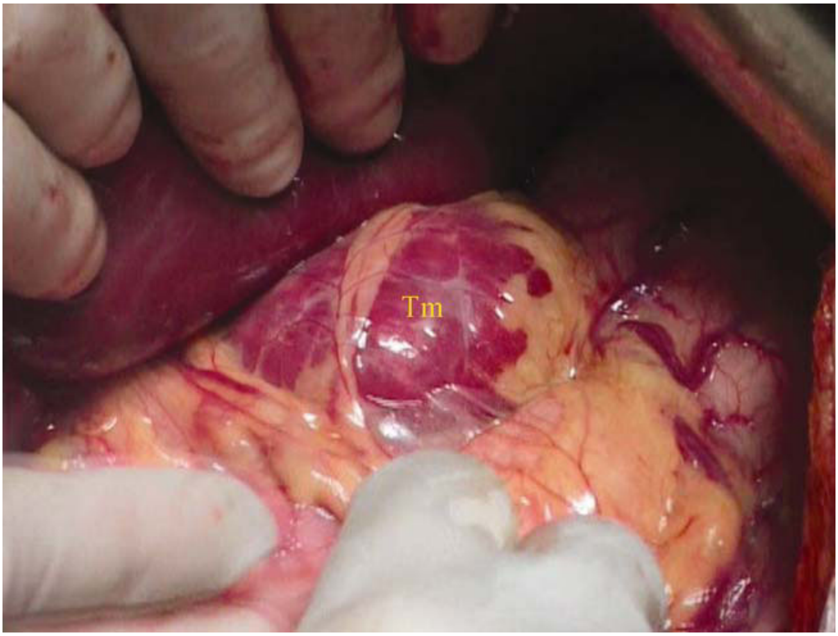
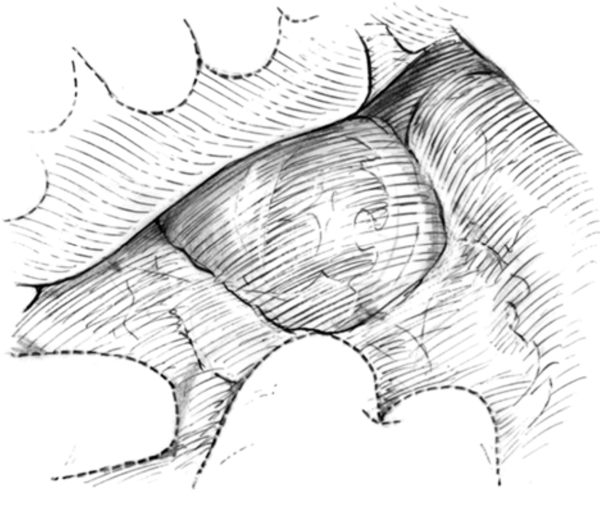


Fig.5.28. CT showing a hemangioma in the caudate lobe

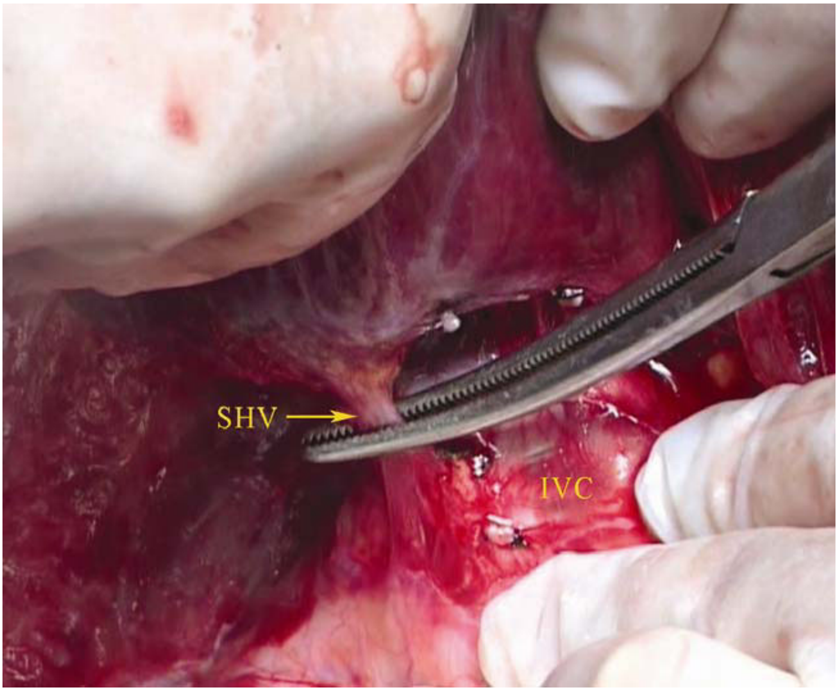


(a)

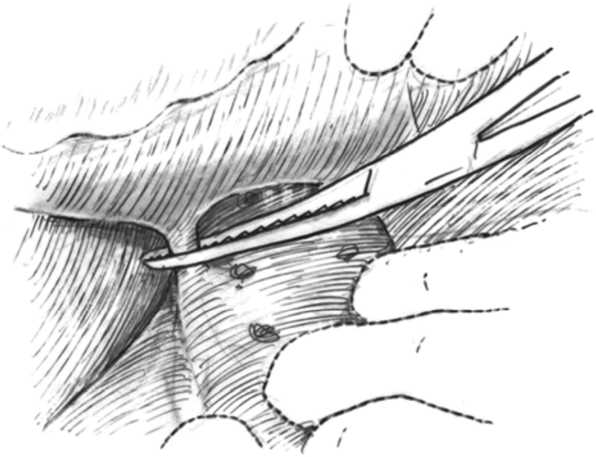


(b)

Fig.5.29. Hemangioma is seen through lesser omentum.
(a) Photograph; (b) Drawing

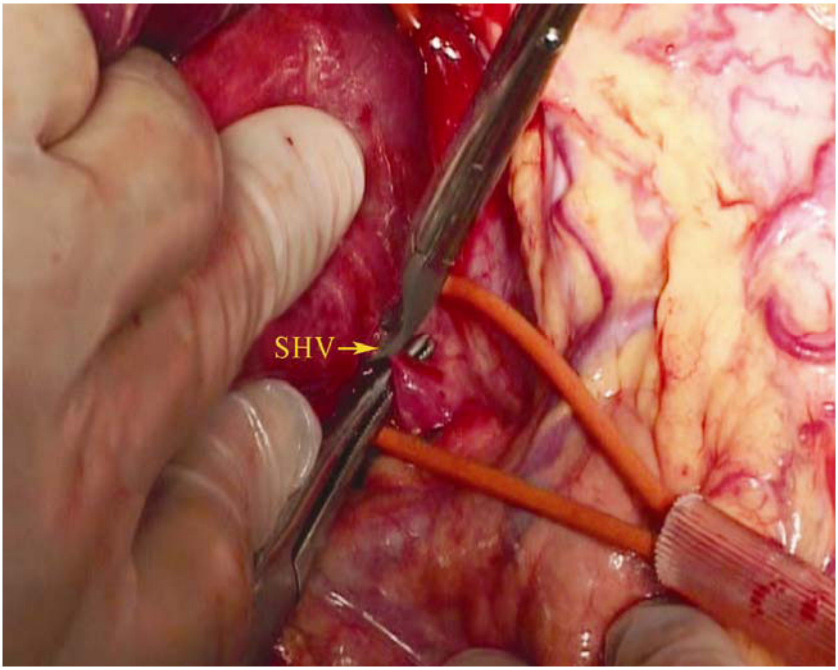


(a)

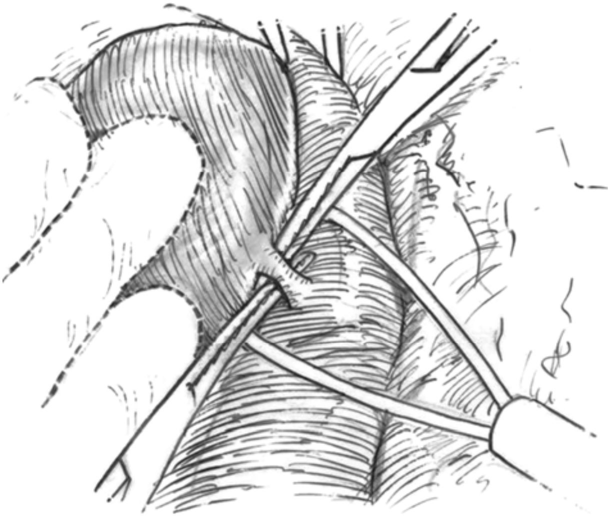


(b)

Fig.5.30. A SHV is dissected.
(a) Photograph; (b) Drawing

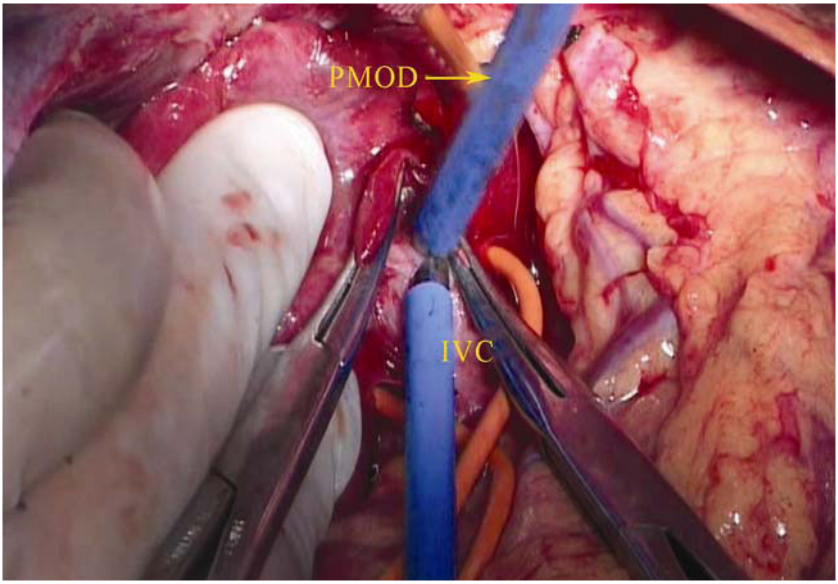


(a)

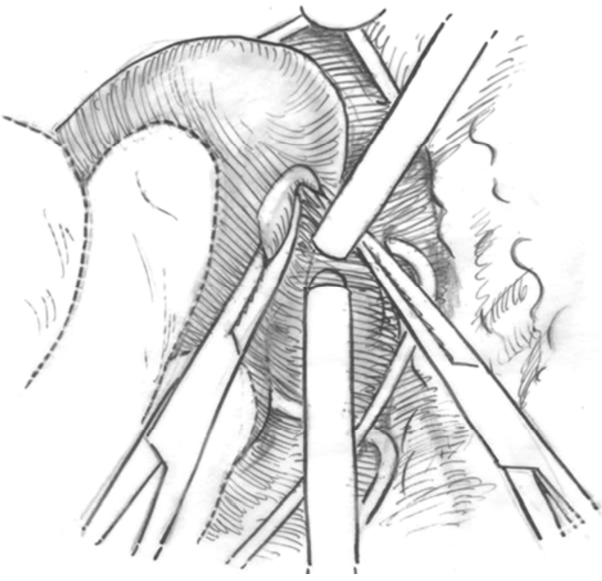


(b)

Fig.5.31. Left lower pole with SHV is dissected.
(a) Photograph; (b) Drawing

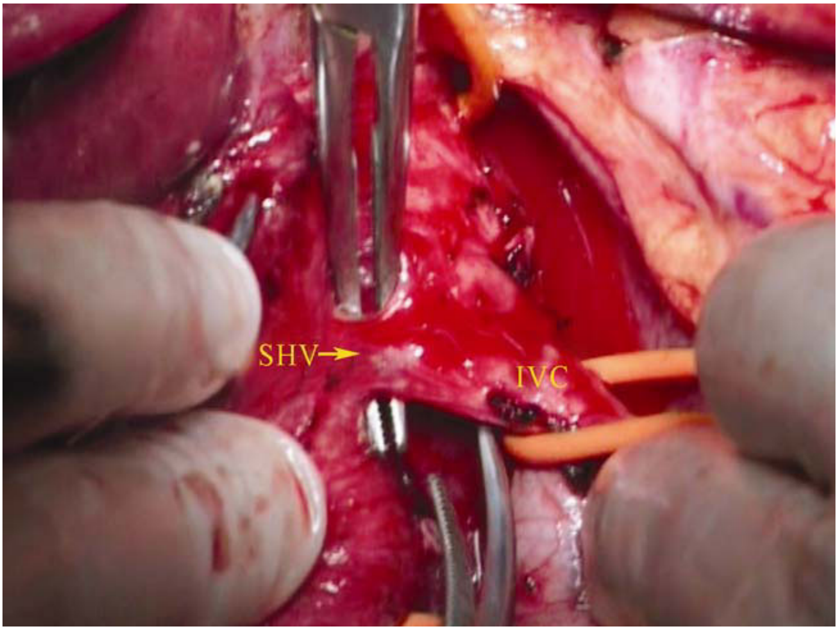


(a)

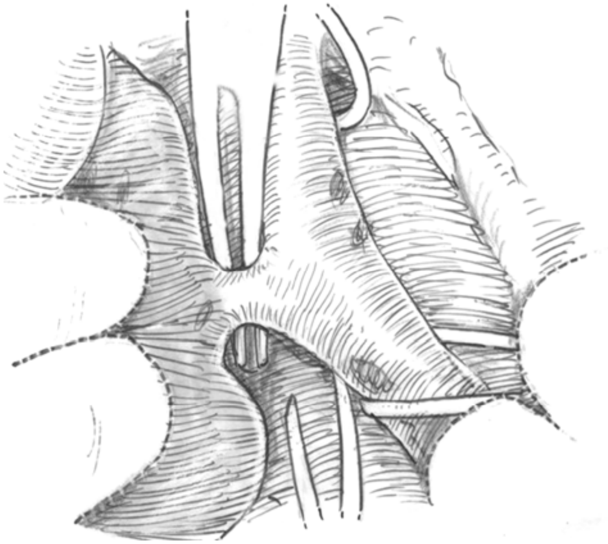


(b)

Fig.5.32. Lower pole of caudate lobe is raised.
(a) Photograph; (b) Drawing

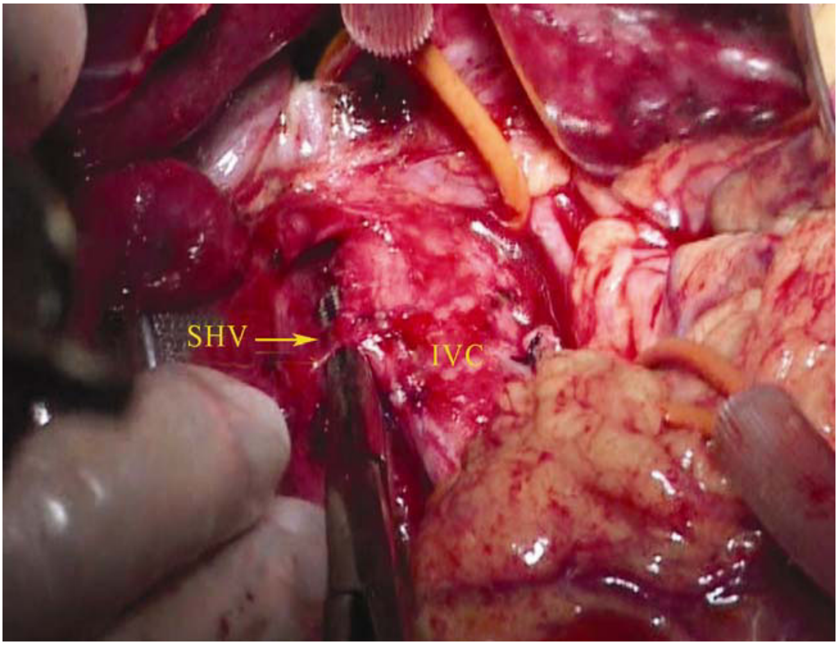


(a)

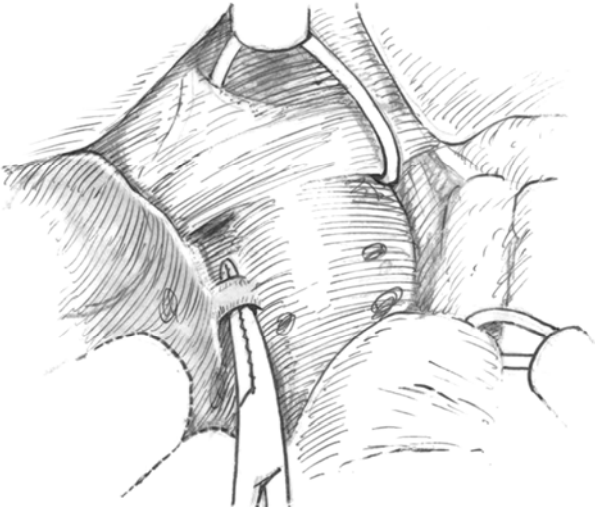


(b)

Fig.5.33. A SHV on the right side is dissected.
(a) Photograph; (b) Drawing

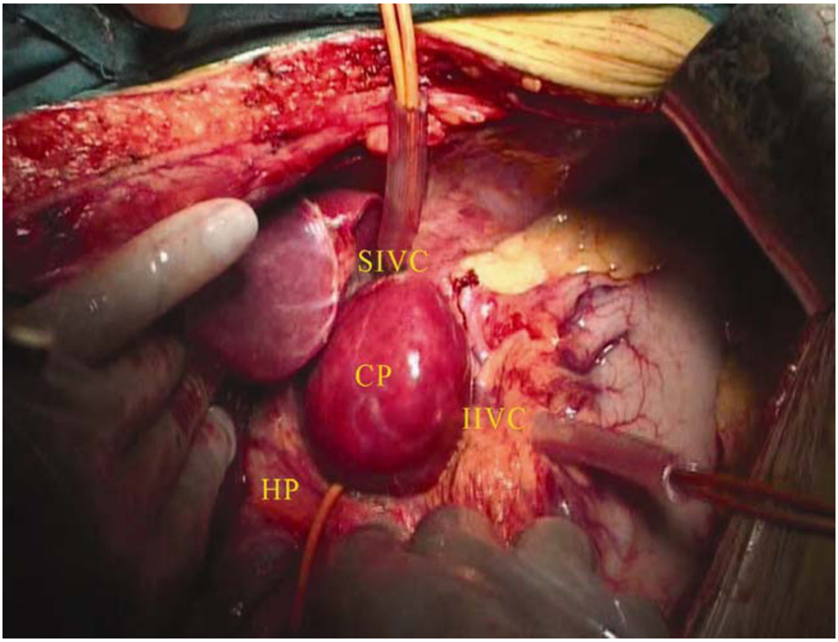


(a)

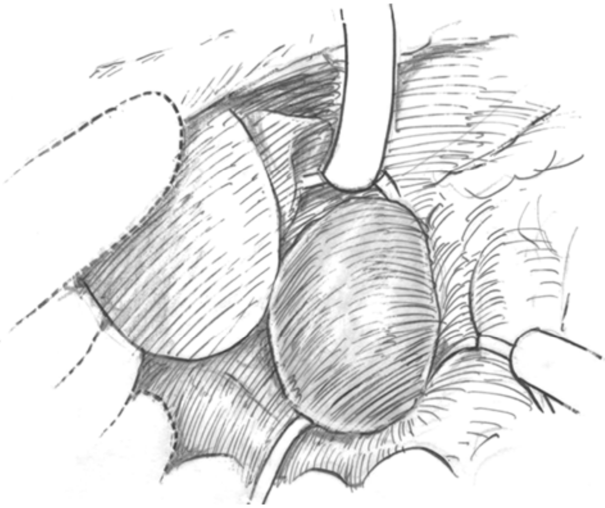


(b)

Fig.5.34. A SHV is dissected.
(a) Photograph; (b) Drawing

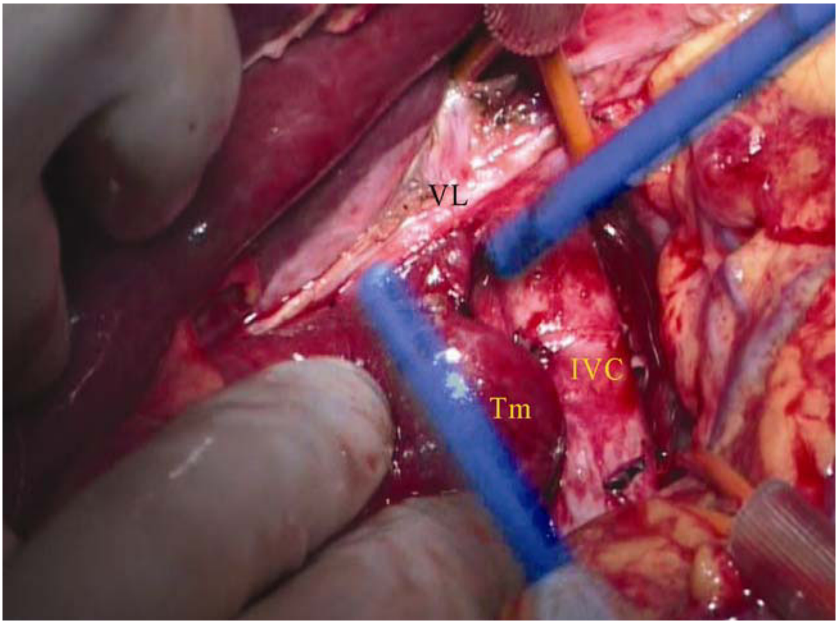


(a)

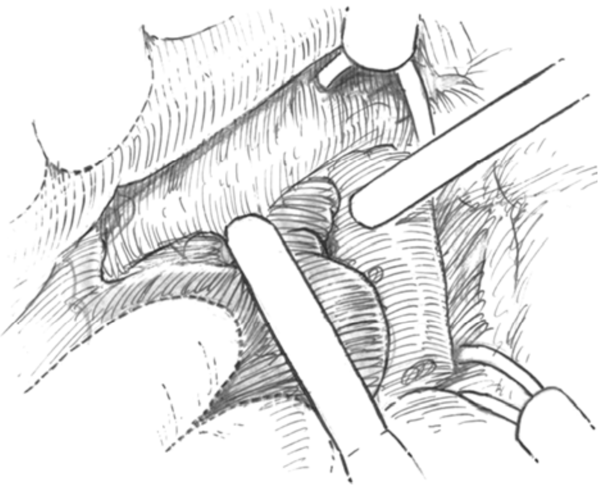


(b)

Fig.5.35. IIVC, SIVC and HDL are taped.
(a) Photograph; (b) Drawing

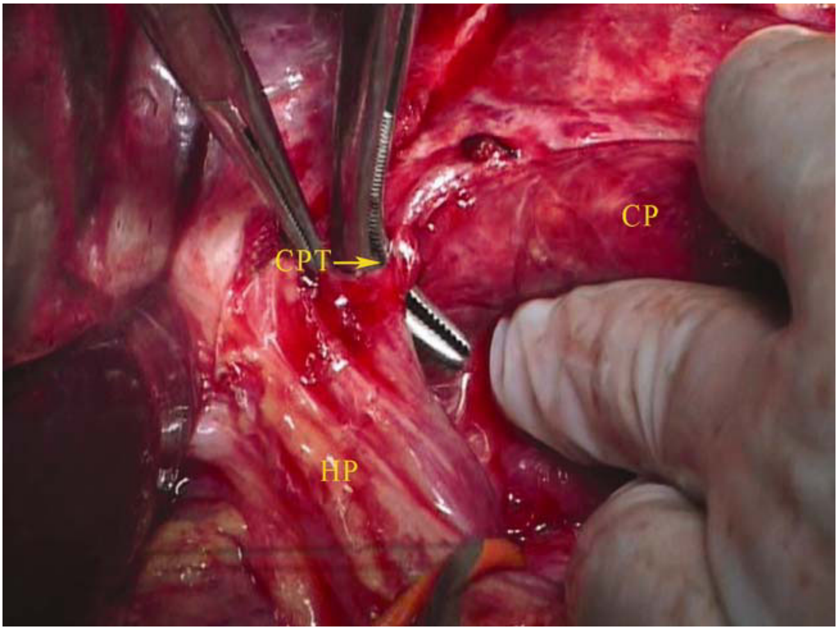


(a)

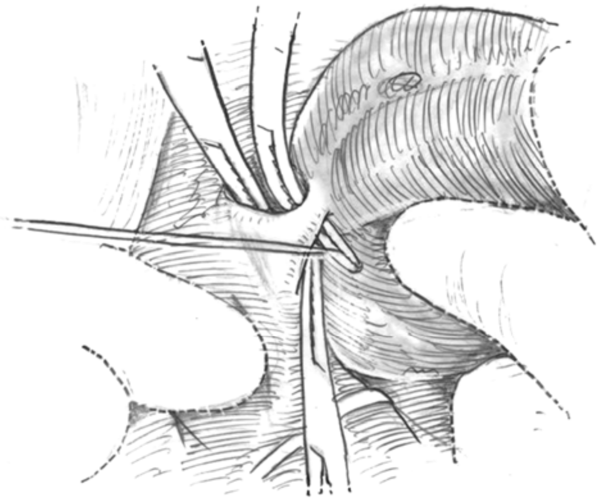


(b)

Fig.5.36. Tumor is detached from VL and left pedicle. (a) Photograph; (b) Drawing

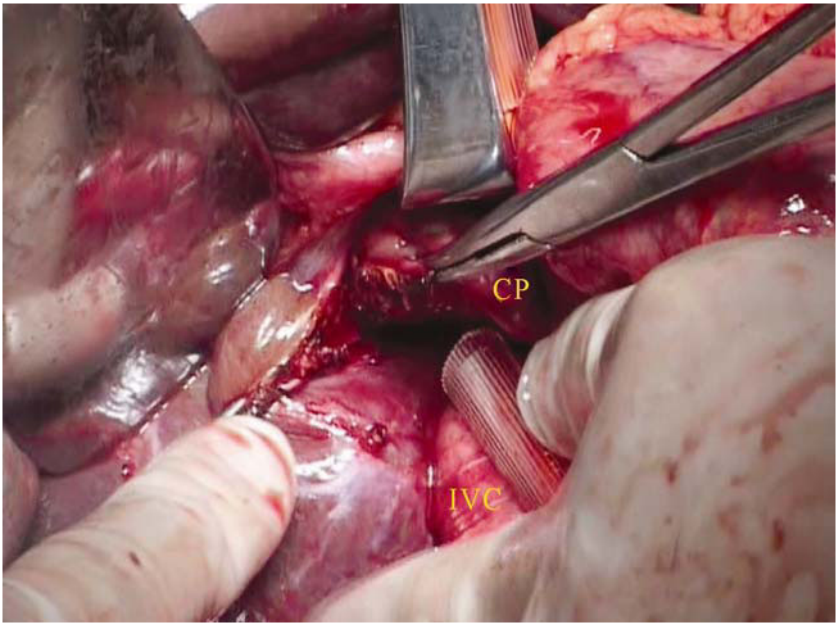


(a)

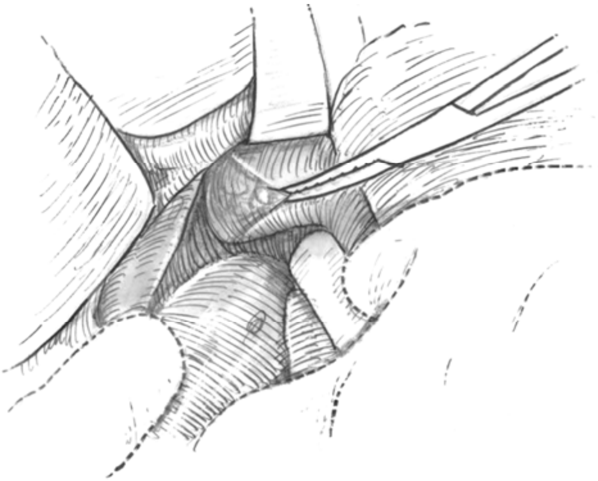


(b)

Fig.5.37. A CPT is dissected.
(a) Photograph; (b) Drawing

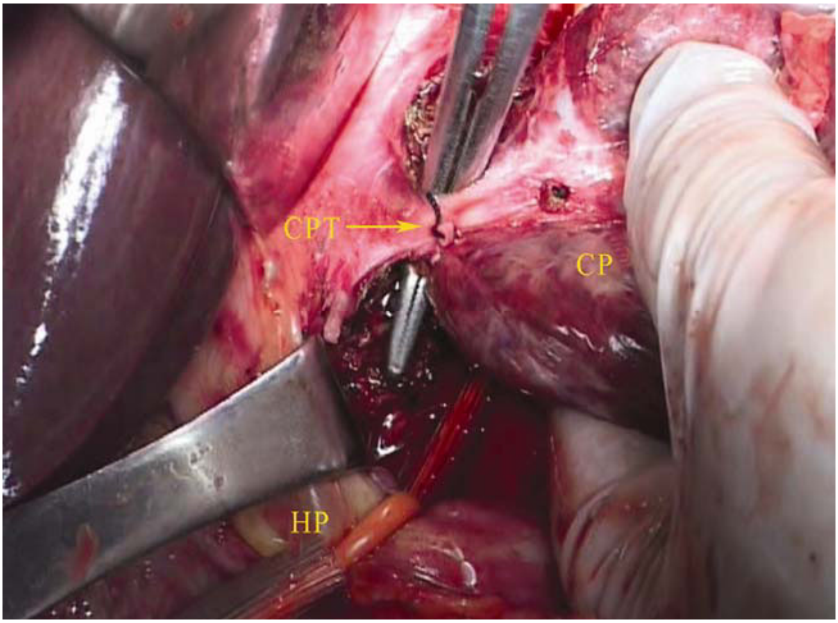


(a)

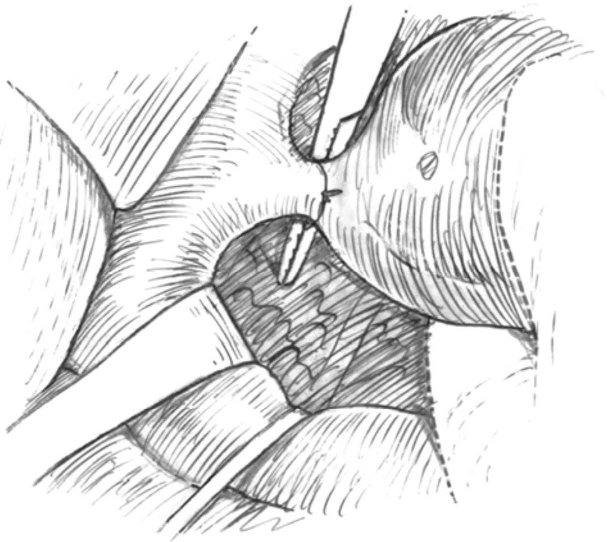


(b)

Fig.5.38. CP is being divided.
(a) Photograph; (b) Drawing

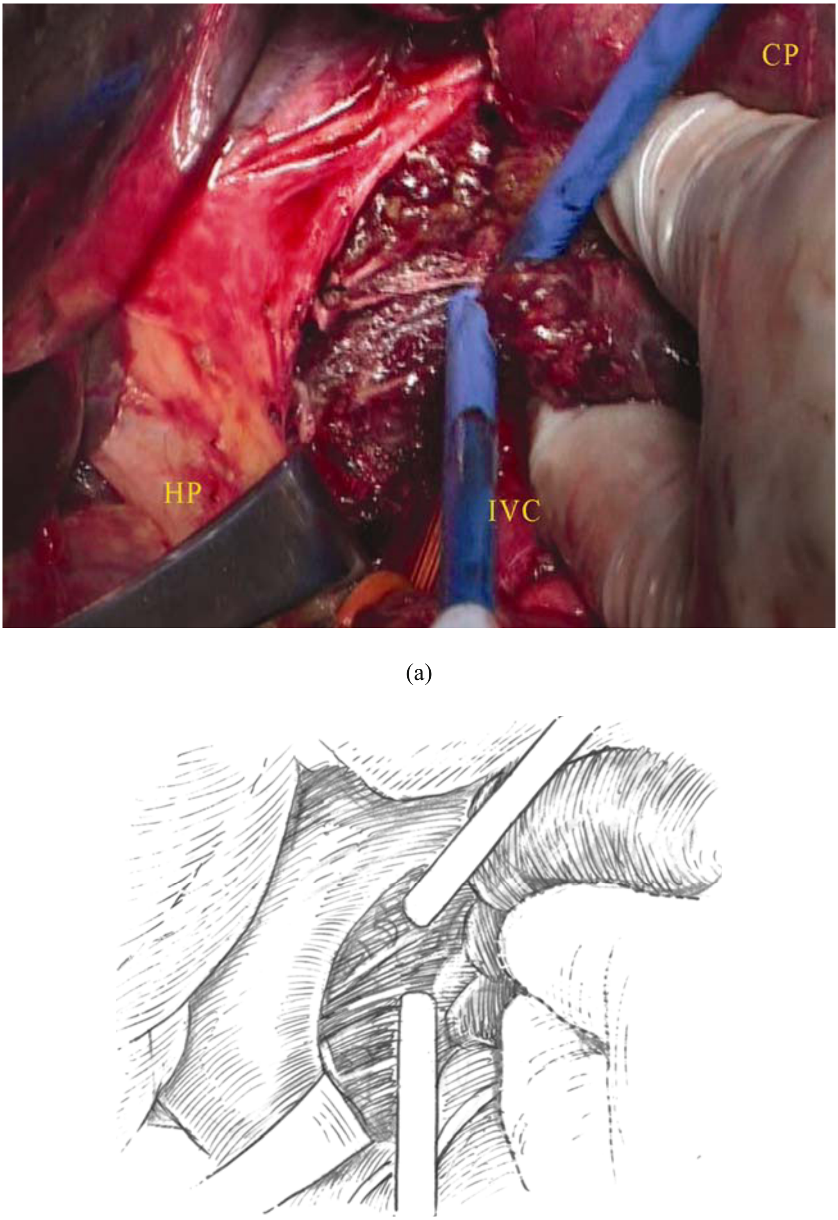


(a)



(b)

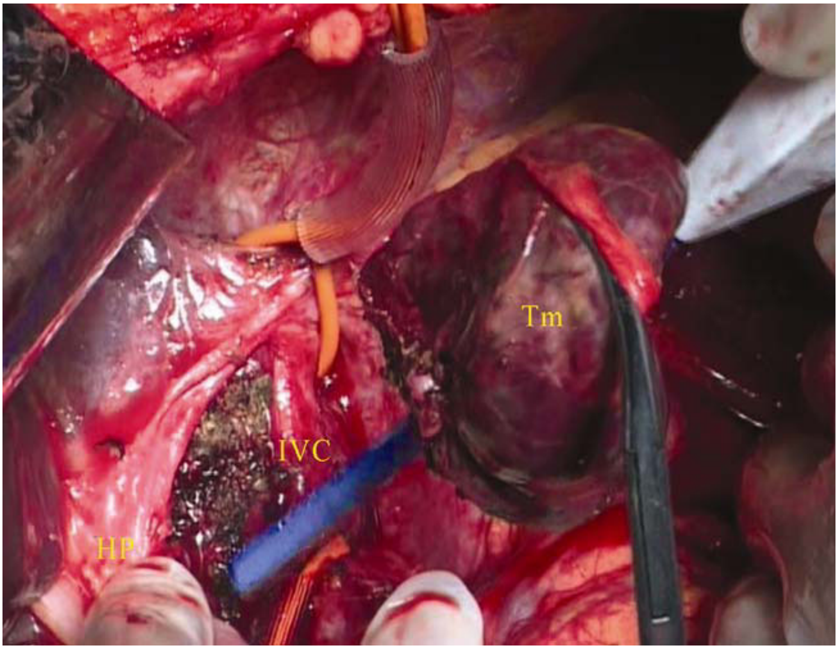
Fig.5.39. A large CPT is dissected and divided.
(a) Photograph; (b) Drawing



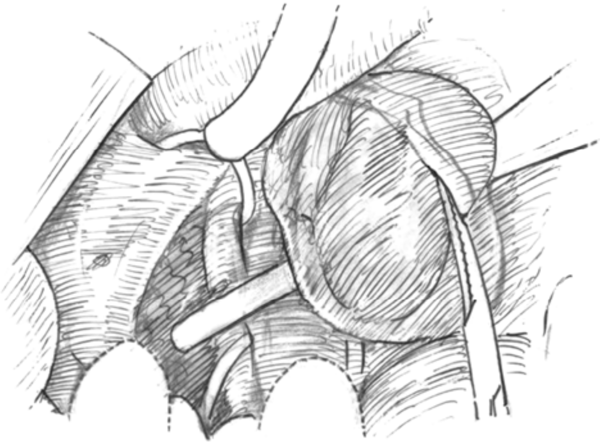
(a)

(b)

Fig.5.40. Vessels to and from the hemangioma are dissected. (a) Photograph; (b) Drawing

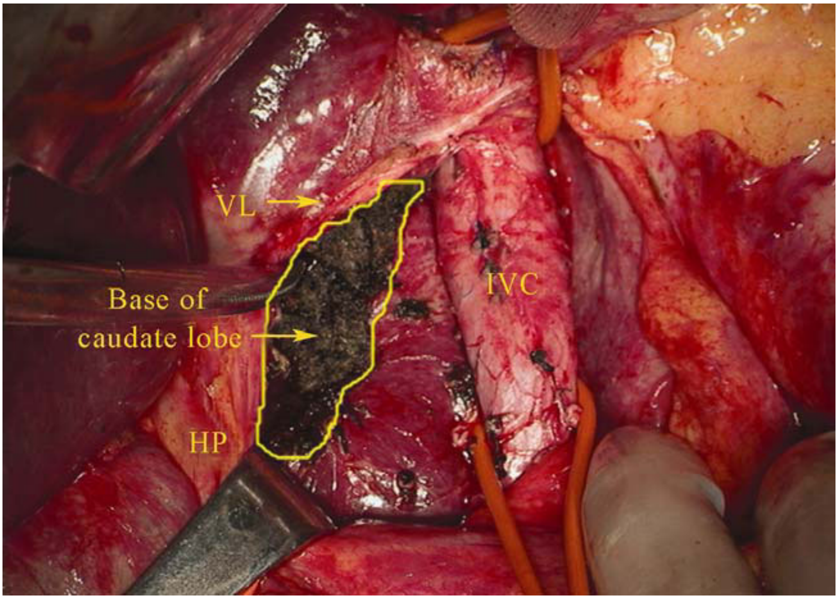


(a)

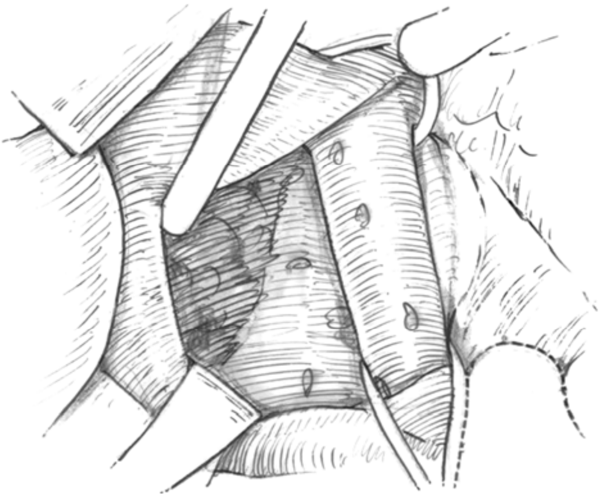


(b)

Fig.5.41. Tumor is completely detached.
(a) Photograph; (b) Drawing



(a)



(b)

Fig.5.42. Tumor was removed, and IVC is completely exposed.
(a) Photograph; (b) Drawing

5.1.4 Isolated Complete Resection of the Caudate Lobe by Combined Approach

See Figs.5.43-5.61, and video 11.

