

Neurosurgery for mental disorder

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of the Royal College of Psychiatrists

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Executive summary

Service issues

Summary

1. The longer-term trend is for fewer operations in fewer centres with fewer referred patients coming to operation.
2. Being vulnerable to changes in key personnel, some services appear to have developed or disappeared for this reason rather than for planned service needs.
3. Surveys suggest that psychiatrists still see a role for neurosurgery for mental disorder (NMD) for a minority of patients who do not respond to conventional treatments.
4. There is no uniformity of access to NMD. In the past, it has not been clear that patients have referred fulfilled the basic referral criteria for NMD.
5. Many aspects of the process of care vary between centres. This was markedly so in the past, and it is a clear indication for the need for greater liaison between centres.
6. Comparative data between UK centres is lacking.

Implications

NMD in the UK may either die out or continue to develop in a piecemeal way. There is no formal sharing of information between centres, and no collection of data on a national basis.

Recommendations

1. Given the evidence base reviewed in this document, it would be unwise to allow NMD to die out.
2. It is inappropriate to sanction the uncoordinated development of new centres.
3. Steps should be taken to conserve the current resources within established centres in London, Dundee and Cardiff through the establishment of a National Advisory Committee (NAC) (see below).

Clinical issues

Clinical effectiveness

1. Despite 50 years of NMD, the general quality of the outcome data is poor. There are no published randomised, prospective, controlled trials of modern operations.

2. Mean global outcome scores suggest some improvement of follow-up in all studies in all clinical groups (affective disorders, obsessive–compulsive disorder (OCD), and non-OCD anxiety).
3. Symptom-based outcome measures suggest more modest improvement.
4. This may be a specific treatment effect of NMD, but it is impossible to exclude other factors (e.g. selection bias or post-operative treatment) in accounting for the success of the operation.
5. There is a trend for more recent outcomes not to be as good as previously, but it is unclear why this is the case (especially with affective disorders and subcaudate tractotomy).
6. The quality of the outcome data does not categorically support the view that any one operation is specific for any one diagnosis. However, some operations are used more commonly for certain diagnoses (e.g. subcaudate tractotomy for depression, capsulotomy for OCD/non OCD anxiety). This means that the data base for using capsulotomy for depression has been small.
7. There are sufficient data to support the view that OCD, depressive disorder, non-OCD anxiety disorder and bipolar affective disorders are indications for NMD.

Implications

There are conspicuous gaps in the outcome literature, particularly concerning the use of operations other than subcaudate tractotomy for affective disorder. The centres in Cardiff and Dundee that currently use capsulotomy should help to fill this gap.

The data suggest that more consideration should be given to targeting symptoms rather than syndromes when contemplating operation. This may mean moving away from merely having restricted diagnostic categories (e.g. treatment-resistant depression), towards a more sophisticated approach looking at targeting specific symptom profiles informed by research (e.g. What acquired neuropsychological deficit caused by a stereotactic lesion is most likely to mediate the therapeutic effects sought in terms of a given symptom?).

Recommendations

1. A standing prospective audit should be set up that routinely collates data from all operations in the UK.
2. This audit should be UK-wide and organised by the NAC for NMD.
3. The Committee's role should be to standardise the audit process across centres and collect information into an annual report.
4. The audit standard should be both process and outcome-oriented, should evaluate inadvertent departures from intended treatment plans, and should focus on the details of the wider therapeutic strategy, for example, rehabilitation.

5. An annual meeting should be held that clinicians from all UK centres for NMD should attend.

Adverse effects

Summary

1. There are few studies dedicated to looking at these issues and much of the reporting can be criticised for lacking independence and a structured approach.
2. Undoubtedly, modern NMD does not carry the grave risks that older operations had, although the types of risks remain similar.
3. Close scrutiny of the data suggests that although some centres have reported low levels of adverse effects, this is variable (in the international context) and different operations may confer different risk profiles (e.g. weight gain and capsulotomy).
4. Tertiary referral centres may lose contact with patients and therefore lose data about longer-term adverse effects.
5. There are specific gaps in the reported UK data – notably concerning the effect of subcaudate tractotomy on personality.

Implications

1. Data collection should be standardised across UK centres, and structured.
2. The use of specific psychometric tools for the assessment of personality change (such as that quoted by Sackdev & Hay (1995) should be considered).
3. Long-term contact with patients post-operatively needs to be encouraged to get more realistic data about adverse effects, especially the incidence of epilepsy.

Recommendations

1. The NAC should establish long-term audit of adverse effects and collate clinical information.
2. There should be a national database of patients having NMD. Patients should have long-term, probably lifelong, follow-up.
3. There is a need for further neuropsychological research.

Implications for future research

Summary

Much neuropsychological research has been defensively framed and carried out by researchers who are not independent of the local NMD programme. There are

specific gaps in the published clinical research, notably the effects of certain operations, such as subcaudate tractotomy on personality.

Other promising areas such as the use of the gamma knife appear to have been abandoned.

Implications

Although NMD has a long clinical pedigree and cannot be regarded as an experimental procedure, the way in which clinical effects by brain lesions are mediated is poorly understood.

The placing of stereotactic lesions provides a unique opportunity to explore mind–brain relationships, but this is clearly not a justification for the operation in the absence of clear clinical indications. These two factors place an ethical obligation on the practice of NMD to be tightly integrated with a research genre that looks at the interface between basic neuroscience and clinical practice.

Recommendations

1. The NAC should have as part of its remit the task of bringing together research interests (in basic and clinical neuroscience) and clinical services.
2. The NAC should foster a culture of enquiry into NMD that is not defensively framed, for example, by hosting annual meetings, establishing a website, etc.
3. Future research should be hypothesis-driven, focusing on what has changed rather than on what has not.

Medical legal issues

The authors note the difference between the Scottish, and English and Welsh, Mental Health Acts, and the recommendation of the Scottish review to allow patients incapable of consent to have the operation.

We feel that the Crown pressures of consent within England and Wales should not be changed.

Central recommendations

1. A NAC should be established whose main function would be to monitor all aspects of NMD practice.
2. A central task for the NAC would be the establishment of a multi-centre prospective audit, through the deployment of standardised process and outcome measures.
3. A second task would be the development of nationally agreed assessment and treatment protocols.

4. The NAC should have a liaison function with other international centres and with researchers.
5. The NAC should convene the NMD community in at least an annual UK meeting.
6. The NAC should develop a service database for referrers, and a confidential clinical database for the long-term follow-up of patients. This would help evaluate adverse effects on long-term outcome.
7. The NAC should produce an annual report about NMD activity in the UK, including an annual update on current activity.
8. The NAC should be independent of the Royal College of Psychiatrists and the Mental Health Act Commission, and of other clinical bodies.
9. The NAC should have representatives from professional bodies as well as medical, legal, lay user and research representatives.
10. The NAC should be funded centrally and report to the Department of Health.

1. Introduction

Background to this report

This report has been produced at the request of the Council of the Royal College of Psychiatrists.

It has been written because of a number of developments in the area of NMD in the last few years.

1. The Scottish Office produced a report in 1996 entitled *Neurosurgery for Mental Disorder: A Report by a Good Practice Group of the CRAG Working Group on Mental Illness*. Although this is an excellent comprehensive document it refers specifically to Scotland and not to the UK as a whole.
2. There have been marked changes in the clinical delivery of neurosurgery. The Brook Hospital has closed, neurosurgery is no longer carried out in Bristol, Birmingham or Leeds, and new centres opened in Dundee in 1992, and Cardiff in 1993.
The Brook Centre stopped operating in 1996 because the yttrium crystals used in the operation were no longer available and the centre had to consider other interventions.
3. The Royal College of Psychiatrists has not to date produced any position statement or clinical guidance on neurosurgery.
4. Most importantly, most of the recommendations of the Scottish Office Report have not been implemented, and there seems to be no will to take these recommendations forward in Scotland.

A small working group was set up. We took evidence from a wide variety of bodies and individuals, and these are listed in Appendix 4. We have also reviewed the published data on neurosurgery up to the end of 1999 as comprehensively as we can.

We have not considered the law and the Mental Health Act in relation to neurosurgery for mental disorder. This was extensively discussed in the Scottish document, in part because there was a debate about whether to bring the Scottish practice in line with that in England and Wales.

The original remit of this working party changed during the course of gathering evidence. Originally, the intention was to establish a prospective audit of UK NMD. It became clear during the period that we met that, first, the activity level was declining and that, second, the audit would mean the development of protocols concerning process and outcome that could not be simply imposed on contemporary operation centres.

The current report also supplements the Scottish document by having a comprehensive review of the literature on efficacy and adverse events. We also

intend to make a more detailed statement about recommendations for future clinical activity and research. We particularly wanted to give further consideration to a key recommendation of the Scottish document – the establishment of the Standing Advisory Committee to oversee the standards of care provided by the Dundee centre.

Definition of neurosurgery for mental disorder

In this report, we use the term 'neurosurgery for mental disorder' (abbreviated to NMD) in preference to 'psychosurgery', for exactly the same reasons described in the Scottish document. We mean by the term 'neurosurgery for mental disorder' a surgical procedure for the destruction of brain tissue for the purposes of alleviating specific mental disorders carried out by a stereotactic or other method capable of making an accurate placement of the lesion. Stereotactic techniques in neurosurgery involve fixing the patient's head in a metal frame and inserting probes through burr holes under computer tomographic (CT) or magnetic resonance imaging (MRI) guidance using the frame as a reference point to indicate the depth and angle of the probe. A target site can therefore be more precisely located. The destruction of brain tissue is then achieved by heat, cold, surgical resection, or implantation of radioactive seeds. In NMD, the size of the lesions made are very small – about the size of a pea. NMD does not refer to other surgical procedures (e.g. temporal lobectomy, amygdalotomy or thalamotomy), nor to similar neurosurgical operations that are used to treat conditions that are not mental disorders, such as epilepsy. Our decision to adopt the term neurosurgery for mental disorder was made for four reasons:

1. 'Psychosurgery' is not a homogenous concept; it subsumes a variety of surgical techniques that have been used to treat a range of different conditions, including pathologically violent behaviour. The term 'psychosurgery' (which was introduced in the 1940s) therefore encompasses a number of operations that are no longer used, as well as a number of disorders for which a neurosurgical approach would no longer be considered appropriate.
2. One of the difficulties surrounding the discussion of NMD is that outwith psychiatry the term 'psychosurgery' continues to be equated with 'lobotomies'. The use of the term NMD distinguishes between long-abandoned 'freehand' neurosurgical techniques and modern procedures.
3. Third, our definition makes reference to 'specific mental disorders'. Future research may extend the range of disorders for which NMD might be appropriate. Later in this report we recommend that NMD should be used in the treatment of refractory OCD, affective disorders, and that it may have a role in the treatment of severe, chronic non-OCD anxiety disorders. The proposed use of NMD for any other diagnoses should be considered as research and be subject to further scrutiny.

4. The fourth reason for favouring the use of 'neurosurgery for mental disorder' is that the term 'psychosurgery' perpetuates the idea that it is a unique form of surgery. The reality is that the procedure is both technically and conceptually very similar to some other forms of neurosurgery (e.g. for control of chronic pain or the treatment of tremors). To continue to make a distinction in this way serves only to stigmatise the patients for whom NMD might be considered a treatment option.

2. Neurosurgery for mental disorder: the issues

Should NMD be allowed to die out? There is no doubt that this is one reading of the wider national and international historical trend. This report aims to draw attention to this possibility so that all those who have a stake in this treatment approach can have the opportunity to take stock. Accordingly, to help with the stock-taking, there are comprehensive reviews contained in this report about the clinical effectiveness of these operations and the adverse effects that they might have.

The reasons why NMD might disappear (in the longer term) are not merely to do with a lack of evidence of efficacy or fears about major adverse consequences. NMD has always been an emotive treatment option and one that has attracted wide political and social concern. The abandonment of the old term 'psychosurgery' can in part be seen as an attempt at re-branding in order to move away from an uncomfortable past.

It may be naive to assume that the ambivalence that the wider health care system has towards NMD is going to be resolved by adopting the recommendations of this report, but the intention is to move towards greater openness of approach and a wider sense of ownership.

This report is not an obituary. It aims to start a debate about the clinical framework within which contemporary NMD ought to exist in line with the new culture of clinical governance. The recommendations that the report makes are essentially concerned with putting NMD on a more strategic footing in the National Health Service (NHS). This has never occurred before.

3. Historical background

Introduction

It is not possible to understand current NMD without reference to the past if we wish to account for certain key aspects of its contemporary practice within the UK – notably why certain diagnostic indications are considered appropriate, why certain neurosurgical sites have been targeted and why the regulative framework within which NMD is currently performed has developed.

These three issues relate back to a fourth – that is, why the operations developed with such enthusiasm but subsequently declined in number. This decline has never been absolute. The aim of this section of the report is to elucidate some of these issues in brief outline and thus set the scene for a review of current practice. A fuller account of the development of NMD can be found elsewhere (Valenstein, 1986, 1990; Berrios, 1991; Diering & Bell, 1991; Swayze, 1995; Pressman, 1999).

Initial enthusiasms

It is conventional to attribute the origin of modern NMD to the Portuguese neurologist Egas Moniz, who published the results of 20 operations performed on the frontal lobes in 1936. However, surgical procedures on the frontal lobes of psychiatric patients had taken place prior to this (Berrios, 1991) and a large literature on the mental and emotional consequences of damage to the frontal areas did exist prior to the Moniz operation (Valenstein, 1990). Nevertheless, within 3 months of this publication, operations were being carried out in five other countries. Neurologist Walter Freeman and neurosurgeon James Watts initiated the programme in the USA in September 1936 and went on to popularise the procedure in developing the 'standard leucotomy'.

By 1949, approximately 10 000 operations had been performed within the USA, 18 600 being completed by 1951 (Swayze, 1995). The first 'modern' operation in the UK was in December 1940; by 1954, at least 10 365 had been performed (Tooth & Newton, 1961). The peak number of operations in the UK occurred in 1949 (1211) declining to 525 per annum by 1960 (Pippard, 1962), thence to an average of 140 per annum by 1974–1976 (Barraclough & Mitchell-Heggs, 1978), 31 per annum in the 1980s and 23 per annum on average between 1990 and 1994 (Good Practice Group, 1996). Since the 1960s, stereotactic procedures have been carried out in the UK and in recent years these have been the only ones used.

A number of factors converged to popularise leucotomy. In the 1940s, there was dire clinical need on the one hand (Dax, 1977) and ineffective alternative treatments on the other (Valenstein, 1986). The surgical procedures were essentially simple, could be performed by non-specialist asylum-based surgeons

(or even non-surgeons) and early results were encouraging (Crossley, 1993). It was considered that leucotomy gave the opportunity for hopelessly ill patients to be discharged (Partridge, 1950). There was a dramatic increase in the asylum population (peaking in the UK in 1949) and there was a perception, at least in the USA, that the operation could be highly cost-effective (Swayze, 1995). Professional factors – such as the sense of renewed therapeutic optimism (Dax, 1977), the desire for respectability fulfilled by the opportunity to administer physical therapies and the relative isolation of psychiatric institutions (Simmons, 1987) – probably played a role too. Theoretical coherence conferred by animal experimentation bolstered confidence as well as the professional support given by distinguished academics like Fulton (Valenstein, 1990). The clinical development of the field was fostered by a small number of highly dedicated practitioners like Freeman who were keen to promote evidence of efficacy. Many relatives and the popular press were equally supportive in the early years.

The accumulating evidence of adverse effects (personality change, obesity, epilepsy and incontinence) and the introduction of chlorpromazine in 1954 are obvious reasons for the decline in operative rates (Tooth & Newton, 1961), although there was little evidence of decline in the rate of modified techniques throughout the 1950s (Pippard, 1962). The proportion of patients accepted for surgery in recent years may be declining as a more robust use of pharmacological and non-pharmacological treatments is advocated (Bridges, 1989*a*). Tighter regulation and social disquiet may have had an influence in constraining the use of NMD, for example, in the USA (Gonzales, 1980), but surveys of the attitudes of UK psychiatrists have consistently supported a role for NMD (Snaith *et al*, 1984; Good Practice Group, 1996). Refined stereotactic techniques with reports of lower adverse effects and continued evidence of treatment resistance in a small group of severely disabled patients are factors in support of its use.

Evolving operations

A number of observations can be made about the development of operations for NMD since the mid-1930s.

The standard leucotomy devised by Freeman & Watts was essentially a 'blind', freehand procedure involving burr holes being made in the temporal area and a surgical instrument inserted into the prefrontal cortex and swept up and down in an arc. The potential for hazards was obvious from the earliest days. Open procedures were developed but not necessarily widely adopted – more than half of all leucotomies performed in 1960 were blind (Pippard, 1962) and, although the stereotactic technique was developed in 1947, even in 1976 only two-thirds of operations were controlled in this way in the UK (Barraclough & Mitchell-Heggs, 1978).

The second trend to note is how a multiplicity of operations devised in the 1940s and 1950s was gradually replaced by a far more limited number of target sites and techniques by the 1990s. Swayze (1995) documents 24 different procedures

prior to 1954 worldwide; at least 10 different procedures were being used in the UK in 1960 (Pippard, 1962). Techniques for tissue destruction have moved away from the use of surgical steel to the use of radiation or thermal injury.

A third point to note relates to the process of innovation. In the 1940s, innovation took place at the hands of general surgeons based in asylums as much as it did in neurosurgical centres (Crossley, 1993). By 1976, two-thirds of UK operations were performed in four units – the remainder in 27 hospitals. At least 19 different target sites have been used for NMD over the years (Bouckoms, 1988). Two of the contemporary operations used in the UK (subcaudate tractotomy and limbic leucotomy) can trace their surgical lineage back to some of the founders of British NMD (Knight, 1969; Kitchen, 1995). A small number of clinicians working from a small number of centres have been important. In the absence of large-scale trials comparing inter-operative efficacy rates, the influence of personal clinical experience (by evaluating individual case series) in modifying surgical procedures has of necessity been great. The final size of the subcaudate tractotomy lesion evolved in this way (Bridges, 1994). The subcaudate tractotomy lesion has had to be changed again now that the radioactive rods are no longer available (Malhi & Bartlett, 1998).