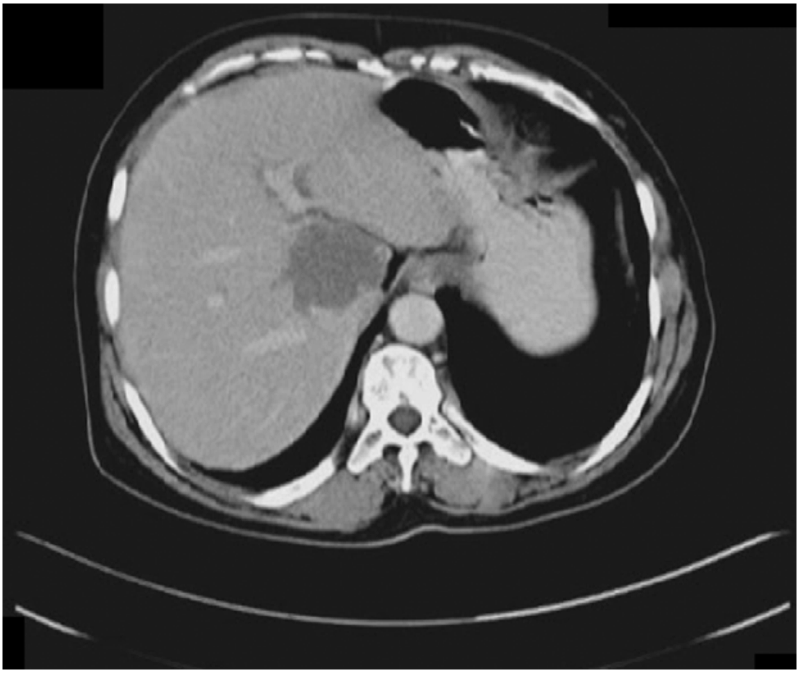


Fig.5.43. CT showing a hemangioma in the caudate lobe

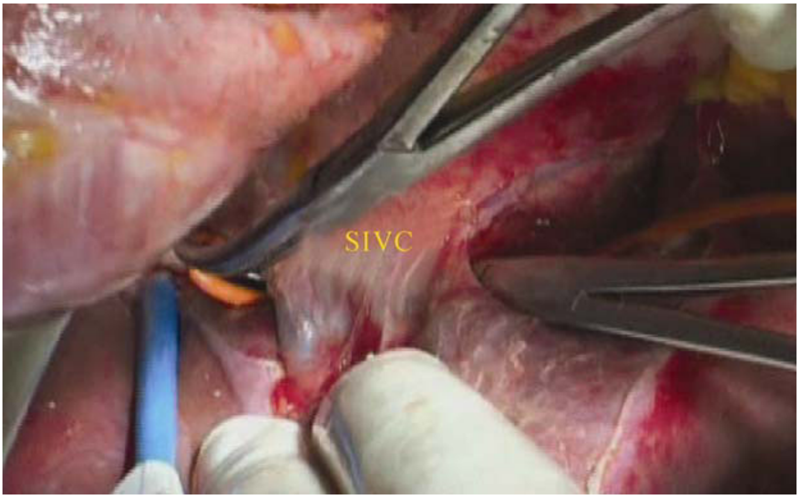
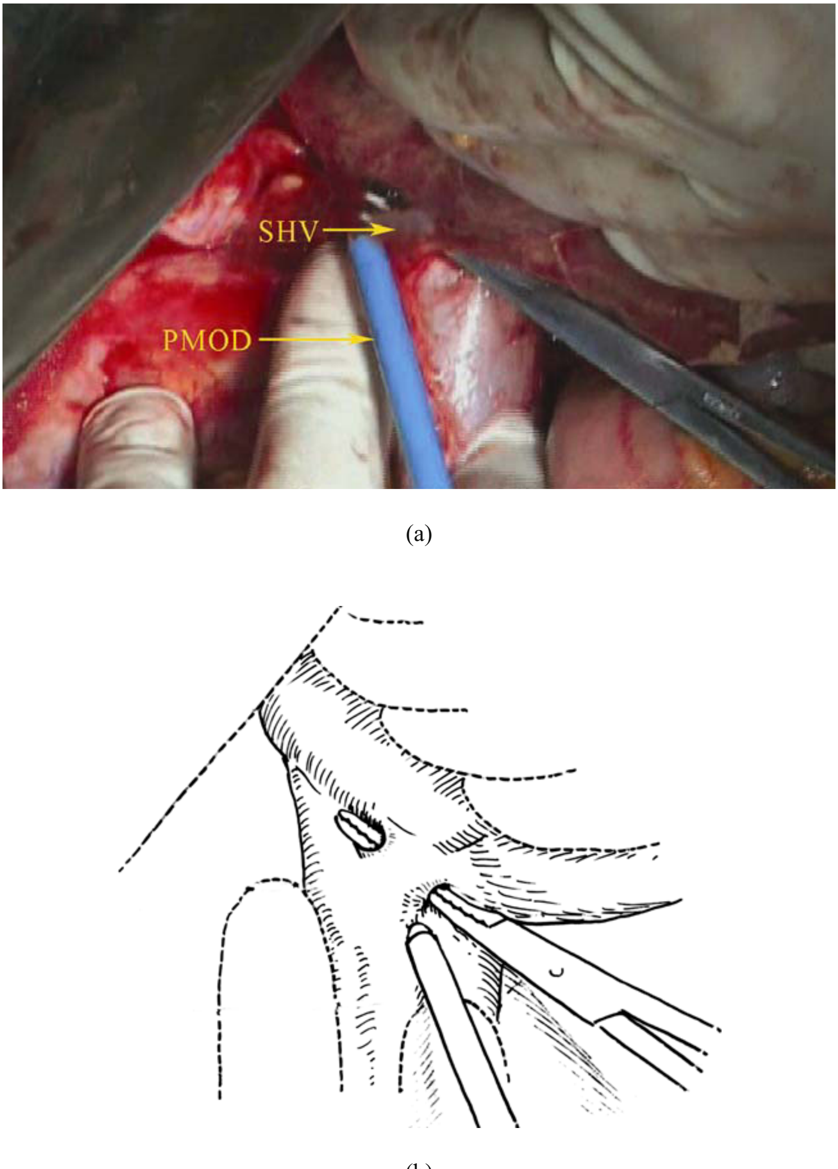


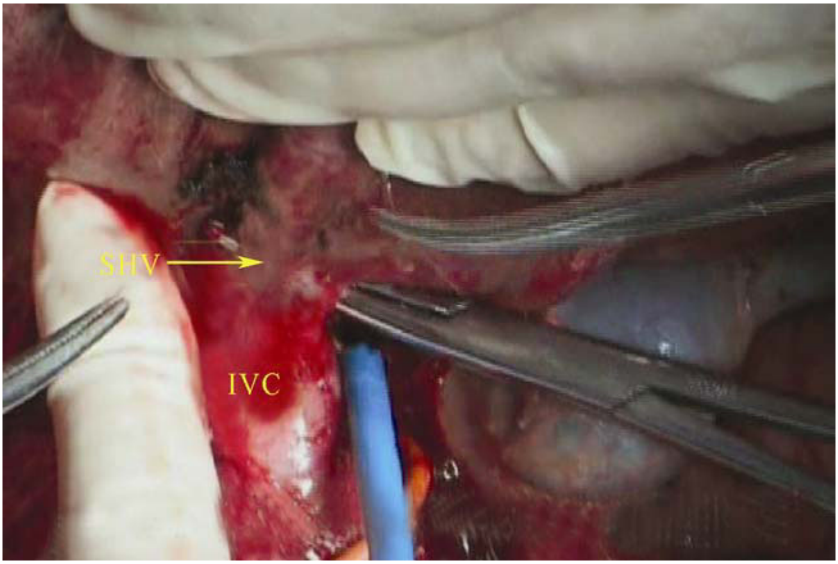
Fig.5.44. A catheter is pulled through the space behind the SIVC



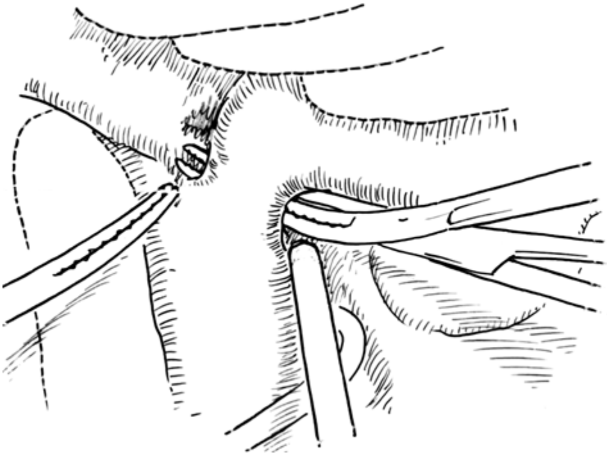
(a)

(b)

Fig.5.45. A SHV is dissected.
(a) Photograph; (b) Drawing

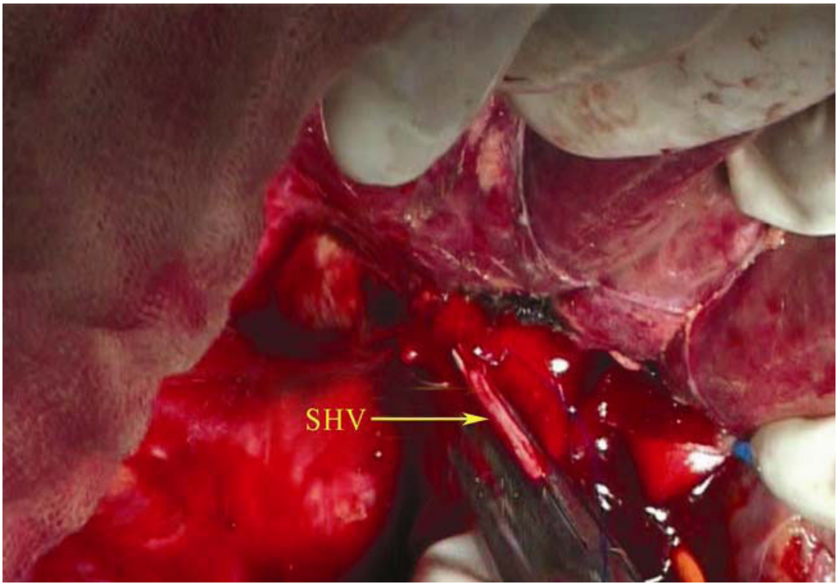


(a)

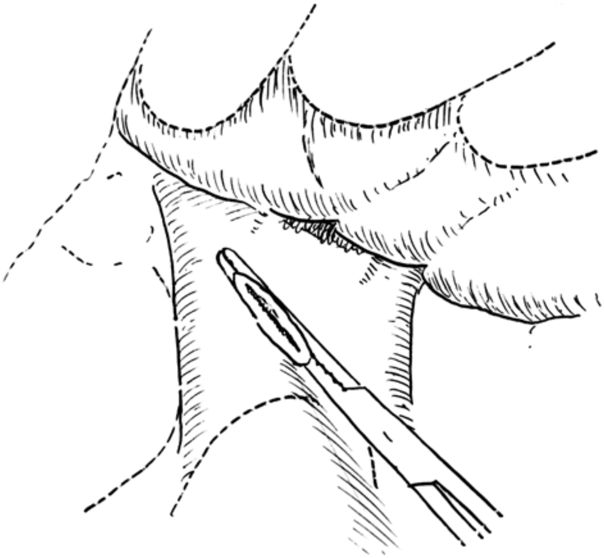


(b)

Fig.5.46. A SHV is dissected.
(a) Photograph; (b) Drawing



(a)



(b)

Fig.5.47. The stump of a large SHV is closed by continuous suture. (a) Photograph; (b) Drawing

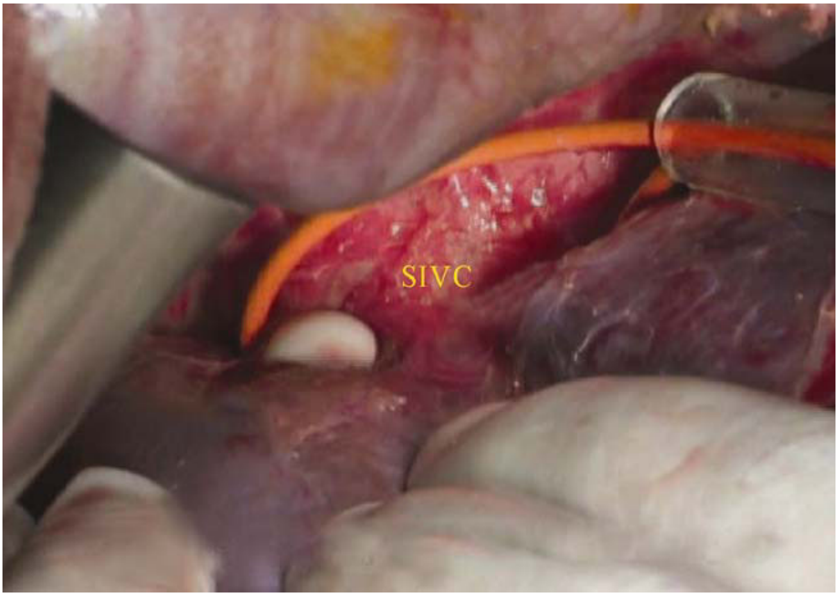


Fig.5.48. Through the retrohepatic tunnel, the fingertip appears at the upper opening

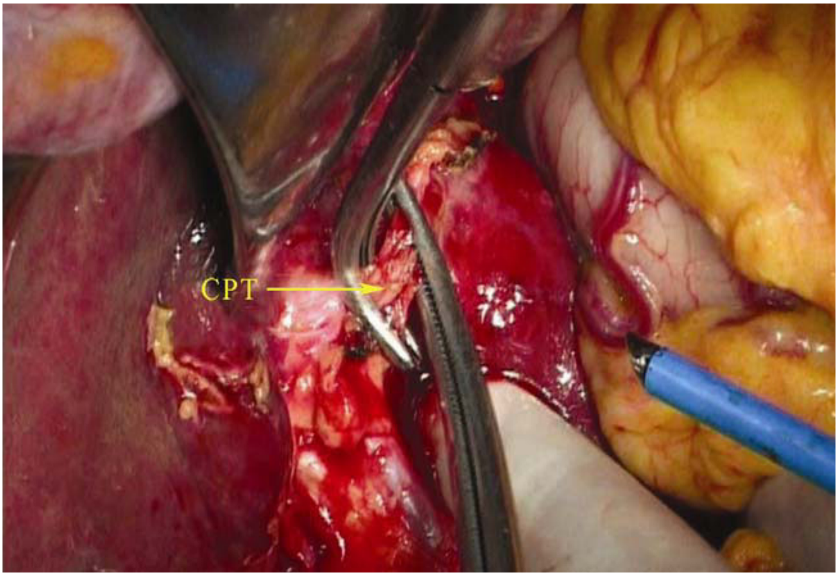


Fig.5.49. The CPT is ligated.
(a) Photograph; (b) Drawing

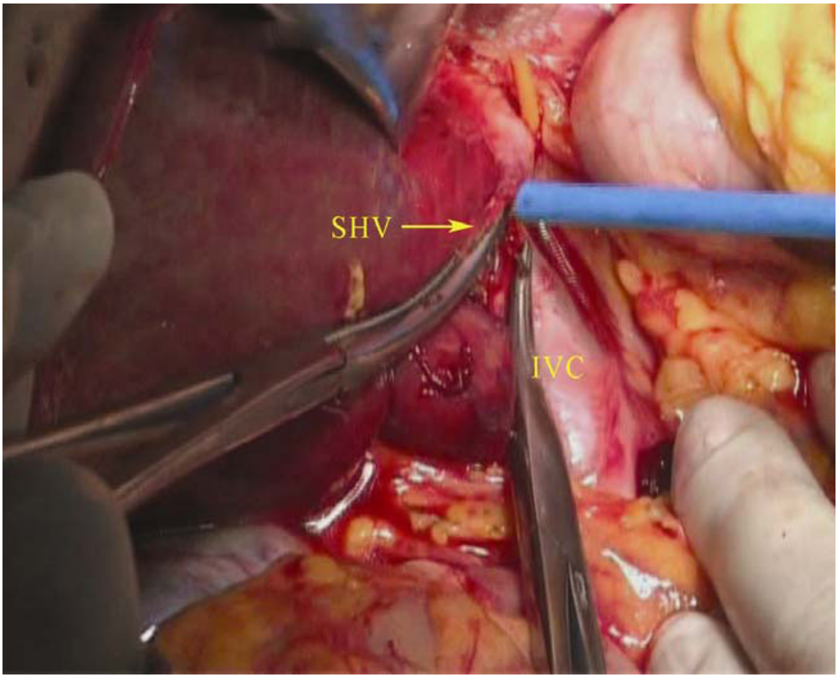


Fig.5.50. A SHV is divided

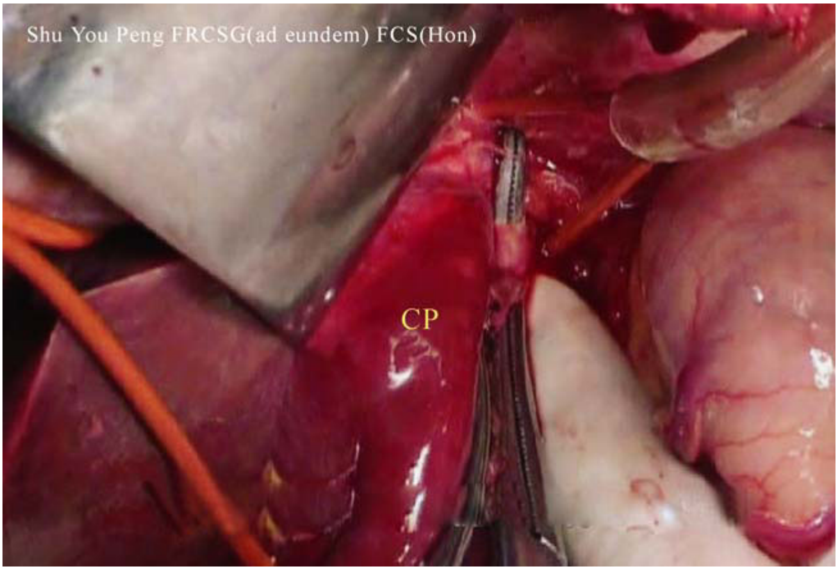
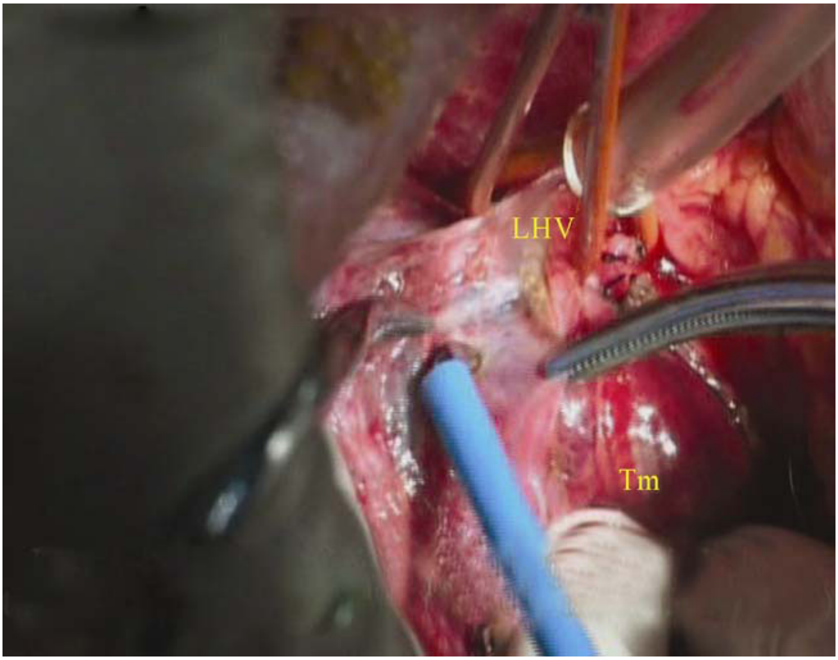


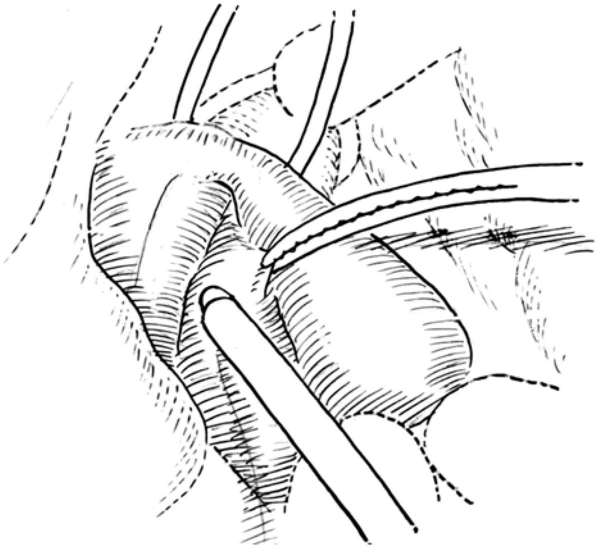
Fig.5.51. The uppermost part of the caudate lobe is divided

Fig.5.52. Dissection on the right side of the IVC

Fig.5.53. The hanging tape is swung round to become a sling for the common trunk



(a)



(b)

Fig.5.54. Dissection of the caudate lobe hemangioma from the LHV. (a) Photograph; (b) Drawing

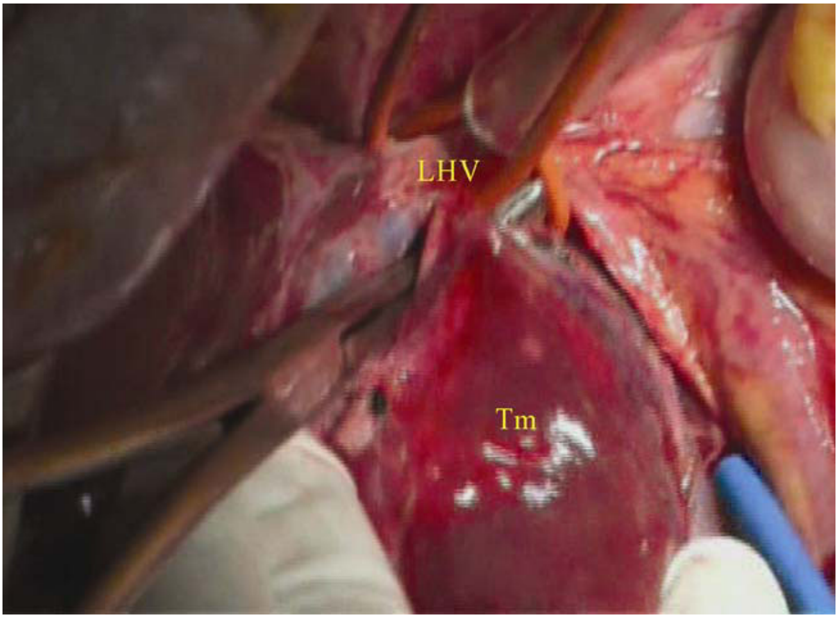
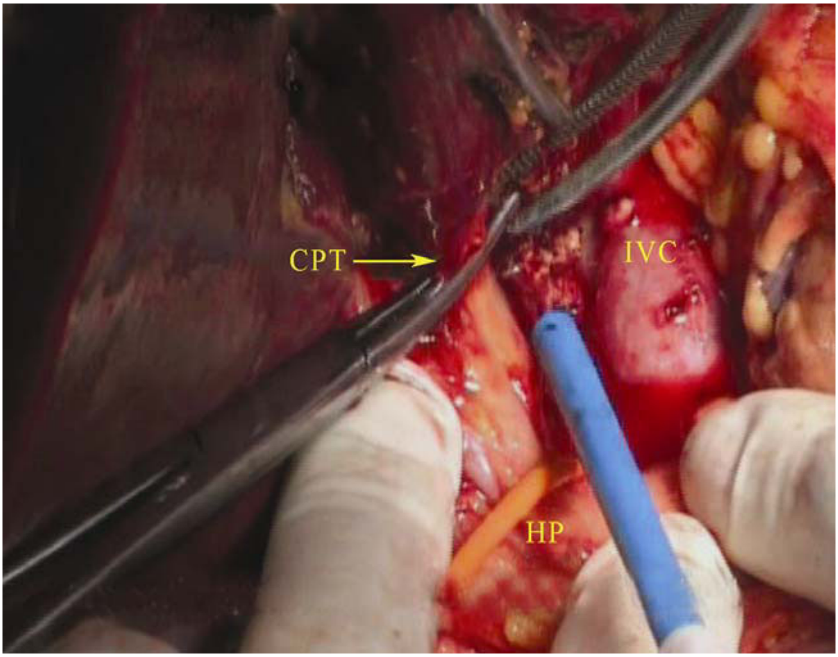
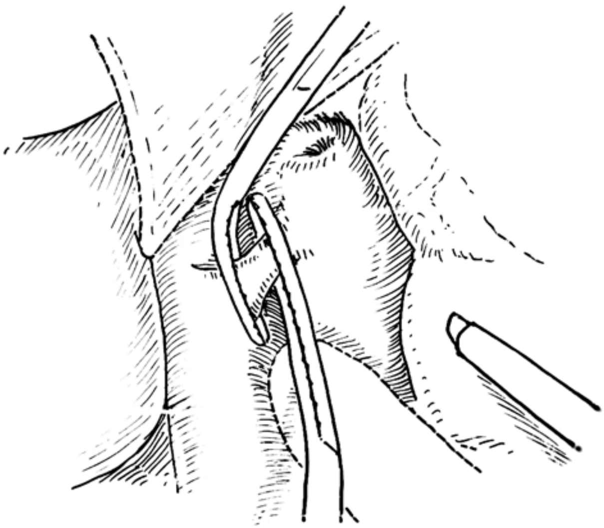


Fig.5.55. The tip of the caudate lobe is dissected



(a)



(b)

Fig.5.56. A CPT is divided.
(a) Photograph; (b) Drawing

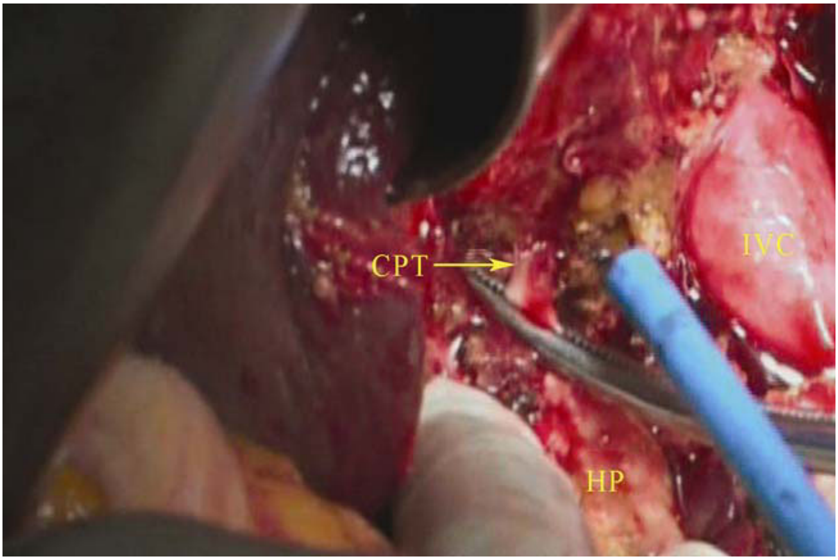
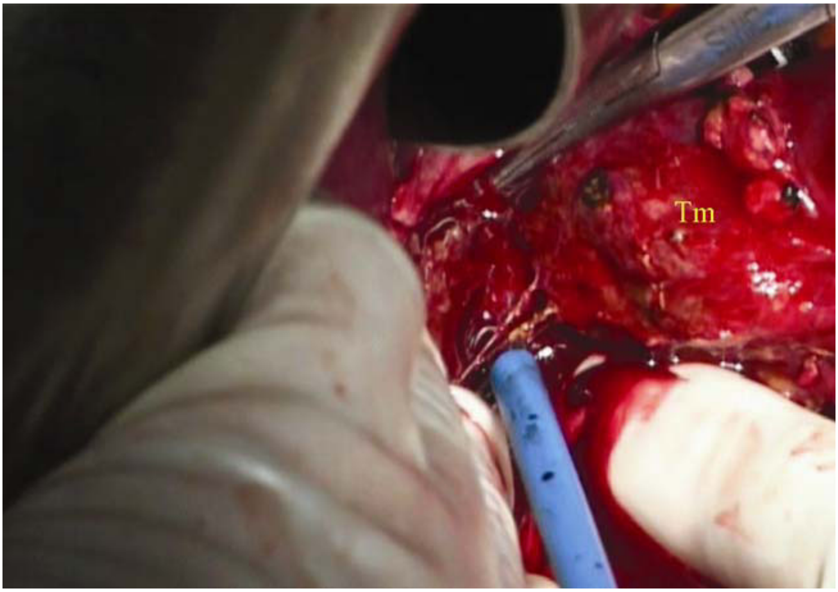
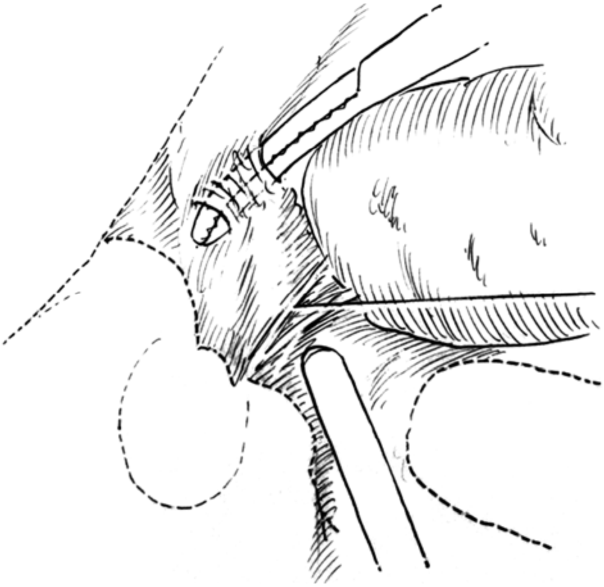


Fig.5.57. Another CPT is divided



(a)



(b)

Fig.5.58. The hemangioma is resected from the liver, and numerous connecting vessels are visible. (a) Photograph; (b) Drawing

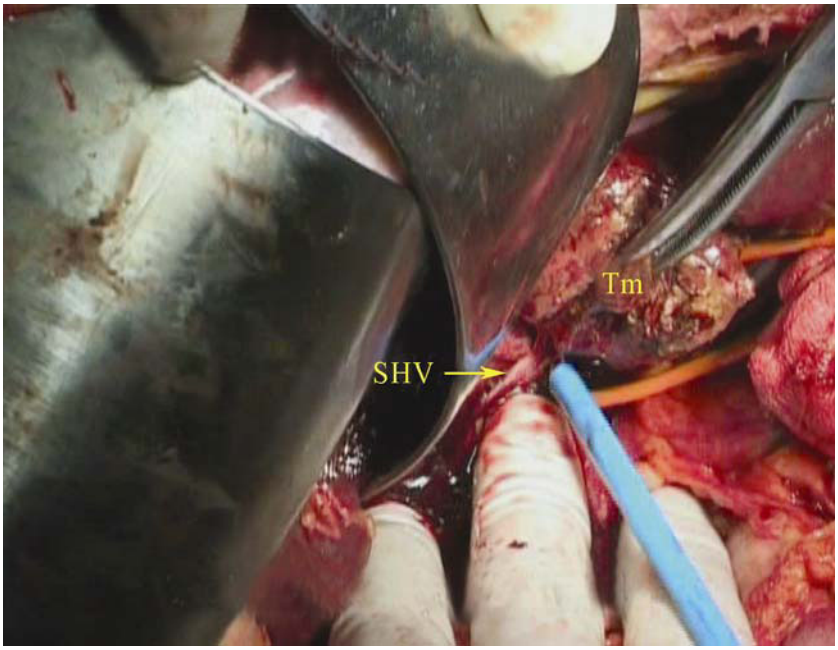


Fig.5.59. A SHV is dissected

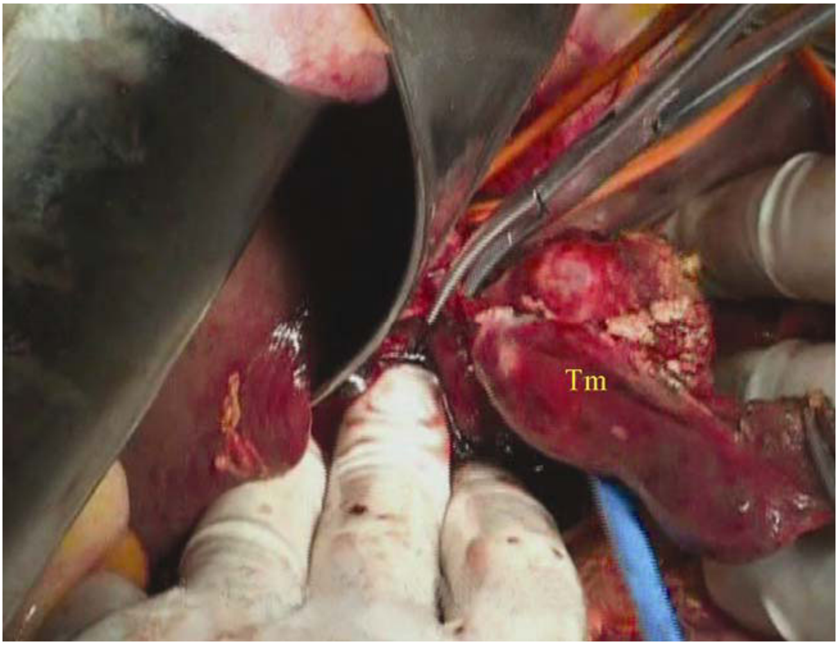
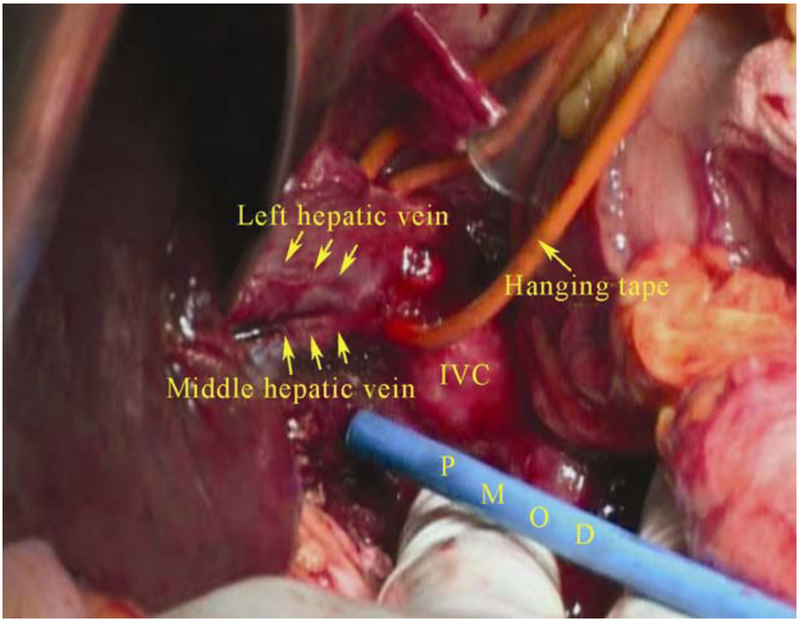
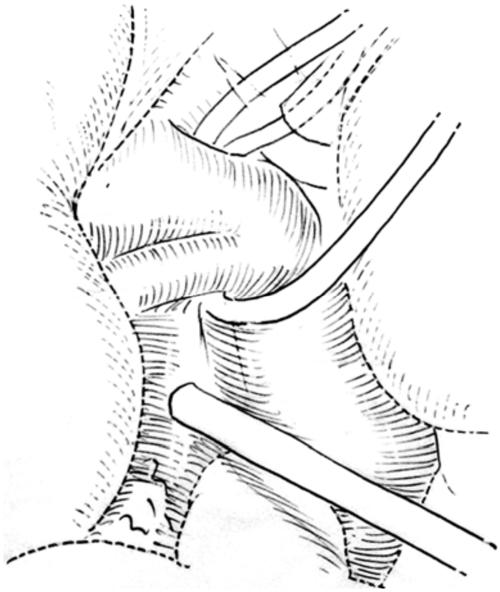


Fig.5.60. The last part of dissection



(a)



(b)

Fig.5.61. After removal of the hemangioma, the length of extra hepatic MHV and LHV is increased by the presence of the hemangioma.
(a) Photograph; (b) Drawing

5.1.5 Isolated Complete Resection of the Caudate Lobe for HCC (1)

See Figs.5.62-5.74, and video 12.

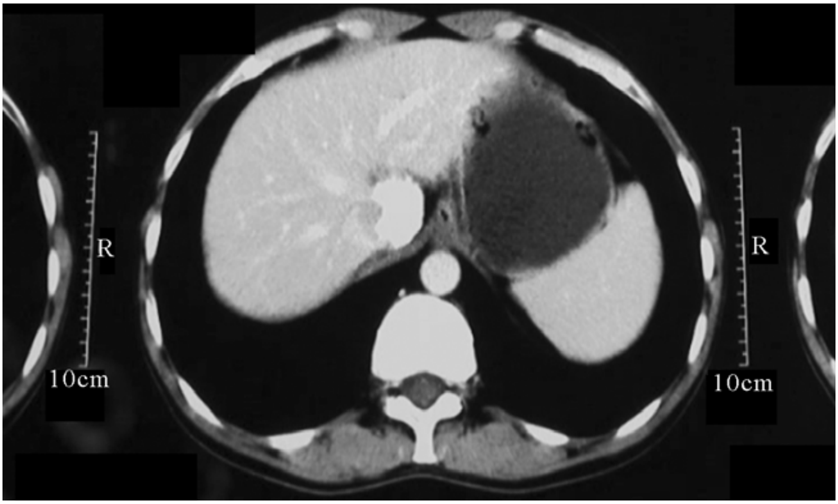


Fig.5.62. CT showing a tumor in the caudate lobe

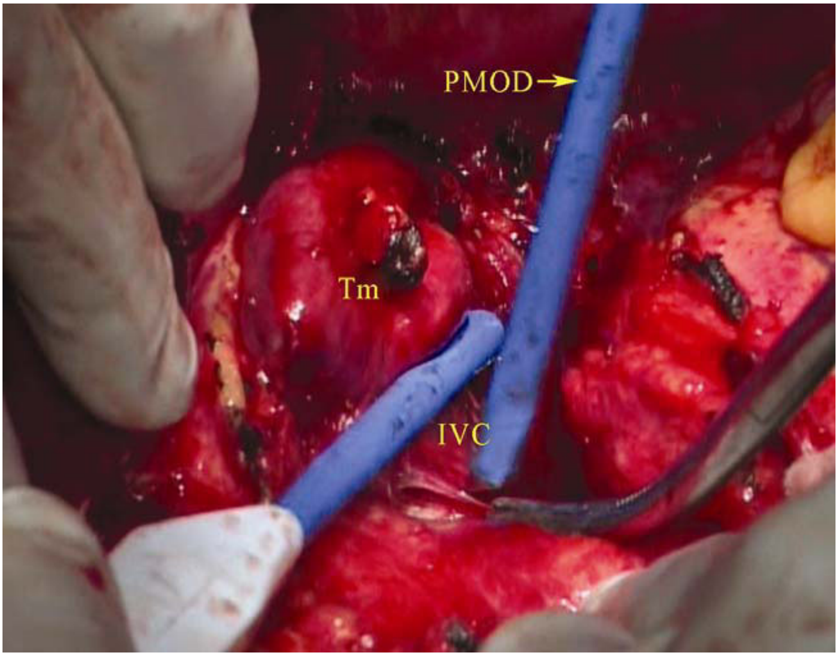


Fig.5.63. Tumor is detached from the IVC

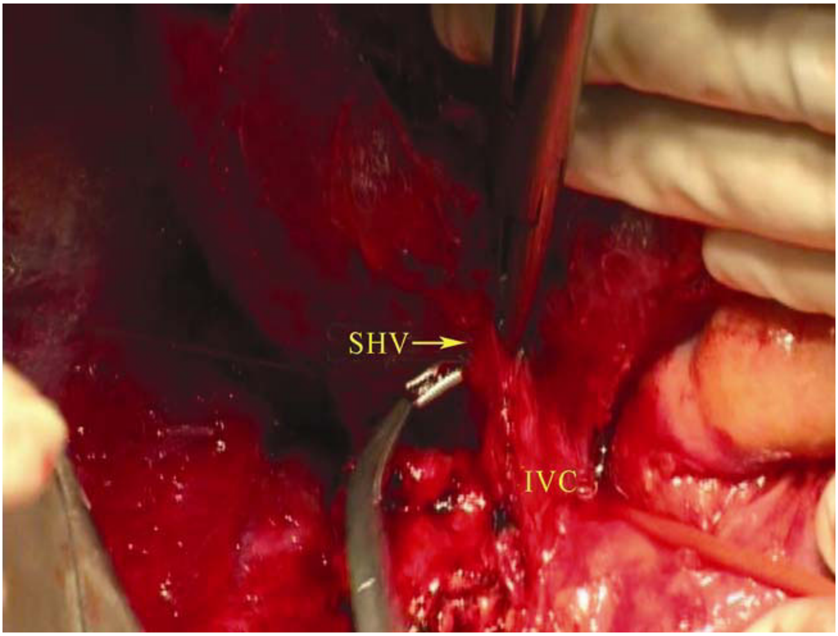


Fig.5.64. A SHV is dissected

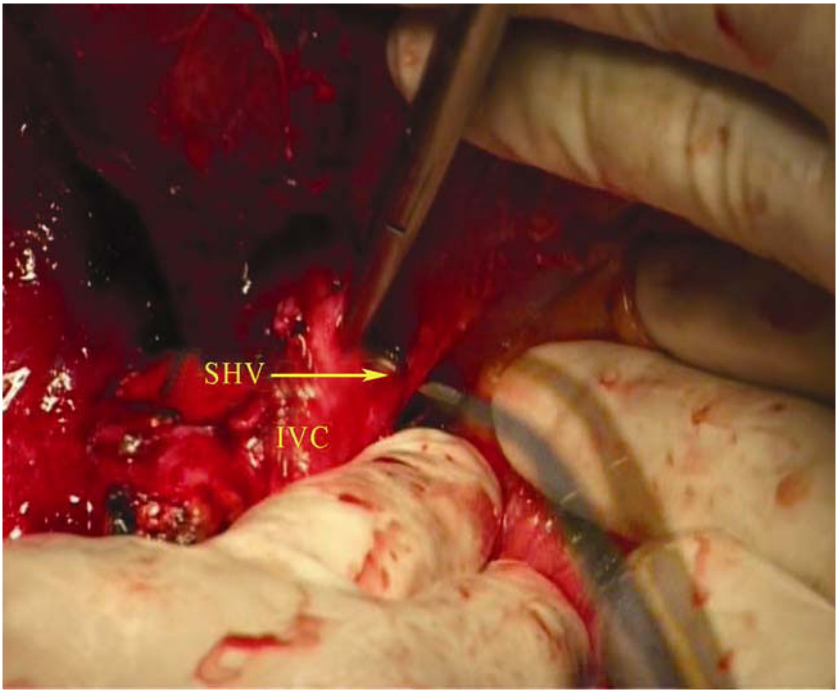


Fig.5.65. A SHV is dissected

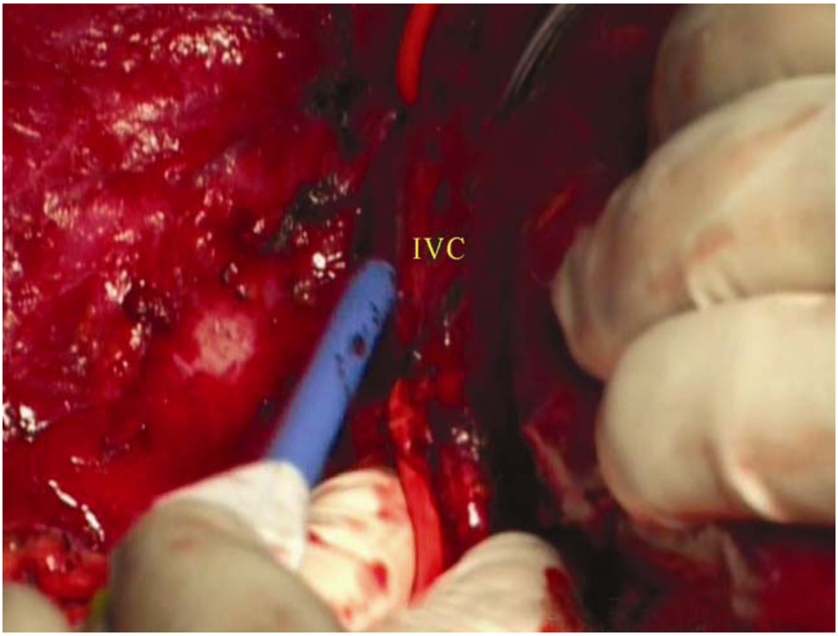


Fig.5.66. The IIVC and SIVC are taped

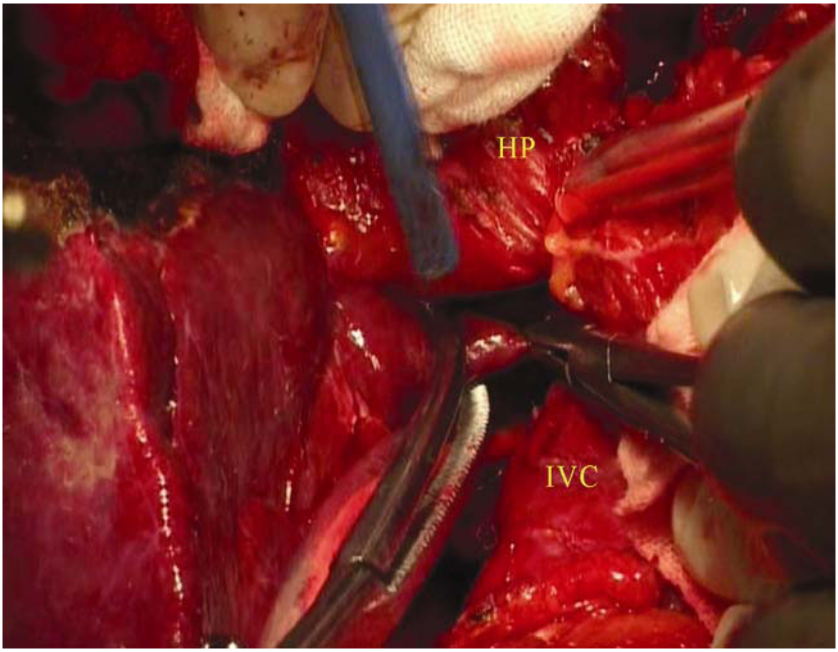


Fig.5.67. Transection is started at the caudate process

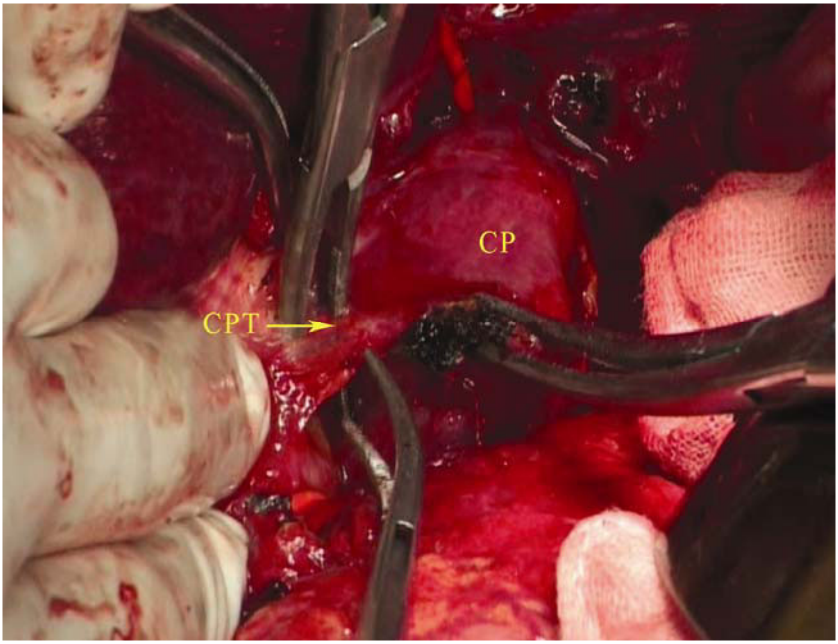


Fig.5.68. A CPT is dissected

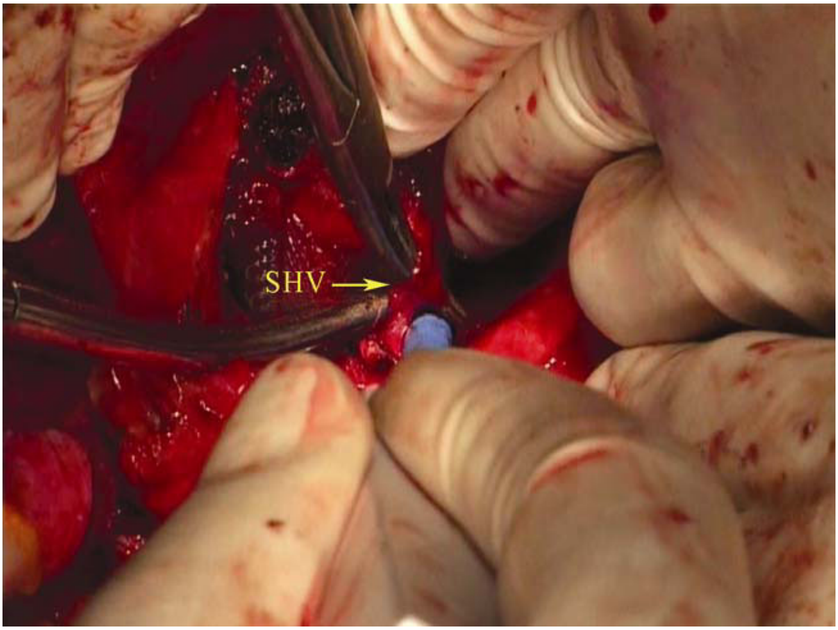


Fig.5.69. A SHV is dissected

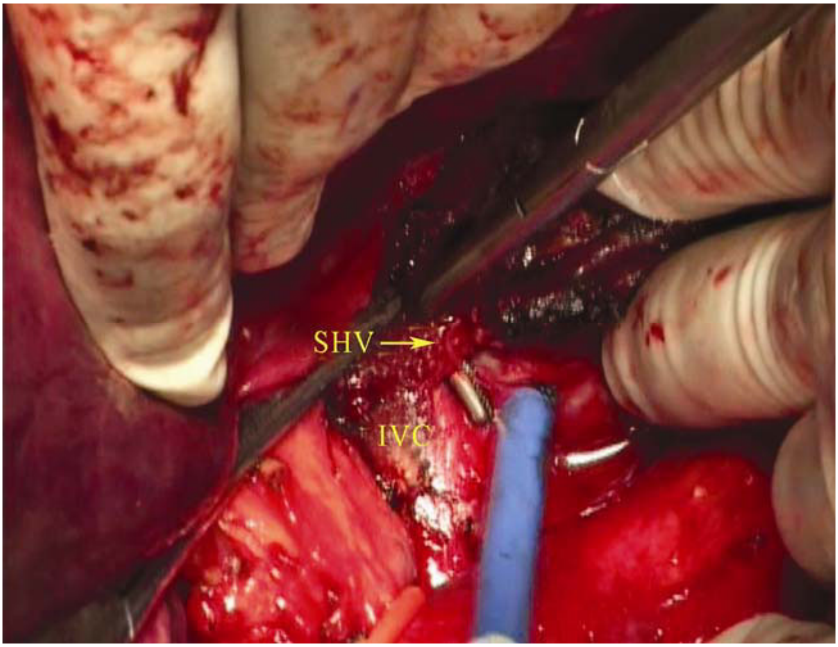


Fig.5.70. A SHV is dissected

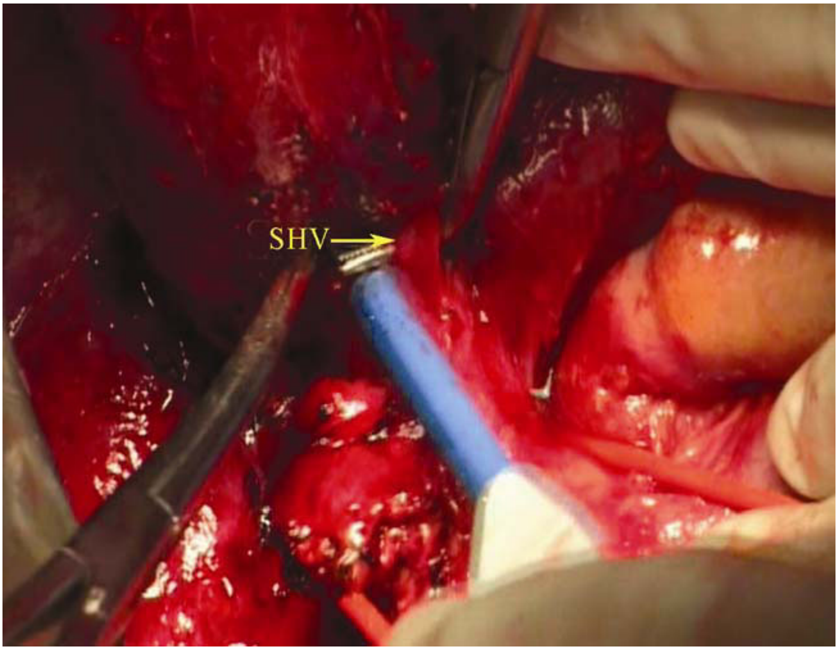


Fig.5.71. A SHV is dissected

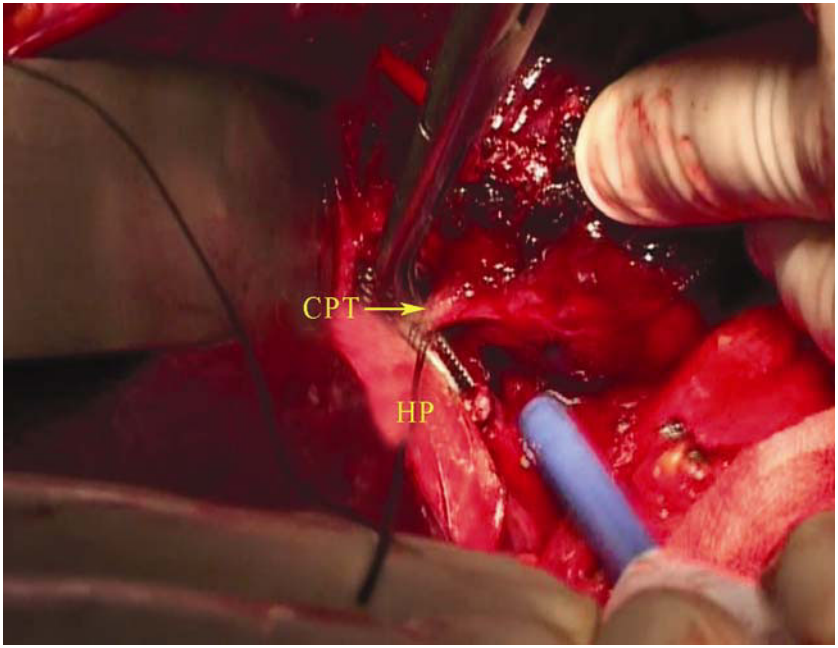


Fig.5.72. A CPT is dissected and divided

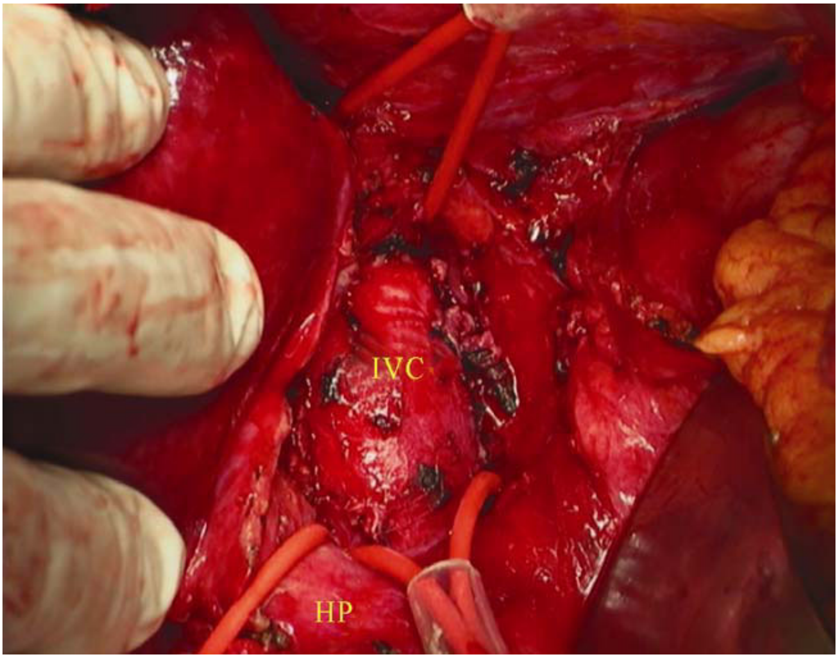


Fig.5.73. The tumor was removed, and the retrohepatic IVC is fully exposed

Fig.5.74. Specimen

5.1.6 Isolated Complete Resection of the Caudate Lobe for HCC (2)

See Figs.5.75-5.83.