A fourth feature to be noted has been the dynamic relationship that NMD has had with the theoretical accounts used to understand its effects. Initially, speculation about its theoretical underpinning were borrowed from contemporary psychological frameworks – Moniz used the idea of the 'idée fixe', Percy Rees (Chairman of the first UK conference on leucotomies in 1943) Freudian metapsychology. MacClean's description of the limbic system (Valenstein, 1990), post-mortem data relating efficacy to surgical targets (Meyer *et al*, 1947) and the influence of neuroscientists such as Fulton – together with other clinical observation (Greenblatt, 1950) – helped to define the target sites towards the ventromedial part of the prefrontal cortex or the cingulate gyrus. More recently, the role of the basal ganglia in OCD has been proposed, but some of these theoretical accounts of the neuroanatomy of OCD are themselves underpinned by the results of NMD operations (Trivedi, 1996). This introduces a certain circularity into the historical argument as to whether innovation in NMD is ever theoretically driven or, as some commentators maintain (e.g. Valenstein, 1990), is essentially empirical.

Indications

Even early outcome literature noted the best symptomatic results were in tension states, depression and obsessional cases, almost regardless of the wider syndromic picture (Hutton, 1943). In Tooth & Newton's review (1942–1954), the majority of operations were carried out on patients with schizophrenia, and behavioural criteria were important (to help in nursing) (Fleming, 1944). Even in 1974–1976, 8% of patients were selected on behavioural grounds (Barracough & Mitchell-Heggs, 1978).

Outcome has consistently been deemed best in affective disorder, obsessional disorder and anxiety. In a 1981 UK consensus statement, schizophrenia came to be an indication only if these other target symptoms were prominent enough to be regarded as important (Bartlett *et al*, 1981). Although a 1970s survey of US surgeons found that the majority did not feel that there were specific neuroanatomical targets for specific diagnoses (Valenstein, 1990), there has been a trend in recent outcome literature towards greater specificity – for example, the subcaudate tractotomy is used primarily for affective disorder whereas other operations have been used in anxiety disorder (including OCD) (Mindus *et al*, 1994a; Hodgkiss *et al*, 1995).

Regulation and scrutiny

Public disquiet about NMD tended to be most vociferous long after its use declined. In part, this may have been to do with more general fears about psychiatric practice, abuses of NMD (dramatically represented in the film *One Flew Over the Cuckoo's Nest*) and a concern that biological solutions were being proposed for social problems. The absence of good-quality outcome data made NMD more difficult to defend, but ironically the 1977 Royal College of Psychiatrists proposal for a prospective multi-centre controlled trial collapsed "for reasons that seem shadowy but which have been related to active political lobbying by critics" (Lancet editorial, 1979). Official enquiries in the USA and Australia in the late 1970s both favoured its continued use but with tighter regulation. The 1983 Mental Health Act imposed a new regulative framework – the relevant section that made it impossible for patients to consent without the agreement of the Mental Health Act Commission coming as a somewhat unexpected amendment (Bluglass, 1984). There have been at times tensions between the Commission, who are empowered to refuse consent, and NMD centres in consequence (Bridges, 1989b).

Summary

1. There is a tendency for fewer cases to come to operation in the longer term.
2. New centres tend to emerge if interested clinicians decide to develop a service. Specifically, this means a neurosurgeon and psychiatrist pairing up.
3. Surveys of clinicians support a continued place for NMD (Snaith *et al*, 1984; CRAG Working Group on Mental Illness, 1996).
4. Surgical innovation has been shaped more by the pragmatic review of personal case series than by theoretical developments of the evidence of clinical trials.
5. The demise of some services demonstrates how vulnerable the continuation of NMD is to changes in key personnel.

6. There are some regional variations within the UK in the legal framework that surrounds NMD in relation to issues of consent.
7. From the earliest days, clinicians have noted that NMD has been better for target symptoms rather than target syndromes.

Implications

Given the historical trends, there is the possibility that NMD could die out within the NHS. There may be a number of reasons for this, but this process is likely to be hastened unless the NHS is prepared to 'own' the service and take responsibility for its future evaluation and development at a more strategic level than previously.

An alternative possibility, bearing in mind the historical trends, is for piecemeal development to occur at regional level with the attendant risk of variation in quality.

4. Neurosurgery for mental disorder: review of efficacy

Introduction

There are no simple answers to the question "Is NMD clinically effective?", let alone the subsidiary question of which procedure may be most effective for which diagnosis. This section of the report aims to review the stereotactic operation literature and discuss the relevant issues that bear on the question of clinical effectiveness. These issues concern the:

- quality of past outcome data
- availability of controlled evidence
- evidence from sham procedures
- relation of lesion site to efficacy
- relative efficacy of one procedure compared with another information from consolidated data reviews.

Finally, there is a review of outcome data as of 1999, which is supplemented by what is intended to be a comprehensive tabulation of outcome studies of stereotactic procedures by three major diagnostic groups (OCD, other anxiety disorders and affective disorders) to be found in Appendices 1–3.

Quality of past data

With some exceptions, much of the older (and some of the recent) outcome literature suffers from a catalogue of deficiencies. These include reports based on poorly defined diagnostic categories, retrospective designs with global outcome measures that neglect specific domains (e.g. symptoms or social criteria), short periods of pre- and post-operative observation, failures to control for observer bias (authors having often both selected their patients and evaluated the outcome) and limited information about neurosurgical technique being given (i.e. the site, size, shape of the lesion remaining unclear).

There are no randomised double-blind placebo-controlled trials. Evaluating efficacy of any last resort treatment is inherently problematic.

Summary

Despite 40 years, experience of stereotactic NMD, the quality of the outcome data is generally poor.

Implications

It should be feasible to set up a prospective audit in the UK that would go some way to answering basic questions about efficacy and quality of care. The audit framework should include well-defined diagnostic criteria, multi-dimensional measures of outcome, measures to minimise observer bias and full details of operative technique. It would fall short of true outcome research by not having control groups or blind measures.

Availability of controlled evidence

Controlled evidence for the efficacy of NMD is in short supply at least as far as contemporary operations are concerned. In total, there are five studies, but two of these report non-stereotactic procedures.

There are two trials of modified leucotomy (a non-stereotactic procedure) that used a similar retrospective design (Marks *et al*, 1966; Tan *et al*, 1971). The earlier study examined outcome in anxiety and severe agoraphobia – the later obsessive–compulsive neurosis. Both used patients matched for age, gender and symptom severity and employed independent 'blind' raters.

Twenty-two patients with anxiety and agoraphobia made up the treatment group in Marks *et al*'s study. After five years, they were significantly less phobic and more likely to be compared at work with the non-surgery group ($p<0.05$). In Tan *et al*'s study, 24 patients with obsessional neuroses compared with 13 control patients over a five-year period had significantly reduced obsessions ($p<0.05$) with better work adjustment without major adverse effects on personality.

A study by Bridges & Goktepe (1973) matched 24 patients with OCD to 24 patients with depression and concluded that, after subcaudate tractotomy three years previously, 67% of the obsessional group and 71% of the depressive group were either symptom-free or required only minimal treatment.

A recent study from Australia by Hay *et al* (1993) compared a subgroup of 10 patients with OCD who had had a stereotactically controlled operation (orbitomedial and/or cingulate lesion) with matched, retrospectively defined controls. The follow-up was 10 years. None of the controls had had any remission for a period greater than six months either spontaneously or in response to treatment compared with 30% ($n=3$) of the surgery patients who had had sustained remissions that could not be ascribed to any other treatment intervention except the operation.

In the Netherlands, using their own target symptom measures (administered postally to both clinician and patient), Cosyns *et al* (1994) compared a group of patients with OCD who had been offered surgery but had chosen not to have it ($n=7$) with an operated group ($n=21$). The operation was either a subcaudate tractotomy or a multifocal leucocoagulation and the follow-up period was on average seven years. There were statistically significant falls in the treated group's symptoms – less marked in the treated patients' own estimation – but no significant change in the non-surgery group.

Summary

Controlled data from five studies supports the view that the operations are effective in a variety of conditions, but all these studies use retrospective control groups.

Evidence from sham procedures

There are obvious ethical objections to performing any sham procedure as part of any treatment trial, but there are a number of case reports in the literature.

There are no case reports of a sham procedure leading to durable clinical benefit. The most often cited case report involved four patients with psychotic disorder in whom skin incisions and burr holes were made but without cerebral lesions. None improved (Livingstone, 1953). There is a case from the Netherlands in which a 50-year-old man with obsessional symptoms had a sham procedure performed. As there was no improvement at two-month follow-up, he was operated on but only improved when the lesions were enlarged (Cosyns & Gybels, 1979).

Balusabramianian *et al* (1973) performed sham procedures on three drug addicts and told them the operation had been performed. There was no effect on their addictive behaviour until cingulate lesions were made. One of the 57 patients in Corkin *et al*'s cingulotomy series (1979) was found to have abnormal cerebral anatomy during the operation and the targets were not lesioned. The woman was told the operation had gone well but had been modified. She appeared to be less disabled by her thoracic pain (the operative indication) but only transiently.