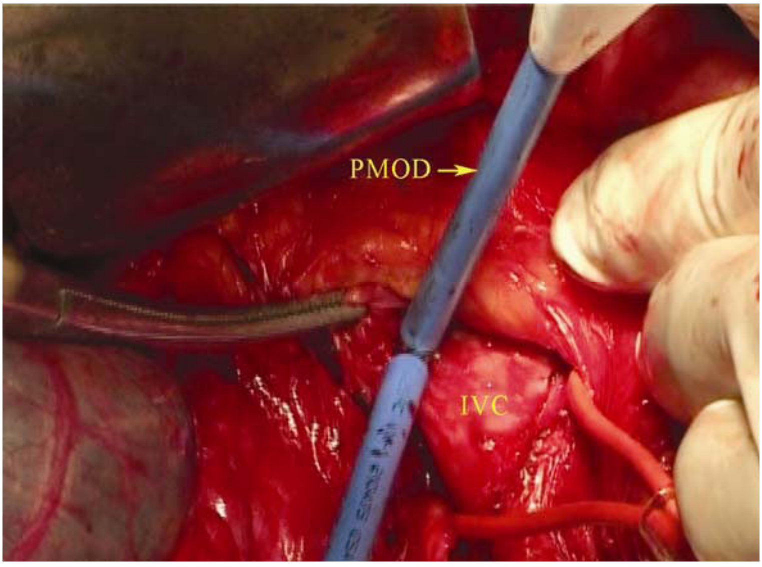


Fig.5.75. The IIVC is taped

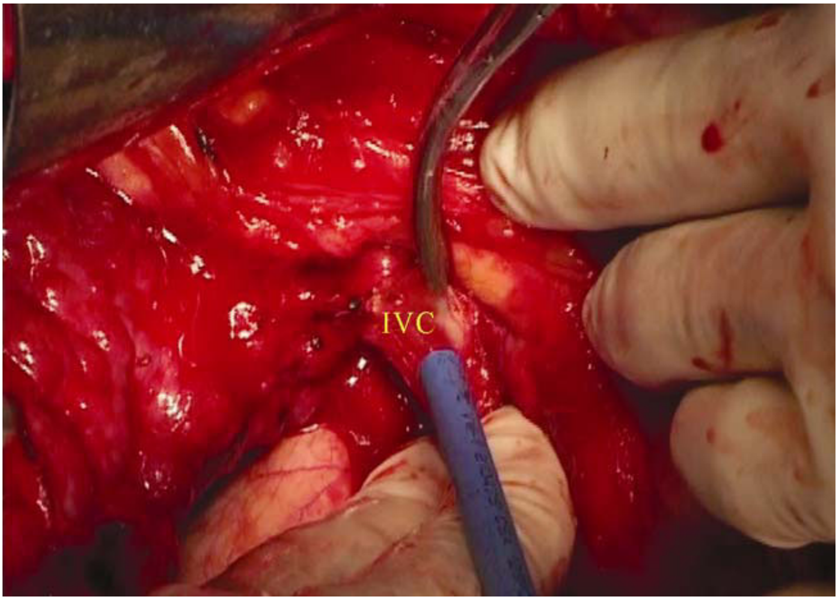


Fig.5.76. Dissecting the IVC

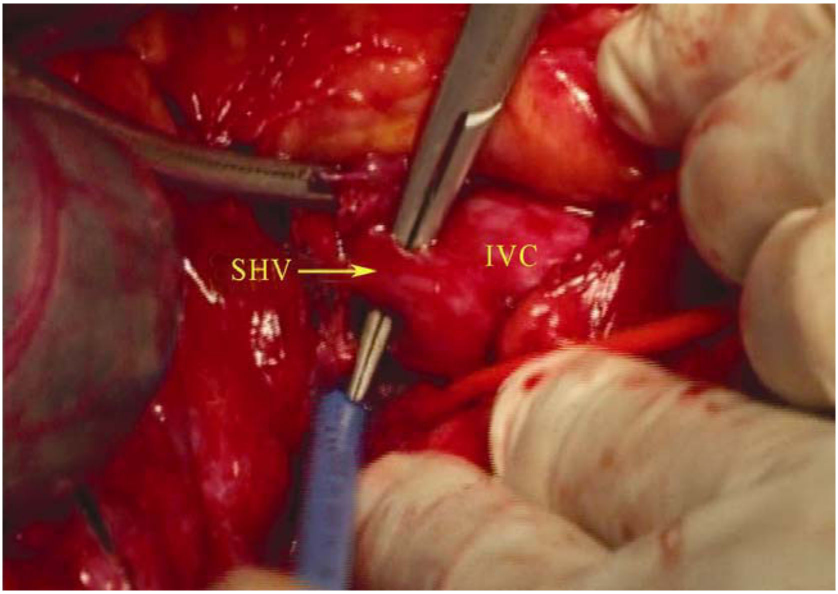


Fig.5.77. A SHV is dissected

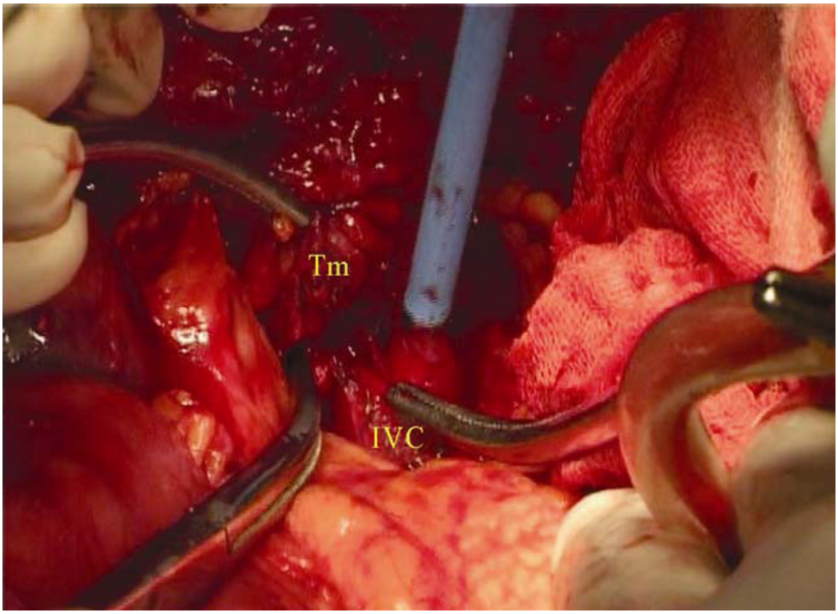


Fig.5.78. The tumor is dissected from the IVC

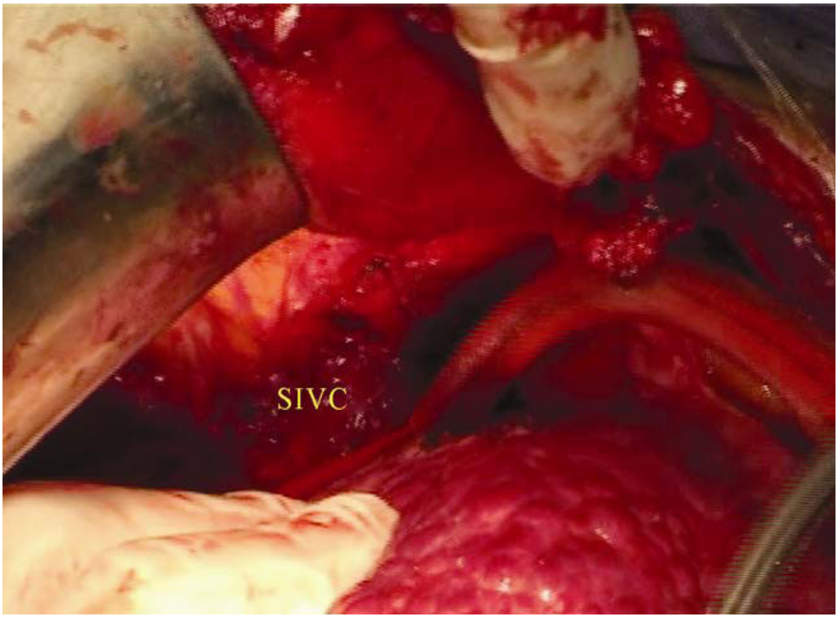


Fig.5.79. The SIVC is taped

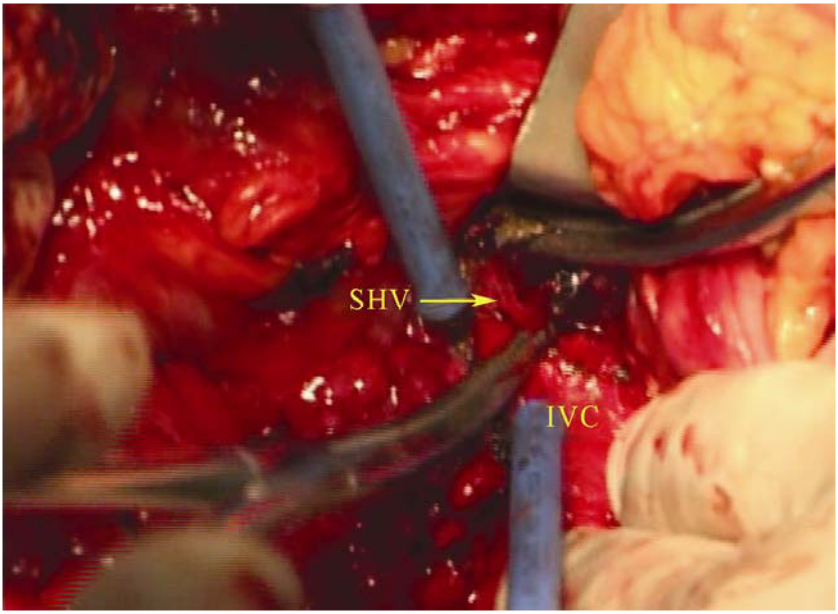


Fig.5.80. A SHV is dissected and clamped

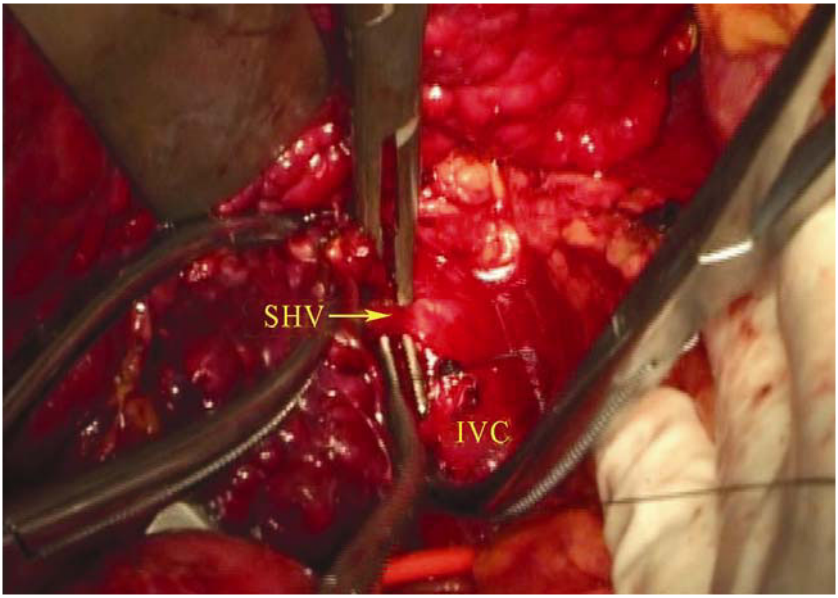


Fig.5.81. A SHV is dissected

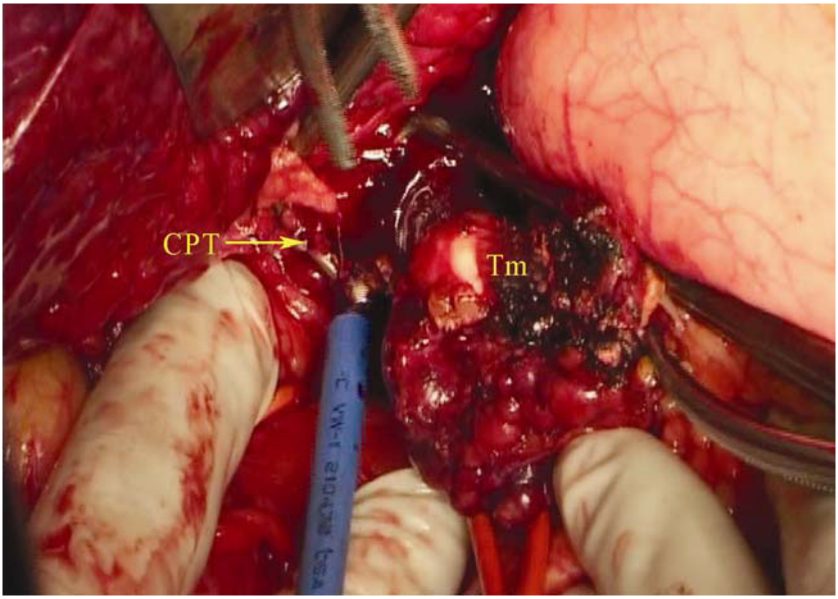


Fig.5.82. A CPT is dissected, clamped and divided

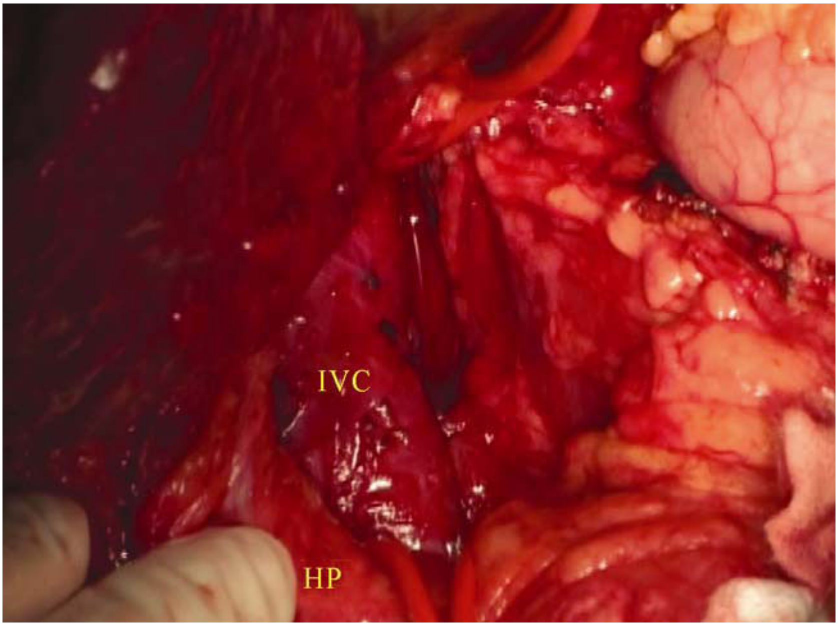


Fig.5.83. The tumor was removed, and the IVC is completely exposed

5.1.7 Isolated Complete Resection of the Caudate Lobe for Solid Cystic Tumor

See Figs.5.84-5.99, and video 13.

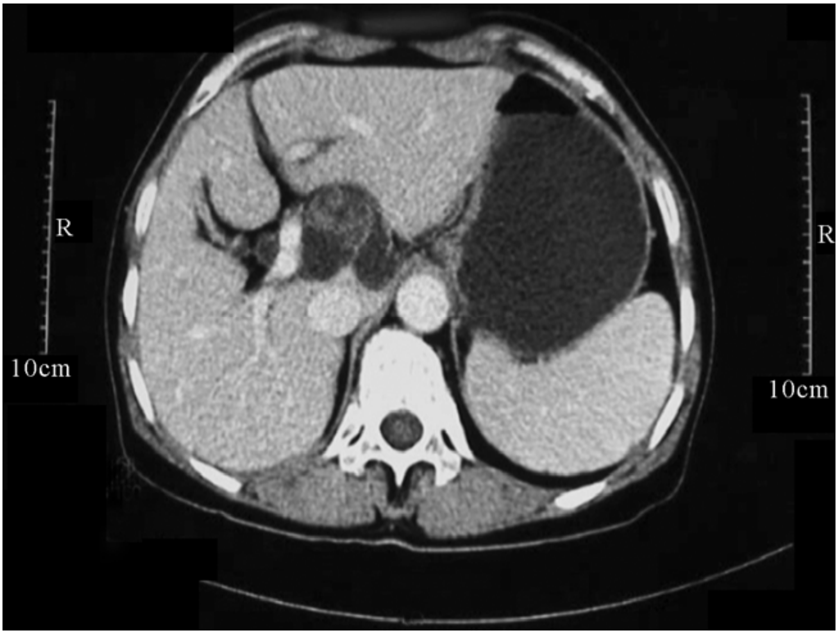
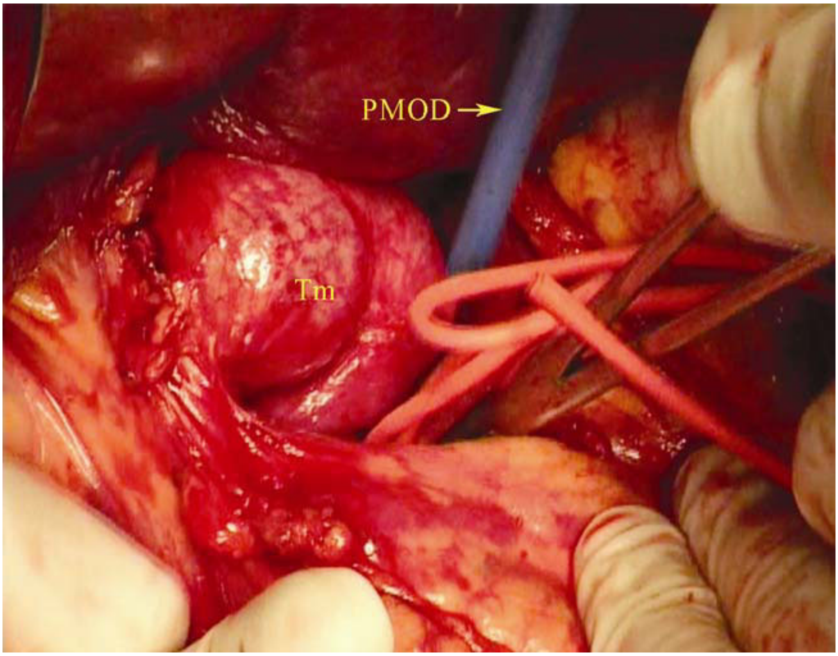
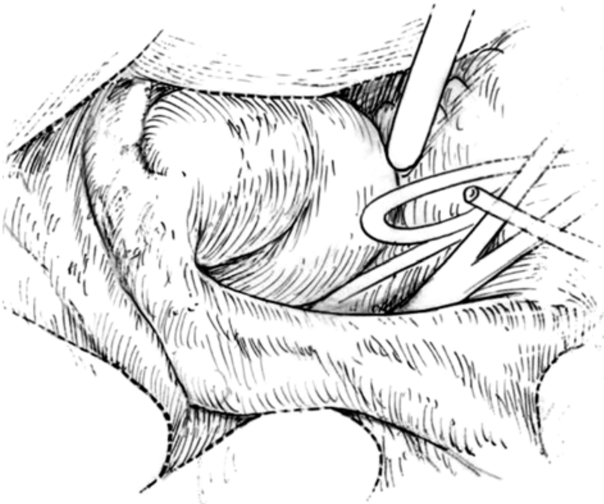


Fig.5.84. CT showing a tumor situated between the PV and IVC

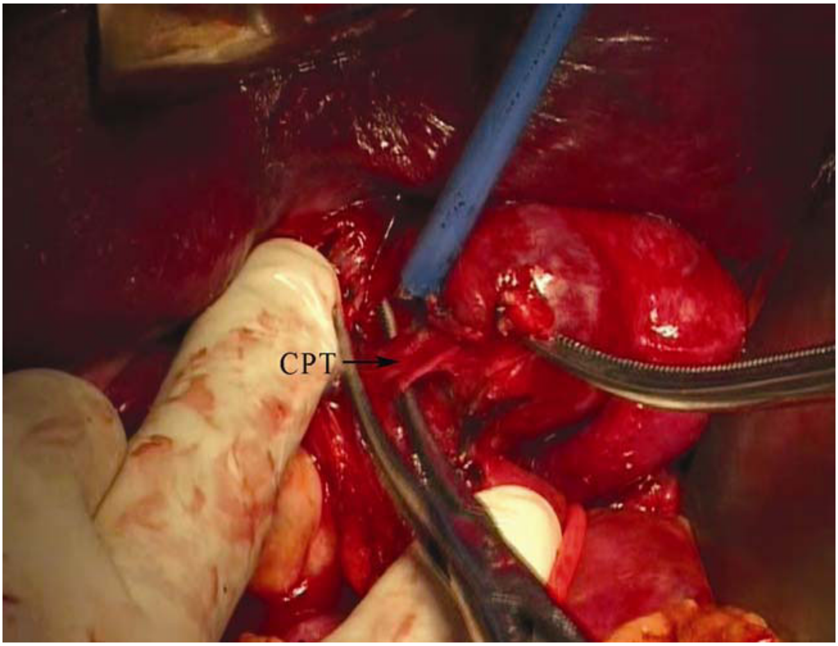


(a)

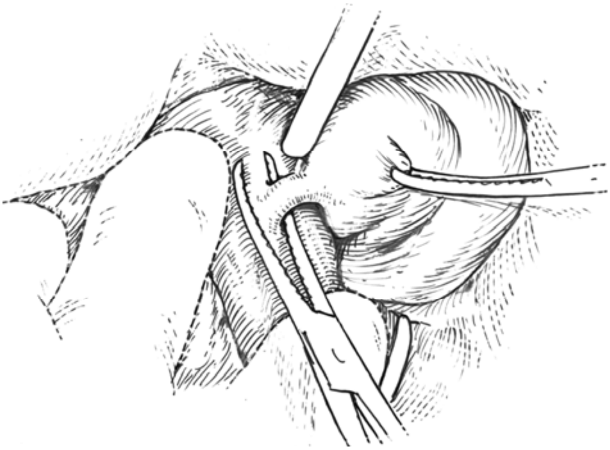


(b)

Fig.5.85. The tumor is shown in the lesser sac, and the IVC is taped. (a) Photograph; (b) Drawing

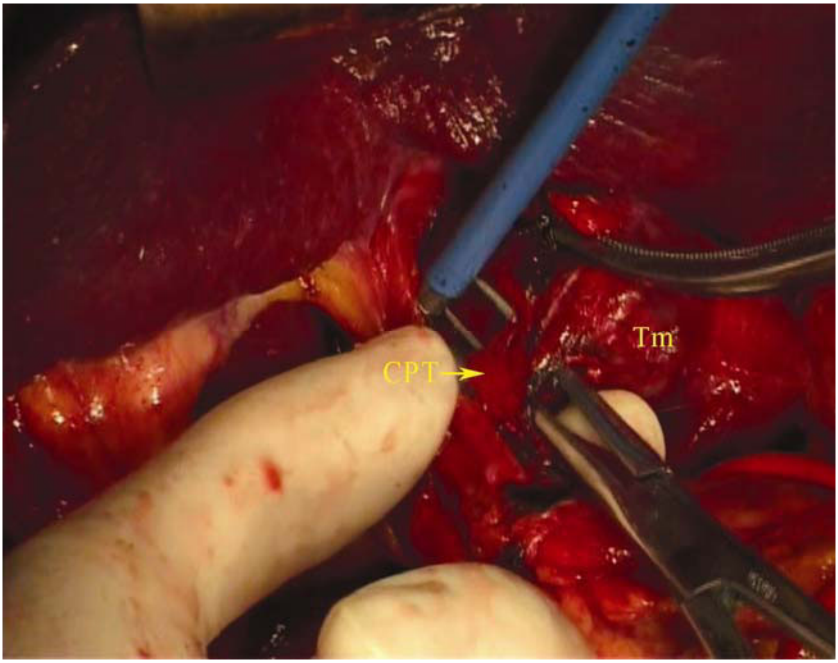


(a)

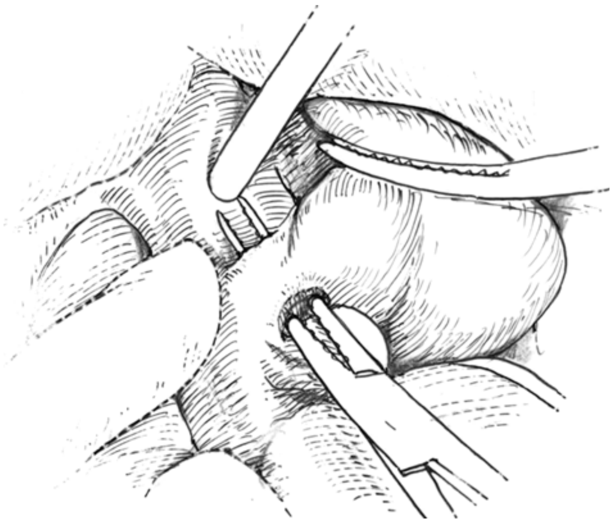


(b)

Fig.5.86. A CPT is isolated and divided.
(a) Photograph; (b) Drawing

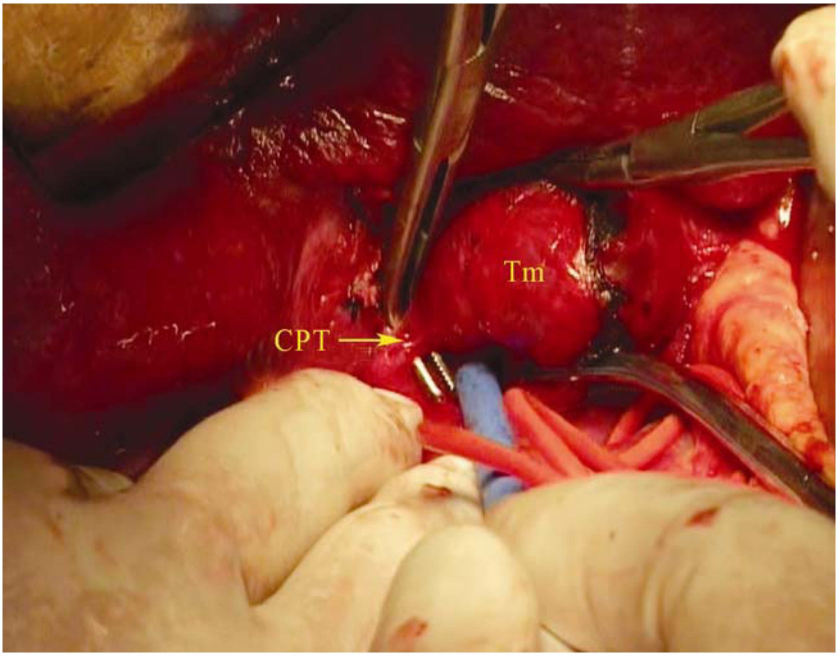


(a)

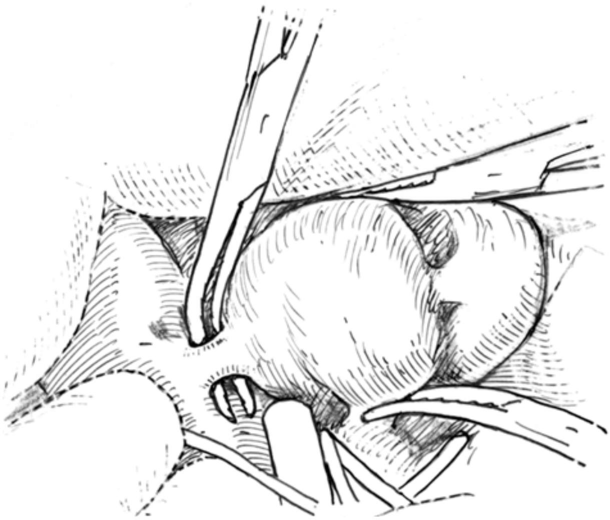


(b)

Fig.5.87. A CPT is dissected and divided.
(a) Photograph; (b) Drawing

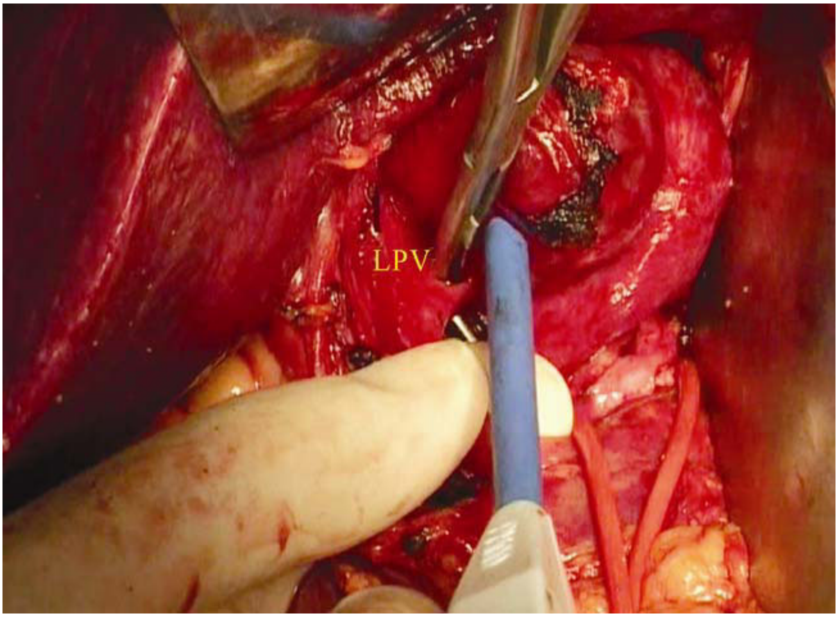


(a)

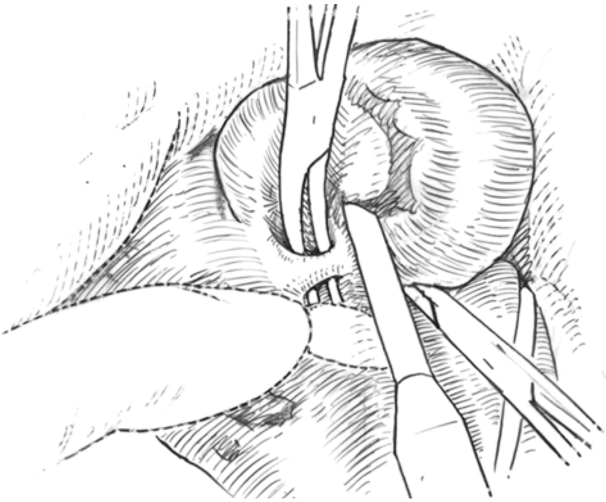


(b)

Fig.5.88. A CPT is dissected and divided.
(a) Photograph; (b) Drawing

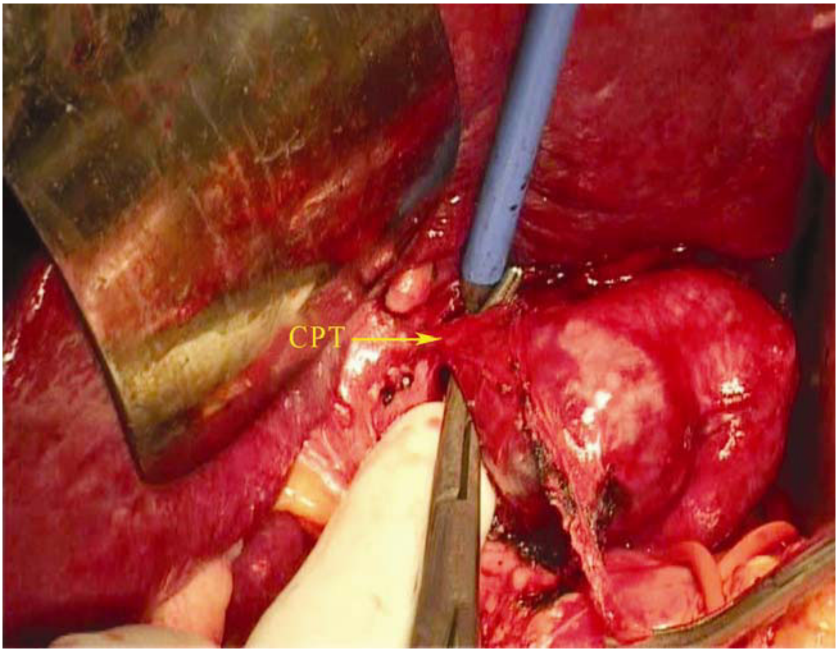


(a)

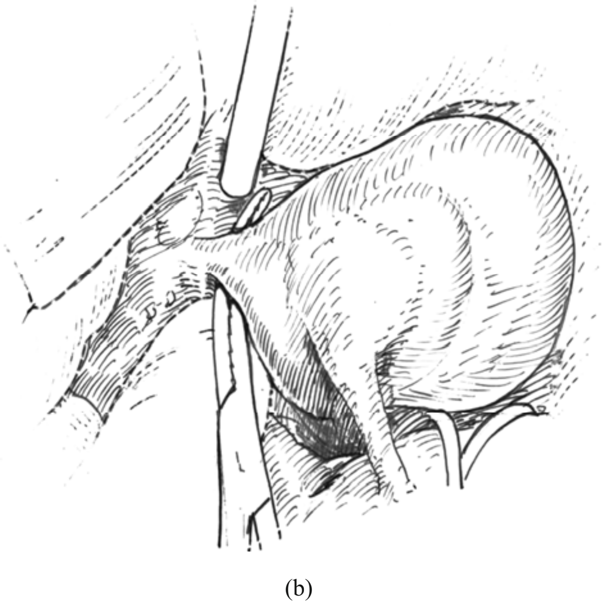


(b)

Fig.5.89. A branch from LPV is isolated and divided. (a) Photograph; (b) Drawing

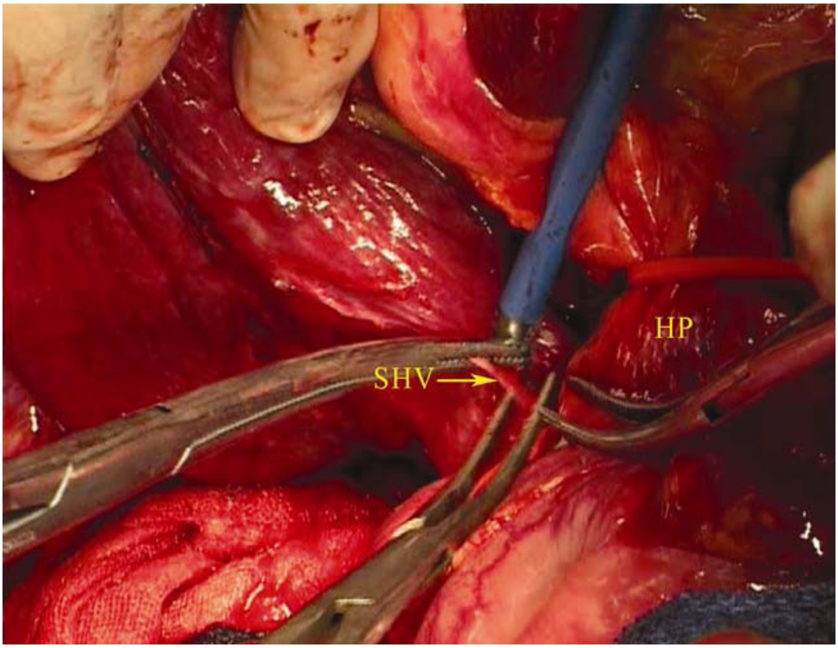


(a)

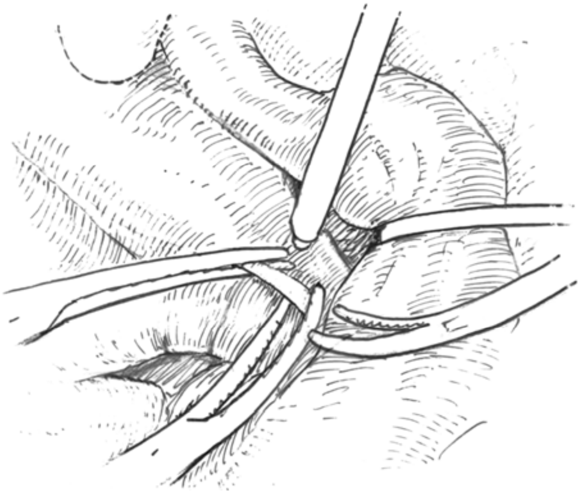


(b)

Fig.5.90. A CPT at a higher level is isolated and divided. (a) Photograph; (b) Drawing

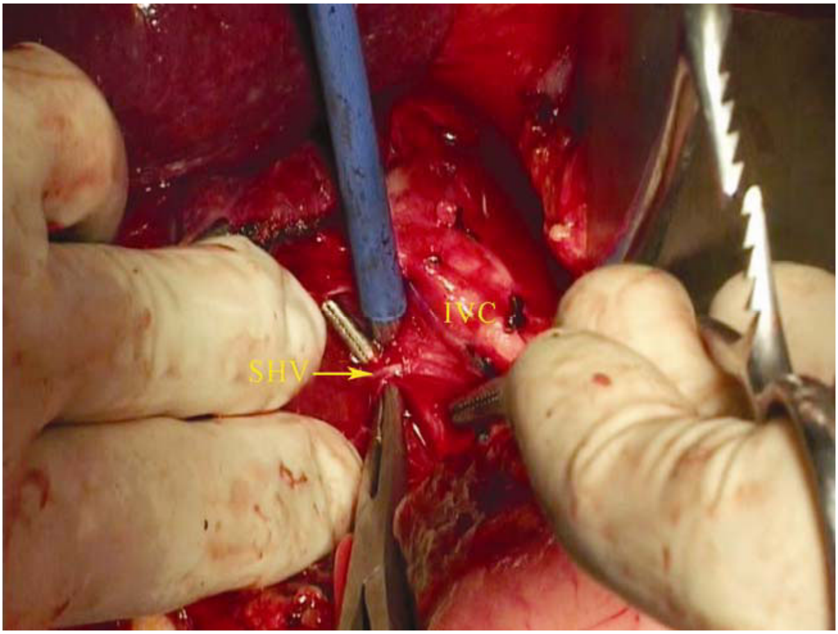


(a)

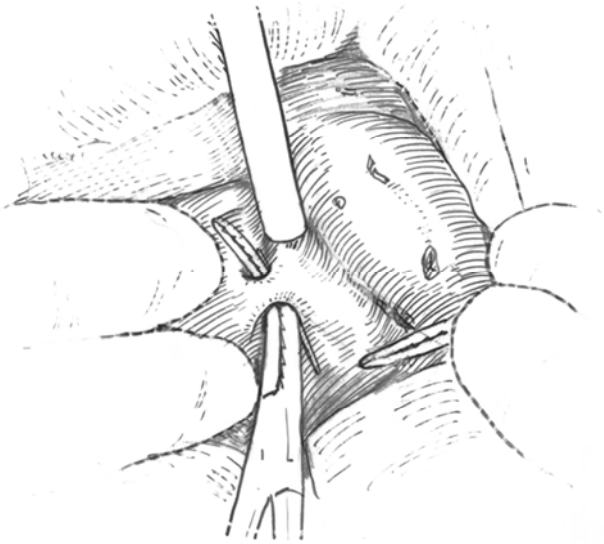


(b)

Fig.5.91. A SHV to the caudate process is isolated and divided. (a) Photograph; (b) Drawing



(a)



(b)

Fig.5.92. A SHV is isolated.
(a) Photograph; (b) Drawing

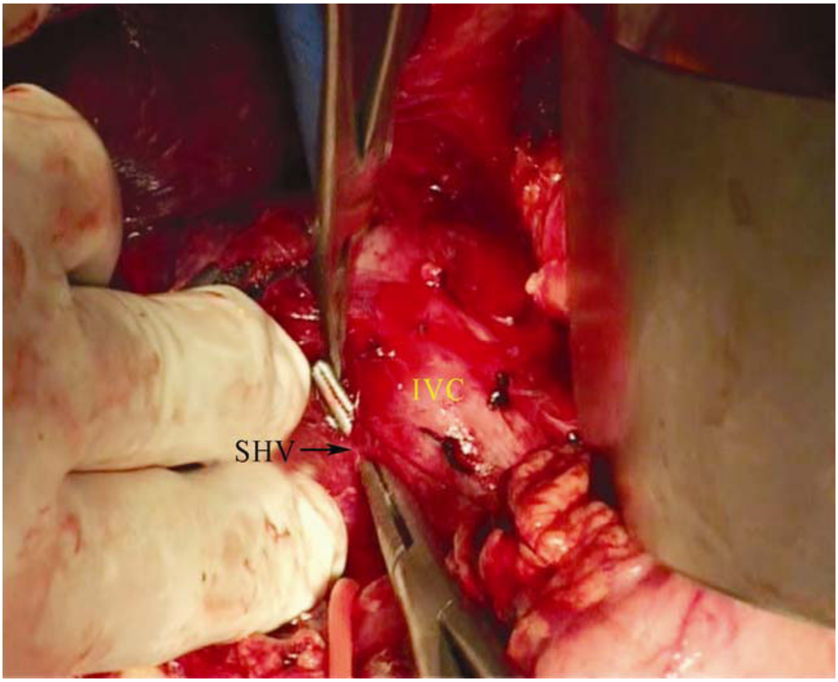
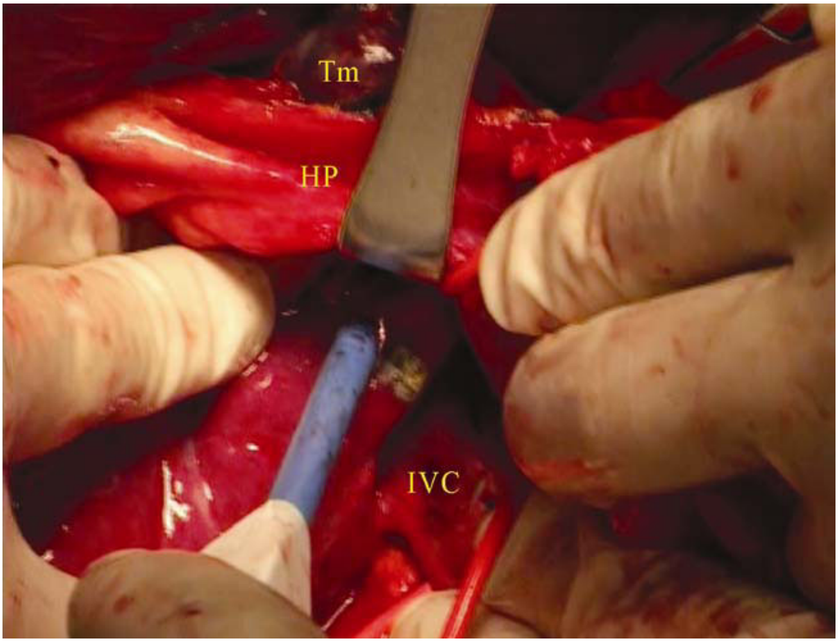
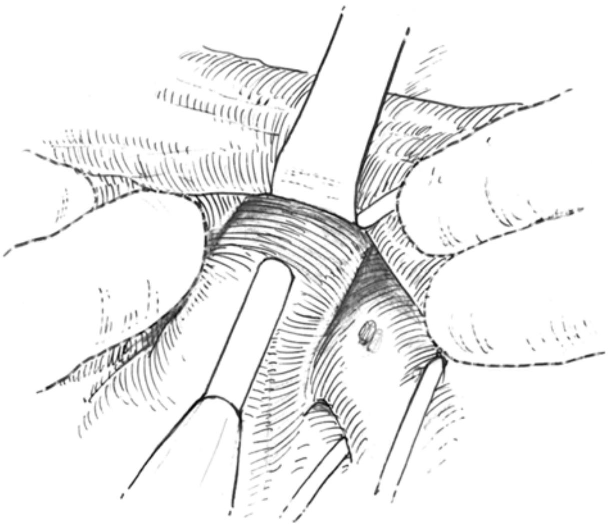


Fig.5.93. A SHV is isolated and divided



(a)



(b)

Fig.5.94. Liver transection is started at the caudate process. (a) Photograph; (b) Drawing

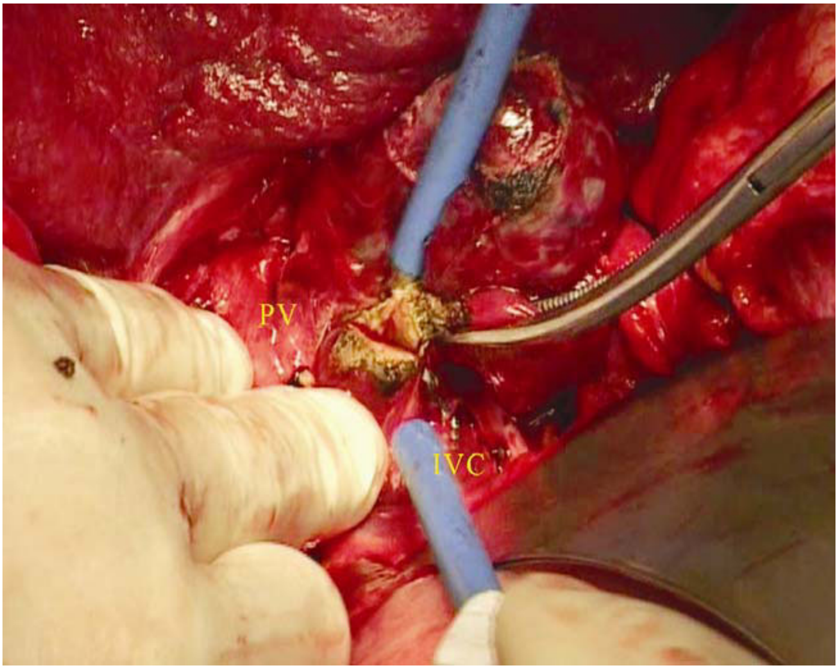
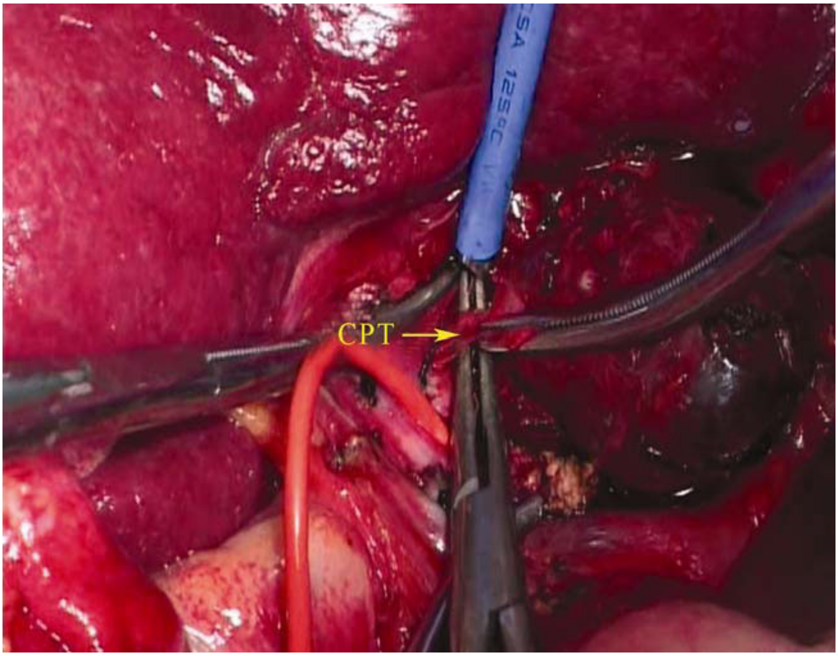
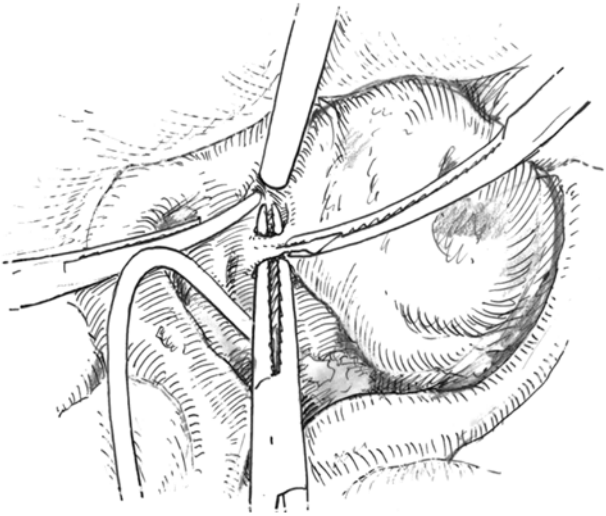


Fig.5.95. The caudate process is pushed to the left of the hepatic pedicle to continue the transection

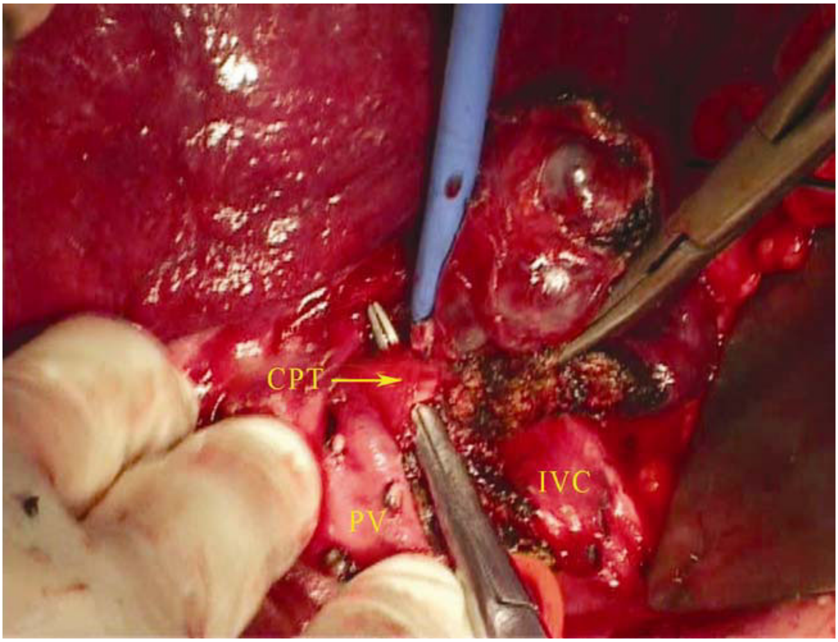


(a)

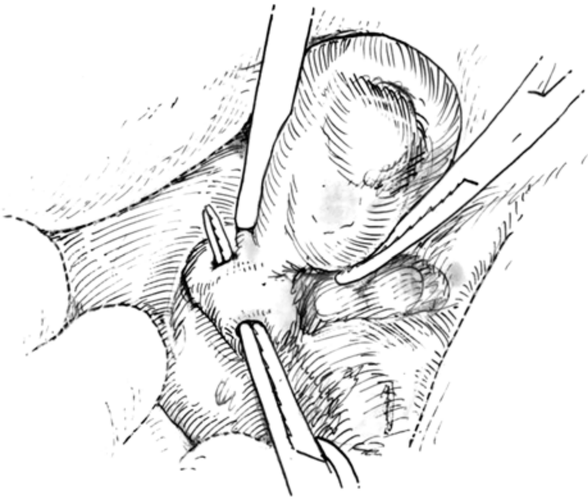


(b)

Fig.5.96. A CPT is isolated and divided.
(a) Photograph; (b) Drawing



(a)



(b)

Fig.5.97. A CPT is dissected.
(a) Photograph; (b) Drawing

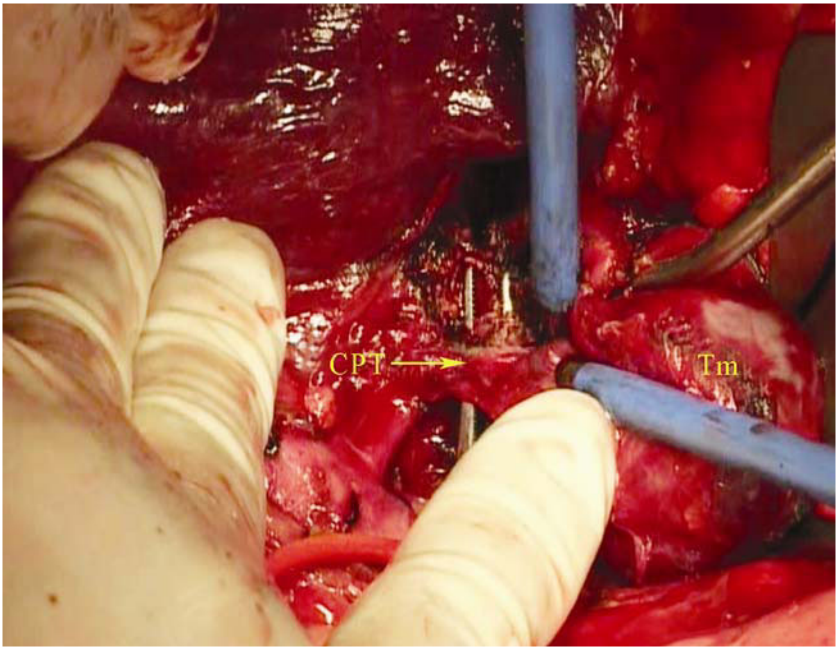


Fig.5.98. The last CPT is divided

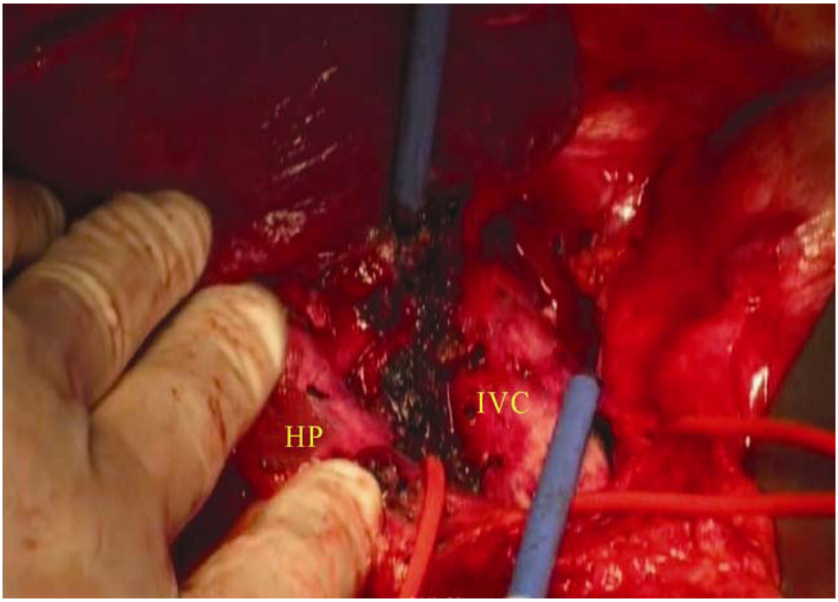


Fig.5.99. After tumor removal, the IVC is completely exposed

5.2 Isolated Partial Resection of the Caudate Lobe

Isolated partial resection of the caudate lobe is suitable for small isolated tumors situated in the peripheral portion of the caudate lobe. This may be the first choice of treatment for patients with liver cirrhosis, achieving removal of the tumor and preserving the maximum amount of non-cancerous hepatic parenchyma at the same time. However, enucleation of a tumor in the caudate lobe is not recommended.

5.2.1 Resection of the Caudate Process for HCC Closely Attached to the IVC

The lesion in this case was a 4 cm × 5 cm hemangioma, not a small one. The hemangioma was completely resected, although only a small portion of normal caudate process was left unresected (Figs.5.100-5.107, and video 14).

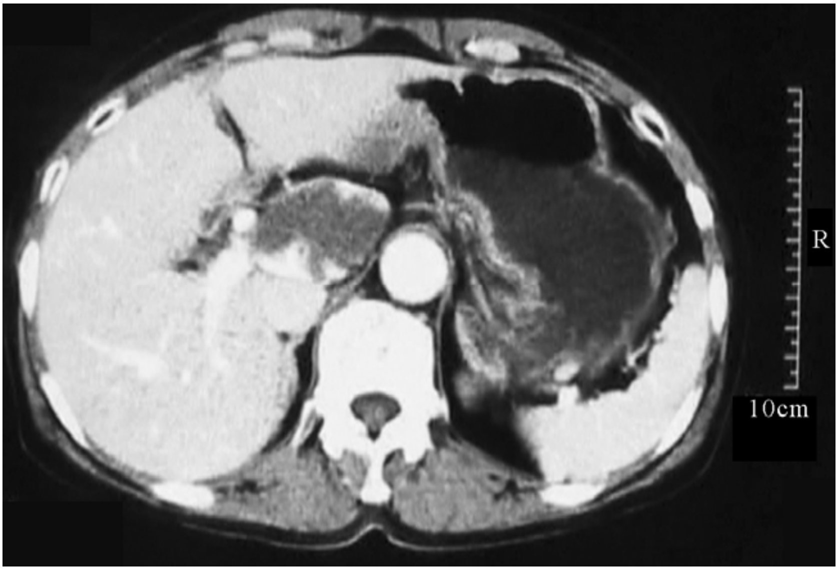


Fig.5.100. CT showing a hemangioma in the caudate lobe

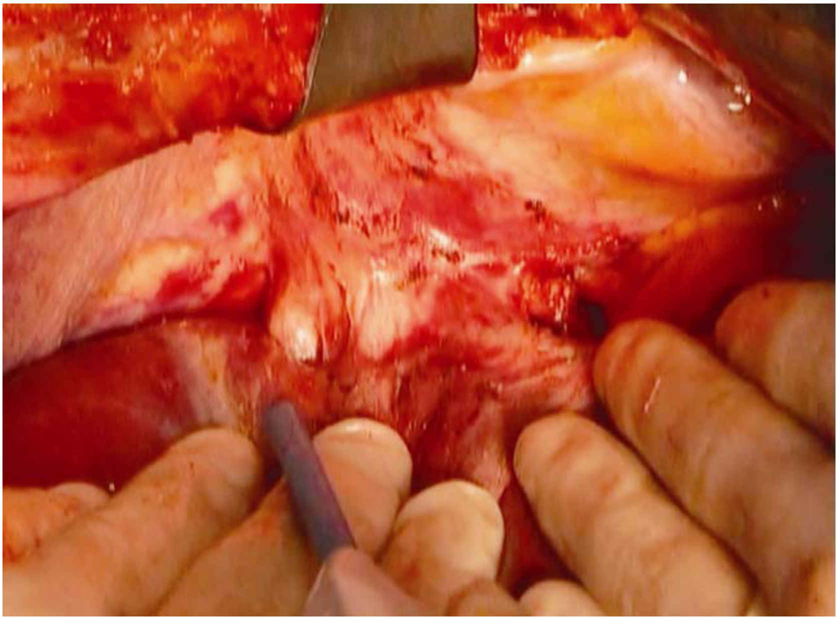


Fig.5.101. Roots of the three major HVs

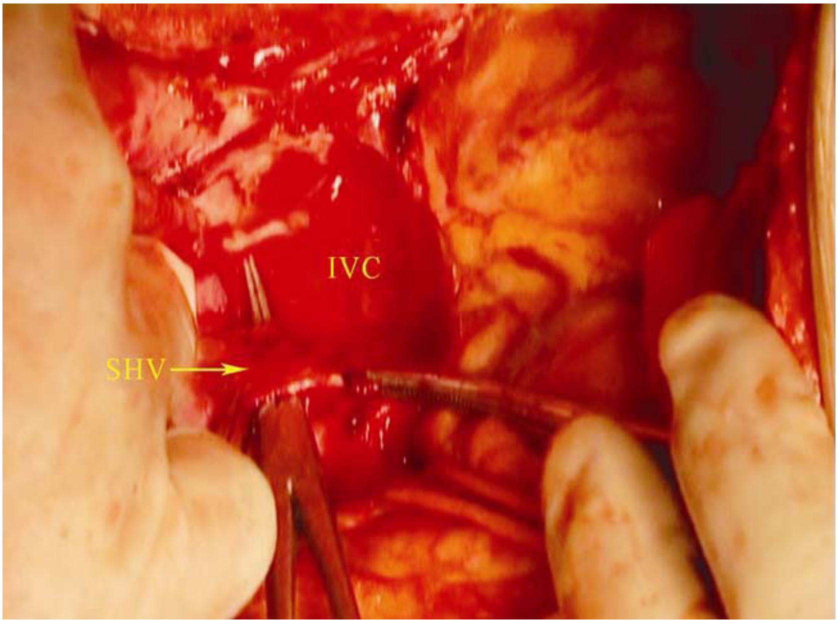


Fig.5.102. A SHV is isolated

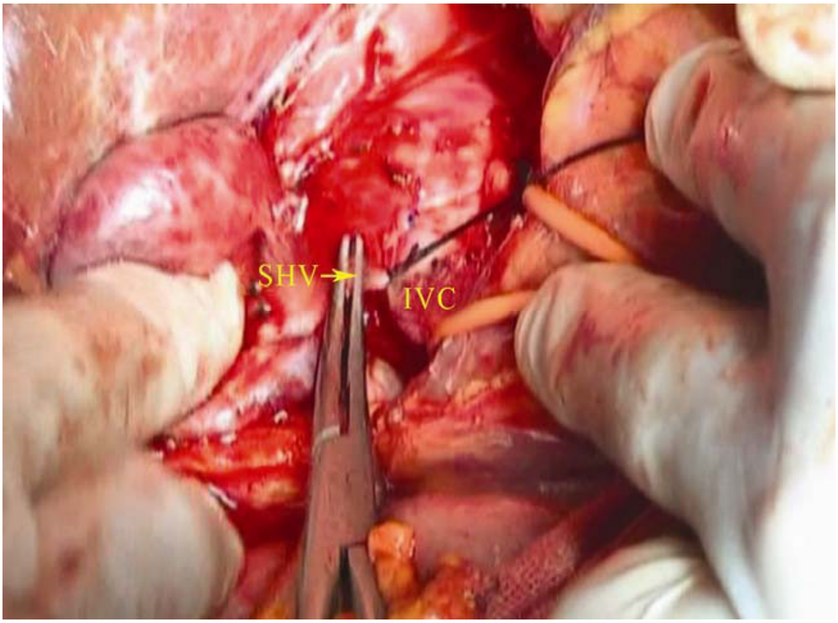


Fig.5.103. A SHV is ready for division

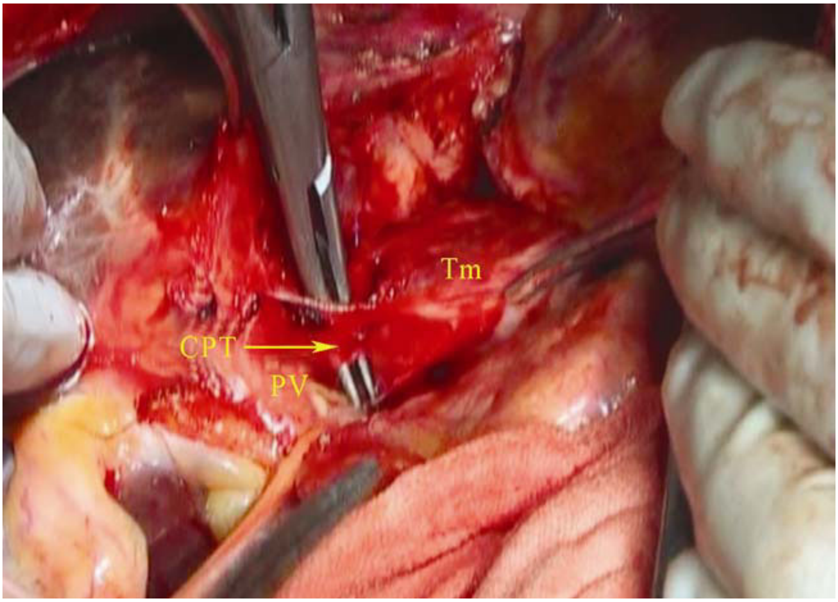


Fig.5.104. A CPT is isolated

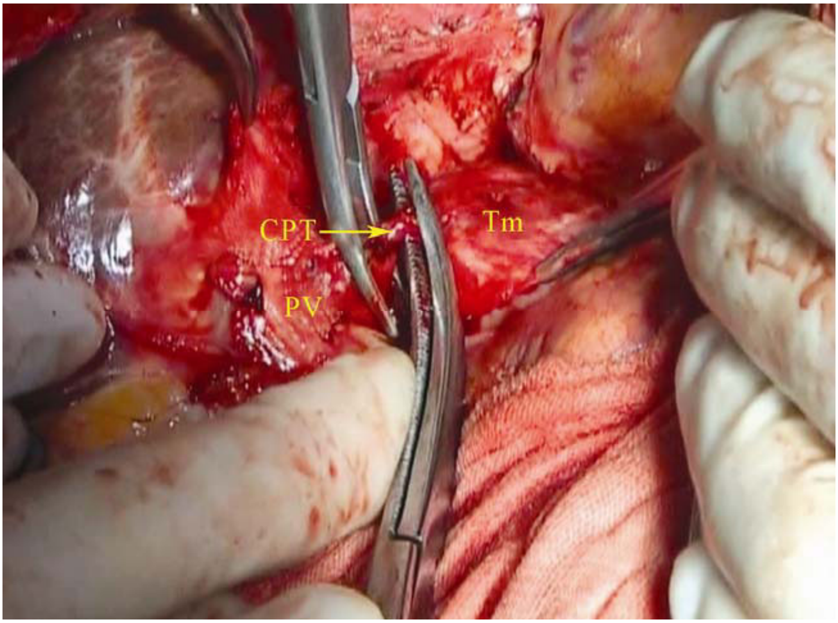


Fig.5.105. A CPT is divided between clamps

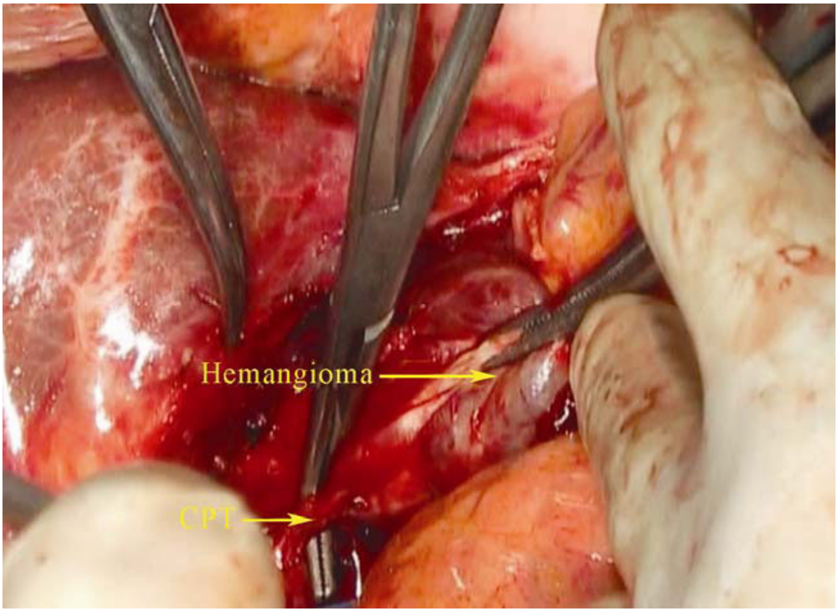


Fig.5.106. A CPT at the lower pole is isolated

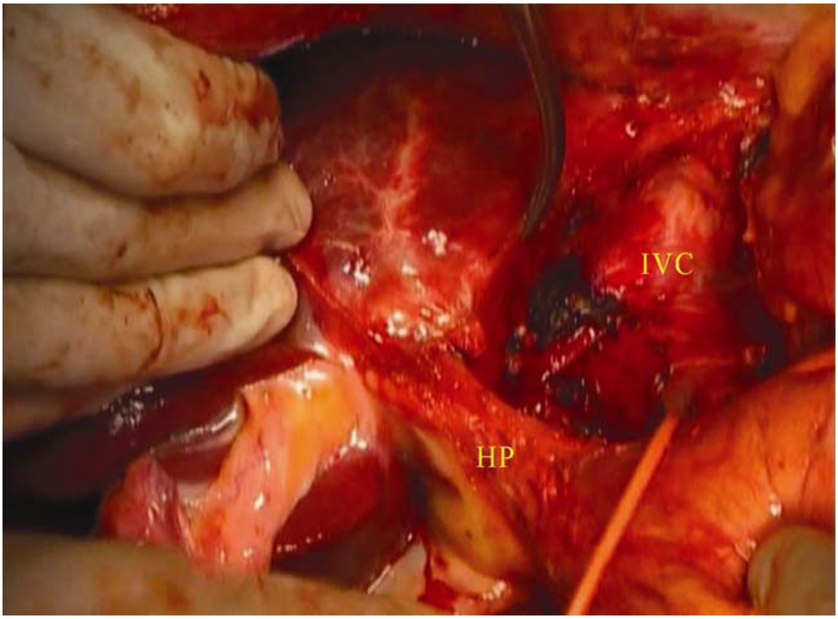


Fig.5.107. After tumor removal, the whole segment of the retrohepatic IVC is exposed

5.3 Combined Complete Resection of the Caudate Lobe

Combined complete resection of the caudate lobe is suitable for large tumors situated in the caudate lobe or when the left or right lobe is also involved in the tumor. One of the frequent indications for combined complete resection of the caudate lobe is hilar cholangiocarcinoma that belongs to Bismuth type III or IV, although in some situations Bismuth type II is also indicated.

5.3.1 Combined with Left Lobe Resection for Hilar Cholangiocarcinoma

See Figs.5.108-5.122, and video 15.

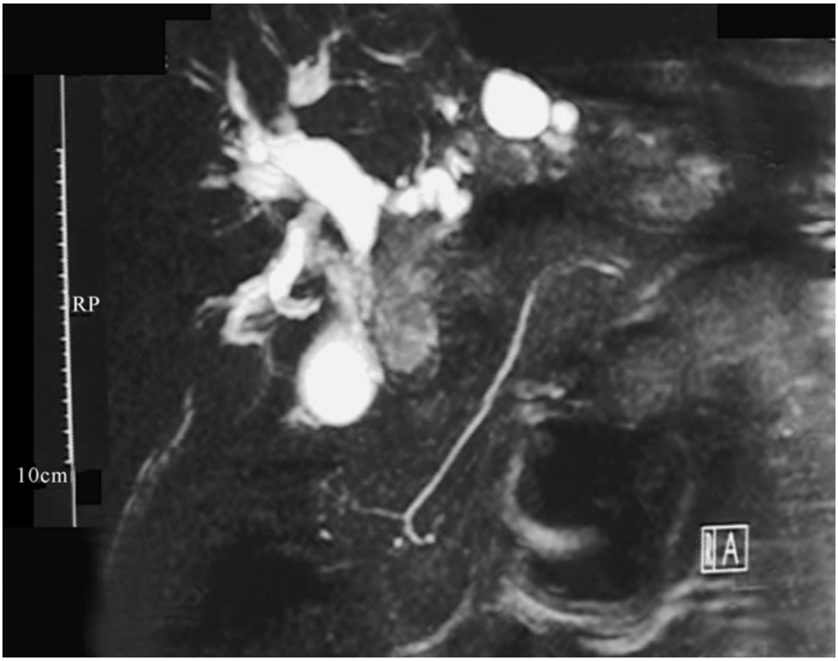
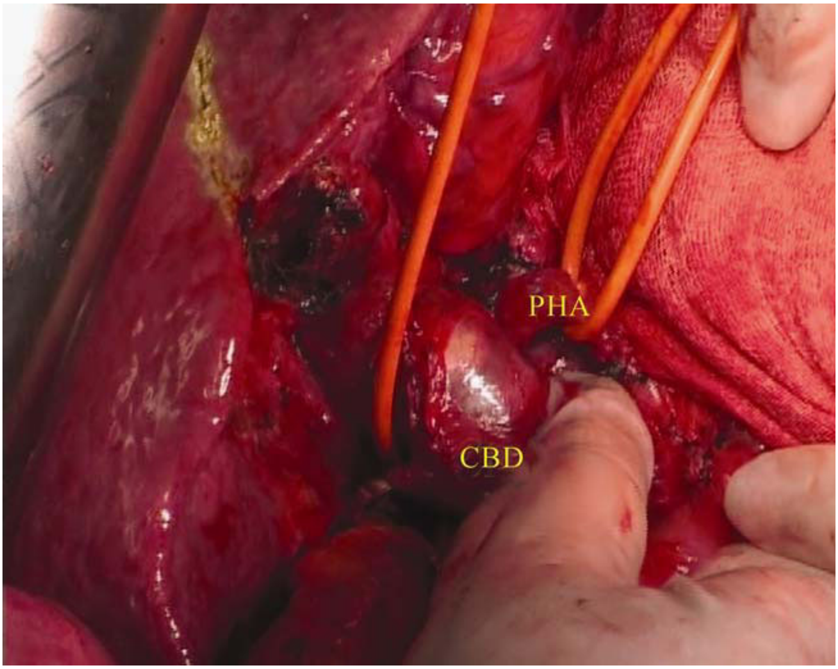


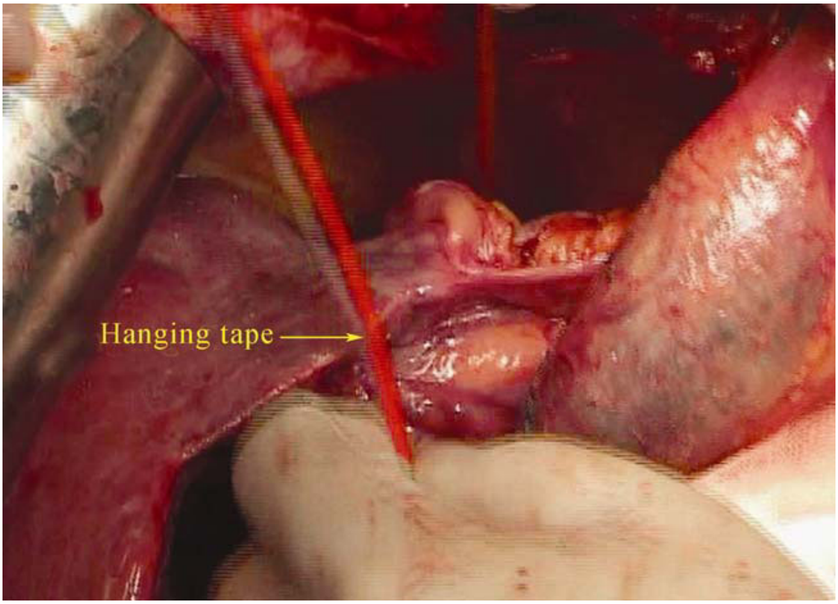
Fig.5.108. MRI showing a cancerous embolus formed in the bile duct



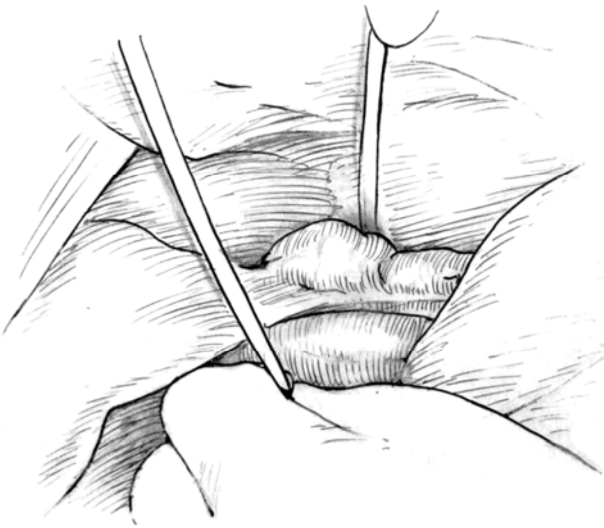
(a)

(b)

Fig.5.109. The bile duct is very distended.
(a) Photograph; (b) Drawing

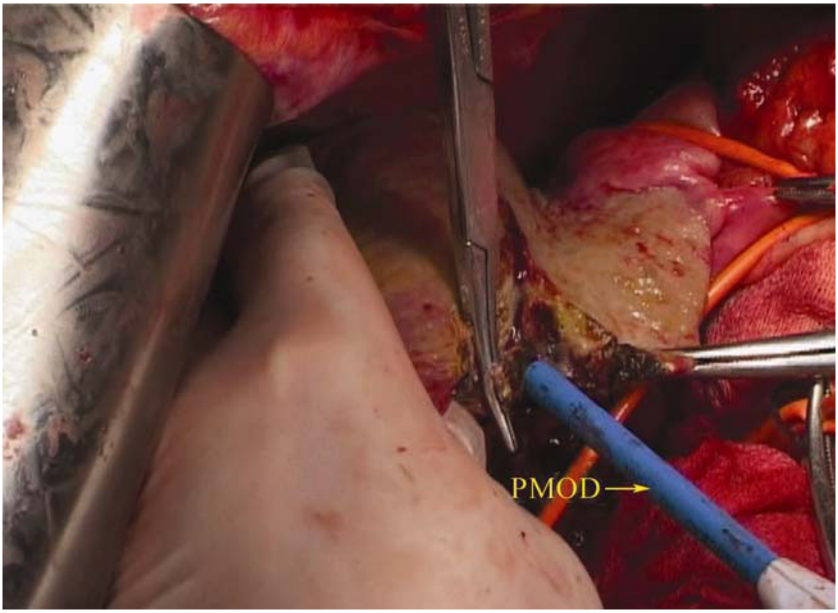


(a)

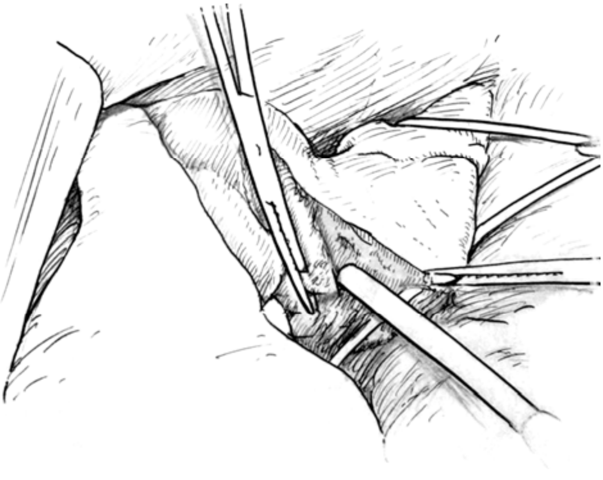


(b)

Fig.5.110. Liver hanging tape is in place.
(a) Photograph; (b) Drawing

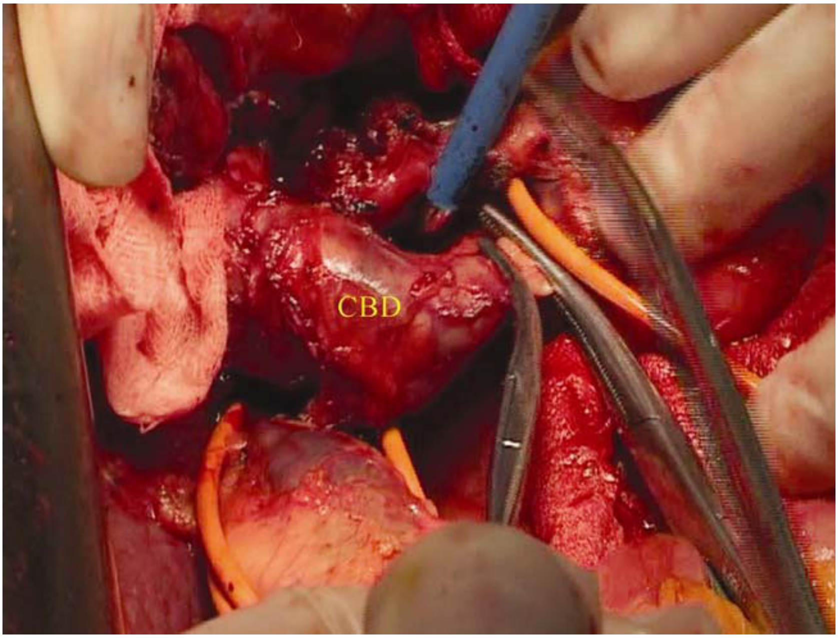


(a)

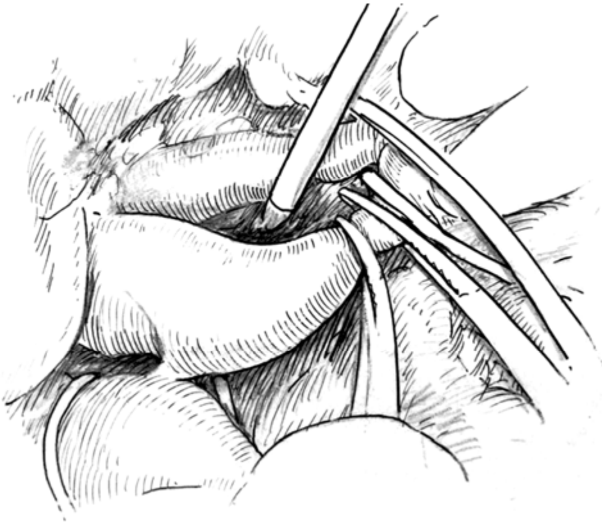


(b)

Fig.5.111. Liver is split through midplane.
(a) Photograph; (b) Drawing

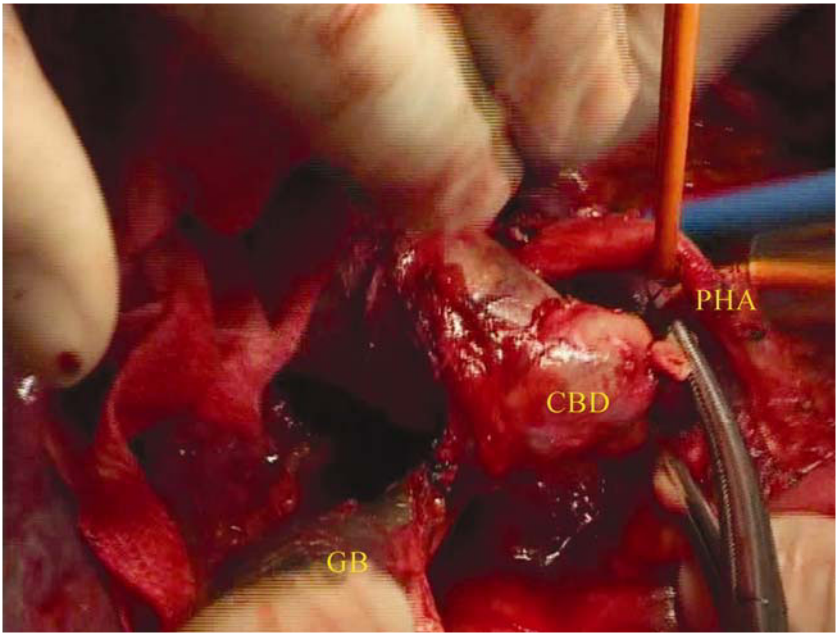


(a)

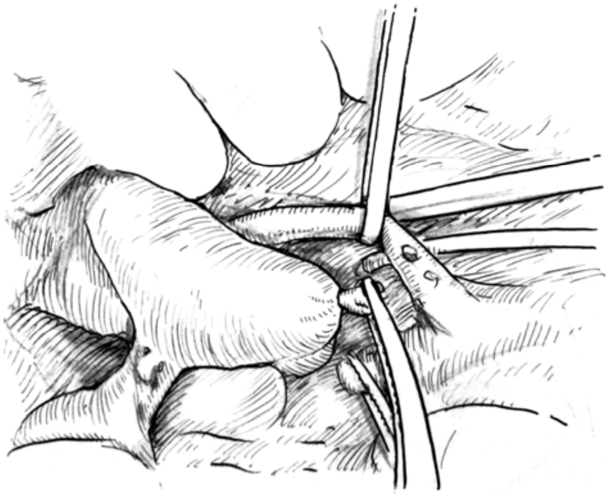


(b)