The literature usually considers that a placebo effect in NMD is unlikely bearing in mind that the psychiatric disorders have run such a long course pre-operatively and some of them – like OCD – are known to have low placebo responses to treatment. However, Poynton *et al* (1995) suggested that some of the very early improvement in about a third of their series of 23 patients may have resulted from a placebo effect of the operation. However, it is unlikely that this would explain long-term clinical improvement.

Summary

The evidence therefore from sham operations suggests that the lesion may have a therapeutic value, but most of the reports quoted above used NMD for non-conventional indications.

Implications

Inadvertent departures from operative technique could lead to useful clinical information and should be reported systematically.

Lesion site and efficacy

How important is it for targets to be accurately localised? In a post-mortem study performed on two cases of suicide of whom both had had old-fashioned leucotomies (which had therefore failed to be clinically effective), it was found that both still had intact fronto-thalamic connections (the putative target site) (Evans, 1971).

In the capsulotomy series, Mindus (1991) accounts for half of the treatment failures as a result of deficiencies in neurosurgical technique and in a small series of patients treated with the gamma-capsulotomy method ($n=7$) lesions were clearly visible and accurately targeted in the responding group on MRI scan ($n=5$) but were asymmetrical in the non-responders when evaluated seven years post-surgery by independent assessor (Mindus *et al*, 1987).

A MRI imaging scan review of 14 patients from Australia (Sachdev & Hay, 1996) who had had mixed lesions (some only orbitomedial, some only cingulate, some both) for the treatment of OCD concluded that an (undetermined) minimum size of lesion was required for clinical improvement beyond which enlargement conferred no further benefit. It also suggested that orbitomedial lesions were more effective than cingulotomy for OCD.

This obviously makes it difficult to know when re-operation is indicated. Re-operation rates vary from 39% in the USA (Baer *et al*, 1995) to 30% in the Australian series (Hay *et al*, 1993) and 20% in Spain (Burzaco, 1981).

Summary

It is possible that accuracy of target site is an important factor in outcome, but it is not clear how important.

Implications

The theoretical basis for deciding the exact neuroanatomical coordinates is poorly understood, which means that deciding about lesion size and enlargement is also unclear. Clinically, it may be difficult to decide whether an operation has failed or whether to re-operate and enlarge the lesion. This should be the subject of audit.

Comparative efficacy rates (across procedures and disorders)

There is little literature that systematically compares efficacy rates between procedures currently in use (i.e. capsulotomy, cingulotomy, subcaudate tractotomy and limbic leucotomy).

Obsessive-compulsive and anxiety disorders

Only two trials have been published that prospectively set out to compare one technique with another. Fodstad *et al* (1982) reported a randomised trial of capsulotomy *v.* cingulotomy for obsessive-compulsive neurosis and claimed

after a two-year follow-up that capsulotomy showed some superiority in anti-obsessional effect – but the trial only had two patients in each treatment cell. A different trial of 14 patients (Kullberg, 1977) also claimed better outcome for a capsulotomy group (with a mixture of OCD and non-OCD anxiety disorders) compared with a cingulotomy group. It was found that a statistically significant 6 out of 13 in the former compared with 3 out of 13 in the latter operative group recovered or significantly improved, but the capsulotomy patients had more organic side-effects. There were more OCD cases in the capsulotomy group, but of those patients who had both procedures improvement only occurred if the second operation was capsulotomy. The average follow-up was 3 years.

In a Dutch series, patient- and clinician-reported symptom measures were significantly improved in patients with OCD (as defined by DSM-III; American Psychiatric Association (APA), 1980) treated by subcaudate tractotomy ($n=9$) but not in those treated by multifocal leucocoagulation ($n=7$). The follow-up was on average 7 years and the symptom measures were devised for the study and no validity data are reported (Cosyns *et al*, 1994).

Recent data from the Australian series (Sachdev & Hay, 1996) suggest that for OCD an anterior capsule lesion may be more effective than a cingulate lesion. This was based on a small study of a total of 14 patients with 8 years' follow-up after NMD. Of these, 14 patients three were found on the MRI scan to have had internal capsule lesions placed inadvertently, and these patients improved more in terms of symptom score (Yale Brown Obsessive Compulsive Score (Y-BOCS); Goodman *et al*, 1989) and global outcome compared with cingulate-only lesions. Lesion size did not relate to outcome. In their review of NMD, Ballantine *et al* (1987) also found that cingulotomy performed less well in patients with OCD than in patients with affective disorders or other anxiety disorders. This view accords with the German series of 16 patients who had had mixed operations and were seen 16–22 years later (Irle *et al*, 1998). This group recommended that restricted ventromedial lesions work best for OCD as dorsally extended or added ventrostriatal lesions confer other problems.

On the other hand, Waziri (1990), in his review of NMD, suggested that capsulotomy may be the best procedure for OCD and anxiety disorders, but Mindus *et al* (1994a), in their most recent review, found results from all four procedures 'comparable' using stringent diagnostic and conservative outcome criteria (if success is defined as a 35% or greater reduction in the major dependent symptom measure).

Affective disorders

The recent outcome data for affective disorders largely relates to one operation – subcaudate tractotomy – whose global success rate is of the order of 34% (Hodgkiss *et al*, 1995; $n=183$, 1-year follow-up) to 67% (Goktepe *et al*, 1975; $n=78$;

2.5-year follow-up). These global rates refer to the top two categories of the five-point Pippard scale (which means either complete recovery, no treatment or mild residual symptoms may still require some medication).

The comparable results from the early capsulotomy series put 48% of patients in the top two categories (Herner, 1961; $n=19$, 2-year follow-up); for cingulotomy, the figure is 41% (Ballantine *et al*, 1987; $n=49$, 8-year follow-up) and limbic leucotomy 38% (Kelly, 1980; $n=36$; 20-month follow-up). These comparisons are crude, not least because the cingulotomy and capsulotomy series used 6-point not 5-point global outcomes and caution should be read into their interpretation.

Summary

Overall, at first sight, no one operation has been proved to have any diagnostic specificity, but some commentators suggest capsulotomy may be better for OCD and anxiety, whereas subcaudate tractotomy (and possibly cingulotomy) is better for affective disorders. However, this tendency for specialisation may merely reflect bias in case reports and historical referral patterns.

Implications

There is a conspicuous gap in the research literature regarding affective disorders and operations other than subcaudate tractotomy and this needs to be addressed.

Consolidated reviews

There have been two major reviews that have tried to consolidate outcome data from NMD studies using the global scales that are frequently used. It is not clear from these reviews how the authors adapted some of the 4–6 point global scales into the scales they ultimately quote, and this may be a problem in their analysis. Some recent studies have preferred to use not the 5-point Pippard global outcomes but the Clinical Global Impression scores of the DSM system instead (e.g. Jenike *et al*, 1991; Baer *et al*, 1995).

Kiloh *et al* (1988) produced a consolidated review for varying diagnoses and their data are summarised below. Only studies with at least a 6-month follow-up were included. Inclusion and exclusion criteria are not otherwise specified by the compilers. Studies were carried out between 1961 and 1980.

Depression

There were 21 studies of NMD in depression. Sixty-five per cent of operations were non-stereotactic. The outcome for the total number studied ($n=727$) is as follows:

Marked improvement	63%
Lesser improvement	22%
No response	14%
Worse	1%

OCD

There were 24 studies of NMD in OCD. 56% of operations were non-stereotactic. The outcome for the total number studied ($n=478$) is as follows:

Marked improvement	58%
Lesser improvement	27%
No response	14%
Worse	1%

Non-OCD anxiety

There were 16 studies of NMD in non-OCD anxiety. Forty-one per cent of operations were non-stereotactic. The outcome of the total number studied ($n=290$) is as follows:

Marked improvement	52%
Lesser improvement	25%
No response	21%
Worse	2%

A review of NMD outcomes for anxiety disorders and OCD published in 1990 of 11 and 12 studies respectively considered to be "the best in terms of methodology" (although this is not clearly defined beyond a 1-year minimum follow-up) is outlined below (Waziri, 1990). Only three of these studies did not use stereotactic techniques. Studies were between 1961 and 1988.

Non-OCD anxiety

There were 11 studies of NMD in non-OCD anxiety. The outcome of the total number studied ($n=225$) is as follows:

Symptom-free	32%
Minor symptoms	23%
Mild/moderate symptoms	22%
Severe symptoms	14%
Worse/dead	9%

OCD

There were 12 studies of NMD in OCD. The outcome of the total number studied ($n=300$) is as follows:

Symptom-free	38%
Minor symptoms	29%
Mild/moderate symptoms	20%
Severe symptoms	10%
Worse/dead	3%

Waziri (1990) goes on to compare these outcomes with conventional treatment efficacy rates, again using consolidated data studies. For example, in a nine-study review article by Rasmussen & Tsuang (1988) concerning the treatment of OCD by pharmacotherapy and psychotherapy with follow-up periods of between 2 and 26 years, 31% of patients were considered to be much improved, 39% improved and 40% unchanged. Mindus (1991) estimated that 20% of patients with non-OCD anxiety disorders will be either treatment-resistant (using conventional means) or will relapse.