Fig.5.112. The common bile duct (CBD) is transected.
(a) Photograph; (b) Drawing

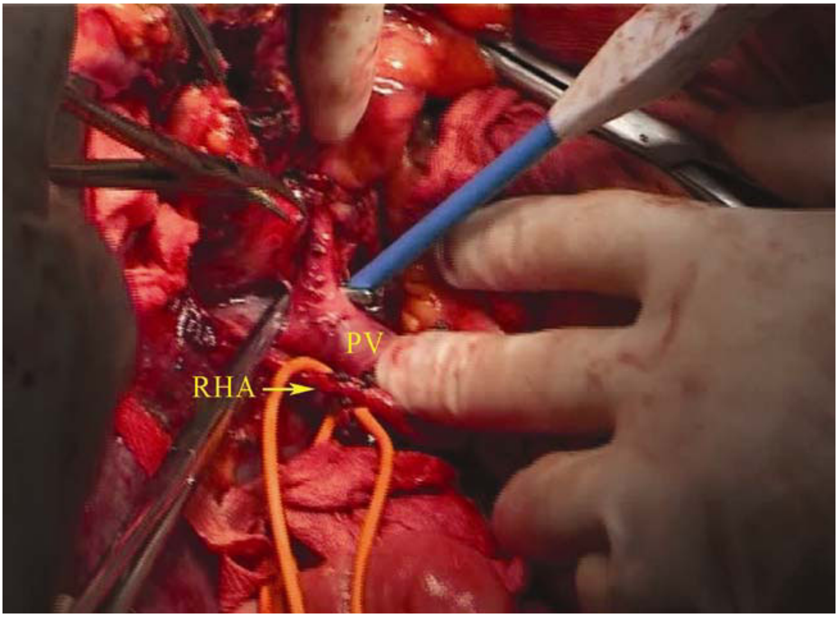


(a)

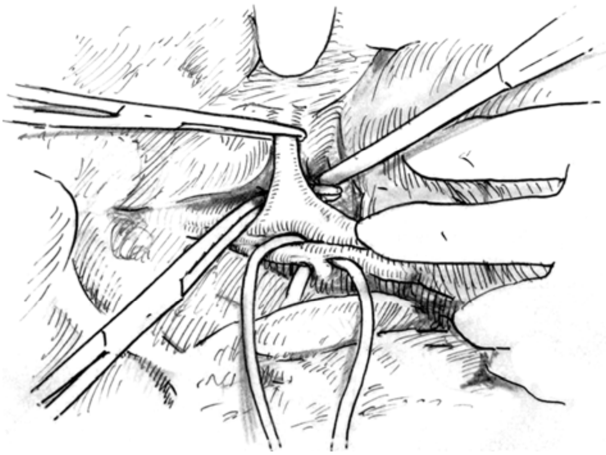


(b)

Fig.5.113. The bile duct stump is closed and the gallbladder (GB) is used for traction. (a) Photograph; (b) Drawing

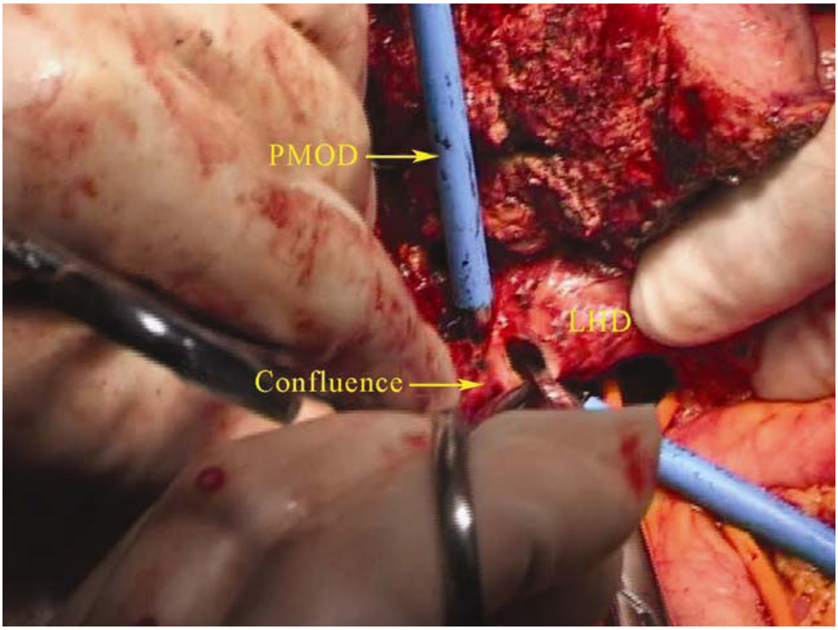


(a)

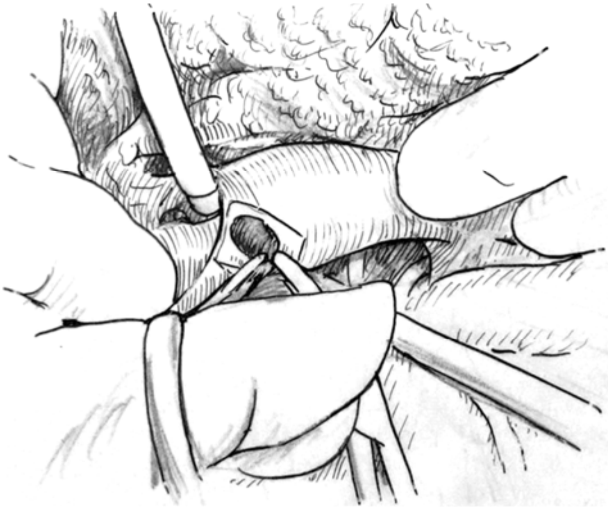


(b)

Fig.5.114. The LPV is dissected and divided.
(a) Photograph; (b) Drawing

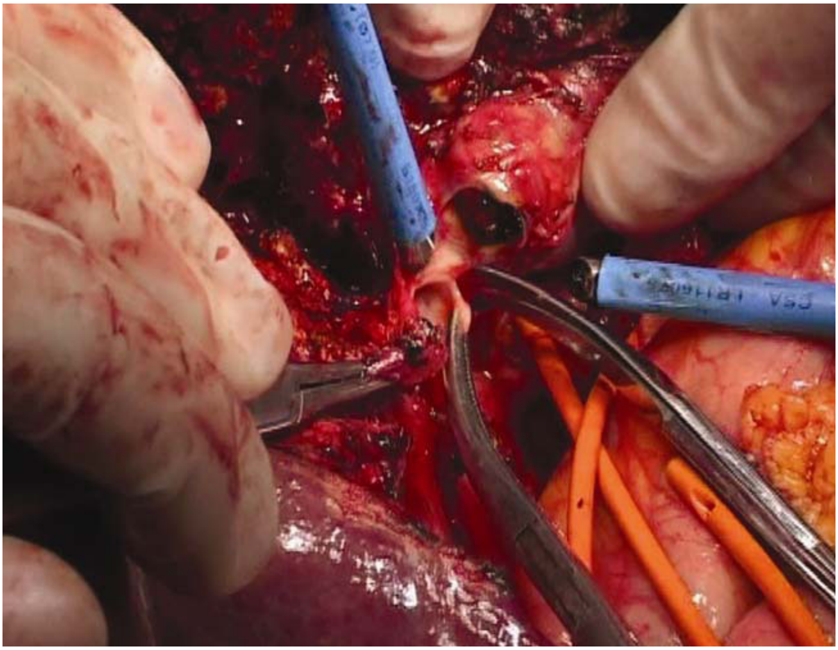


(a)

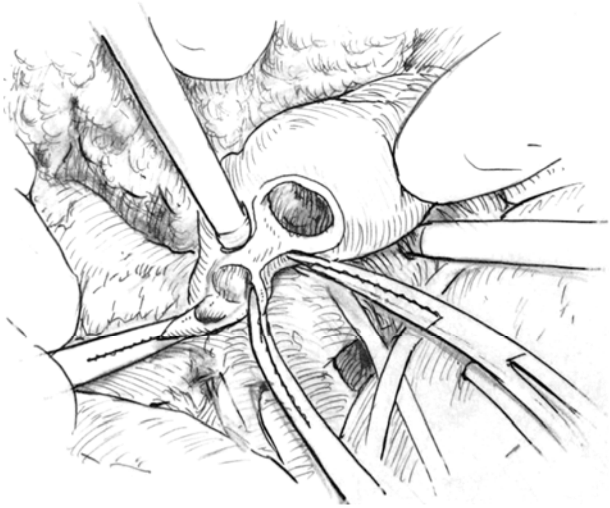


(b)

Fig.5.115. The bile duct is cut open at the junction between the left hepatic duct (LHD) and the confluence.
(a) Photograph; (b) Drawing



(a)



(b)

Fig.5.116. The right hepatic duct is cut at its junction with the confluence; the thrombus is clearly seen in the lumen of the LHD.
(a) Photograph; (b) Drawing

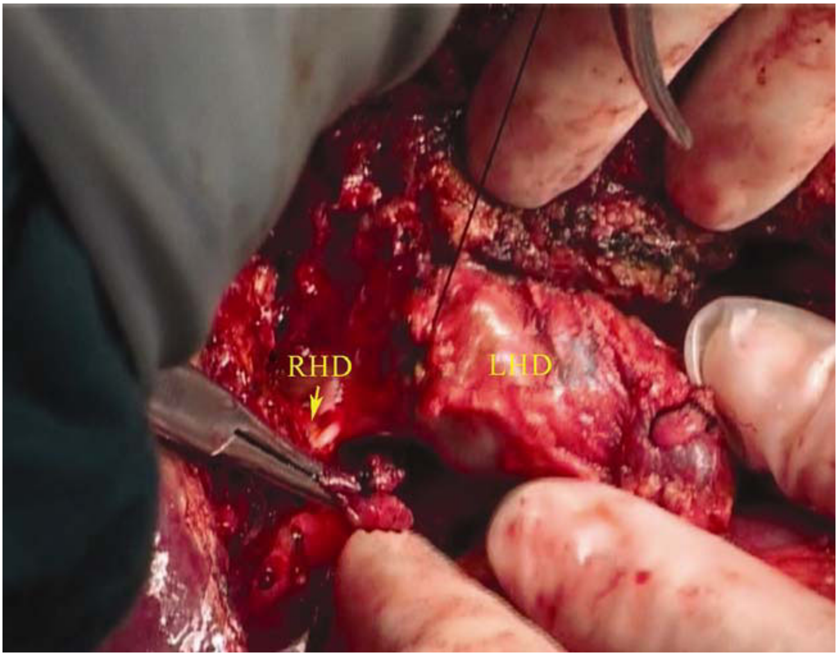
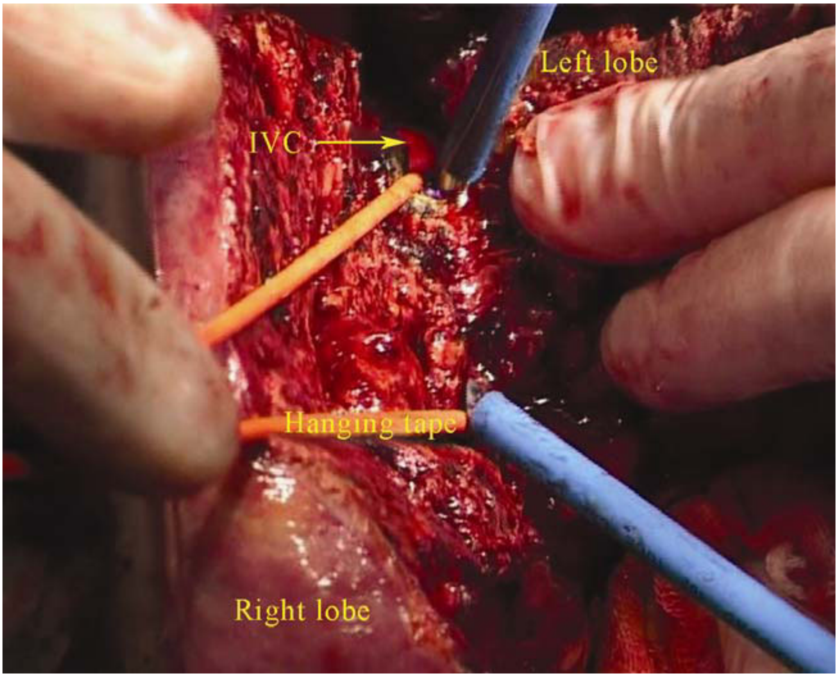
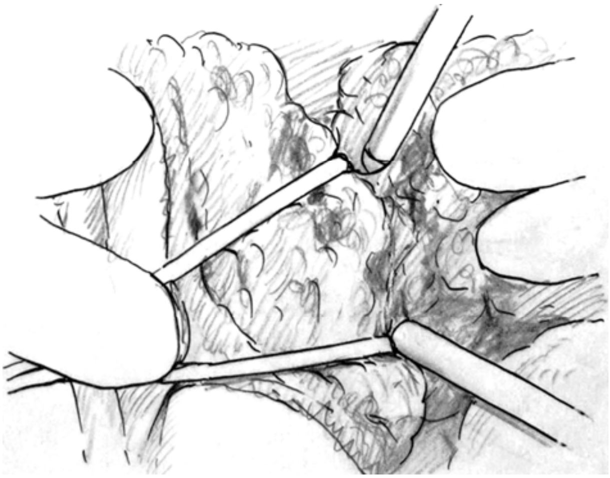


Fig.5.117. The LHD cut end is closed; the right hepatic duct (RHD) opening is not very dilated

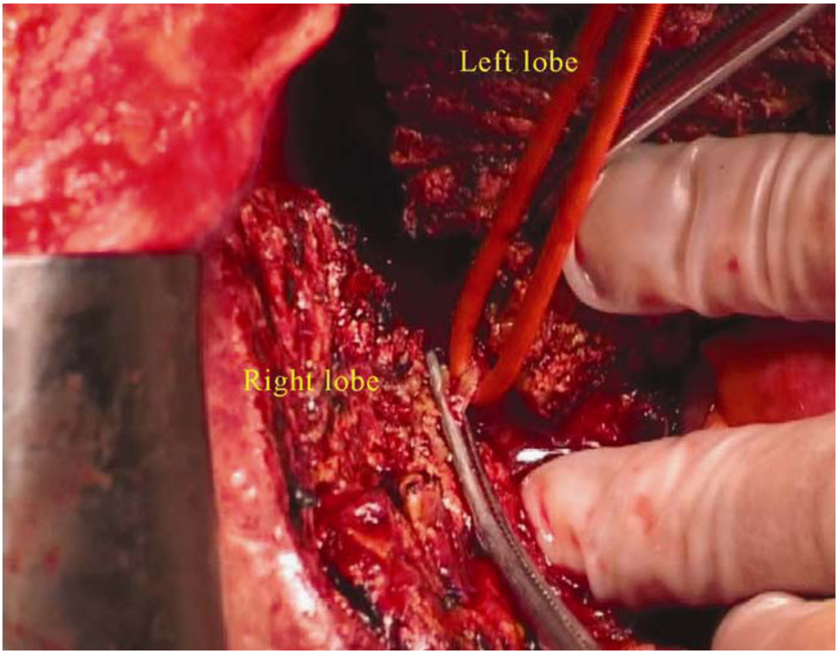


(a)

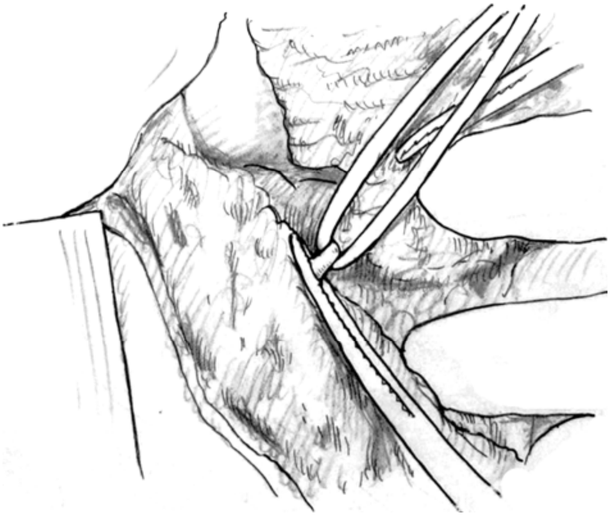


(b)

Fig.5.118. Parenchymal transection against the hanging tape is a safe way toprotect the IVC. (a) Photograph; (b) Drawing

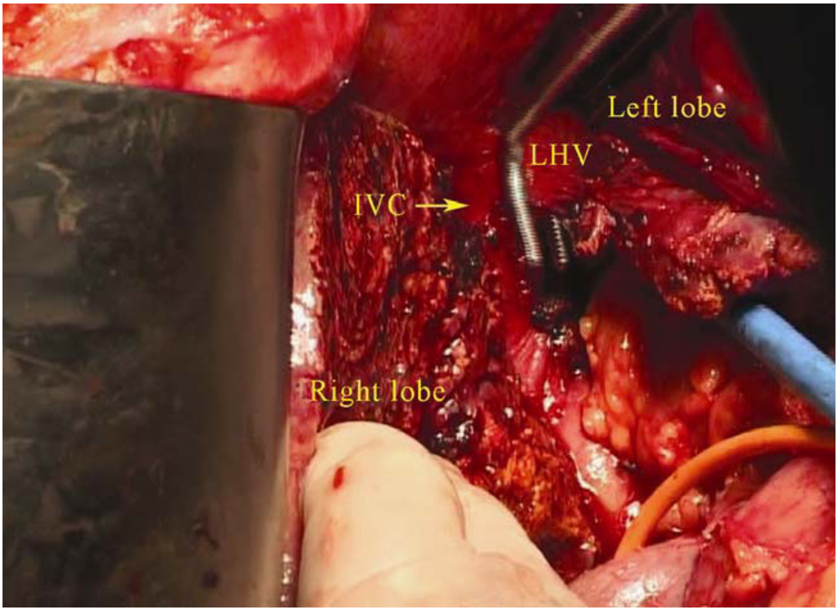


(a)

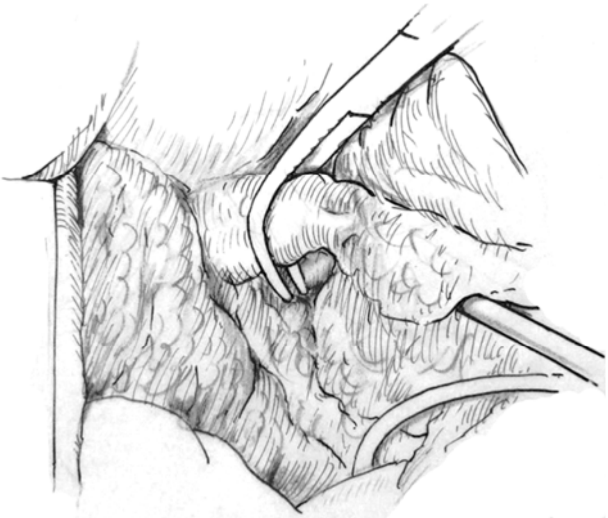


(b)

Fig.5.119. Last part of transection.
(a) Photograph; (b) Drawing

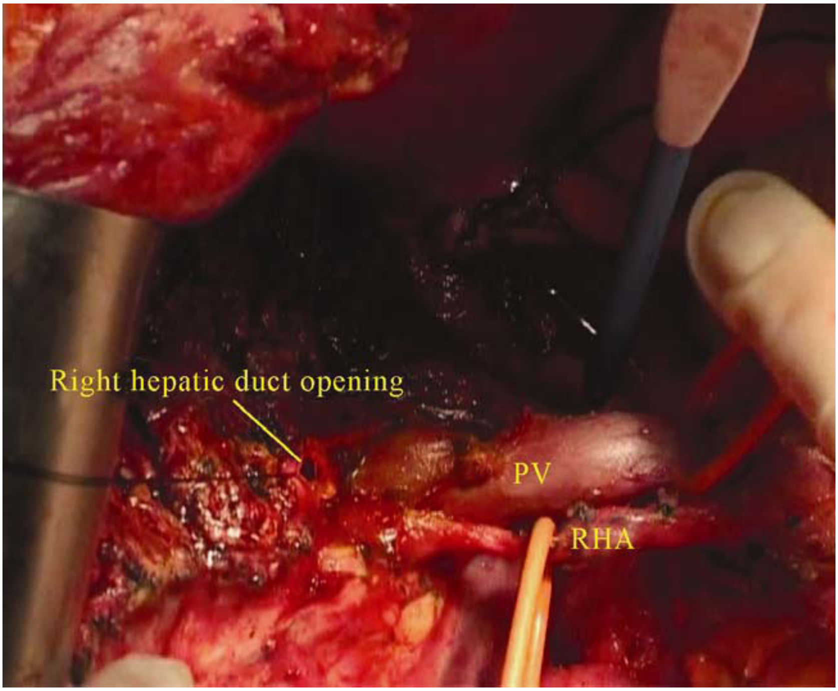


(a)

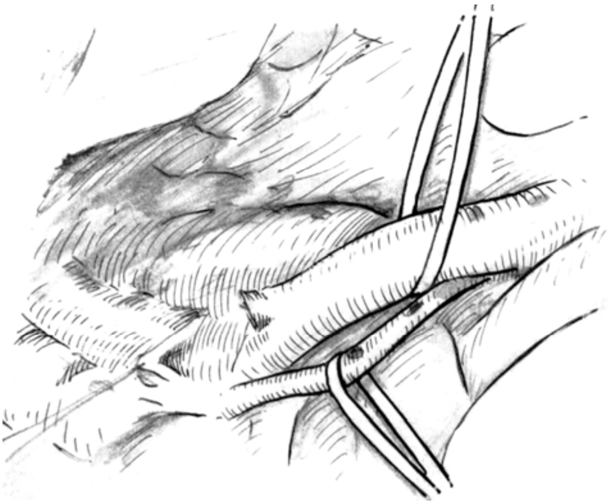


(b)

Fig. 5.120. The LHV is clamped and divided.
(a) Photograph; (b) Drawing

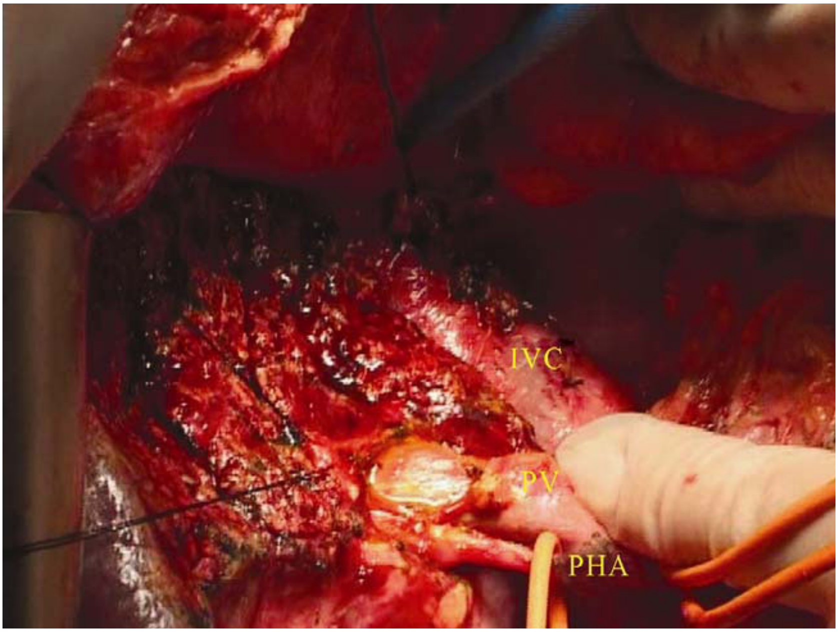


(a)

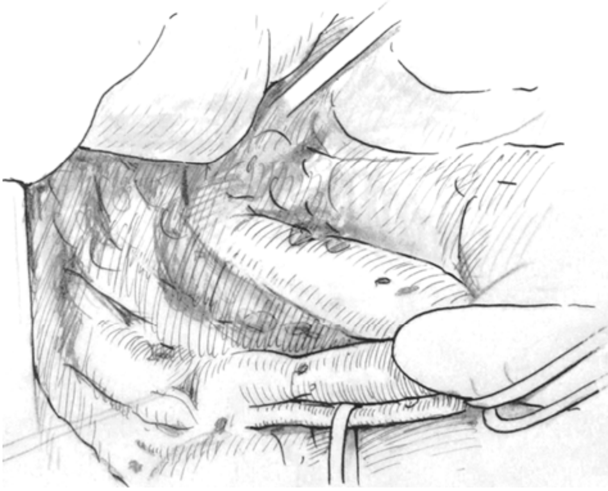


(b)

Fig.5.121. The hepatoduodenal ligament is skeletonized, the RHA derives from a superior mesenteric artery (SMA).
(a) Photograph; (b) Drawing



(a)



(b)

Fig.5.122. The retrohepatic IVC is completely exposed after removal of the caudate lobe and the left liver. (a) Photograph; (b) Drawing

5.3.2 Combined with Left Lobe Resection for HCC

See Figs.5.123-5.131, and video 16.

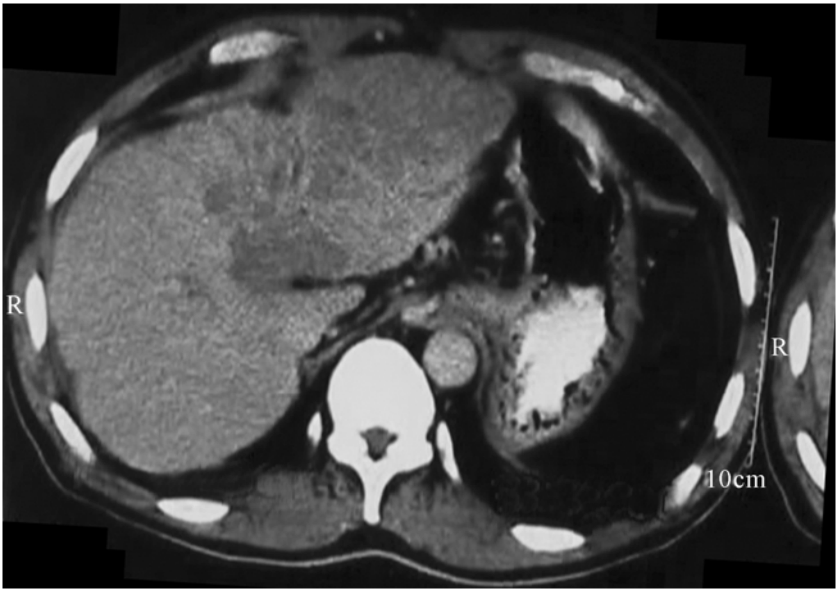


Fig.5.123. CT showing tumor in the caudate lobe and the left lobe

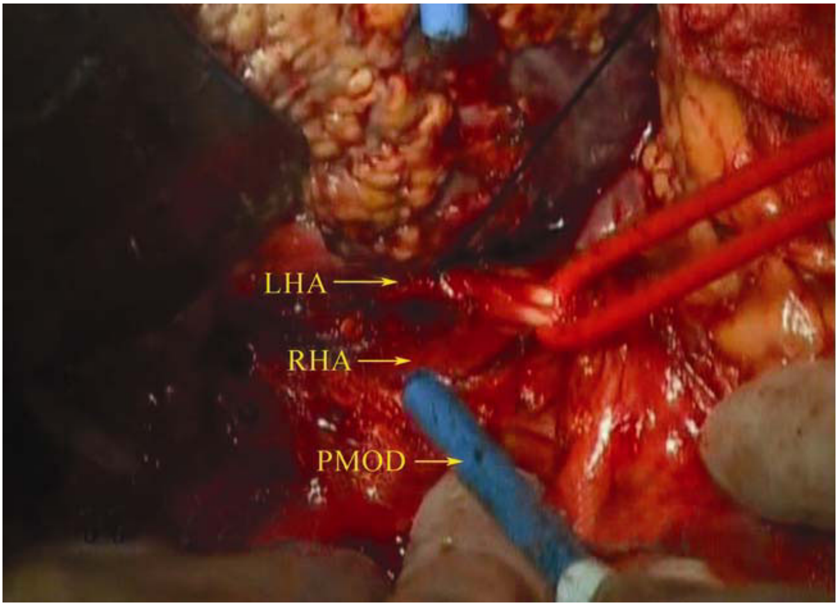
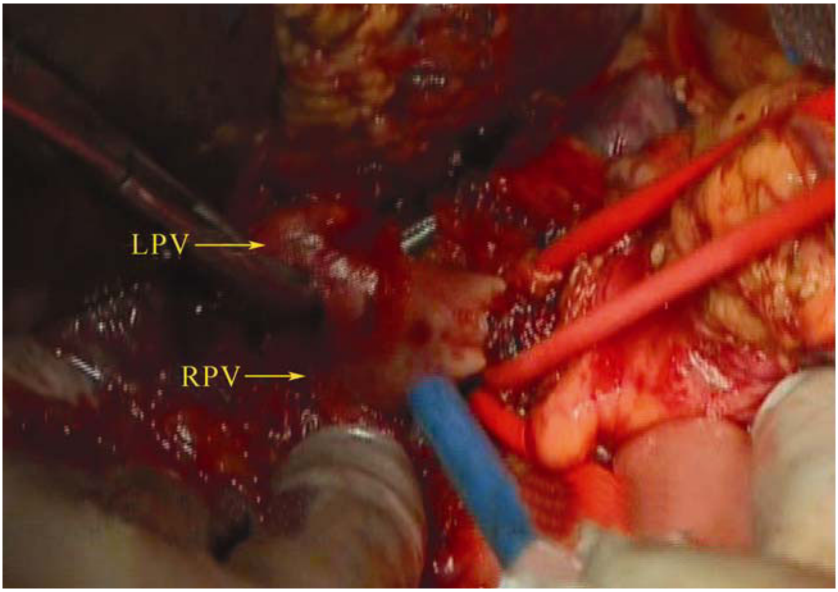
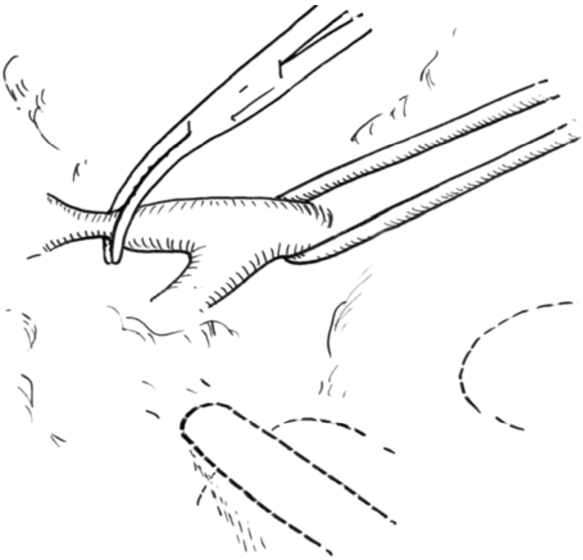


Fig.5.124. The right hepatic artery (RHA) is clearly shown before the LHA being ligated

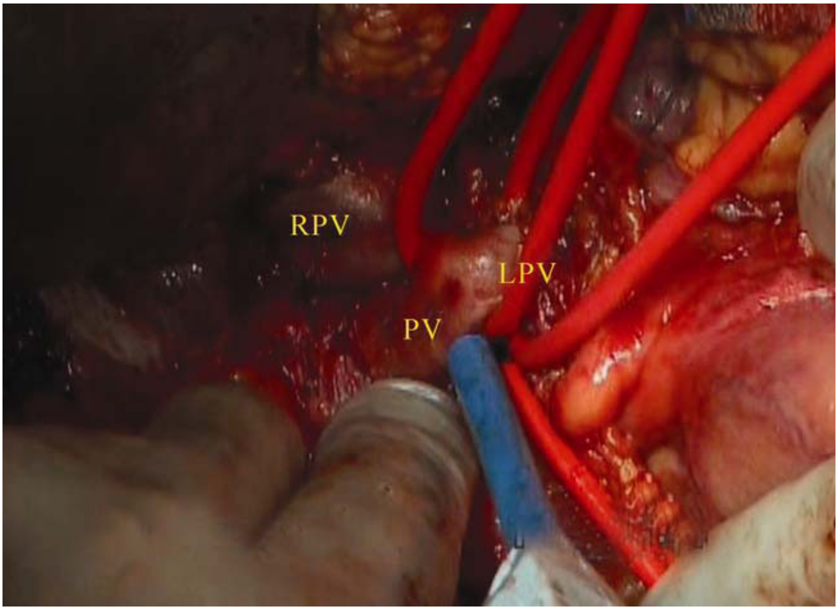


(a)

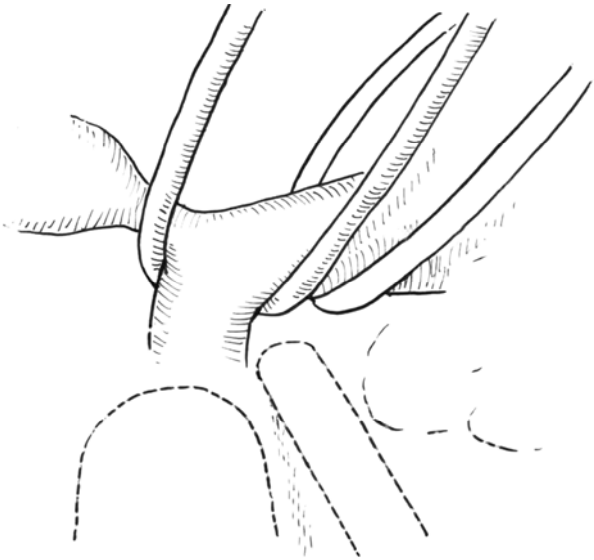


(b)

Fig.5.125. The LPV is isolated.
(a) Photograph; (b) Drawing

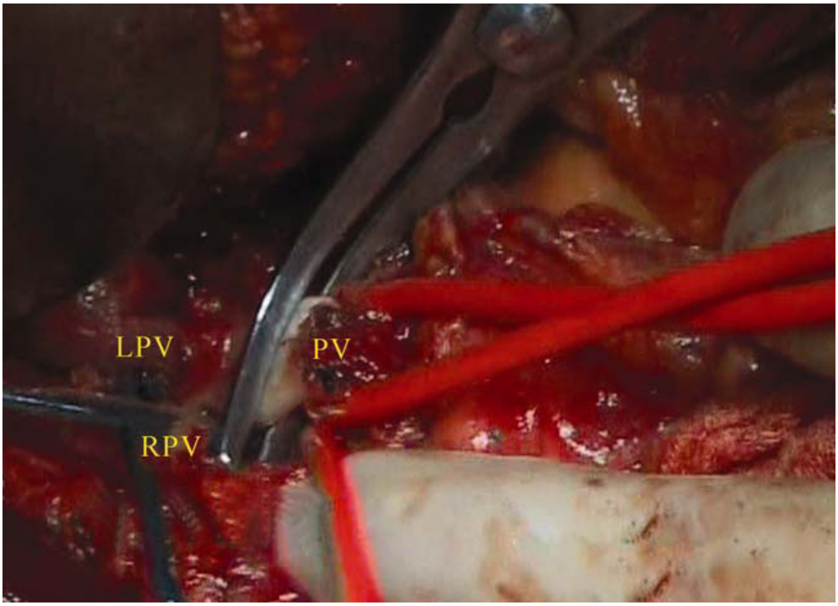


(a)

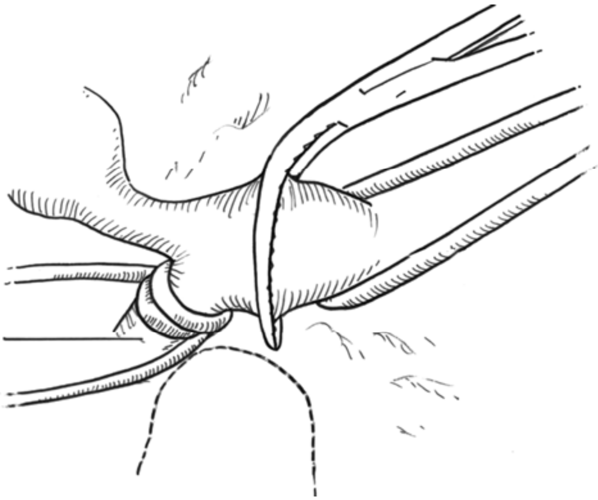


(b)

Fig.5.126. The PV trunk and RPV are taped.
(a) Photograph; (b) Drawing

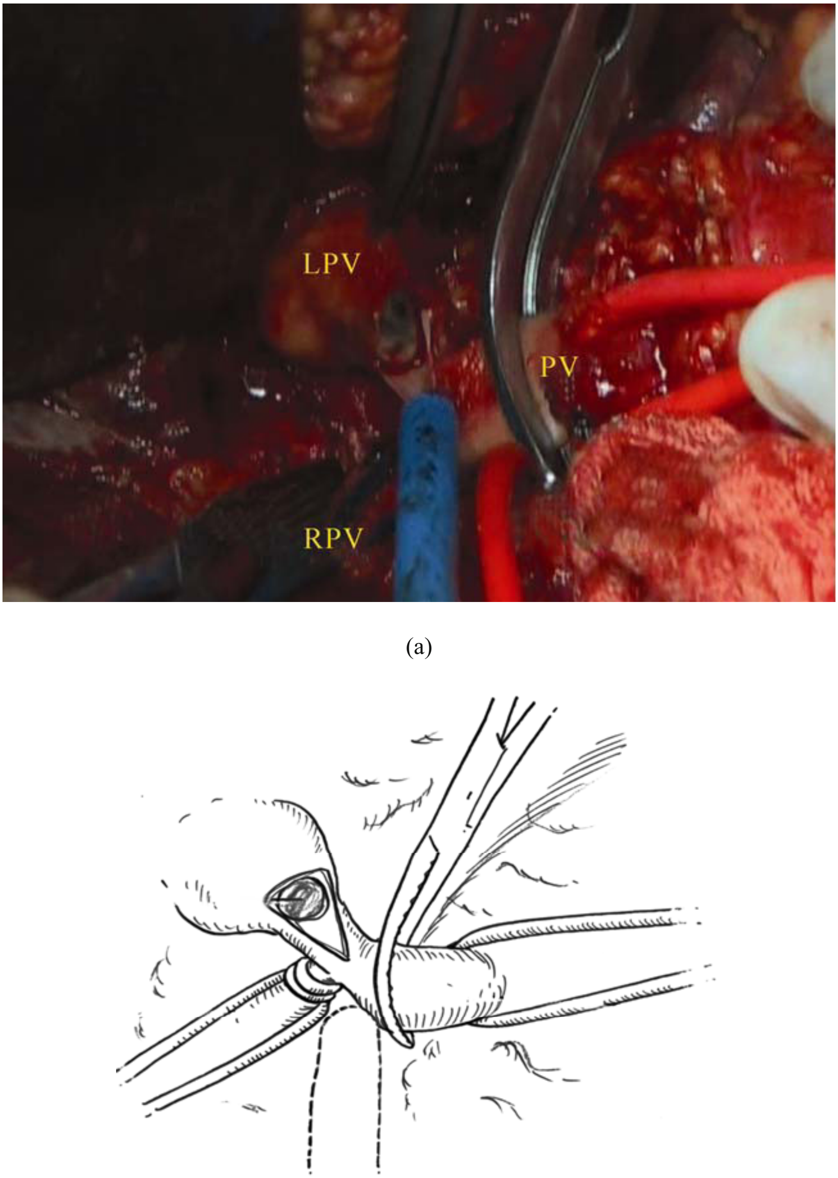


(a)



(b)

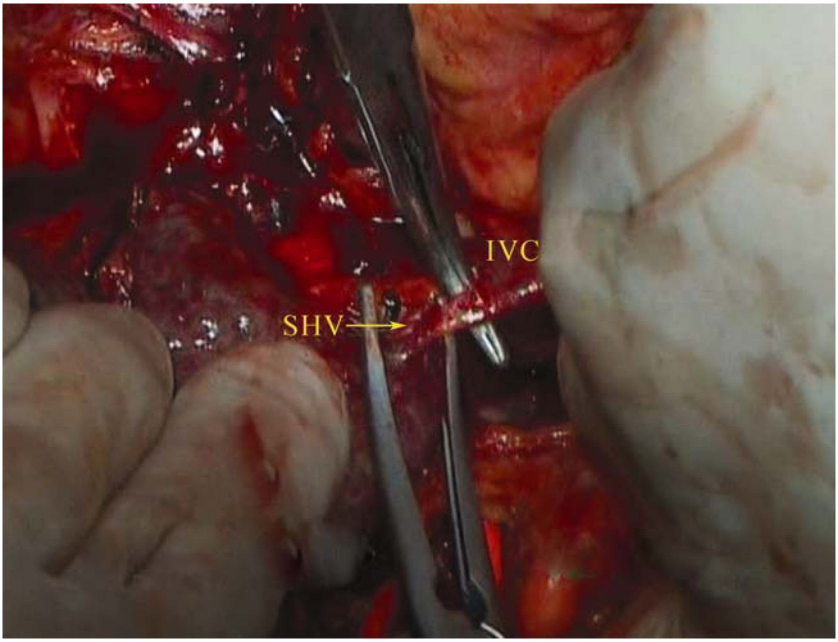
Fig.5.127. The PV trunk and RPV are controlled before the LPV being cut open. (a) Photograph; (b) Drawing



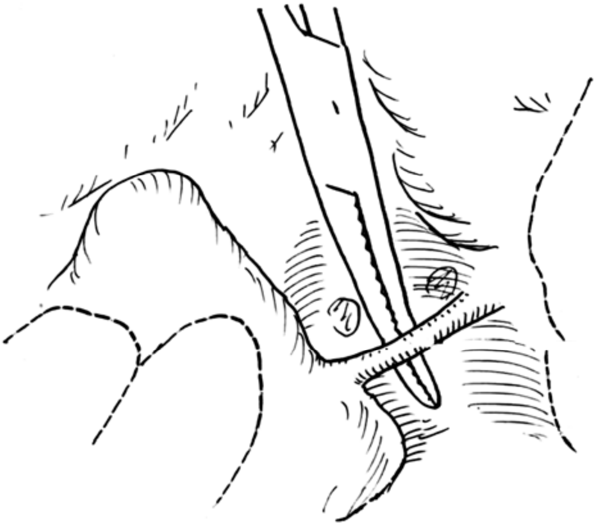
(a)

(b)

Fig.5.128. The portal vein tumor thrombus (PVTT) is clearly seen in the LPV lumen. (a) Photograph; (b) Drawing



(a)



(b)

Fig.5.129. A SHV is isolated and divided.
(a) Photograph; (b) Drawing

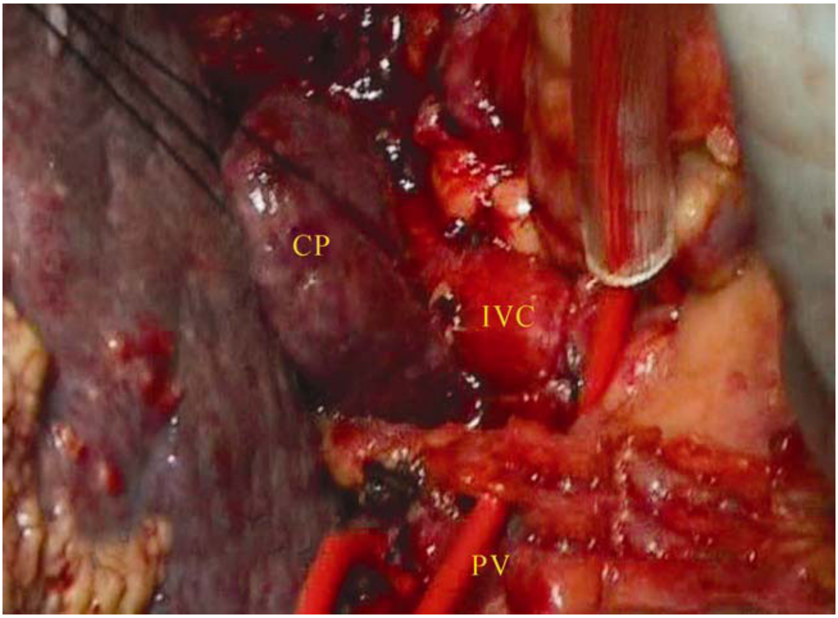


Fig.5.130. The caudate lobe is completely detached from the IVC

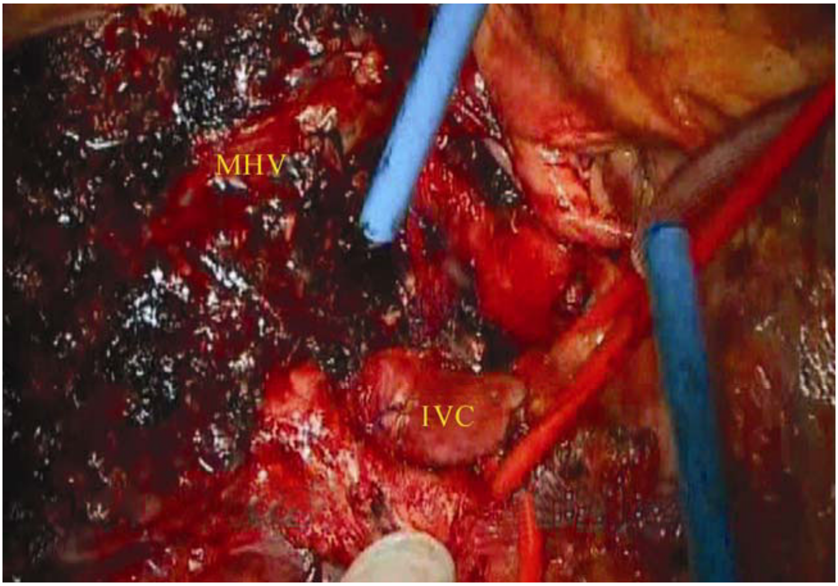


Fig.5.131. The retrohepatic IVC is completely exposed and the MHV is clearly seen on the raw surface

5.3.3 Combined with Left Lobe Resection for Cholangiocarcinoma with Thrombus

See Figs.5.132-5.148, and video 17.