Summary

Consolidated reviews of large numbers of patients indicate that improvement occurs (i.e. symptom-free to mild symptoms only) in depression, anxiety and OCD in around 50% of patients. These reviews, although quoting trials from the best available studies from over 10 years ago, contain the deficiencies outlined at the start of this section.

Review of outcomes of stereotactic operations as of 1999

Obsessive-compulsive disorder

Twenty-eight studies have been found that report on outcome by a stereotactic operation for OCD as of 1999 (see Appendix 2). This represents a total series of 570 separately reported on patients. The majority of these patients have some of the global scores quoted (along Pippard-type lines). However, most of the 28 studies do not quote all of the five categories of the global scoring system, leaving only 198 patients from six studies with a five-category global outcome quoted in full in which none of the categories were conflated (Strom-Olsen & Carlisle, 1971; Tippin & Henn, 1982; Bingley *et al*, 1977; Burzaco, 1981; Kelly, 1980; Fodstad *et al*, 1982). The follow-up ranged from 1 to 8 years.

Summary of obsessive-compulsive disorder studies There have been five studies, on a total of 198 subjects, treated with NMD. The outcome for these subjects is as follows:

Symptom-free	33
Minor symptoms	34
Moderate symptoms/some improvement	23%
Unchanged	8%
Worse	2%

This is comparable to the Waziri (1990) series.

Recent studies have employed symptom measures too. Jenike *et al* (1991) reviewed 33 patients in a retrospective study covering 5–24 years after cingulotomy for OCD. Using conservative criteria, 25–30% of patients "benefited substantially" and almost 60% had a 50% or greater reduction in the major symptom measure (Y-BOCS), but of the total only 43% of patients attributed this improvement to the operation alone.

The recent retrospective study of German patients (Irle *et al*, 1998) examined 16–22 years after stereotactic frontal lobe surgery, also claimed that about 70% of the group had had a 50% fall in the Y-BOCS, but the pre-operative scores upon which this comparison is based appear to be an estimate.

This raises the possibility that the operation may be an augmenting strategy in a significant number of cases. Indeed, some authors report greater efficacy of psychotherapy and drug treatments post-operatively (Cosyns & Gybels, 1979; Kelly, 1980).

A partially controlled 10-year retrospective study conducted on the Australian series of cases (Hay *et al*, 1993) (with variable stereotactic operations) also concluded that 38% of cases showed obvious improvement on the main dependent symptom measures.

The most recent US data (Baer *et al*, 1995) produced similar results to the 1991 study by Jenike *et al* – with 28% of patients showing at least a one-third improvement in the main symptom measure at 2-year follow-up but half showing no improvement. The Baer *et al* study prospectively followed up 18 patients after cingulotomy, 17 of whom also had major depressive disorder. Improvements in the OCD symptoms significantly related to improvement in depression and other anxiety symptoms, which raised the question as to which was the primary improvement. Baer *et al* consider the OCD symptoms to be the primary improvement (as all had OCD at some time without depression), but the issue is not conclusively settled.

The same intercorrelation with depressive symptoms improvement and OCD symptoms can be seen in the limbic leucotomy series (Kelly, 1980) but not in the mixed operative Australian Group (Hay *et al*, 1993).

The recent data from Sweden (Mindus *et al*, 1994a), where they used thermocapsulotomy, suggest that 60% of patients globally improve (top two categories) and remain so at review 8 years post-operatively.

Summary The most recent data suggest that between 30% and 40% of patients have significant symptom relief and a further proportion show some improvement.

Non-obsessive–compulsive disorder anxiety disorders

Fourteen studies have been found reporting outcome on 220 patients with non-OCD anxiety disorders who have had a stereotactic operation as of 1998 (see Appendix 3). Only three of these studies quote in full the 5-point (Pippard) global outcome (Strom-Olsen & Carlisle, 1971; Kelly, 1980; Mindus, 1991), representing 80 patients with a follow-up range of between 16 months and 7 years.

Summary of non-OCD anxiety studies There have been three studies, on a total of 80 subjects, treated with NMD. The outcome for these subjects is as follows:

Symptom-free	20%
Minor symptoms	20%
Moderate symptoms/some improvement	27%
Unchanged	30%
Worse	3%

These figures may not compare as favourably to the Waziri review (1990) (although two of the studies are included in his review), but these data do not include any outcomes from cingulotomy operations.

Of recent stereotactic operations, Mindus' outcome data (Mindus *et al*, 1987; Mindus, 1991) are probably the best available qualitatively as far as non-OCD anxiety disorders are concerned. He reports outcomes from the capsulotomy operation based on patients with agoraphobia, social phobia or generalised anxiety disorder as defined by the DSM-III-R system (APA, 1987). A recognised symptom rating scale – the Comprehensive Pathological Rating Scale (CPRS; Åsberg *et al*, 1978) – was used as the major dependent measure of symptomatic outcome. For 14 patients at 1-year follow-up followed prospectively, half were deemed to be symptom-free, 93% achieving the top two categories in the global Pippard scale after thermocapsulotomy (Mindus, 1991). In a smaller series ($n=7$) with a longer follow-up (7 years) after gammacapsulotomy, there was a highly significant improvement in the CPRS score post-operatively, three patients remaining symptom-free, two with only minor symptoms (Mindus *et al*, 1987).

However, a recent report (Kihlstrom *et al*, 1995) of six patients treated by gammacapsulotomy for non-OCD anxiety disorders reported 'unsatisfactory' results at 1–5 year follow-up, although no further details were given.

In the limbic leucotomy series, Kelly (1980) reported on 27 patients followed up prospectively for 20 months. He recorded significant improvement on a variety of validated symptoms measures (e.g. Hamilton Anxiety Scale (HAS); Hamilton, 1959) comparing group mean scores pre-operatively and at follow-up: overall, 30% of his patients were either symptom-free or had minor symptoms at follow-up. Significant symptom improvement in depression scores – Beck Depression Inventory (BDS; Beck *et al*, 1961) and Hamilton Depression Rating Scale scores (HDRS; Hamilton, 1967) – was also in evidence in this series.

Summary Consolidated data from global outcome measures suggest that 20% of patients are symptom-free, and a further 20% have only minor symptoms. The most recent studies from Sweden are broadly in support of but not entirely consistent with this.

Affective disorders

Eleven studies report new outcome data for stereotactic procedures for affective disorder from 1961 to 1999, which has not been published elsewhere. A further five report data that may be contained in these 11 studies. All 11 report on depressive disorders (for a total of 526 patients) and two also give some outcome on bipolar disorder. One further study gives outcome for bipolar disorders alone (Lovett & Shaw, 1987). Thus, in total, 76 patients with bipolar disorder are reported on in the literature. Few of the studies use operationalised diagnostic criteria and it may be possible that some studies (e.g. Strom-Olsen & Carlisle, 1971; Hansen *et al*, 1982) conflate unipolar and bipolar diagnoses.

Of the studies found, only three (all of which report on outcome for depressive disorders only) using two different operative techniques (subcaudate tractotomy and limbic leucotomy) report fully a 5-point global scale that allows data to be consolidated. Together these three studies (Strom-Olsen & Carlisle, 1971; Goktepe *et al*, 1975; Kelly 1980) report on 189 patients.

Summary of depression studies There have been three studies, including 189 subjects, treated with NMD. The outcome for these subjects is as follows:

Symptom-free	34%
Minor symptoms	23%
Moderate	22%
Unchanged	19%
Worse	2%

Subcaudate tractotomy for depressive disorders The largest single series of cases have been performed in one centre (the Geoffrey Knight Unit at the Brook Hospital London) using one operation (subcaudate tractotomy). Indeed, about 65% of all reported stereotactic operations for affective disorders have used this technique.

Recent outcome is worse than in the earlier reports (Strom-Olsen & Carlisle, 1971; Hodgkiss *et al*, 1995). The first substantial review of patients by Strom-Olsen & Carlisle in 1971 reported that 56% of patients with depressive illness showed satisfactory improvement post-operatively. They fell into categories 1 and 2 using the global rating scale, which meant they were either completely recovered or were improved to the extent that no treatment was required, but they had slight residual symptoms.

The Geoffrey Knight group looked at cases again up to 1973 and then between 1979 and 1991. In the first group of patients, Goktepe *et al* (1975) described 78

fully assessed patients, of whom 68% appeared to be in category 1 or 2 as described above. In the second analysis (1979–1991), Hodgkiss *et al* (1995) reviewed 183 patients with depression, 34% of whom had outcome within categories 1 or 2. These global categories of change following operation were said to correlate well with self-report questionnaires such as the Wakefield Depression Score and the Taylor Manifest Anxiety Scale (Snaith *et al*, 1976). Justification for such global scales was the fact that an independent consultant looking at the cases blind had results that correlated very highly with those of the unit's consultant with no more than a difference of one category. Hodgkiss *et al* argue that the apparent decrease in efficacy in the operation can be put down to the use of high dose and combined antidepressants successfully treating patients who would otherwise have been operated on in the earlier years. Thus, whereas in 1989 21% of patients referred for operation actually had it done, in 1979 the comparable figure was 64% (Bridges, 1992). They suggest that more recent patients are more treatment-resistant and therefore may not respond as well to the operation.

A further attempt to evaluate change in patients following subcaudate tractotomy was that of Curson *et al* in 1983. He used the weighted Present State Examination (PSE; Wing *et al*, 1974) before the operation and 12 months after the operation. The assessment was independent but the groups were mixed incorporating both patients with depression and with true obsessional disorder. Overall, 15 of the 34 had a good outcome and the rest poor. Their comments were that the operation was most useful for nervous tension, psychic anxiety, depressed mood and somatic anxiety. Poynton *et al* (1995) also used the PSE and noted that in their series of 23 patients, although virtually all could be given a research diagnostic criteria diagnosis – about 70% were suffering from depression – the whole group was polysymptomatic. However, they found that the self-reported anxiety scores at their 6-month review were the least likely to have changed compared with the pre-operative scores. A similar result was reported in a small series from Spain (Broseta *et al*, 1979). It was not, as in all the series, possible to predict on presentation what the outcome would be.

Capsulotomy in depressive disorder With regard to other operations, there is only one published record of the use of capsulotomy for depressive disorders and this dates to the 1950s. Of the 19 patients assessed, 48% were said to be symptom-free or markedly improved, but 21% ($n=4$) were deemed to be worse symptomatically or behaviourally at follow-up 2 years later (Herner, 1961).

Two centres in the UK in Dundee and Cardiff currently use this operation for affective disorders but outcome data are not yet available. The use of capsulotomy in the UK is therefore based on a low data base (19 patients) operated on in Sweden in the 1950s.

Cingulotomy for depressive disorder Martin *et al* (1977) report on 27 patients classed as having neurotic depression treated by cingulotomy. Of these, 11 (41%) reported

an excellent result and the authors also reported four cases of psychotic depression, three having an 'excellent result'. There have been reports of other patients treated by cingulotomy with comparable levels of efficacy – claiming that about 45% of patients are asymptomatic either with or without further treatment (Winston, 1979; Ballantine *et al*, 1987; Bouckoms, 1991).

Limbic leucotomy in depressive disorder In the limbic leucotomy series, which also used symptom-rating scales, significant symptomatic gains in the dependent symptom measures were found after 20 months follow-up. In this series of 36 patients, 19% of the patients were in the top category and a further 19% in the next category – that is, requiring minimal treatment (Kelly, 1980). For the subcaudate tractotomy group, Hodgkiss *et al* (1995) argue that their most recent results (from the 1980s) are worse because the patients are in effect more difficult to treat – but even so their results are comparable with the limbic leucotomy operations done in the 1970s (Kelly, 1980) (34% in the top two categories for subcaudate tractotomy compared with 38% for limbic leucotomy).

Suicide risk There are claims that NMD reduces suicidal risk. In the subcaudate tractotomy series, Bridges *et al* (1994) maintain that 1% of the patient group had committed suicide 3–13 years after their operation ($n=303$). This compares with 5% of the limbic leucotomy group after 20 months and 9% of the cingulotomy series (Ballantine *et al*, 1987). Bridges *et al* (1994) conclude that compared with long-term outcome data of untreated patients with depression NMD confers a "marked reduction in suicidal activity", but this remains somewhat speculative.

Summary About two-thirds of all reported stereotactic operations for affective disorder are from one procedure (subcaudate tractotomy). It does not seem possible to conclude that any particular operation has a significant advantage over another in affective disorder, although the earlier results for subcaudate tractotomy (up to 1973) had reported significant improvement of between 56% and 68%, which in the more recent series in the 1980s had fallen back to 34%. There is a growing series of cases using capsulotomy for affective disorder in the UK.

Implications It is unclear why results from the subcaudate tractotomy series are getting worse. It is possibly the result of patients becoming more treatment-resistant, but this hypothesis is not supported by the observation that the 1980s subcaudate tractotomy results are comparable with the limbic leucotomy results of the 1970s. Other hypotheses also need to be considered.

The choice of capsulotomy for affective disorders in Dundee and Cardiff NMD centres was made on a database of 19 patients in the 1950s in Sweden in which 21% of patients were said to have got worse. There are clear implications here for the choice of lesion site when considering the development of NMD.

Studies of bipolar patients

Only one study has been entirely devoted to reporting outcome of bipolar disorders treated by neurosurgery. This concerned a small group of nine patients with bipolar affective disorder resistant to drug treatment who had a reduction in severity and frequency of depressive and manic depressive episodes when followed up on up to 5 years after subcaudate tractotomy (Lovett & Shaw, 1987). No symptom measures were reported in outcome assessment.

Two years after subcaudate tractotomy, just under 40% of another sample of nine patients were deemed to have completely, or very significantly, improved – especially with regard to the number of hypomanic episodes. Pre-existing brain lesions detected on CT scan appeared to be a poor prognostic factor (Poynton *et al*, 1988).

In the most recent outcome data from the subcaudate tractotomy operation, 44 patients with bipolar mood disorder were reported on at 1-year follow-up. Using the 5-point global scale, about a third of these were either completely or substantially better, with a further 40% considered to be slightly better and 13% either the same or worse. Again, no information is given about the specific symptomatic benefits gained (Hodgkiss *et al*, 1995).

A further 23 patients are reported as suffering from bipolar depression diagnosed retrospectively using the DSM-III criteria operated on using cingulotomy (Ballantine *et al*, 1987). On average, the follow-up time was over 8 years, but unfortunately the results conflated all types of affective disorders – although the authors say that there are no differences in between diagnostic groups. This would mean that 41% of the patients were either well or required minimal treatment, with a further 24% considered to be significantly improved.

Summary The evidence for bipolar disorder may favour surgery but is based on low-quality data.

Implications There is probably sufficient evidence to consider bipolar disorder as a valid indication.

General conclusions of the review on efficacy

1. Despite 50 years of NMD, the general quality of the outcome data is poor. There are no published randomised, prospective, controlled trials of modern operations.
2. Mean global outcome scores suggest some improvement of follow-up in all studies in all clinical groups (affective disorders, OCD and non-OCD anxiety).
3. Symptom-based outcome measures suggest more modest improvement.
4. This may be a specific treatment effect of NMD, but it is impossible to exclude other factors (e.g. selection bias or post-operative treatment) in accounting for the success of the operation.

5. There is a trend for more recent outcomes not to be as good as previously, but it is unclear why this is the case (especially with affective disorders and subcaudate tractotomy).
6. The quality of the outcome data does not categorically support the view that any one operation is specific for any one diagnosis. However, some operations are used more commonly for certain diagnoses (e.g. subcaudate tractotomy for depression, capsulotomy for OCD/non-OCD anxiety). This means that the data base for using capsulotomy for depression has been small.

Implications

There are conspicuous gaps in the outcome literature, particularly on the use of operations other than subcaudate tractotomy for affective disorder. The centres in Cardiff and Dundee that currently use capsulotomy should help to fill this gap.

The data suggest that more consideration should be given to targeting symptoms rather than syndromes when contemplating operation. This may mean moving away from merely having restricted diagnostic categories (e.g. treatment-resistant depression) towards a more sophisticated approach looking at targeting specific symptom profiles informed by research (e.g. What acquired neuropsychological deficit caused by a stereotactic lesion is most likely to mediate the therapeutic effects sought for in terms of a given symptom?).

A standing prospective audit should help to improve the quality of the outcome data, short of doing a randomised controlled trial. This audit should be UK-wide and be organised by the NAC for NMD. The NAC should include representatives from each of the NMD centres. The Committee's role should be to standardise the audit process across centres and collate the information into an annual report. The audit standards should be both process and outcome-oriented, should evaluate inadvertent departures from intended treatment plans, and should focus on the details of the wider therapeutic strategy (e.g. rehabilitation). An annual meeting should be held, to which clinicians from all the UK centres for NMD should be conferred by the Standing Advisory Committee as part of this audit process.

5. Neurosurgery for mental disorder: adverse effects

In large measure, it was the adverse effects of the pre-stereotactic operations that led to their demise. The contemporary operations undoubtedly have a better safety record, but the adverse consequences of the operations are still similar in type. These can be considered in four ways – the perioperative/somatic complications, epilepsy, personality change and neuropsychological deficits.

Quality of the data

The data concerning adverse reactions to stereotactic NMD are largely derived from outcome studies and the shortcomings about this literature have already been alluded to. There are a small number of papers dedicated to neuropsychological assessment of NMD, but the follow-up periods tend to be relatively short – usually up to 1 year (Long *et al*, 1978; Corkin *et al* 1979; Vasko & Kullberg, 1979; Kartsounis *et al*, 1991; Cumming *et al*, 1995; Nyman & Mindus, 1995).

There are also very few published data whose principal focus is on post-operative personality change (Mindus & Nyman, 1991). Understandably, most of the literature about the adverse effects of NMD is written by authors who are not entirely independent of the NMD programme they write about. Few studies have set out to examine adverse effects of the operations *per se*.

Inevitably, NMD is performed at a tertiary referral level, which has meant that establishing a comprehensive data-set about adverse events at follow-up has often been difficult to achieve owing to the distance that patients ultimately live from the neurosurgical centre. This has been particularly the case with the recent American cingulotomy data (Jenike *et al*, 1991; Baer *et al*, 1995).