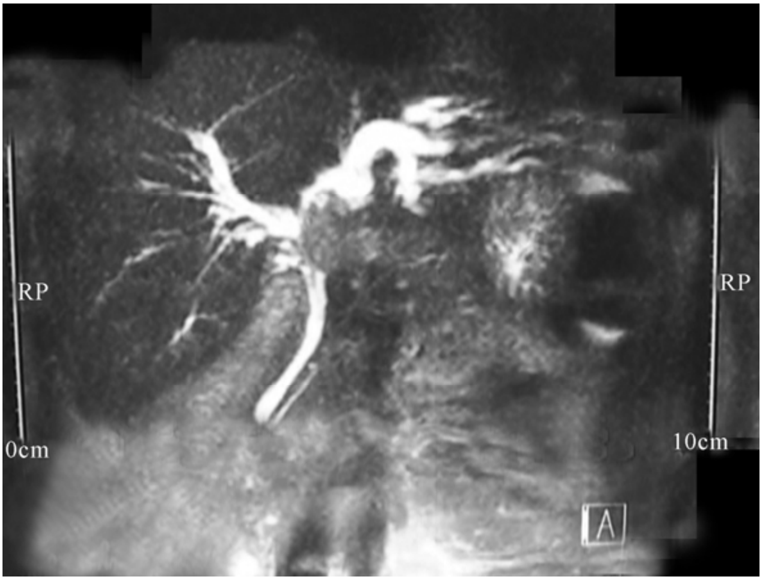


Fig.5.132. Magnetic resonance cholangiopancreatography (MRCP) showing a caudate lobe tumor involving the hepatic duct

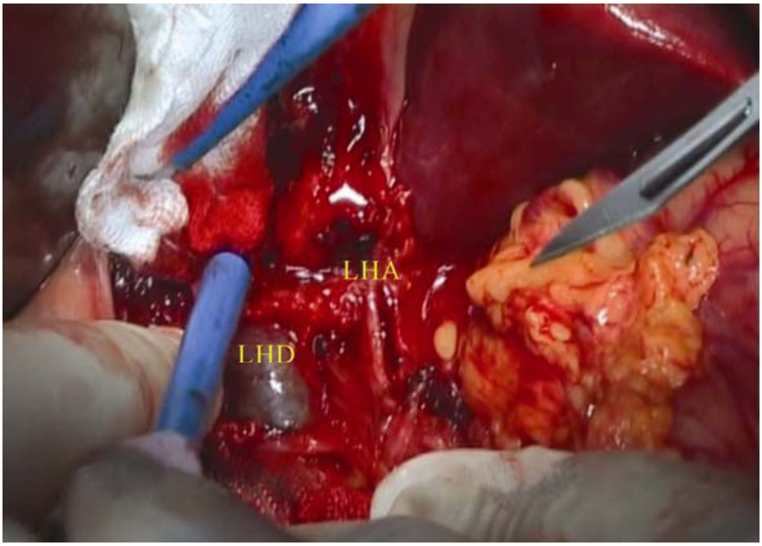


Fig.5.133. The LHD looks bluish and is very distended

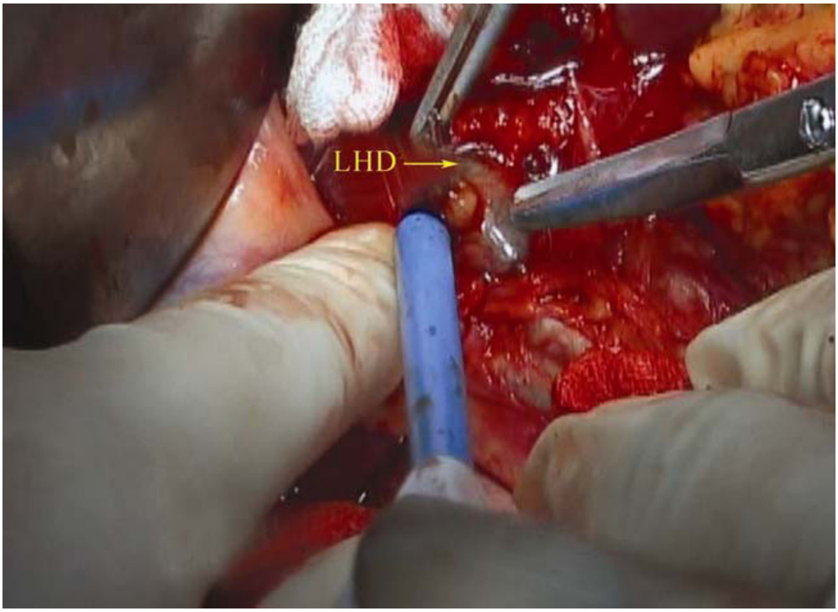


Fig.5.134. The LHD is full of cancerous thrombus and blood clot

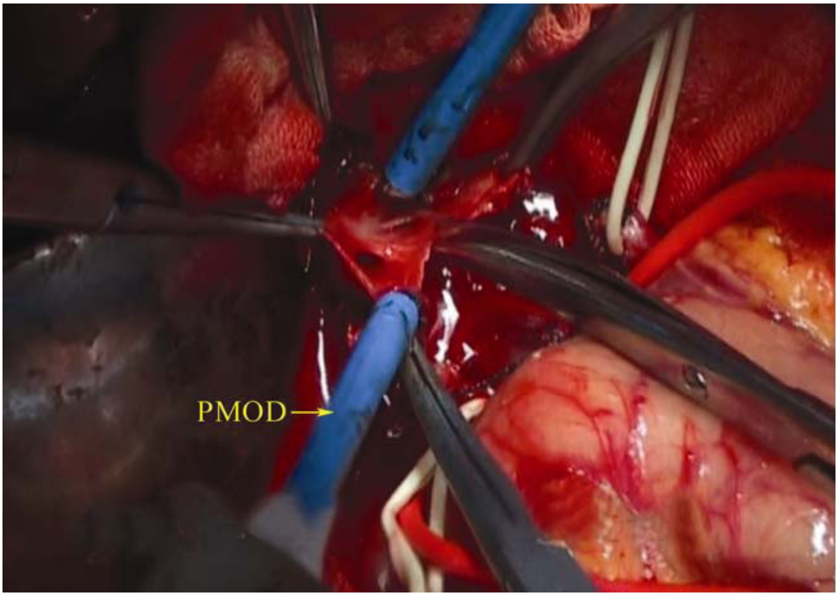


Fig.5.135. The LHD is divided near the confluence

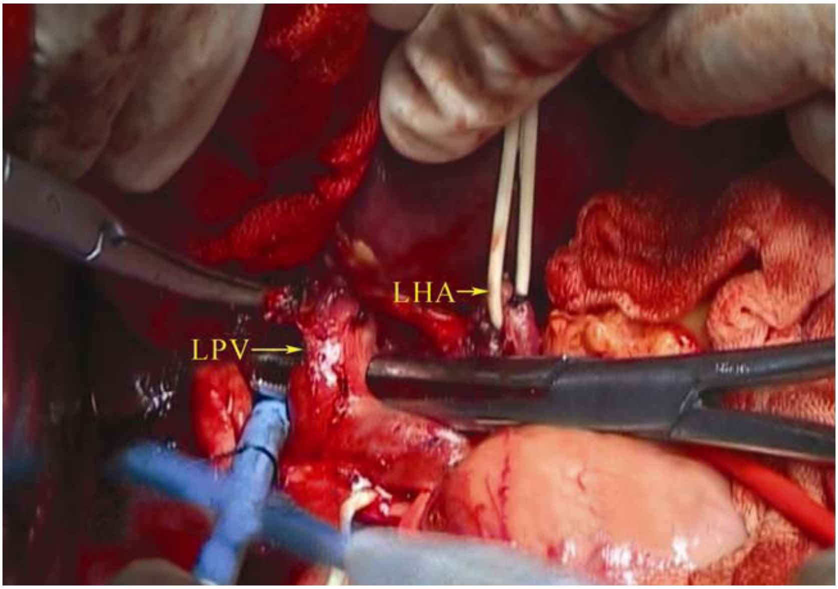


Fig.5.136. The LPV is isolated and divided

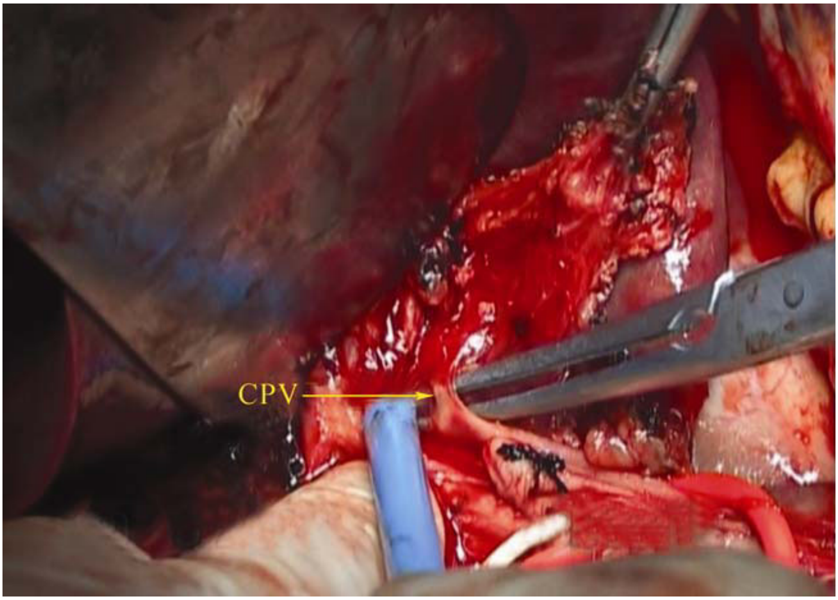


Fig.5.137. A caudate portal vein (CPV) is isolated and divided

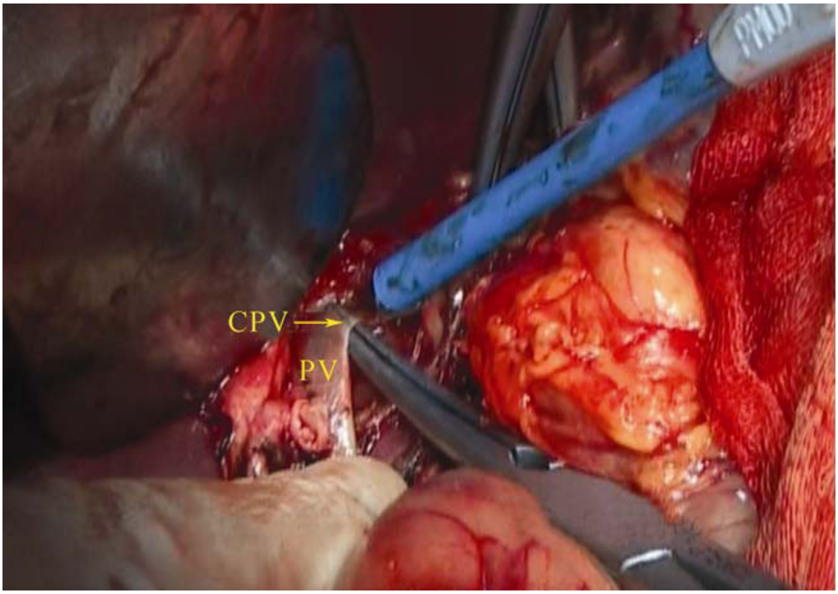


Fig.5.138. Another CPV is divided

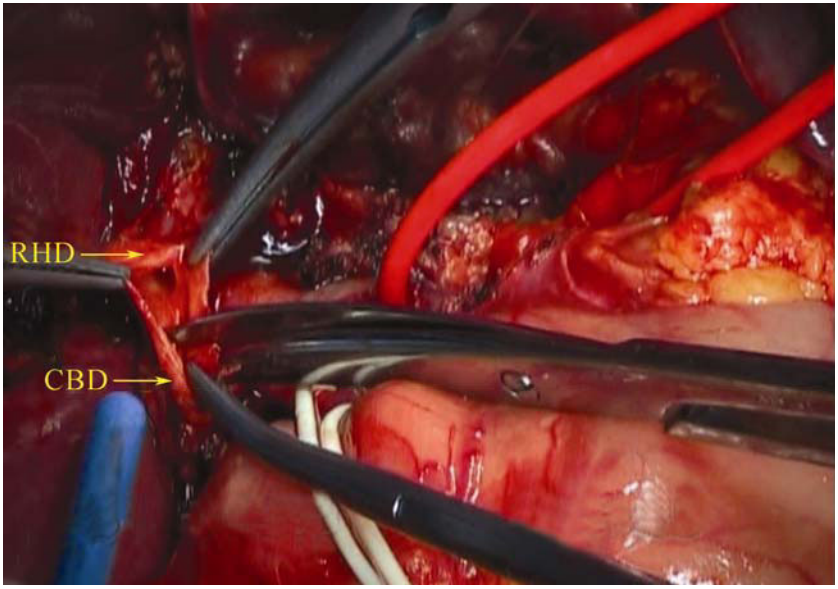


Fig.5.139. The CBD is divided near the confluence

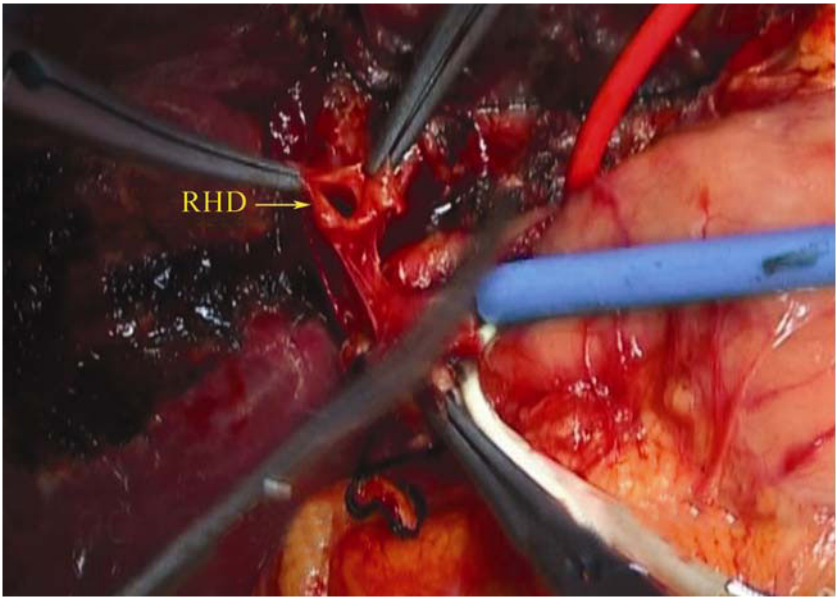


Fig.5.140. Dissection around the stump of the RHD

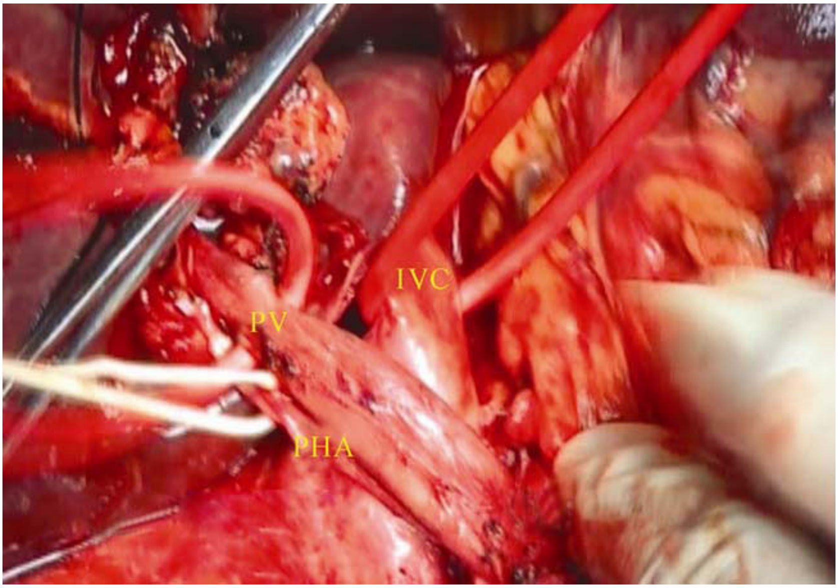


Fig.5.141. The hepatic pedicle is skeletonized and the IVC is taped

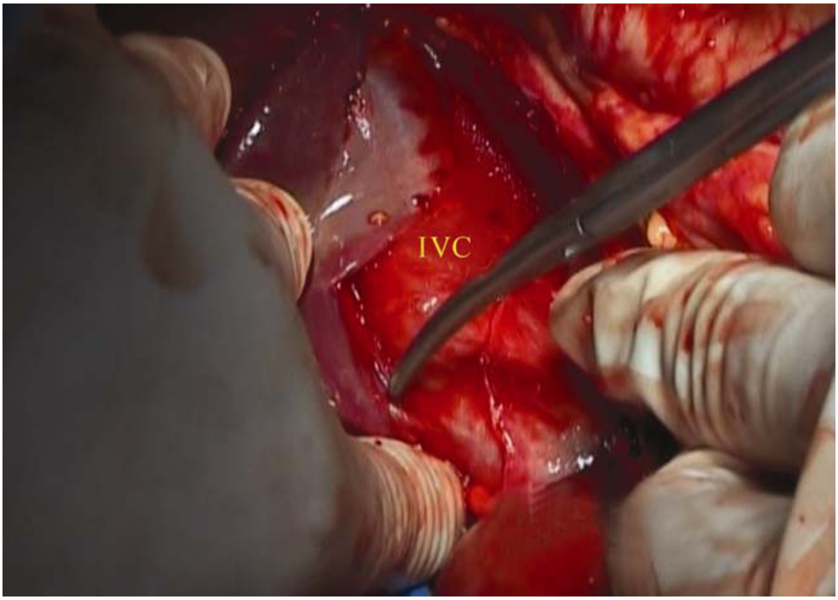


Fig.5.142. A SHV is dissected

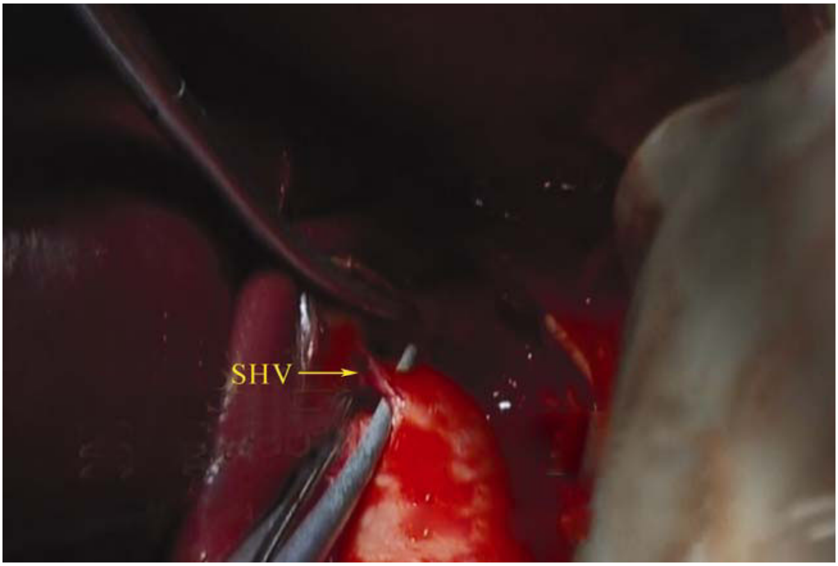


Fig.5.143. A SHV is dissected

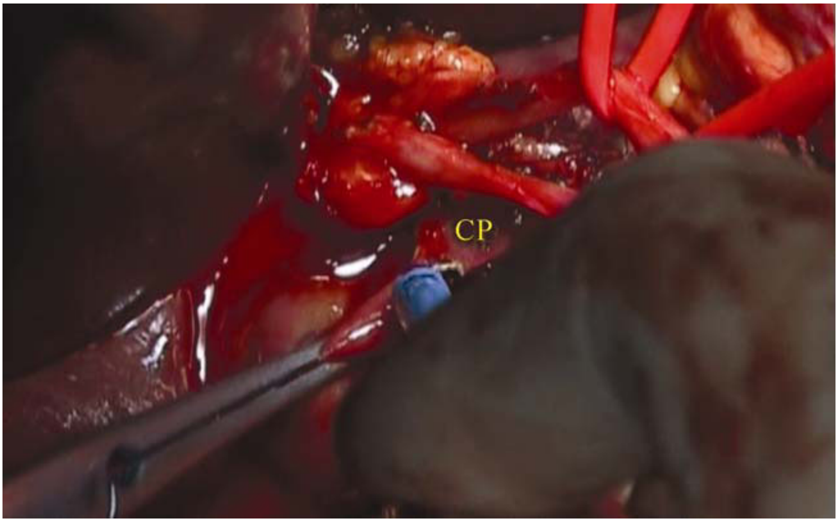


Fig.5.144. Transection is started at the CP

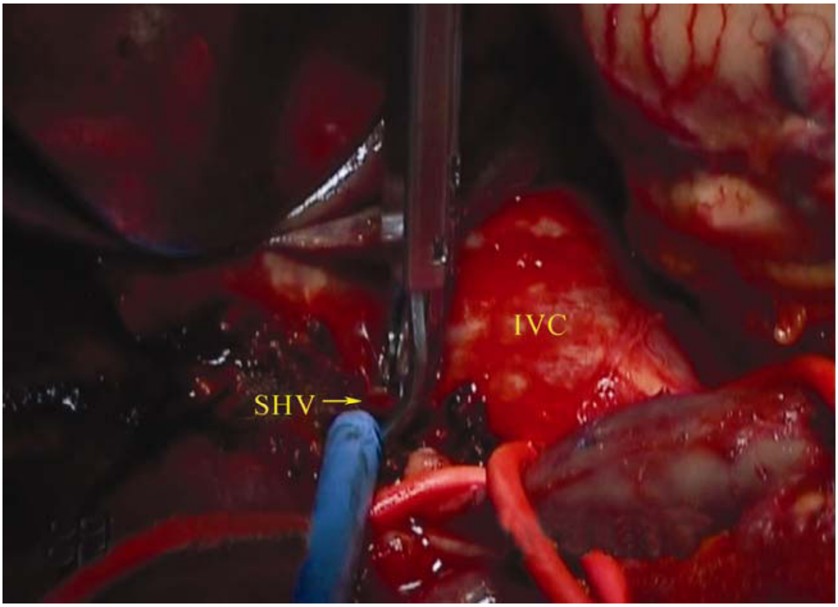


Fig.5.145. A SHV is dissected

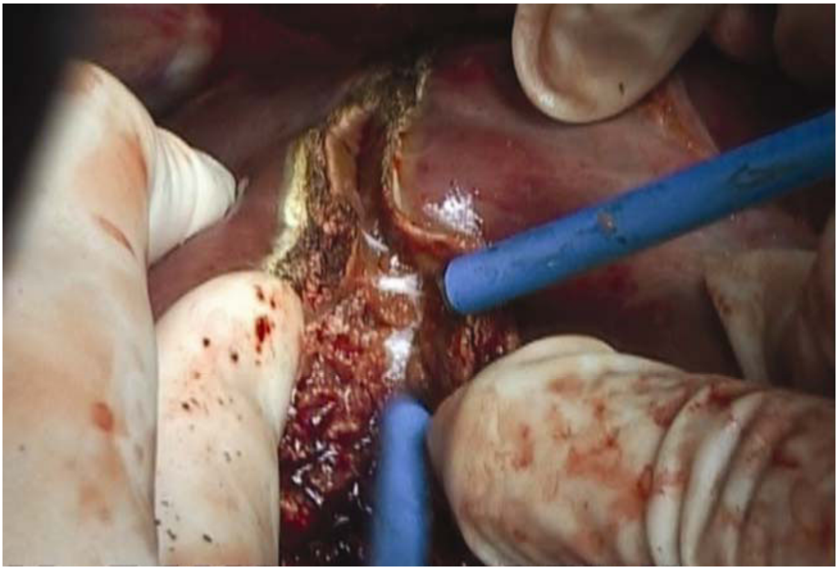


Fig.5.146. Parenchymal transection through the midplane; several branches of the MHV are divided and ligated

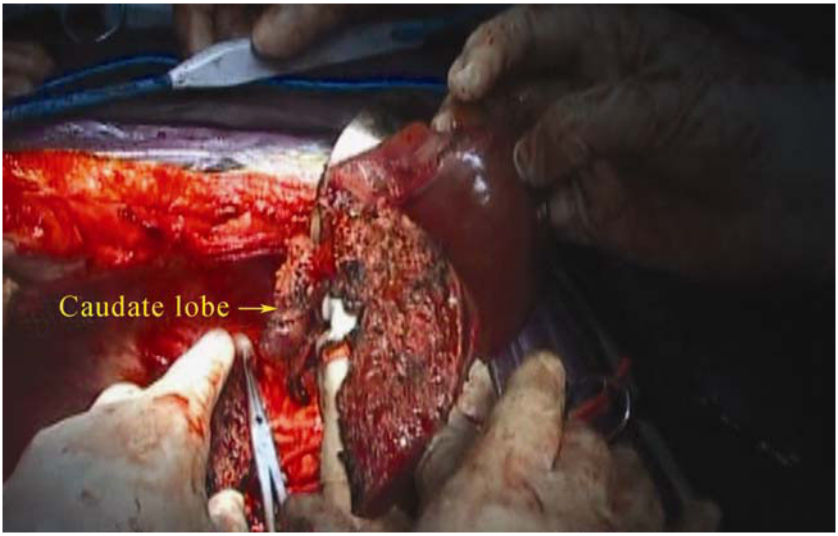


Fig.5.147. The caudate and left lobes are removed en bloc

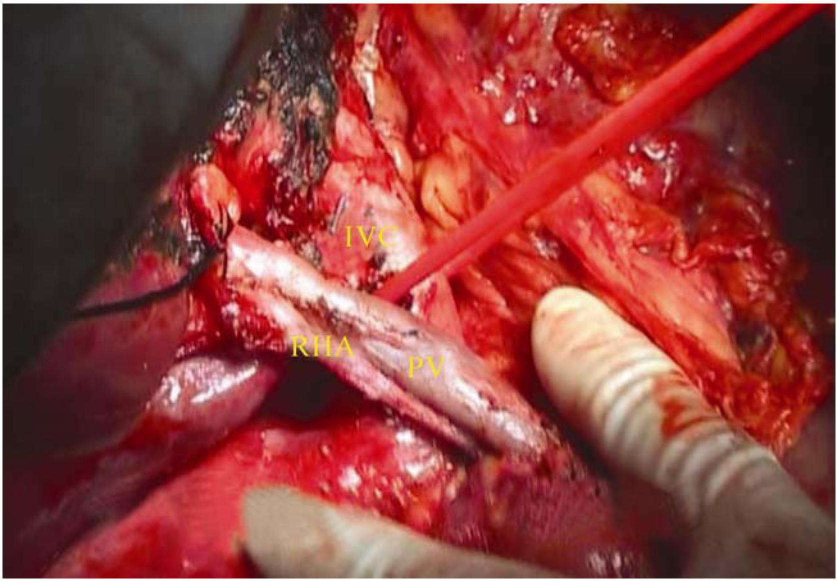


Fig.5.148. The IVC is completely exposed and the hepatic pedicle is skeletonized

5.3.4 Left Lobe and Caudate Lobe Resection for HCC

See Figs.5.149-5.160.

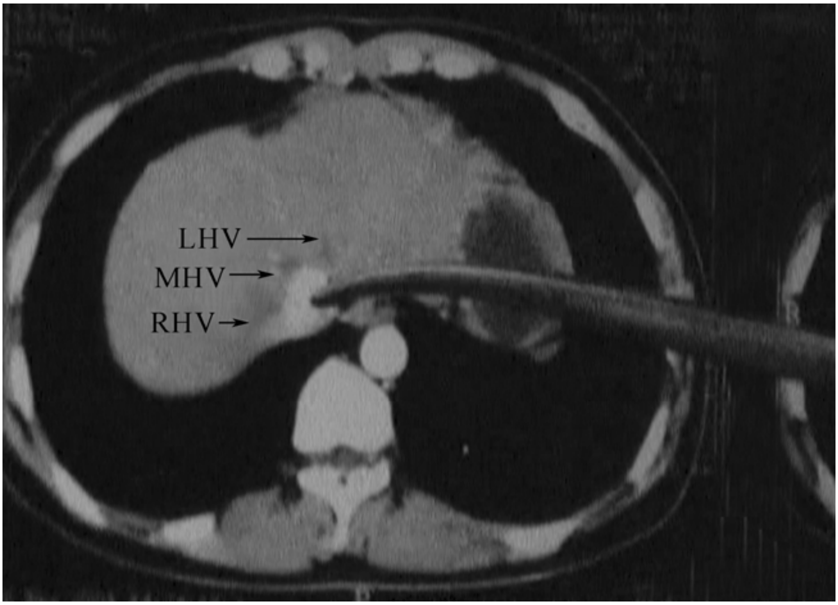


Fig.5.149. Tumor is located at the junction of MHV, LHV and IVC

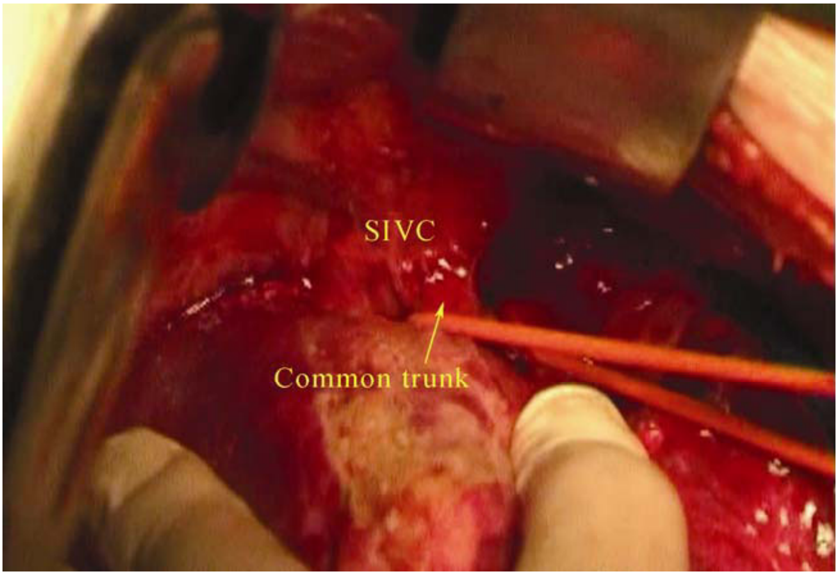


Fig.5.150. The common trunk is taped

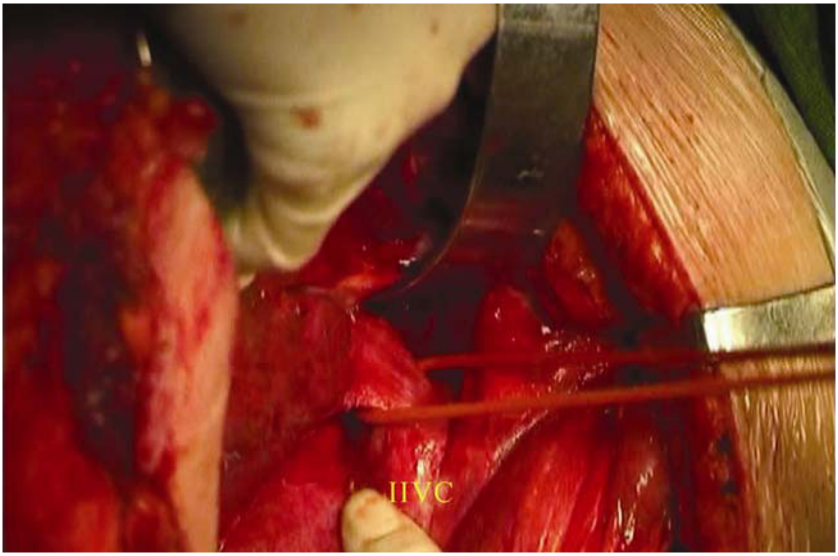


Fig.5.151. The IIVC is taped

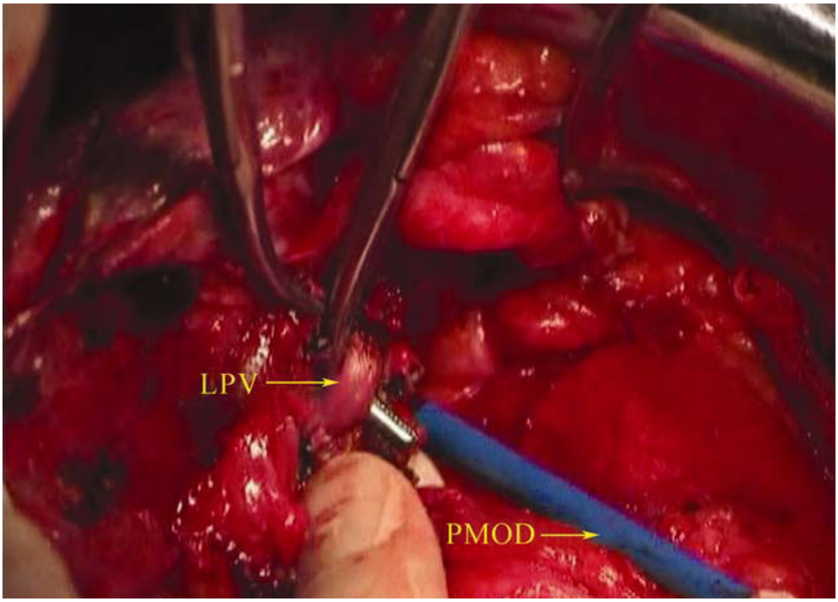


Fig.5.152. The LPV is dissected

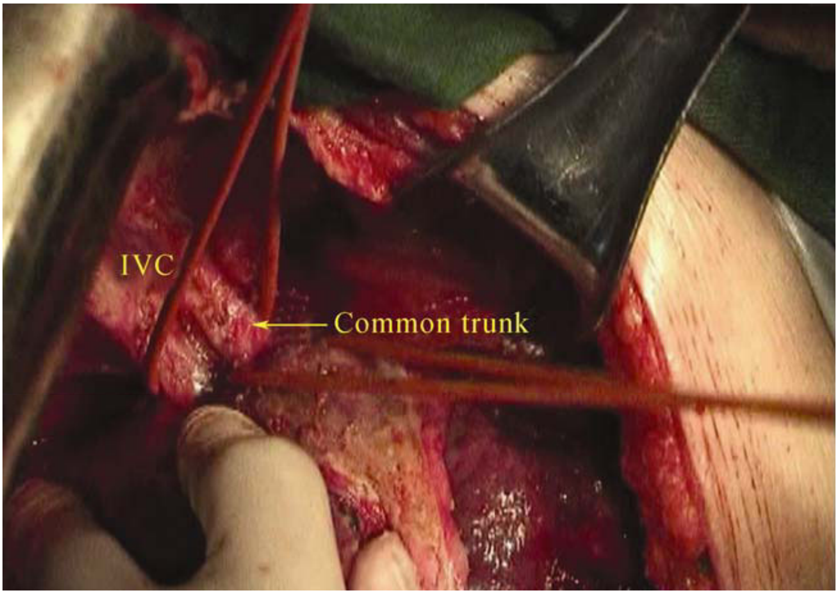


Fig.5.153. The SIVC and common trunk are taped respectively

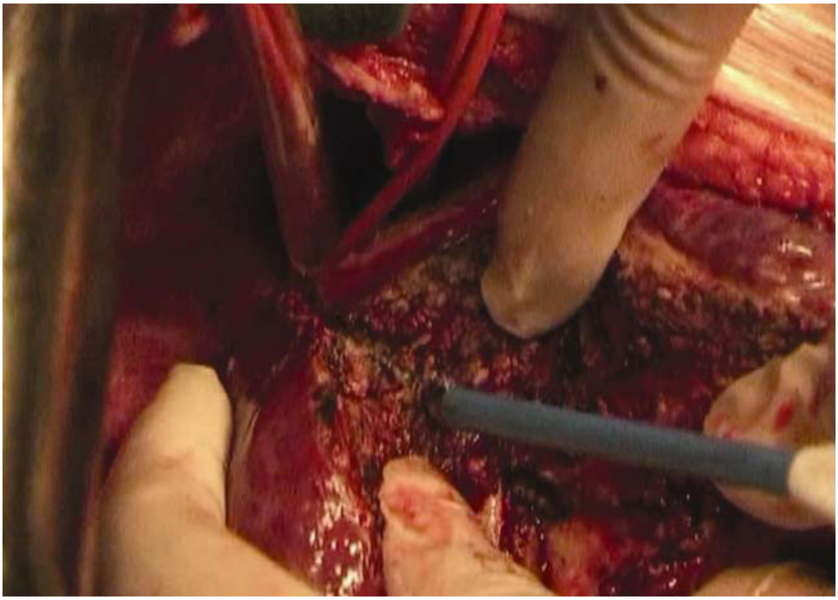


Fig.5.154. The liver is transected through the midplane

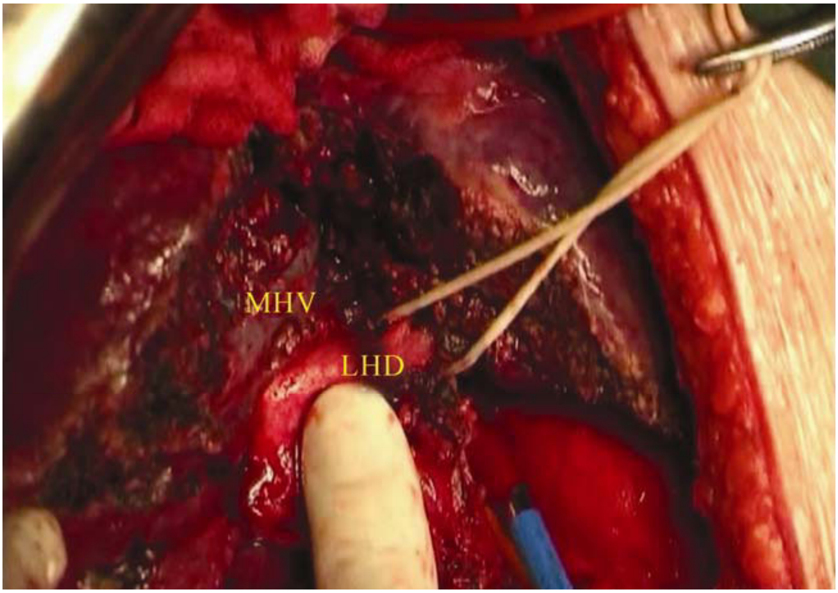


Fig.5.155. The LHD is isolated

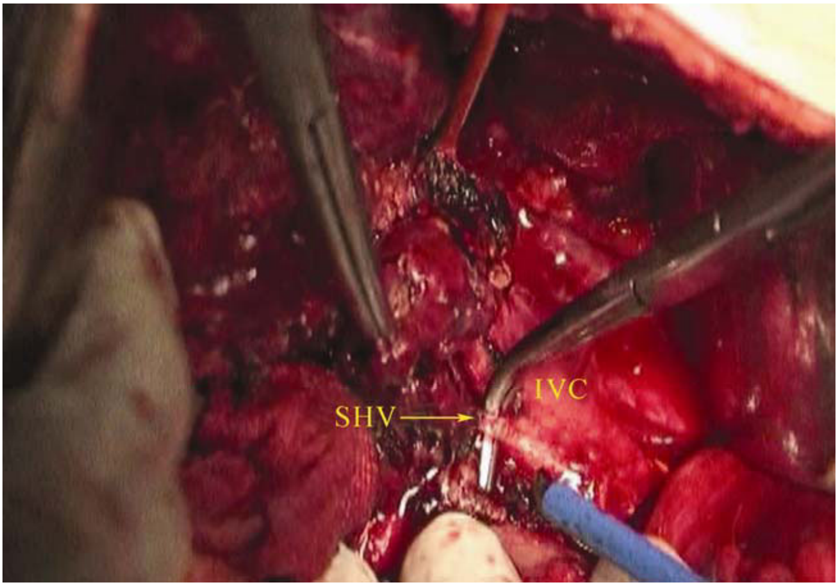


Fig.5.156. A SHV is dissected

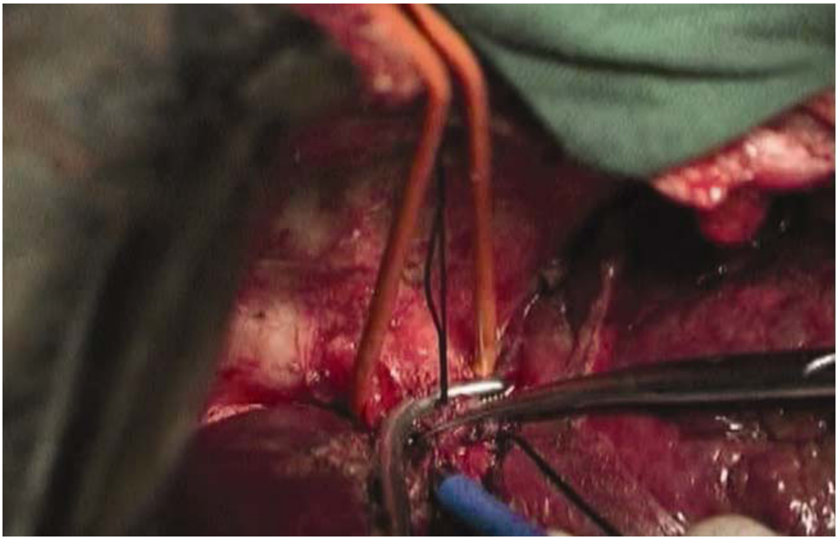


Fig.5.157. The common trunk is ligated and divided

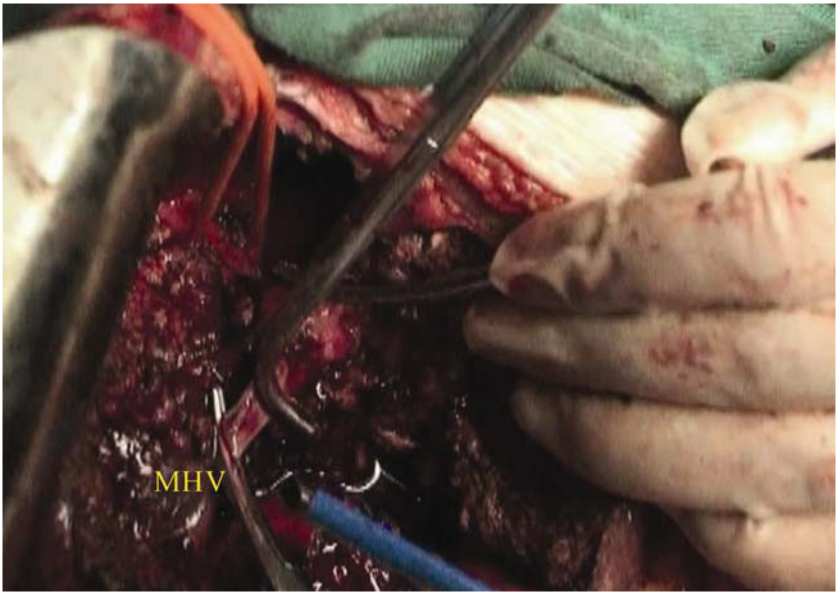


Fig.5.158. The MHV is ligated and divided

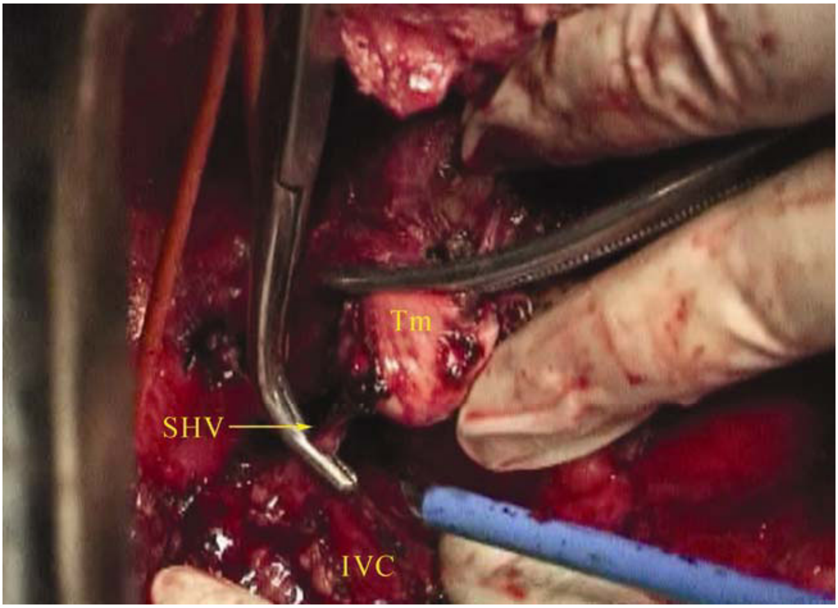


Fig.5.159. The tumor is lifted, and a SHV is dissected and ligated

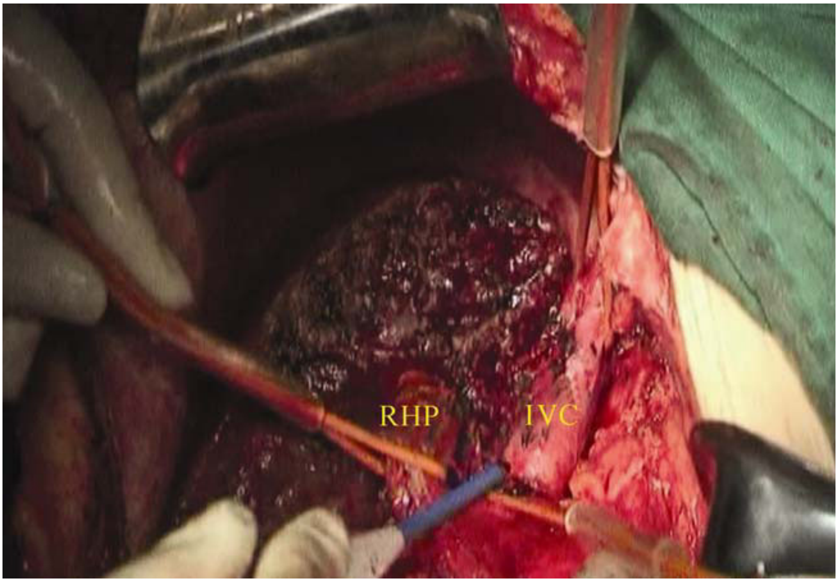


Fig.5.160. The caudate and left lobes with tumor are removed

5.3.5 Combined with the Right Lobe and IVC Resection for Cholangiocellular Carcinoma

See Figs.5.161-5.174, and video 18.

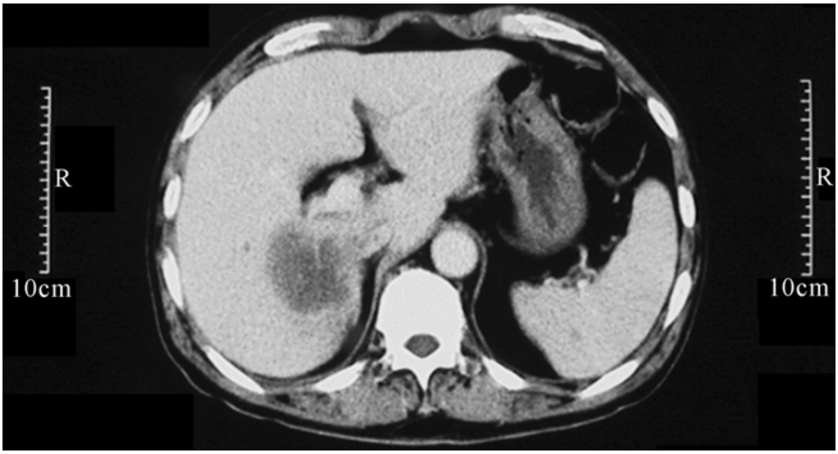


Fig.5.161. CT showing a tumor involving both right and caudate lobe

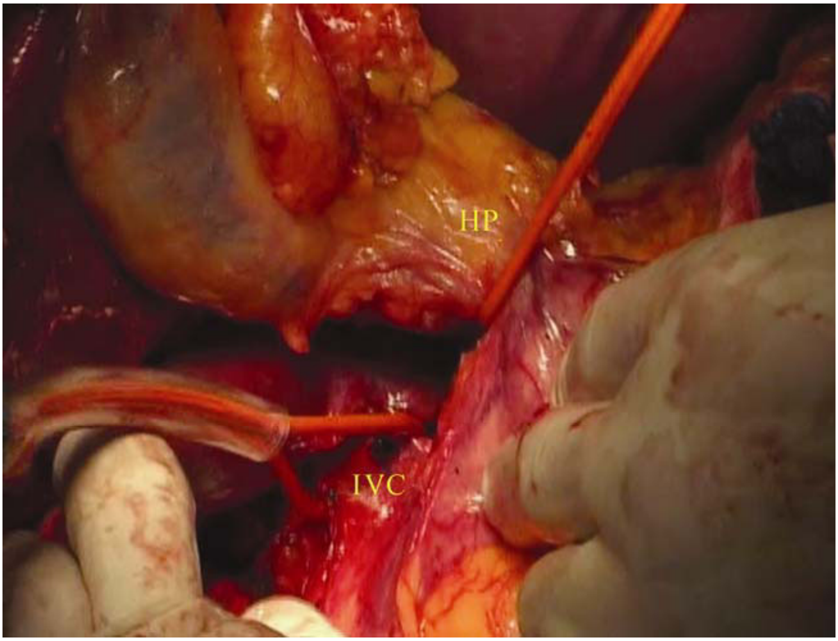


Fig.5.162. The IVC is taped

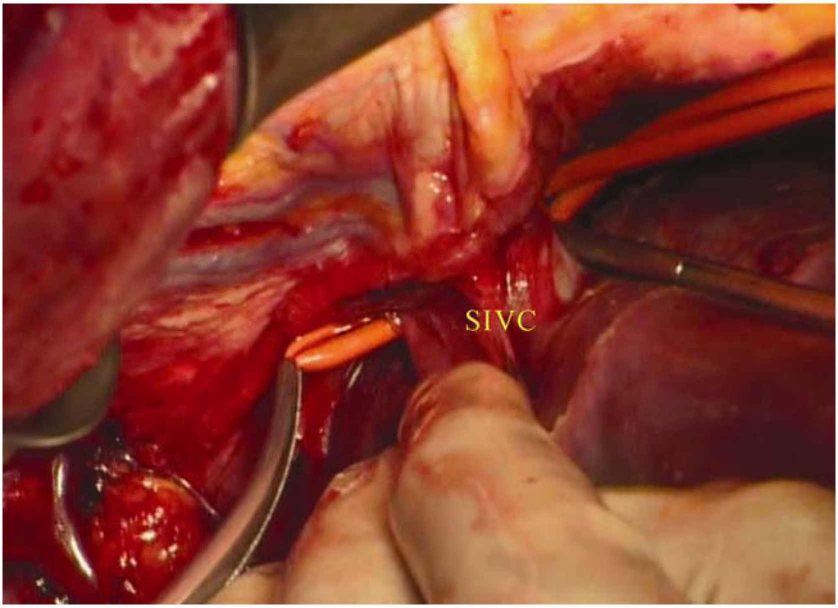


Fig.5.163. The SIVC is taped

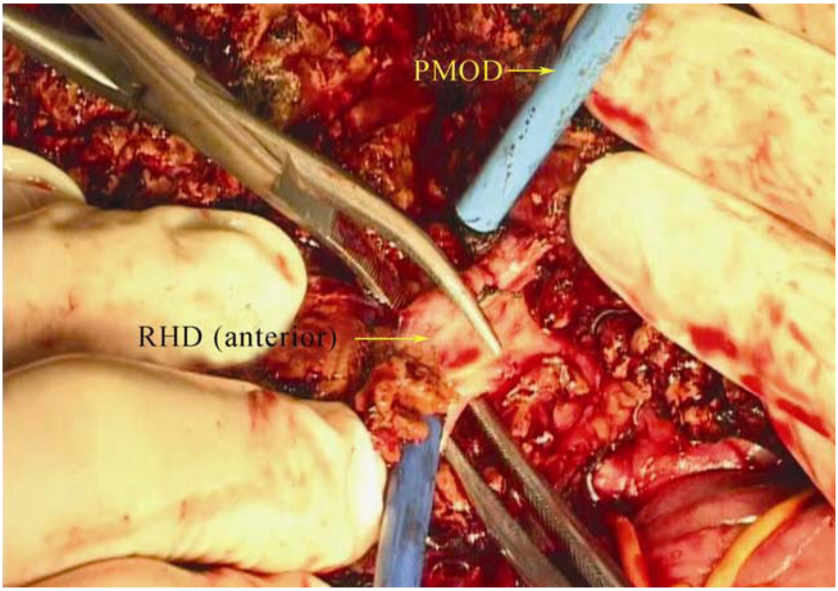


Fig.5.164. The right anterior hepatic duct is divided

Fig.5.165. The right posterior hepatic duct is divided

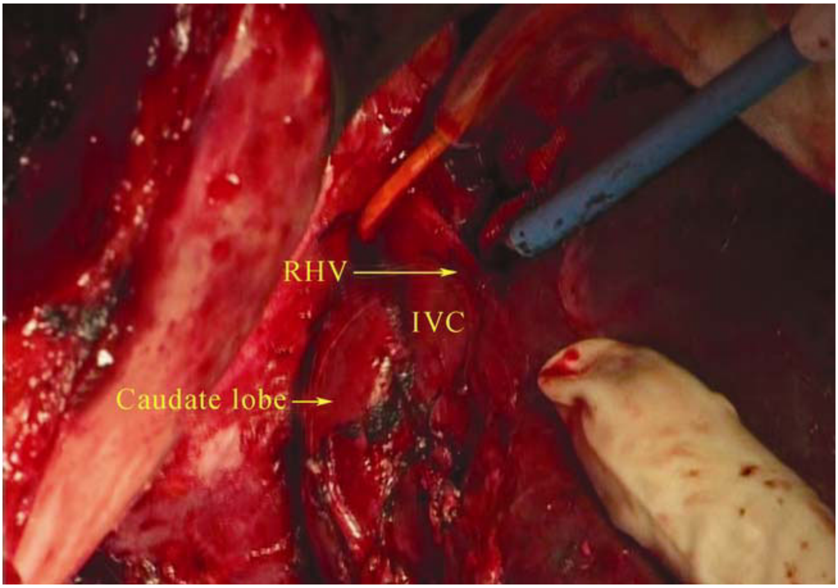


Fig.5.166. The IVC is encased by a large piece of the caudate lobe

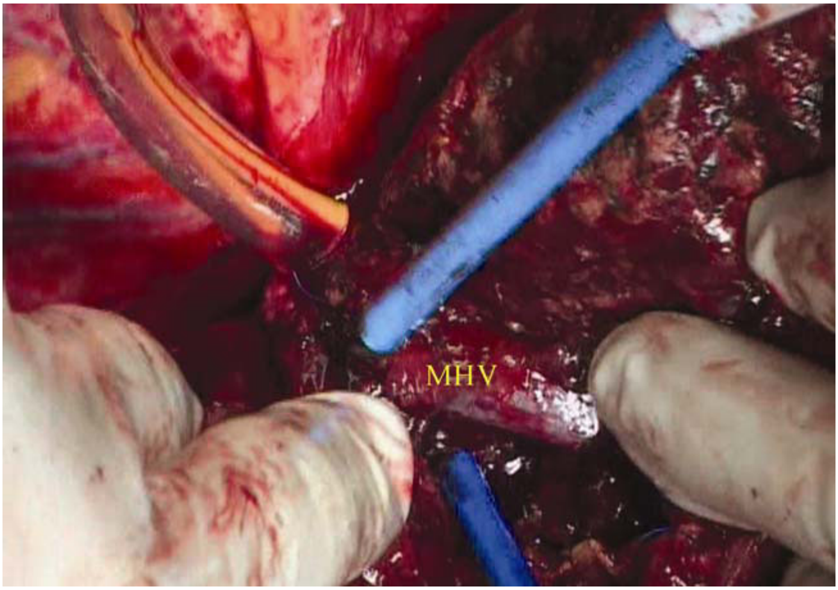


Fig.5.167. Parenchymal transection with the MHV preserved

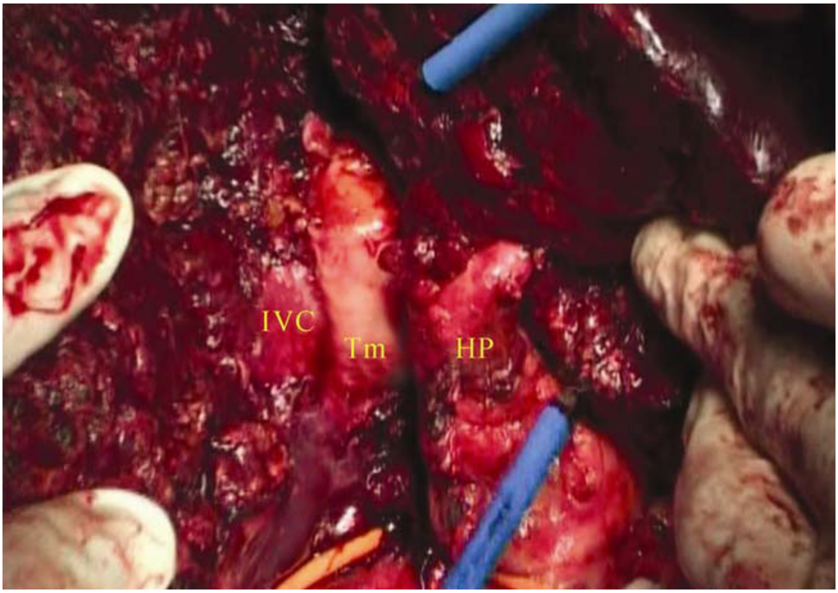


Fig.5.168. Caudate tumor is situated between the IVC and the liver pedicle

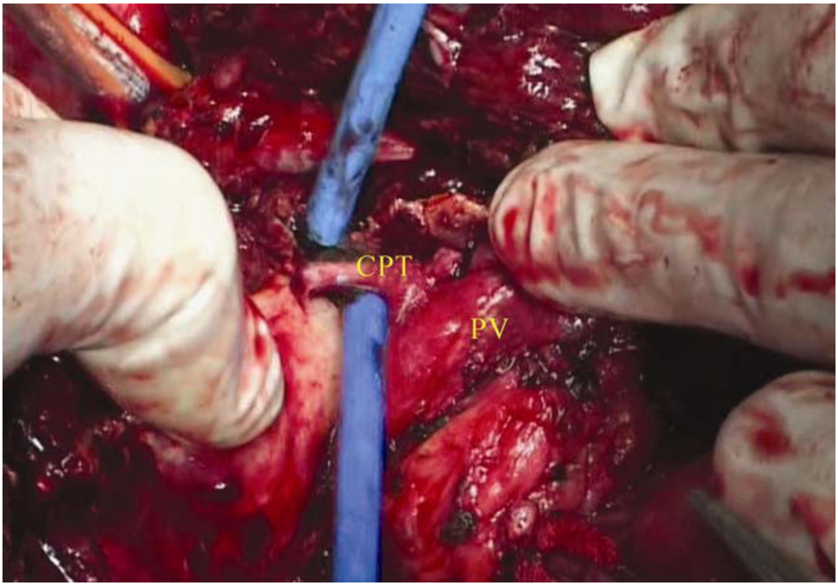


Fig.5.169. A CPT is divided

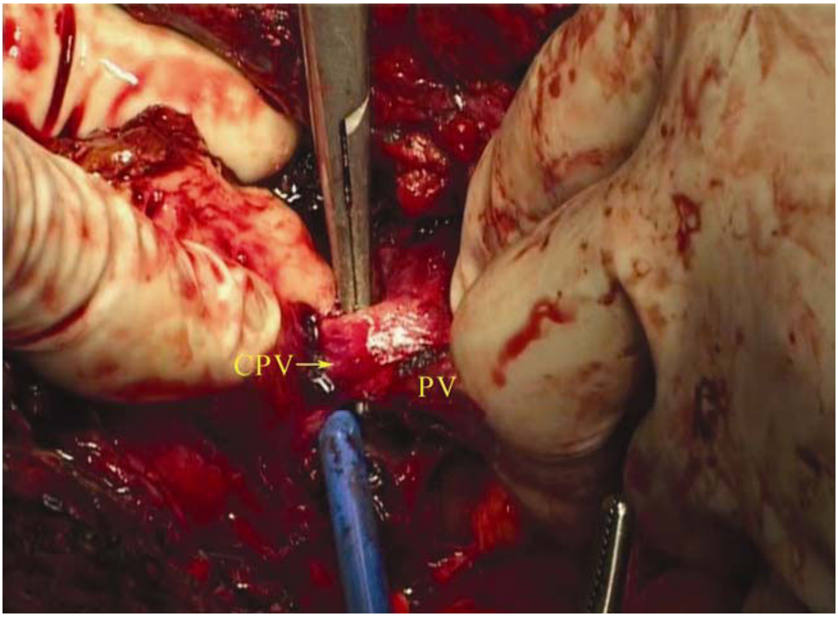


Fig.5.170. A large CPV is divided

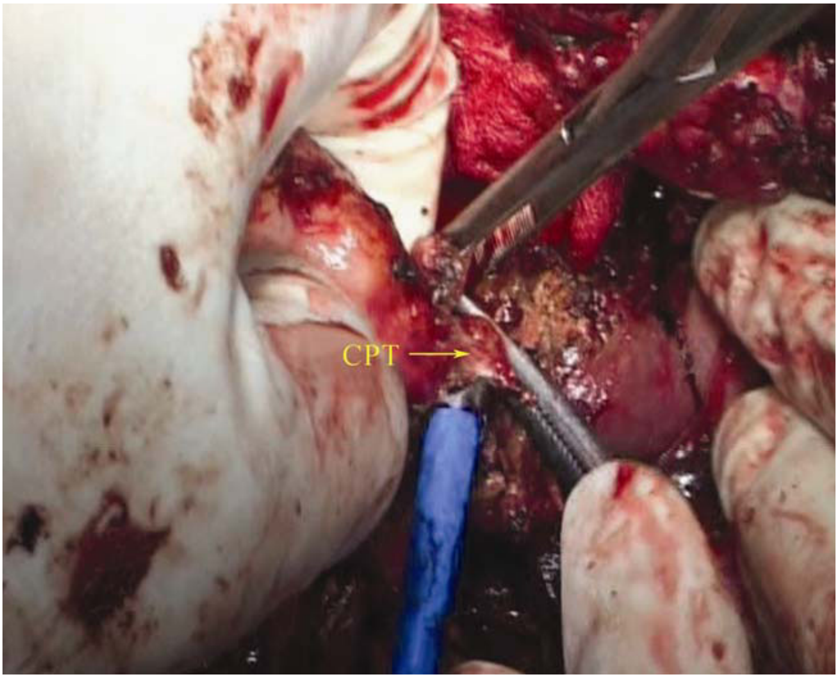


Fig.5.171. A CPT is divided

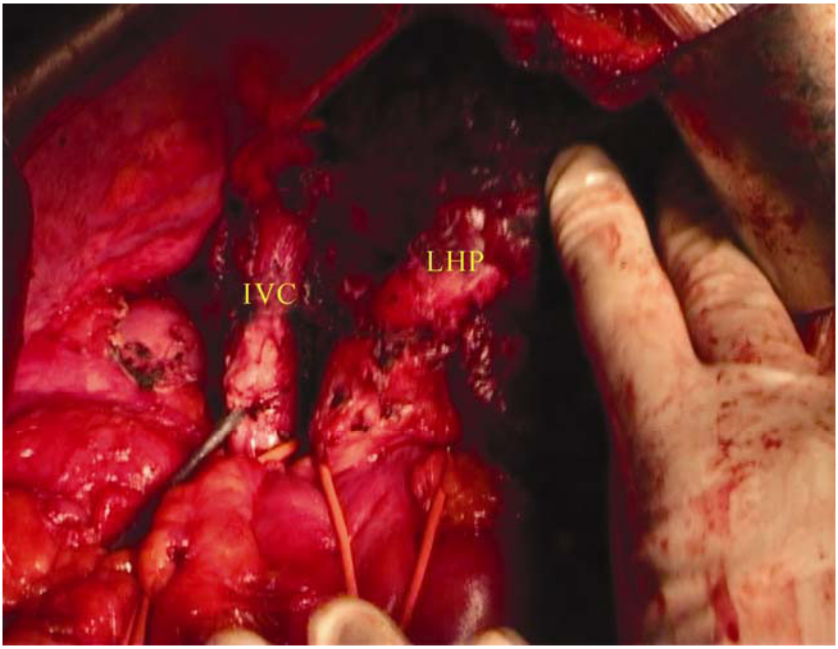


Fig.5.172. This segment of the IVC with the remaining large piece of caudate lobe behind it is to be resected

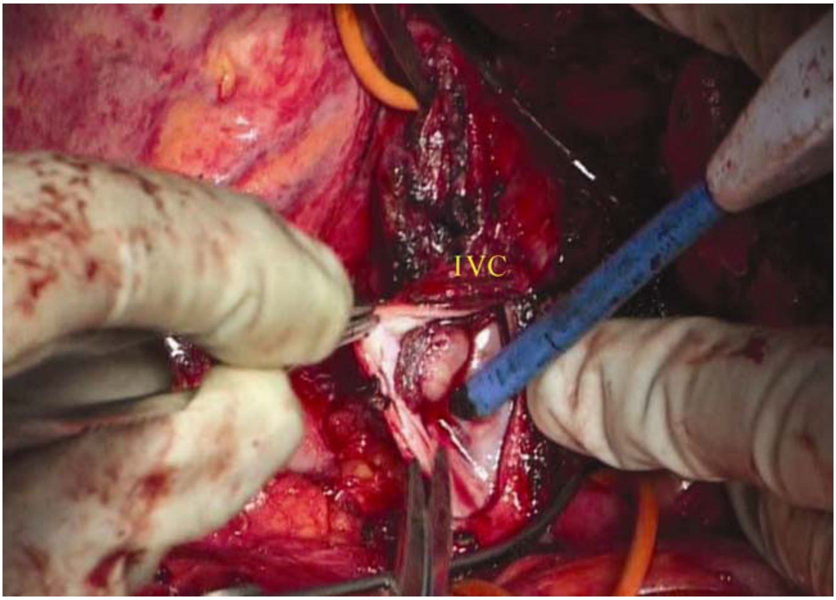


Fig.5.173. The IVC is cut open, revealing the tumor in the lumen

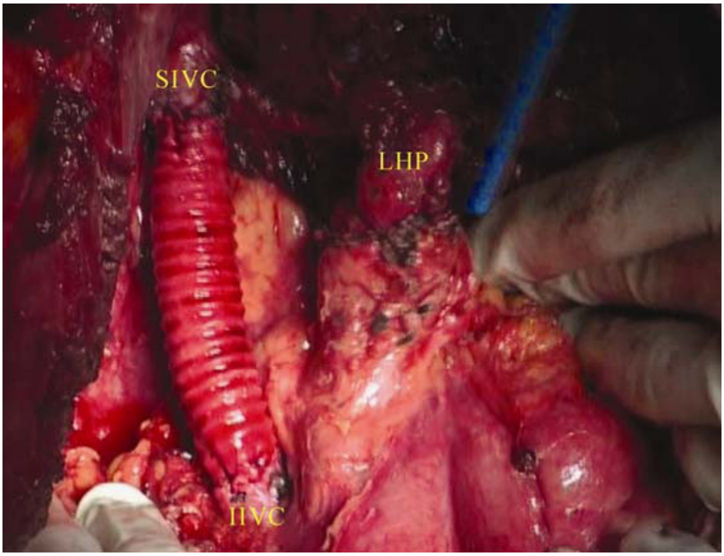


Fig.5.174. A long segment of prosthesis is used for IVC reconstruction

5.4 Combined Partial Resection of the Caudate Lobe

Combined partial resection of the caudate lobe is indicated when this lobe is partially involved in a tumor in an adjacent segment/lobe (Figs.5.175-5.188).

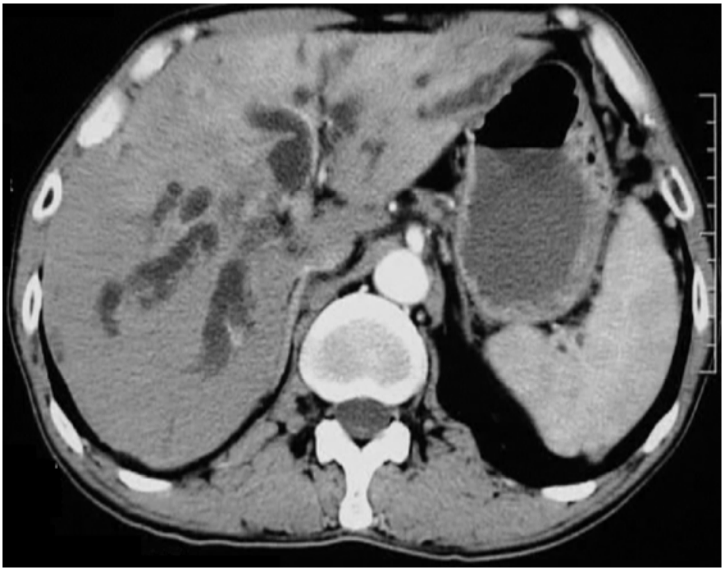
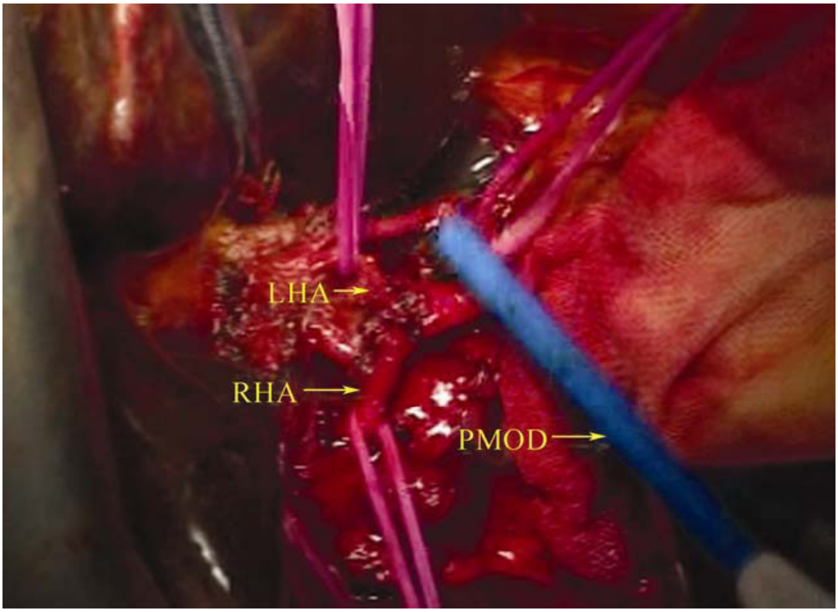
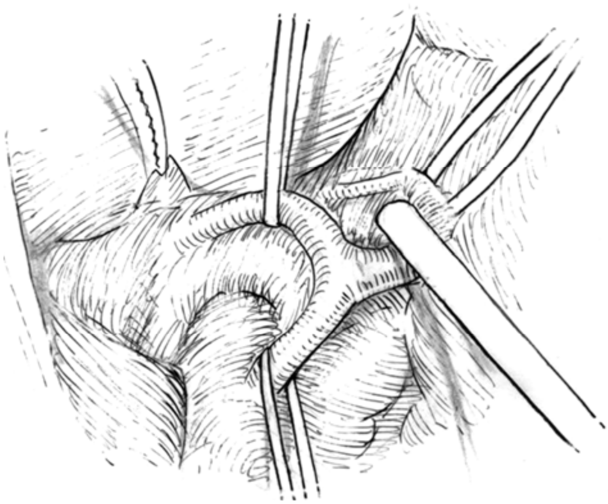


Fig.5.175. CT showing a tumor in the caudate lobe and dilation of the hepatic duct

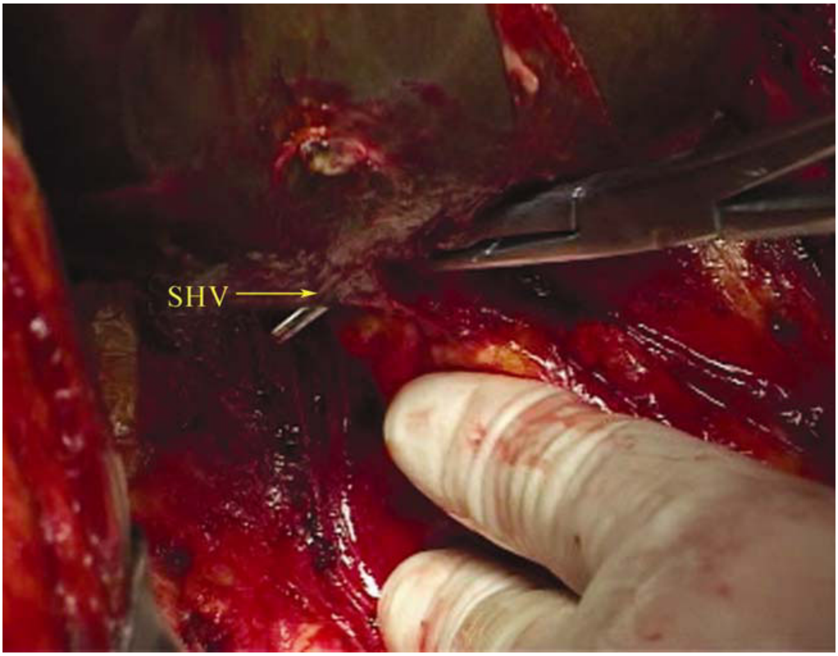


(a)

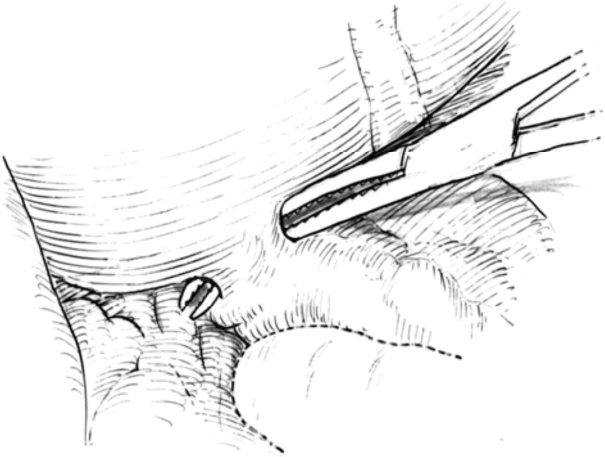


(b)

Fig.5.176. Skeletonization of the hepatoduodenal ligament. (a) Photograph; (b) Drawing

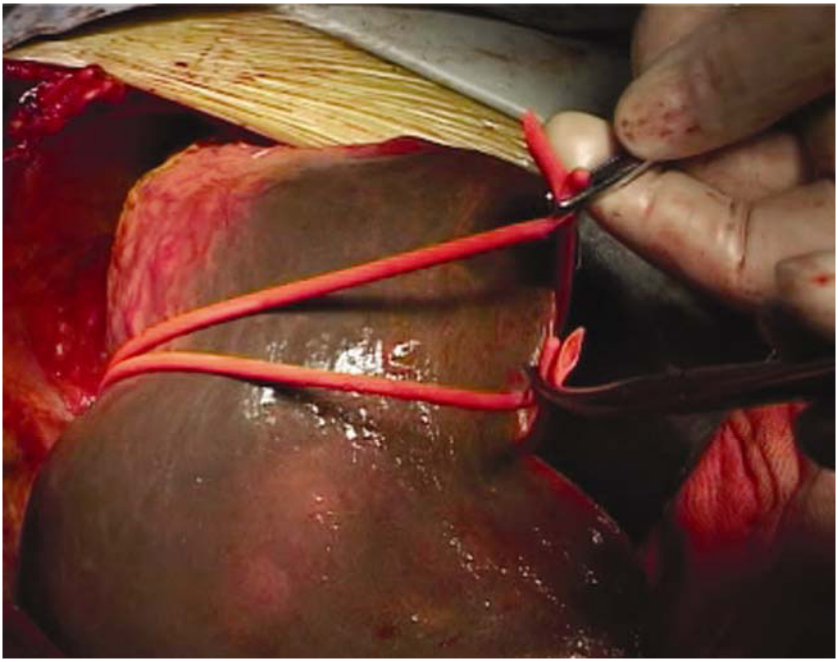


(a)

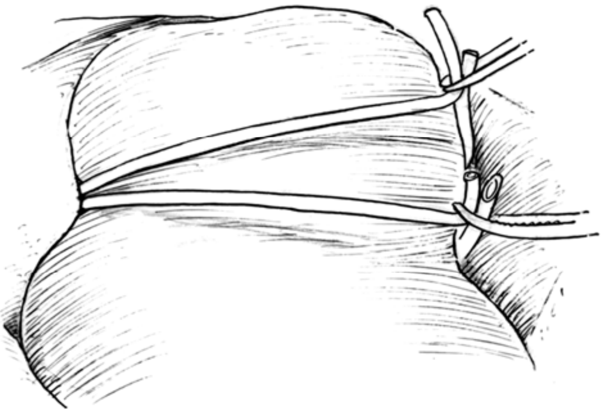


(b)

Fig.5.177. A SHV is dissected.
(a) Photograph; (b) Drawing

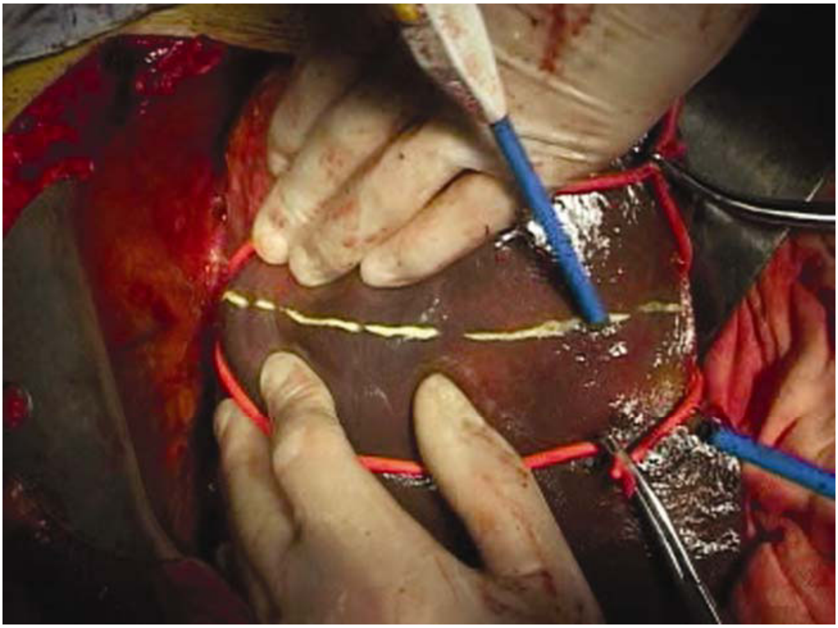


(a)

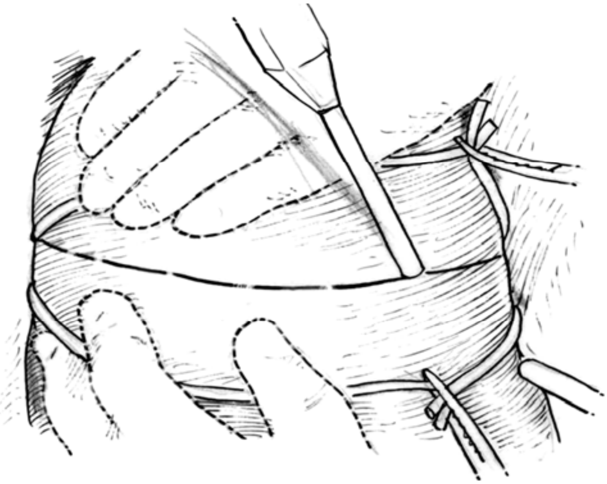


(b)

Fig.5.178. Two hanging tapes are used simultaneously. (a) Photograph; (b) Drawing

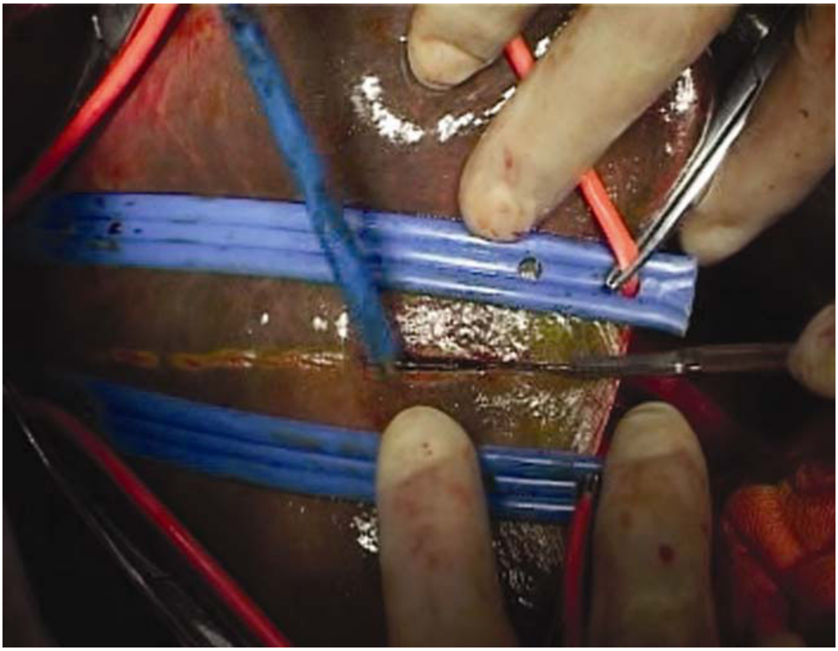


(a)

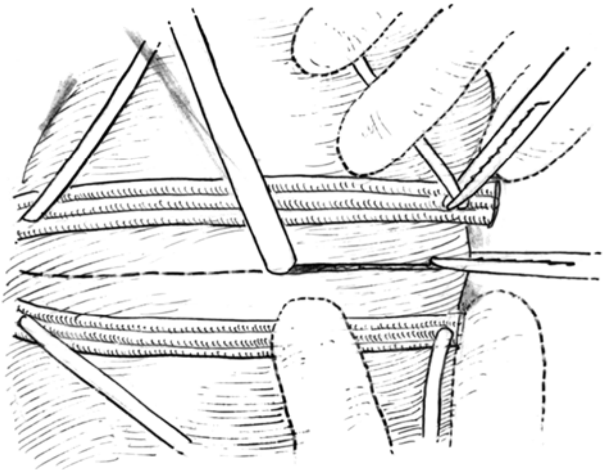


(b)

Fig.5.179. Transection line is marked on the liver surface. (a) Photograph; (b) Drawing



(a)



(b)

Fig.5.180. Hemostatic plates are in place.
(a) Photograph; (b) Drawing

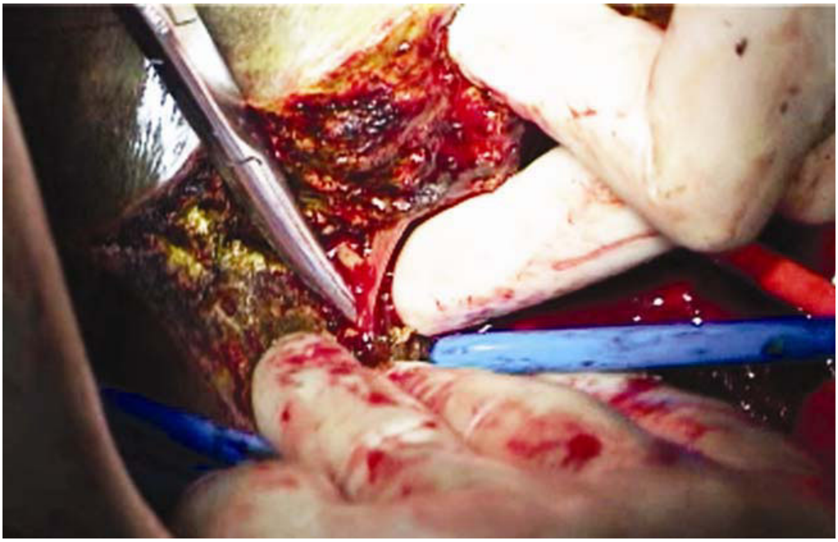
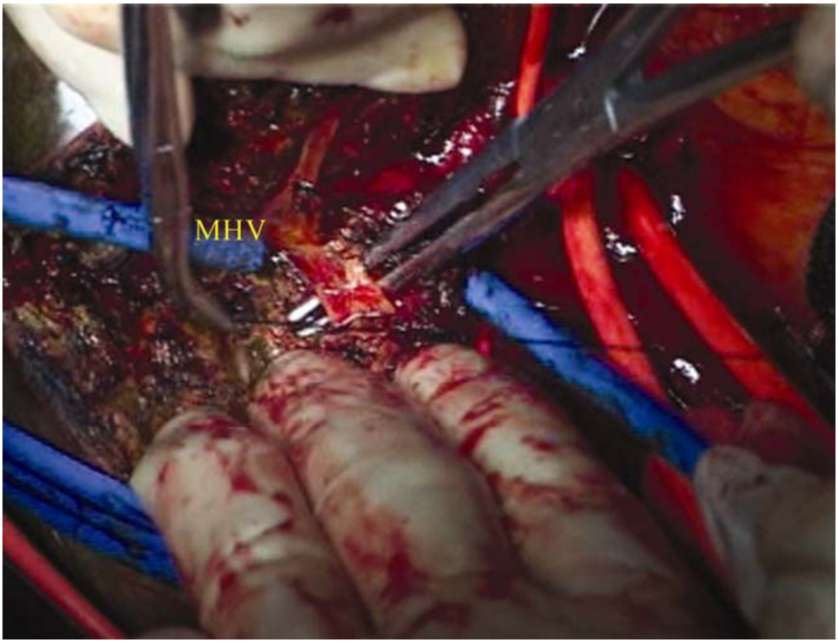
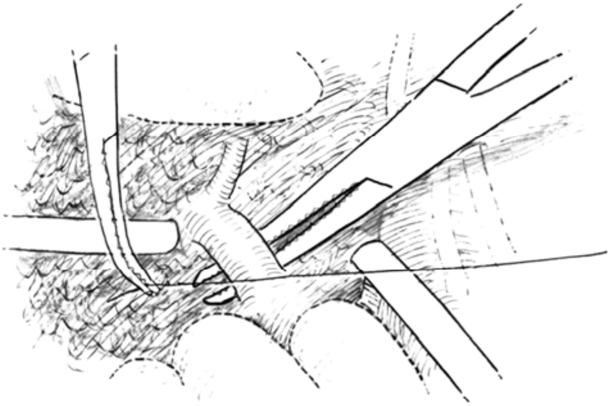


Fig.5.181. A branch of the MHV is dissected



(a)



(b)

Fig.5.182. A branch of the MHV is dissected.
(a) Photograph; (b) Drawing

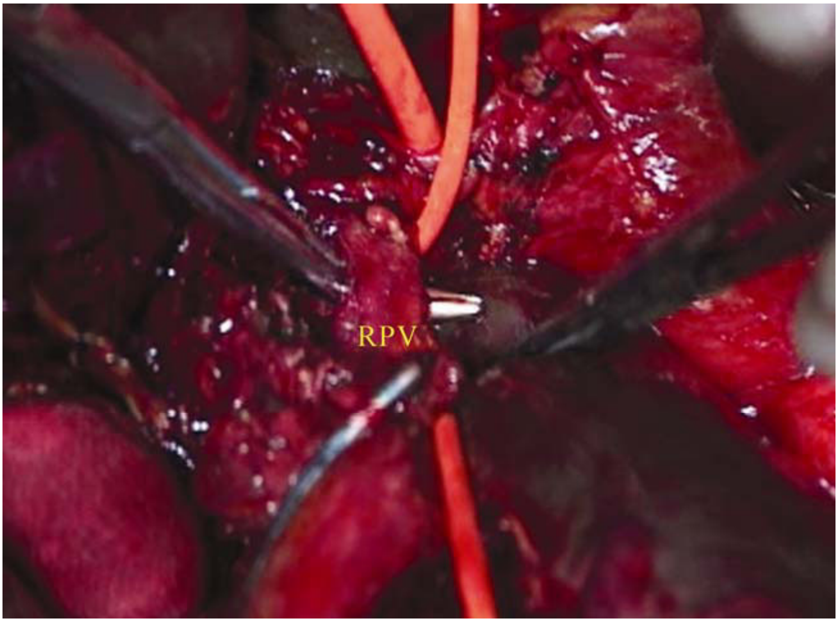
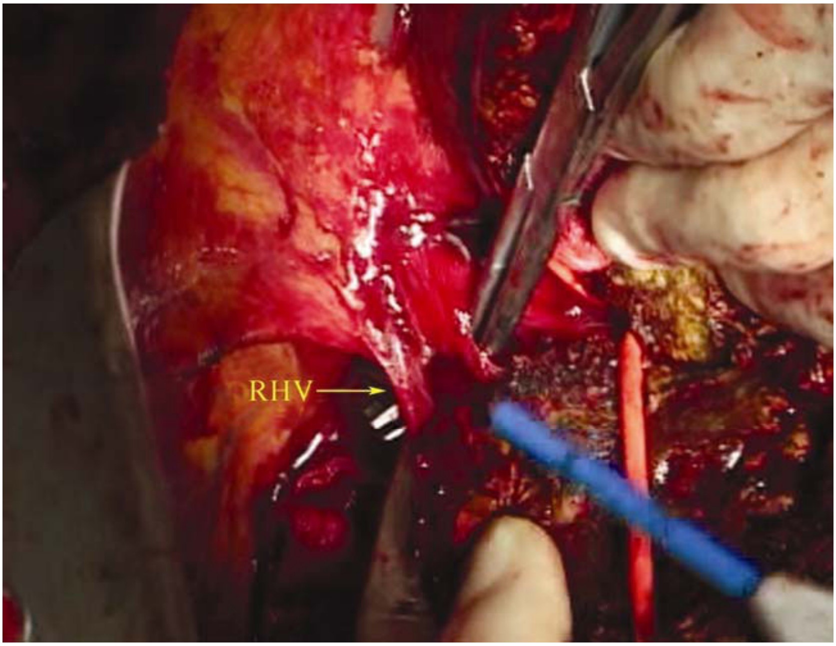
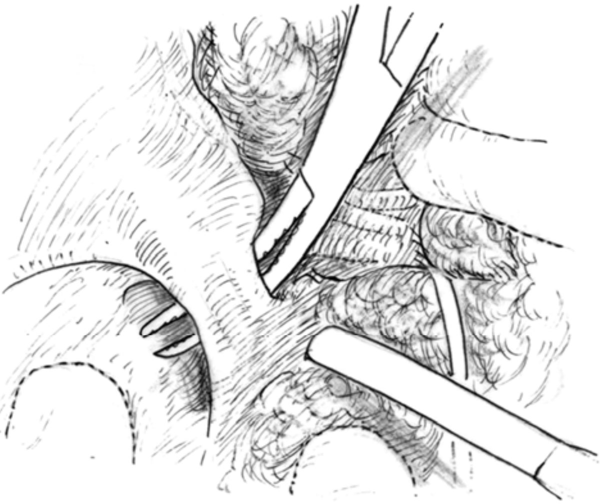