Perioperative and somatic complications

The perioperative death rate for all the major stereotactic procedures approaches zero and is no greater than other neurosurgical procedures (Mindus & Meyerson, 1995).

Vascular injury

The risk of vascular injury is also low. One case of hemiplegia has been reported in the cingulotomy series, giving a rate of 0.03% for the 696 patients reviewed by Ballantine *et al* in 1987. One frontal lobe bleed was recorded in the Dutch group when they used subcaudate tractotomy in a series of 33 patients (Cosyns *et al*, 1994), but no cases of persistent hemiplegia have been reported with capsulotomy, subcaudate tractotomy or limbic leucotomy patients.

Headache

The early post-operative course of patients commonly includes a transient headache and there are very occasional reports of persistent headache (Baer *et al*, 1995; Kihlstrom *et al*, 1995).

Confusional states

Post-operative confusional states are more likely in older patients, as they are in any operation, and Bridges *et al* (1994) estimates that about 10% of patients over the age of 50 years have a degree of confusion after subcaudate tractotomy for up to 1 month, but that this is subsequently resolved.

Fatigue

Fatigue may be a transient post-operative feature and is mentioned most often in the capsulotomy series (Bingley *et al*, 1977; Mindus & Meyerson, 1995). The Spanish group suggest that this passes within 3–6 months (Burzaco, 1981), and Swedish reports suggest that it may be at its most prominent 1 week post-operatively (Mindus & Meyerson, 1995).

However, in the early subcaudate tractotomy series, 12.5% of patients reported tiredness and lethargy persisting at follow-up (range 16 months to 8 years) (Strom-Olsen & Carlisle, 1971). Also, mild lethargy was reported in 8 out of 66 patients in the limbic leucotomy series 16 months post-operatively (Mitchell-Heggs *et al*, 1976).

Urinary incontinence

The pre-stereotactic operations sometimes led to urinary incontinence; this is almost unheard of in contemporary operations, although occasional cases are reported (Cosyns *et al*, 1994; Baer *et al*, 1995).

Weight change

Weight change is consistently reported in a proportion of the capsulotomy patient group.

Mindus *et al* (1994a) suggests that on average a post-capsulotomy patient will gain 5–10 kg but in some female patients, especially if there is a previous history of weight difficulties, it could be more. Indeed, there was a 20% weight gain in female patients on average in the earlier capsulotomy group (Herner, 1961) and the Spanish series suggests that 25% of patients gained 10% of their pre-operative weight (Burzaco, 1981). Weight changes are not prominent in a list of adverse effects in other operations but the early subcaudate tractotomy series did record that almost 10% of patients gained between 9.5 and 12.7 kg by follow-up (i.e. 16 months to 8 years later) (Strom-Olsen & Carlisle, 1971). There was no weight gain in the limbic leucotomy series of 66 patients followed up at 16 months (Mitchell-Heggs *et al*, 1976).

Addiction

A study from Germany (Irle *et al*, 1998) shows that a significant proportion of patients followed up 16–22 years after surgery had some form of addiction problem if their operation site was in the ventrostriatal part of the frontal lobe (8 out of 11 cases). The addiction was not closely defined and it is unclear if NMD confers an independent risk.

Influence of reporting method

The outcome data that have used check-lists or structured interview techniques to elicit adverse events post-operatively show that a considerable proportion of patients report at least some physical symptomatology as a consequence of the operation. Baer *et al* (1995) used a 62- item structured interview for the identification of side-effects and concluded that 56% of the post-cingulotomy group had some "emergent or significantly worsened symptoms" ($n=16$), but few serious adverse events were found. However, this review was done retrospectively and many of the symptoms could be attributable to other post-operative treatments. Nevertheless, 37% of the Danish series (Hansen *et al*, 1982; $n=71$) also complained of at least one somatic complication, but these operations took place prior to modern imaging techniques (1965–1974).

Summary

1. Post-operative death-rates and vascular injury is very low.
2. Tiredness that can persist is consistently reported in most operations, probably in less than 10% of cases.
3. Very significant weight gain can occur, especially in capsulotomy.
4. Side-effect rates vary with reporting methods.

Implications

Differential side-effect profiles between operation needs to be carefully collated as this may have a bearing on the choice of operation.

The method of data collection (for side-effects) should be structured and form part of a protocol.

Epilepsy

Kiloh *et al* (1988) review the chronic epilepsy rates that arose as a consequence of stereotactic NMD operations reported on between 1961 and 1982 for a total of 854 patients and concluded that the rate was of the order of 0.4% – which is somewhat lower than the general population prevalence of 0.5%. However, Kiloh *et al* do not quote the studies contained in this group and the most recent series have reported higher rates of epilepsy.

In the cingulotomy series, Ballantine *et al* (1987) quote a rate of 1%, but in a more recent series Jenike *et al* found that 3 out of 33 patients (9%) had "easily controlled seizures" 5–20 years after cingulotomy.

In the capsulotomy group, Mindus (1991) suggests that epilepsy is a very rare complication – none of the 35 patients in Bingley *et al*'s series (1977) nor any of the Burzaco (1981) patients had "neurological complications". One out of the 24 patients in Mindus's series (1991) did develop epilepsy, although it might not have been a consequence of the operation.

The subcaudate tractotomy operation causes a risk of inducing epilepsy of 1.6% according to Bridges *et al* (1994), who reviewed a thousand patients. But the authors admit that this may be an underestimate. Three out of the 21 patients (14%) who had this operation in Holland developed epilepsy (Cosyns *et al*, 1994).

In the mixed operative group that has been reported most recently in Australia, 5% of patients developed seizures post-operatively (Hay *et al*, 1993). No patients have been reported to have developed epilepsy as a result of the limbic leucotomy at a 16-month follow-up (Mitchell-Heggs *et al*, 1976) and only 1 out of 142 patients developed epilepsy at a 9-year follow-up following multifocal leucocoagulation (Kiloh *et al*, 1988).

Summary

Epilepsy rates vary widely and it is unclear why this might be (figures from large series being of the order of 0.4–1.6%, but from individual series much higher levels have been reported).

Implications

Long-term follow up is essential and differential rates between operations and NMD centres needs to be audited.

Personality change

Obviously, changes in personality after frontal lobe surgery will in part depend on the definition used for 'personality'. Although there is widespread agreement that frontal lobe damage leads to personality change ('organic personality disorder', a term used in the ICD-10; World Health Organization, 1992), there have been very few papers dedicated to looking at post-stereotactic operation personality change (Long *et al*, 1978; Mindus & Nyman, 1991; Mindus *et al*, 1999).

Trait-based measures of personality (such as the Eysenck Personal Inventory (EPI; Eysenck & Eysenck, 1964) and the Minnesota Multiphasic Personal Inventory (MMPI; Morey *et al*, 1985) have been used in other outcome studies (e.g. Bingley *et al*, 1977; Kelly, 1980), but data from structured assessments of personality is missing with regard to some other operations, for example, subcaudate tractotomy.

There is a difficulty in selecting an appropriate measure of personality with regard to post-operative evaluation, because the very construct on which personality is founded relates to stability and enduring characteristics and so the personality assessment techniques do not focus on change.

Subcaudate tractotomy

In the subcaudate tractotomy outcome literature, Bridges *et al* (1994) suggest, in a review of 1300 patients, that "no significant adverse effects (on personality) are attributable to the operation". However, the two earlier outcome studies do detect personality change in the subcaudate tractotomy group. Goktepe *et al* (1975) found that 6.7% of patients had undesirable personality effects according to relatives (e.g. excessive eating, volubility and lowered social standards), and in the earlier outcome data 2.6% of patients had serious behavioural changes and a further 14% minor ones (irritability, outspokenness and volubility) (Strom-Olsen & Carlisle, 1971; Goktepe *et al*, 1975).

Cingulotomy

In the cingulotomy series, Ballantine *et al* (1987) suggest that "there was no evidence of diminution in emotional tone or social control" in their review of 696 patients on average 8.5 years after operation. However, no structured assessment methods are reported in these data and in a smaller group of cingulotomy patients followed up after 2 years in Finland, Vilkki (1977) found that 3 out of 27 patients had an observable degree of "indifference, irresponsibility, lack of judgement, lack of self-criticism or initiative". However, in a 1-year follow-up study of 19 cingulotomy patients, there was a significant trend reported towards normative values in the MMPI – especially measuring traits associated with anxiety and depression – although it needs to be noted that the pre-surgical data were collected only a few days prior to the operation, which may have increased the 'baseline' measure of anxiety (Long *et al*, 1978).

Limbic leucotomy

Kelly (1980) also used trait measures to evaluate personality change (the Maudsley Personality Inventory, and the EPI) and found that after 20 months in his review of 123 patients there was significantly reduced neuroticism and introversion and increased extroversion scores.

Capsulotomy

This finding was also corroborated by Bingley and colleagues (1977) evaluating 12 capsulotomy patients who found at 1-year follow-up significant reductions in anxiety and depression, obsessive thinking, neuroticism and introversion using

the EPI and MMPI. He also had anecdotal evidence to suggest that the operation does not affect creativity but does improve social confidence.