Fig.5.183. The RPV is divided



(a)



(b)

Fig.5.184. The RHV is divided.
(a) Photograph; (b) Drawing

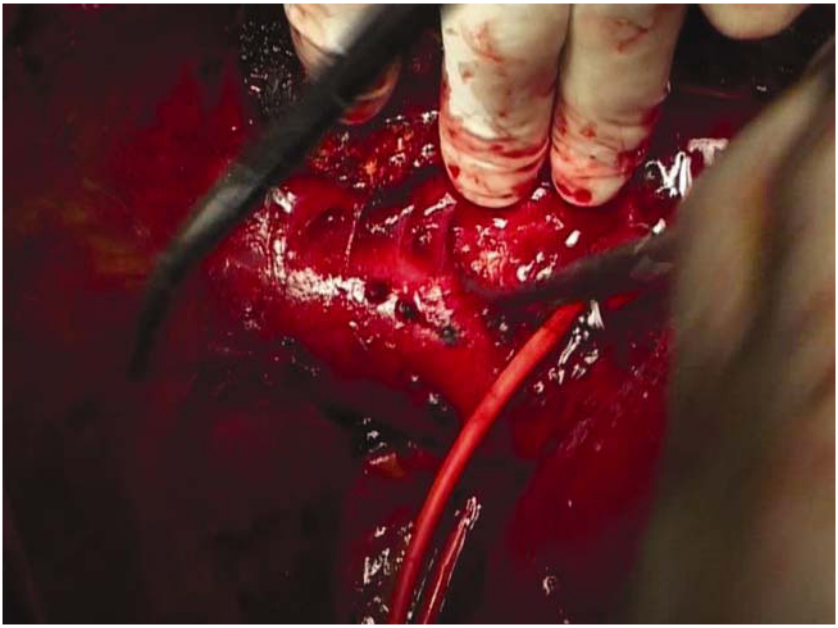


Fig.5.185. Several SHVs are in view

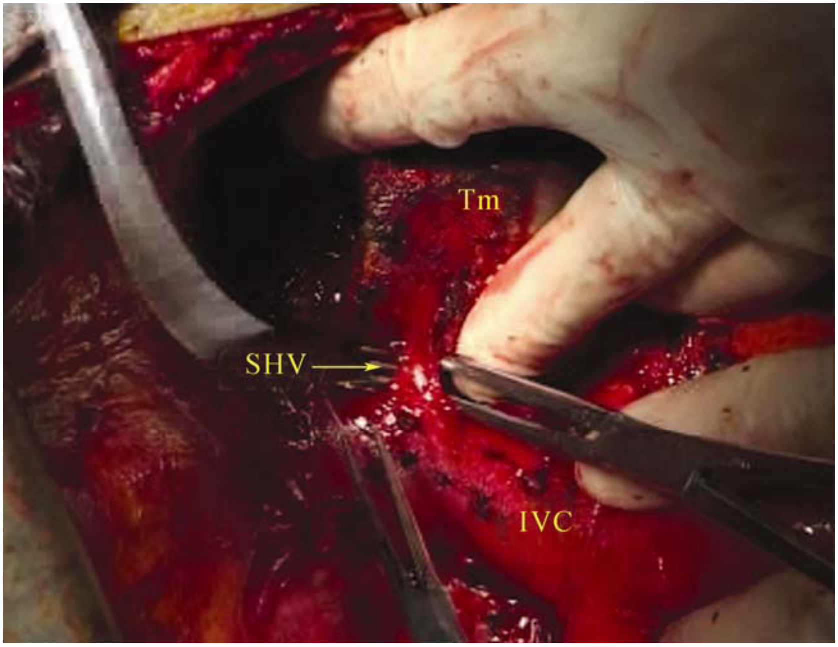
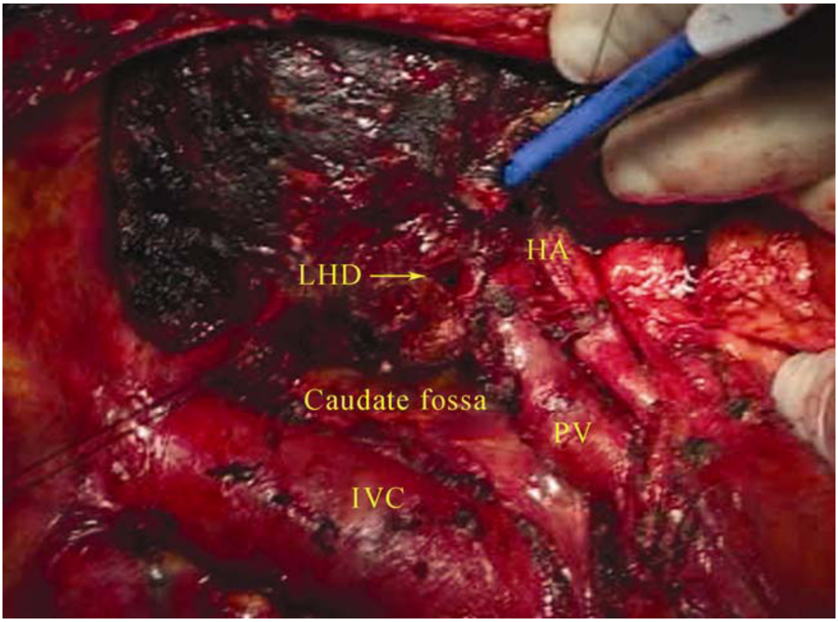
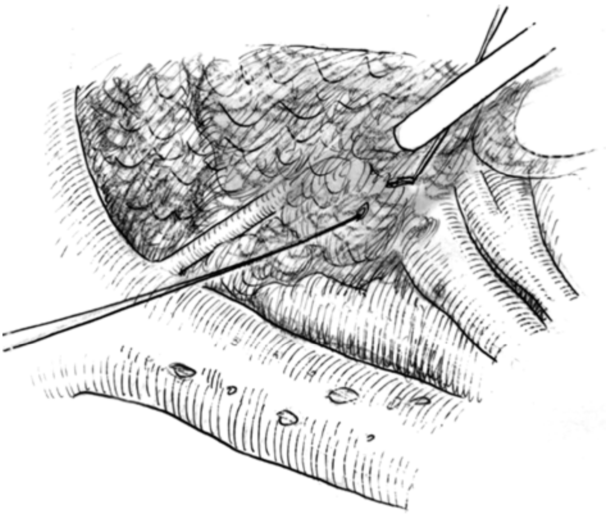


Fig.5.186. A SHV is dissected

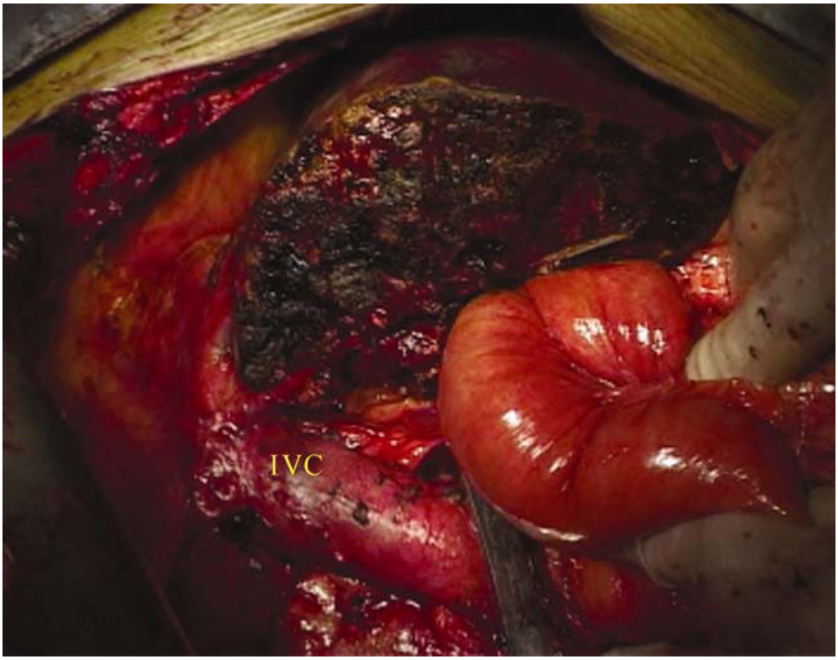


(a)

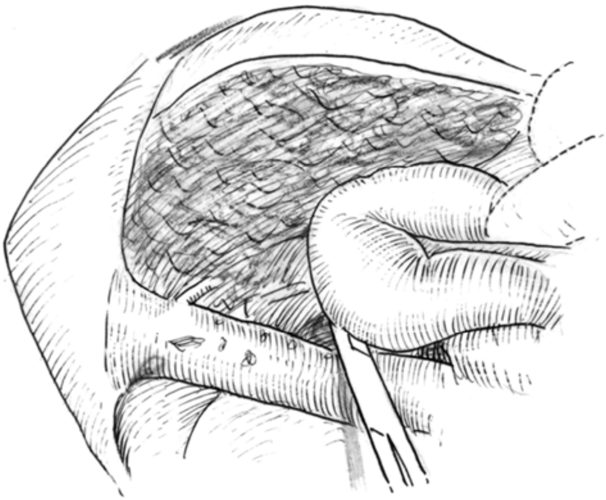


(b)

Fig.5.187. Both the right and caudate lobes were removed, LHD opening is ready for anastomosis. (a) Photograph; (b) Drawing



(a)



(b)

Fig.5.188. Cholangiojejunostomy is performed.
(a) Photograph; (b) Drawing

5.5 Giant HCC Originating in the Caudate Lobe

Isolated complete resection of the caudate lobe by the anterior approach is difficult to perform in patients with a giant tumor originating in the caudate lobe. In this patient, the huge tumor was initially resected by the anterior approach (Figs.5.189-5.193). However, after removal of the tumor, it was found there were too many small holes in the RHV to be repaired. Eventually, the RHV had to be ligated, resulting in a combined resection. Fortunately, the patient survived the operation, but died of recurrence 17 months later.

Fig.5.189. MRI showing a giant tumor in the caudate lobe

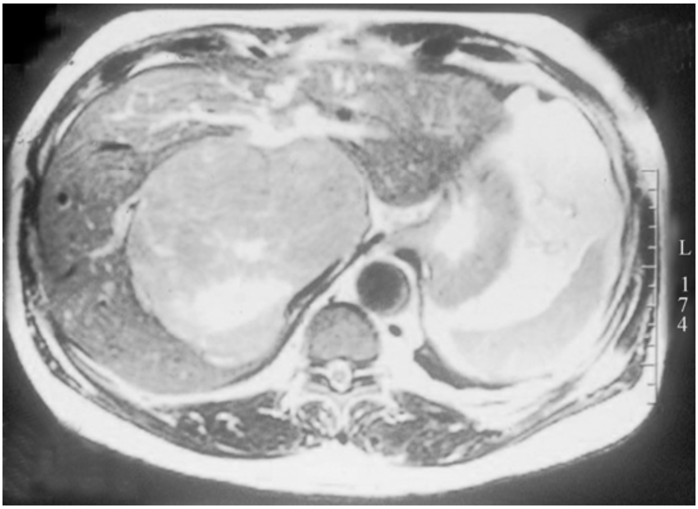


Fig.5.190. MRI showing a giant tumor in the caudate lobe

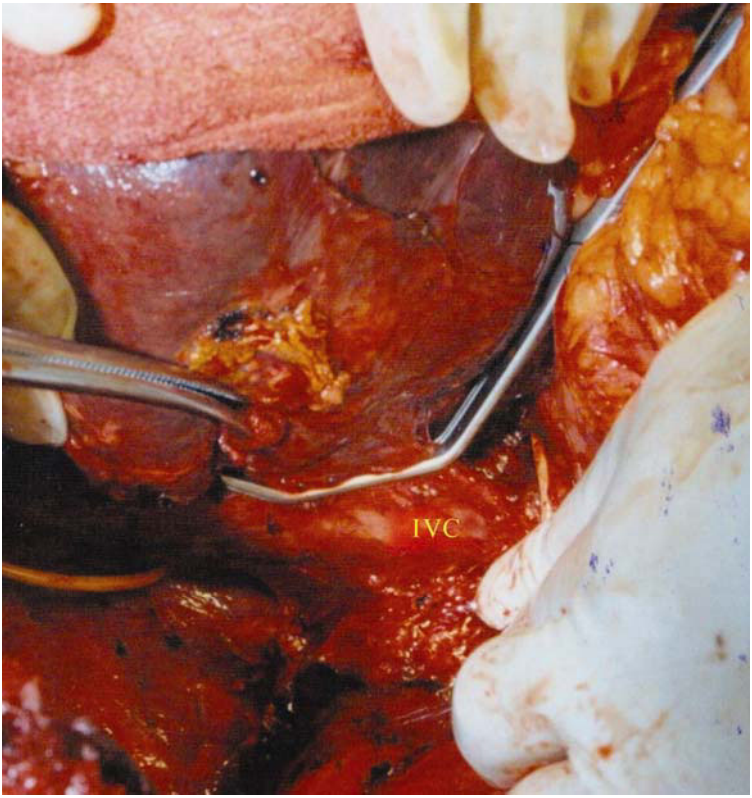


Fig.5.191. The IVC is partially clamped for safe dissection of the inferior RHV

Fig.5.192. A very large inferior RHV is safely isolated

Fig.5.193. The tumor is even larger than the right lobe

6

Retrograde Resection of Caudate Lobe*

The technical approach of conventional caudate lobectomy, as described by Lerut, Colonna, Nagasue and their colleagues (Lerut et al., 1990; Schwartz, 1997; Nagasue et al., 1997), emphasizes the importance of proceeding by dividing the vascular attachments from the lobe to the IVC as the first step, and following this with parenchymal transection. In the procedure of this classic approach, SHVs originating in the caudate lobe are divided and ligated at the initial stage. But when the caudate neoplasm is closely adherent to or infiltrating the IVC, or is too big to be turned from side to side, which precludes dissection of the SHVs, this technique is not suitable for conventional caudate lobectomy. We design and use a technique, retrograde caudate lobectomy, in which division and ligation of the SHVs are carried out at the final stage of the operation instead of at the initial stage. This has proven to be of great help on such occasions.

6.1 Surgical Procedures

The procedure of retrograde resection includes three steps.

6.1.1 Mobilization of the Whole Liver

All cases adopted a reversed L-shaped skin incision from the base of the xiphoid to the tip of the 12th right rib. The perihepatic ligaments (teres hepatis, falciform, coronary, hepatorenal, and triangular ligaments) were divided so as to completely mobilize the liver. The hepatoduodenal ligament was taped for control of blood inflow. Both the SIVC and IIVC were also taped for temporary control when needed (Peng et al., 2004).

*Abridged from Peng SY, Liu YB, Wang JW, et al. (2008) Retrograde resection of caudate lobe of liver. J Am Coll Surg 206: 1232 1238. Used with permission from Elsevier

6.1.2 Detachment of the Caudate Lobe from the Liver

Choice of approach is essential to the success of caudate lobectomy. Approaches were based on size and location of the lesion, severity of cirrhosis, and the general condition of the patient. This group included the combined approach and the anterior transhepatic approach. In the combined approach, the operation started from the healthy side of the caudate lobe. For example, when the tumor was located chiefly in the Spiegel lobe and paracaval portion, the right-sided approach was adopted first. The liver was turned to the left to expose the right side of the IVC. The right adrenal gland was fully detached from the liver. Then, the operative procedure on the left side was started. The liver was turned to the right to expose the left side of the IVC. The retroperitoneum covering the IVC was incised along the caudate lobe border from below toward the upper pole of the caudate lobe, which was then raised a little from the IVC. The right side of the upper pole served as a landmark, joining the other landmark, the right side of the caudate process, to become an imaginary line of parenchyma transection. The caudate hilum was now dissected. There were two to five branches of caudate portal triads entering the caudate lobe from the left and right liver pedicles. These branches were sequentially isolated and divided one after another from left to right until the caudate lobe was completely detached from the liver pedicle. The next step was transection of the liver parenchyma to separate the caudate lobe from the other segments. Transection was carried out from the point where the caudate process meets segment VI toward the upper pole of the caudate lobe, as mentioned previously. The boundary of the caudate lobe was now clear, as the color of the whole lobe became dusky after division of all the caudate portal triads. Anteriorly, the transection plane was just behind the major HVs. A thin layer of liver parenchyma was left for protection of the HVs. How thin is the liver parenchyma left? This depends on the size of the tumor. In our practice, the transection line was 1.0 to 1.5 cm from the tumor. On some occasions, when the tumor was very closely in contact with the HVs, using the combined approach would be difficult and it would be risky to dissect from behind. As an important alternative, the anterior transhepatic approach should be adopted, where the midplane of the liver is split open through the Cantlie line to expose the tumor (Peng et al., 2003a; 2003b). HVs were under direct view in this way and meticulous dissection should be undertaken to deal with the branches connecting the tumor; all branches from the HVs must be carefully ligated; small holes, if any, in the HVs should be sutured with 5-0 prolene (Ethicon). After completion of liver parenchymal transection, the tumor was completely detached from the liver and now the only attachment is the IVC.

6.1.3 Detachment of the Caudate Lobe from the IVC

At this time, the caudate lobe was completely freed from the liver, but was still closely attached to the IVC, the SHVs not being dealt with yet. At that moment the IVC, both distal and proximal to the tumor-bearing caudate lobe, could be controlled without interrupting the blood flow to the liver, enabling the surgeon to take time to dissect and divide all the SHVs until the tumor-bearing caudate lobe was completely removed. Occasionally, part of IVC could be resected with the tumor and repaired with 4-0 prolene or reconstructed with an artificial vessel (Fig.6.1). The liver parenchyma was transected by "curettage and aspiration" technique (blunt and precise dissection incorporated with suction and coagulation) using Peng's Multifunction Operative Dissector (PMOD) under intermittent inflow occlusion at the hepatoduodenal ligament (Pringle's maneuver); the limit is 10 min each time, with a 2 min interval for reperfusion (Peng et al., 2003b). Total vascular exclusion was adopted only when absolutely necessary. PMOD is a single specially-designed instrument, with the functions of dissection, electro-coagulation, and aspiration working separately or synchronously, with which the operation field can be kept clear and clean. All intrahepatic ductal structures can be clearly identified, isolated and dealt with individually, and the operating process can be expedited (Peng et al., 2003b).

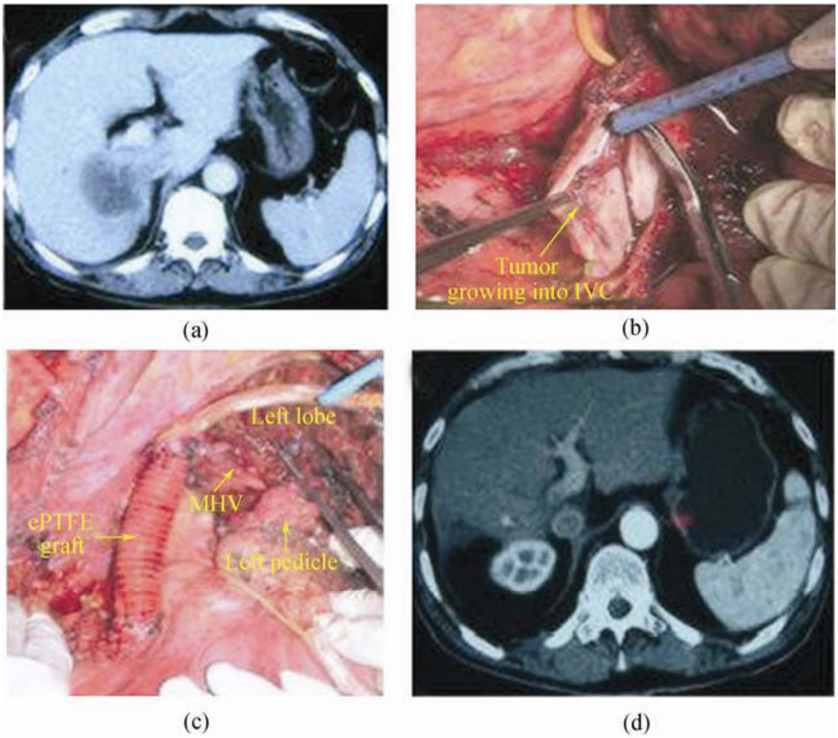


Fig.6.1. Right hemihepatectomy plus complete caudate lobectomy. (a) Preoperative CT scan showing tumor involving segments V, VI, and I; (b) Tumor infiltrating into the IVC; (c) The retrohepatic IVC resected and reconstructed with a PTFE graft; (d) Postoperative CT scan showing artificial graft at 45 days after operation. Copyright (2008), with permission from Elsevier

6.2 Summary

The caudate lobe is situated in a very tricky location just behind the portae hepatis. Portae hepatis in the Chinese literature denote not only the hepatic hilum in a general sense, but also two other locations, *i.e.*, the confluence of the IVC with the major HV and the segment of retrohepatic IVC with a series of SHVs. These three different locations are named, respectively, the first, second, and third portae hepatis. The caudate lobe is surrounded by the three portae hepatis. In view of the unique anatomic location, caudate lobe resection, especially isolated complete caudate lobectomy, has been considered to be technically challenging. In the past two decades, resection of the caudate lobe has been used increasingly, mainly because of precise anatomic knowledge and many descriptions of surgical techniques for caudate lobectomy (Lerut et al., 1990; Schwartz, 1997; Nagasue et al., 1997; Takayama and Makuuchi, 1998; Yamamoto et al., 1999; Bartlett et al., 1996; Hawkins et al., 2005; Peng et al., 1999; 2003a; 2003b; 2004; 2005). Bartlett and colleagues (1996) reported 21 consecutive complete caudate lobe resections during a 30-month period. The major complication rate was 38%, with a 10% mortality rate. Similar results for caudate lobectomy were reported by Elias and colleagues (Elias et al., 1992). In this series, there were only minor complications and no operative death, showing that caudate lobectomy is a feasible and safe procedure. Caudate lobectomy is classified by complete and partial resection, and also by isolated and combined resection (Peng et al., 2006). During the classic caudate lobectomy, precise dissection is carried out to divide and ligate SHVs, followed by dissection of the portal triads to the caudate lobe. The liver parenchyma is finally transected between the caudate lobe and segments IV, VI, and VII to complete the operation. But if the neoplasm is adherent to or infiltrating the IVC or too big to be turned from side to side, the dissection of SHVs is extremely difficult and risky. Under such circumstances, we would leave the dissection and division of SHVs to the final stage. Because this procedure is reversed in terms of the sequence of dissection, we call it retrograde caudate lobectomy. We have adopted this technique successfully for twelve patients with difficult caudate lobe resections.

References

Bartlett D, Fong Y, Blumgart LH (1996) Complete resection of the caudate lobe of the liver: technique and results. Br J Surg 83: 1076-1081

Elias D, Lasser PH, Desruennes E, et al. (1992) Surgical approach to segment I for malignant tumors of the liver. Surg Gynecol Obstet 175: 17-24

Hawkins WG, DeMatteo RP, Cohen MS, et al. (2005) Caudate hepatectomy for cancer: a single institution experience with 150 patients. J Am Coll Surg 200: 345-352

Lerut J, Gruwez J, Blumgart LH (1990) Resection of the caudate lobe of the liver. Surg Gynecol Obstet 171: 160-162

Nagasue N, Kohno H, Yamanoi A, et al. (1997) Resection of the caudate lobe of the liver for primary and recurrent hepatocellular carcinomas. J Am Coll Surg 184: 1-8

Peng SY, Feng XD, Liu YB, et al. (2005) Surgical treatment of hepatocellular carcinoma originating from caudate lobe. Zhonghua Wai Ke Za Zhi 43: 115-122 (In Chinese)

Peng SY, Li JT, Liu YB, et al. (2006) Surgical treatment of hepatocellular carcinoma originating from caudate lobe: a report of 39 cases. J Gastrointest Surg 10: 371-378

Peng SY, Li JT, Mou YP, et al. (2003b) Different approaches to caudate lobectomy with "curettage and aspiration" technique using a special instrument PMOD: a report of 76 cases. World J Gastroenterol 9: 2169-2173

Peng SY, Liu YB, Xu B, et al. (2004) Role and significance of extrahepatic control of hepatic vein and inferior vena cava in difficult hepatectomies for patients with liver tumors. Zhonghua Wai Ke Za Zhi 42: 260-264 (In Chinese)

Peng SY, Mou YP, Cai XJ, et al. (2003a) Isolated complete caudate lobe resection through anterior transhepatic approach. Chin J Gen Surg 18: 74-76 (In Chinese)

Peng SY, Mou YP, Peng CH, et al. (1999) Resection of caudate lobe of liver: report of 26 cases. Zhonghua Wai Ke Za Zhi 37: 12-13 (In Chinese)

Schwartz SI (1997) Resection of the caudate lobe of the liver. J Am Coll Surg 184: 75-76

Takayama T, Makuuchi M (1998) Segmental liver resections, present and future: caudate lobe resection for liver tumors. Hepatogastroenterology 45: 20-23

Yamamoto J, Kosuge T, Shimada K, et al. (1999) Anterior transhepatic approach for isolated resection of the caudate lobe of the liver. World J Surg 23: 97-101

7

Measures for Safe Resection of Caudate Lobe

Recent advances in liver surgery have made hepatic resection much safer. However, hepatic resection for tumors located around the hepatic hilum or near the IVC remains technically difficult, even if the tumor is small. The caudate lobe is situated between the three portae hepatis, so isolated resection of the caudate lobe is still a challenge. There are some tips and tricks for a safe caudate lobe resection.

7.1 Adequate Abdominal Incision

The abdominal incision for caudate lobe resection should be large enough to give an adequate exposure of the whole liver. A reverted L-shaped incision (the upper end should reach the base of the xiphoid; the lower end should reach the tip of the 12th rib) and a pair of self-retaining retractors can be used to achieve an excellent exposure, while a left side extension is occasionally performed.

7.2 Taping of Major Veins

As a precautionary measure, the SIVCs and IIVCs should be taped (Peng et al., 2004). The RHV and LHV should also be taped (Hong et al., 2006), if possible (refer to Chapter 3).

7.3 IVC Controlled with Fingers

Routinely, the anterior surface of the IVC is dissected free from the caudate lobe. However, bleeding from the IVC or SHVs is very likely to occur in some difficult cases, the alveolar tissue behind the IVC is dissected to create a retrocaval space, through which the fingers can be inserted to the other side. Once bleeding occurs during dissection of the SHVs, the bleeding point can be easily and promptly controlled by pressing the IVC against the caudate lobe at the distal and proximal sites of the bleeding point.

7.4 Application of the Liver Hanging Maneuver

The liver suspension maneuver (Fig.7.1) has been widely used for right lobe resection without mobilizing the right liver ever since it was first described by Belghiti et al. (2001). It was rarely used in caudate lobe resection. We found that it is also useful for caudate lobe resection (Peng et al., 2005). Not only can it help in the dissection of SHVs by lifting the liver forward to better expose them, but also is useful in patients who require liver resection through the midplane for the anterior transhepatic approach.

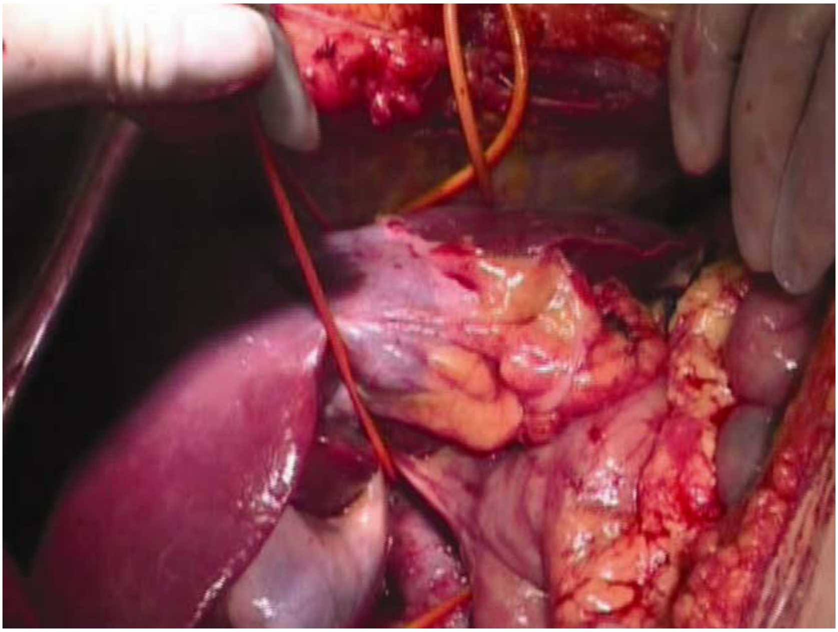


Fig.7.1. Liver hanging maneuver

7.5 Application of Retrograde Resection

It would be unwise to insist on dividing the SHVs as a first step of caudate lobe resection. When the caudate tumor is closely adherent to or infiltrating the IVC, or is too big to be turned from side to side, precluding the SHVs to be dissected, it is advisable to employ the technique of retrograde caudate lobectomy (refer to Chapter 6).

7.6 Using the Curettage and Aspiration Dissection Technique

In performing caudate lobe resection, the caudate lobe has to be detached from the three portae hepatic requiring isolation and division of a series of vessel. Curettage and Aspiration Dissection Technique (CADT) using PMOD would be of great help in doing these (refer to Chapter 2).

References

Belghiti J, Glevara OA, Noun R, et al. (2001) Liver hanging maneuver: a safe approach to right hepatectomy without mobilization. J Am Coll Surg 193: 109-111

Hong DF, Xu B, Peng SY (2006) Role of anatomic hepatectomy performed under vascular exclusion in management of hepatolithiasis. Zhonghua Wai Ke Za Zhi 44: 18-22 (In Chinese)

Peng SY, Liu YB, Xu B, et al. (2004) Role and significance of extrahepatic control of hepatic vein and inferior vena cava in difficult hepatectomies for patients with liver tumors. Zhonghua Wai Ke Za Zhi 42: 260-264 (In Chinese)

Peng SY, Qian HR, Li JT, et al. (2005) The significance of liver hanging maneuver in liver-splitting anterior approach for hepatectomy. Zhonghua Wai Ke Za Zhi 43: 1239-1242 (In Chinese)

8

Laparoscopic Resection of the Caudate Lobe*

With the development of surgical instruments and accumulation of surgical experience, the laparoscopic technique was used in liver resection (Reich et al., 1991). Retrograde laparoscopic Spiegel lobectomy combined with left hepatectomy was performed (Cai et al., 2009). This proved to be a safe procedure when performed by experienced surgeons, but its safety still needs to be further evaluated. This chapter introduces the initial experience of laparoscopic resection of the caudate lobe.

8.1 Entries, Position and Instrument

The surgery was performed on the patient in a supine position. Pneumoperitoneum was established via the Hasson technique and the CO_2 pressure was maintained at 14 mmHg. Four entries were made (Fig.8.1): the observation port (10 mm) below the umbilicus, the main manipulation port (10 mm) below the left costal margin, and two assistant ports (5 mm) at the right flank area. The technique of blunt curettage and aspiration was applied with a Laparoscopic Peng's Multifunction Operative Dissector (LPMOD) (Cai et al., 2006), a proven version of PMOD (Fig.8.2).

---

*Abridged from Cai XJ, Dai Y, Yu H, et al. (2009) A case report of retrograde laparoscopic Spiegel lobectomy: an alternative surgical procedure. Chinese Med J. In print. Used with permission from Chinese Med J

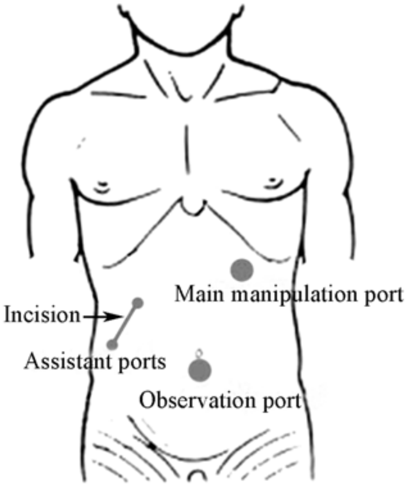


Fig.8.1. Incision

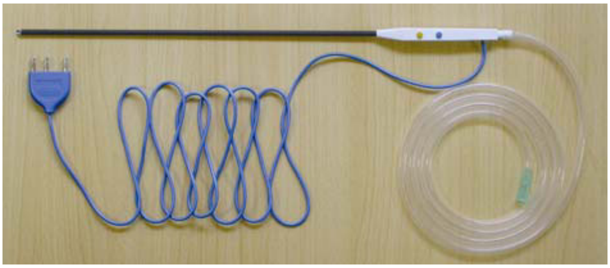


Fig.8.2. LPMOD

8.2 Retrograde Laparoscopic Spiegel Lobectomy Combined with Left Lateral Segmentectomy

The left lateral Glisson ducts and left hepatic vein branches were divided after ligation by titanium clips or absorbable ligating clips (Figs.8.3-8.6). Capillary hemorrhage and bile leakage were meticulously controlled with electrocautery after the left lateral lobe had been removed.

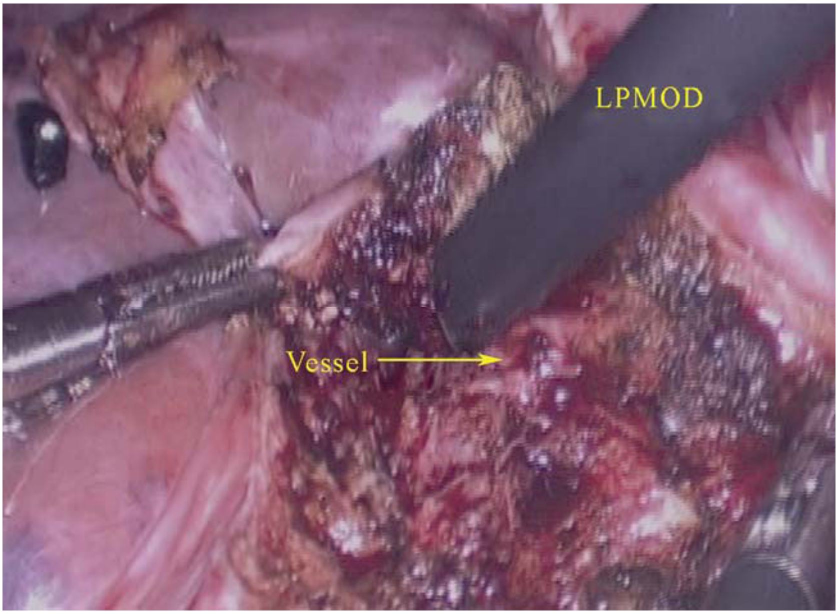


Fig.8.3. Liver parenchyma is transected by LPMOD

Fig.8.4. A small vessel is dissected by LPMOD

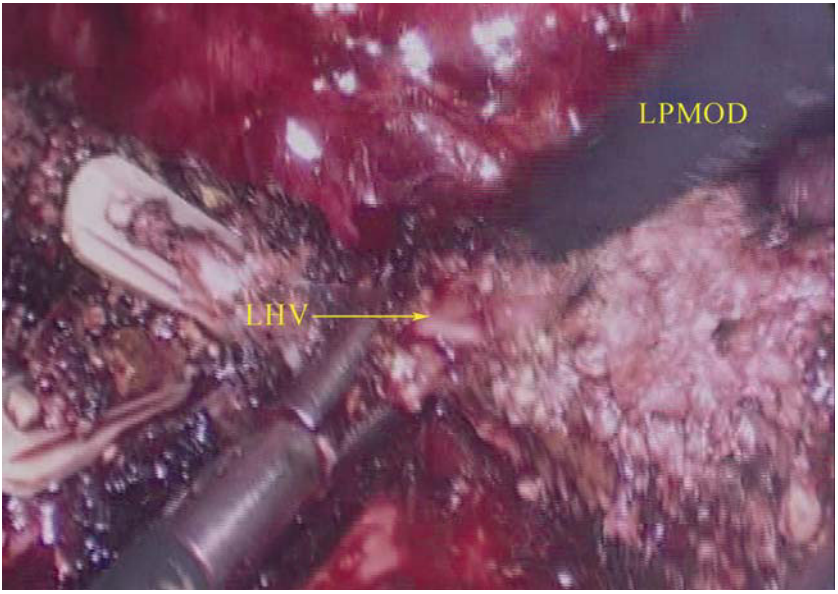


Fig.8.5. The LHV is dissected by LPMOD

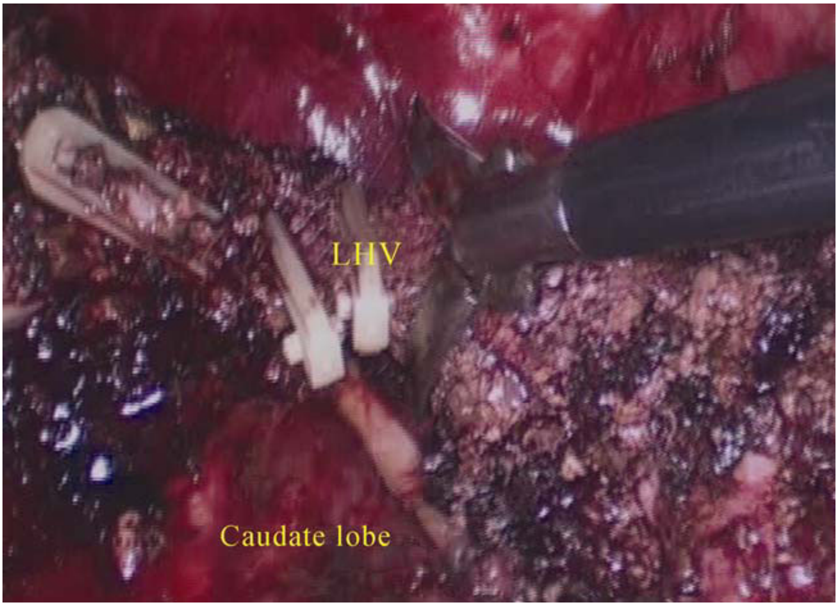


Fig.8.6. The LHV is dissected and ligated

The hepatic artery and its partial branches were easily identified due to its superficial location. The hepatoduodenal ligament was transected by blunt dissection technique to expose the hepatic artery; its partial branches were identified, clipped and divided. The left inferior border of the hepatic hilum transversal furrow was well exposed by the assistant using two grasping forceps to push caudate lobe upward (Fig.8.7). The liver capsule and parenchyma were opened and bluntly removed by LPMOD and all the small branches of the left hepatic artery and portal vein supplying the Spiegel lobe as well as small biliary ducts were progressively identified, clipped and divided (Fig.8.8). The Spiegel lobe was gently pushed left to expose the left border of the umbilical venous ligament anterior to the IVC. The bridge hepatic parenchyma was dissected along the border of the hemangioma and the Spiegel lobe was excised after clipping or electrocauterizing the communicating vascular branches. Having been completely separated from the remaining portion of the liver, the Spiegel lobe was maneuvered upward with a grasping forceps, and a right-angled forceps was used to expose the short retrocaudate veins to be clipped and divided.

The raw resected parenchymal surface was coagulated by LPMOD (Fig.8.9) and sealed with fibrin glue to control minor bleeding and bile leakage. A new 3-5 cm laparotomy incision was made via the two original 5 mm trocar entry points in order to remove the sterilized plastic packaging along with two entire tissue specimens.

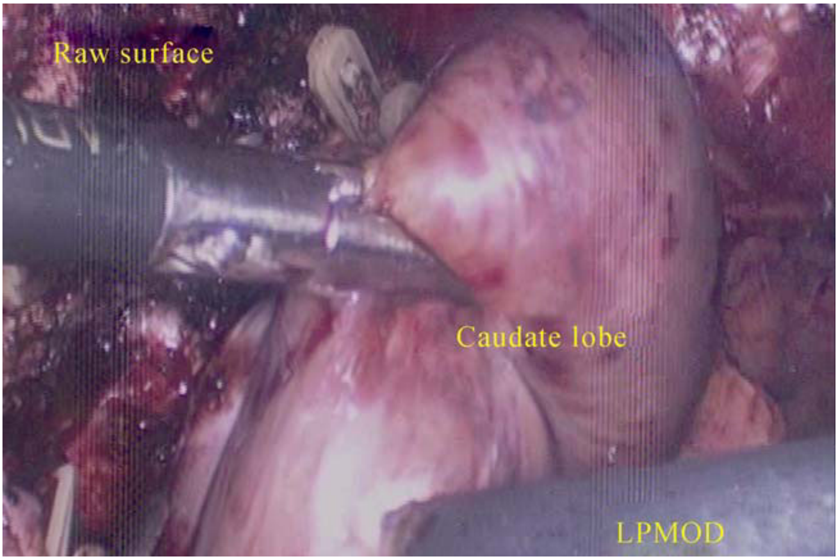


Fig.8.7. The caudate lobe is pushed upward and transected

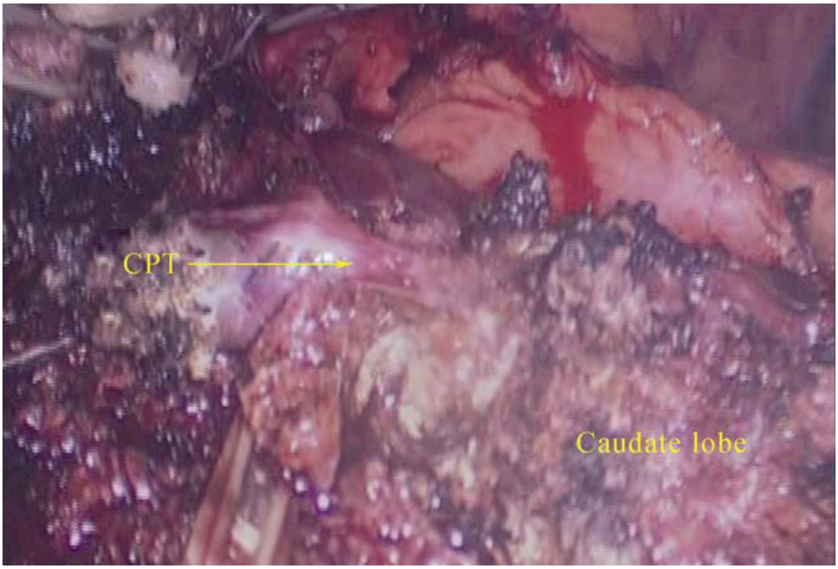


Fig.8.8. A CPT is dissected

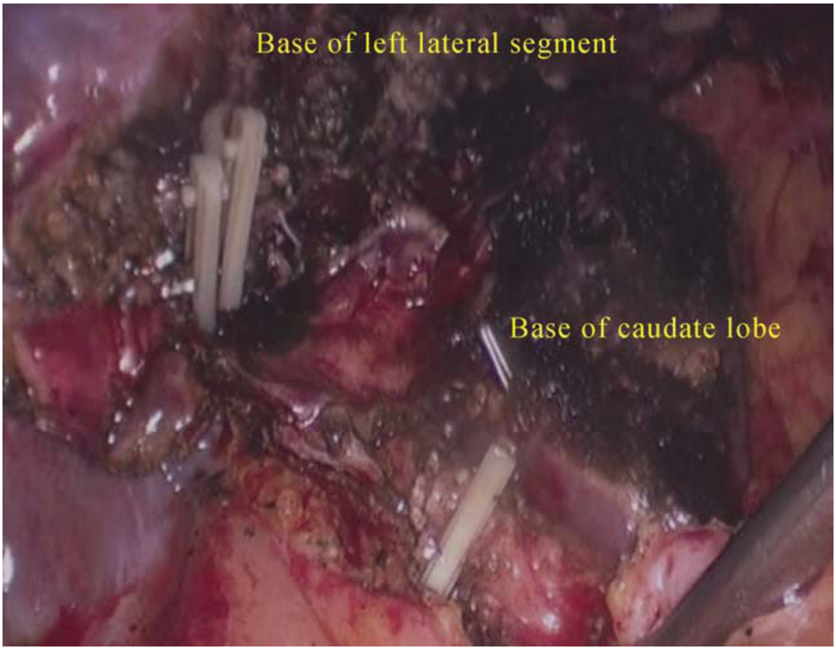


Fig.8.9. The caudate lobe and left lateral segment are resected, and the raw surface is coagulated

References

Cai XJ, Dai Y, Yu H, et al. (2009) A case report of retrograde laparoscopic Spiegel lobectomy: an alternative surgical procedure. Chin Med J (In print)

Reich H, Mcglynn F, Decaprio J, et al. (1991) Laparoscopic excision of benign liver lesions. Obstet Gynecol 78: 956-958

Cai XJ, Yu H, Liang X, et al. (2006) Laparoscopic hepatectomy by curettage and aspiration: experiences of 62 cases. Surg Endosc 20: 1531-1535

Index