The earlier capsulotomy data, however, did show evidence of personality change in a significant proportion of patients. Herner (1961) reported that two-thirds of his group of patients treated for depression, obsessional neurosis or anxiety had mild or transient changes in emotional, volitional or intellectual spheres and 3 out of his 116 cases had "very poor community adjustment" leading to conflicts with the law. Also, Kullberg's later review (1977) found some personality changes in the majority of cases of patients treated with capsulotomy ($n=12$) and one case had gross personality changes. Several patients showed emotional shallowness and some had loss of initiative, but the changes were not necessarily negative. A comparison group of 12 cingulotomy patients had no detectable personality change, but the symptomatic outcome for the cingulotomy group was not as good.

The use of specific personality tests

Two groups have used personality assessment measures targeted at frontal lobe function. The Australian group developed a 34-item Schedule of Change in Personality (Sachdev & Hay, 1995) administered to both the patient and an informant who had known them at least 2 years pre-operatively. This is a trait-based measure designed to assess aspects of personality most likely to be affected by NMD. Thirteen patients suffering from OCD were followed up 10 years post-operatively (plus or minus 5 years), and the majority reported no change, but two patients had adverse changes – one of these had a combined lesion, the other an orbitomedial operation. Both these patients also had some neuropsychological deficits. Some patients in this series reported positive changes – less obsessiveness, anxiety and dependency and greater depth of feeling and sociability – which correlated with improved global outcome.

In Sweden, the most recent capsulotomy group has also been evaluated using a 24-item self-report personality measure that was constructed to assess "temperament traits assumed to have a biological basis" relating to frontal lobe function such as impulsivity, hostility and aggressiveness and anxiety proneness (the Karolinska Scales of Personality (KSP; Schalling *et al*, 1987). There was a tendency to normalising values post- compared with pre-operatively in the 24 patients assessed. In particular, impulsivity, hostility and aggressiveness and the psychopathy scales tended towards the normative (Nyman & Mindus, 1995). These patients had a thermo-capsulotomy. Nineteen of these patients were followed up 8 years after operation and these results remained stable, although one patient (who had had a surgical complication) also had increased scores on the psychopathy subscale (Mindus *et al*, 1999).

However, in a small gamma-capsulotomy series of 11 patients (Kihlstrom *et al*, 1995), excessive radiation doses were given inadvertently, in one case leading to the patient having a frontal lobe syndrome. However, the clinicians underestimated

the dose response in other cases too, and a further patient also had a frontal lobe syndrome at follow-up and one other remained 'disinhibited'. Smaller doses of radiation are now given.

Consolidated data

In Kiloh *et al*'s (1988) consolidated data from studies conducted between 1961 and 1982, of 854 patients who had a stereotactic procedure, the risk of marked personality change was of the order of 0.4% and mild personality change 4%, but the studies used for these data are not quoted in full. Kiloh *et al* considered that different neurosurgical targets can have different risks as far as the nature of personality change is concerned. Cingulate lesions may lead to apathy and lack of concern, orbitomedial lesions towards greater disinhibition, impulsivity, lower frustration, greater sexual interest and difficulty maintaining interest leading to a poorer work record.

Summary

NMD carries a risk of personality change, although this is not necessarily negative. It is unclear which operations are more likely to cause adverse change. Trait-based measures tend to show change occurring in a normative direction, but it is clear that all operations can cause adverse changes.

Implications

There are methodological problems measuring personality change, but instruments have been developed outside the UK and should be considered for use here. Subcaudate tractomy in particular has been under-researched in terms of its effects on personality and this needs to be addressed.

Neuropsychological effects

There is a consensus in the outcome literature that gross intellectual impairment is a very rare consequence of stereotactic NMD and that mean IQ – as measured, for example, by the Wechsler Adult Intelligence Scale (WAIS; Wechsler, 1955) – may be unchanged or improved slightly (Herner, 1961; Bailey *et al*, 1977; Broseta *et al*, 1979; Corkin *et al*, 1979; Hansen *et al*, 1981; Kartsounis *et al*, 1991; Cosyns *et al*, 1994, Cumming *et al*, 1995; Nyman & Mindus, 1995). It may even have improved significantly at follow-up (Kelly, 1980). This may be the result of practice effects or of psychiatric symptoms being improved and therefore performance enhanced at follow-up.

There are very few papers that are dedicated to evaluating the neuropsychological consequences of stereotactic NMD per se. For most modern operations, there is at least one paper that examines this issue in a prospective

study, but the subject groups are often small (10 in the latest capsulotomy series followed up at 1 year (Nyman & Mindus, 1995); 23 in the subcaudate tractotomy group followed up at 6 months by Kartsounis *et al* (1991) and 34 in the cingulotomy group reported followed up at 1 year by Corkin *et al* (1979) and 19 in Long *et al*'s paper (1978) reporting on cingulotomy patients). Incidentally, these appear to be the last neuropsychological review of cingulotomy patients apart from data contained in general outcome assessments (i.e. the data concerning cingulotomy is over 20 years old).

From Australia, Cumming *et al* (1995) reported on a mixed operative group of 17 patients with OCD 1–18 years post-operatively compared with 'symptomatically' equivalent patients who formed a control group who had the same battery of neuropsychological tests. However, this study was not conducted longitudinally (perhaps this is not possible) and it may mean that the operated group were in some ways more severely ill and that their greater cognitive impairment could be put down to the excess severity of their illness rather than the effects of the operation itself.

There is a retrospective study from Germany of 16 patients with OCD who underwent mixed operations 16–22 years prior to review (Irle *et al*, 1998). There was a comparison group of six patients who were not operated on. Intellectual functioning was largely preserved in the patients with ventromedial and frontostriatal lesions, but all had sub-normal Wisconsin Card Sorting Test (Nelson, 1976) results – especially the latter group. If the operation site involved dorsolateral regions then there was also evidence of slower memory and attention and lower performance IQ.

There is a very small series of six patients followed up only days after a cingulotomy. Many of the patients had psychotic disorders and obviously the acute effects of the operation influenced the neuropsychological data (Levin *et al*, 1977).

The more recent studies of neuropsychological effects of NMD have used tests more specific to the frontal lobe, rather than merely examining the change in general intellectual functioning, memory or motor performance – none of which seem to be affected by modern NMD (Kartsounis *et al*, 1991; Cumming *et al*, 1995; Nyman & Mindus, 1995).

All of these studies showed significant deterioration in laboratory tests in an aspect of executive function tested by the Wisconsin Card Sorting Test (or a form of it). In the case of the capsulotomy series, 5 out of the 10 patients showed significantly more perseverative errors (Nyman & Mindus, 1995).

The Australian group's data (Cumming *et al*, 1995) are a bit more difficult to evaluate since there was significant impairment of this test in a mixed operative group, but the authors conclude that "while it is true that many such patients performed poorly there is no evidence that the (operated) group performed characteristically poorly on tests sensitive to frontal lobe damage". This was not to say that in this series a minority of operated patients did demonstrate poorer function post-operatively than pre-operatively.

The subcaudate tractotomy series, on the other hand, showed significant degrees of impairment soon after the operation in a test of word fluency and on the Wisconsin Card Sorting Test, but by the time the patients were re-assessed at 6 months there was no significant difference compared with their pre-operative assessment. The transient difference was put down to the effect of frontal lobe oedema following the operation, which was subsequently resolved (Kartsounis *et al*, 1991).

It is not clear why this effect is transient in one operative group (the subcaudate tractotomy), but not in others such as the capsulotomy group, nor whether the effect is clinically important outside of the laboratory

However, Poynton *et al*'s review (1995) of the same series of patients noted that the improvement in psychiatric status at 6 months significantly correlated with the degree to which patients showed impairment of certain neuropsychological tasks – two of which were related to frontal lobe function. They suggest that maybe a reduction in self-monitoring is "instrumental in improving mood related phenomena".

Data concerning frontal lobe functioning in patients who have only had a cingulotomy lesion tend to be older and more scant. Corkin *et al* (1979) reported that in patients over the age of 30 years assessed within 5 months of the operation there was a significant decrease in the ability to perform an embedded figure task and the copying of a complex drawing for a group of 24 patients, but it is not clear whether these deficits persist or whether they are of clinical significance. Overall, these authors conclude that "there is no evidence of the lasting neurologic or behavioural deficits after cingulotomy". In a review of 19 patients after cingulotomy, Long *et al* (1978) concluded as well that as a group there were no significant neuropsychological deficits but there was a non-significant deterioration in verbal fluency, associative learning, visual memory and in a finger-tapping test. Overall, 13 of the group improved in their performance, three remained the same and three generally declined.

Summary

There are few dedicated studies looking at psychological effects, but there is at least one study for most operations. IQ measures suggest that there is no deterioration or possible improvement. No single operation seems to confer a significantly greater risk of neuropsychological damage. Tests of frontal lobe function suggest that permanent or transient perseverative deficits are acquired, but it is unclear if this is clinically significant.

Implications

If the clinical effects of NMD are mediated by an acquired neuropsychological deficit then the research agenda of the future should be focused on describing the deficit rather than (as it has until now) being defensively framed and

minimising the deficits. Neuropsychological assessment procedures should be standardised across NMD centres. This process should be agreed within the forum of a NAC for NMD.

General conclusions on the section on adverse effects

1. There are few papers dedicated to looking at these issues and much of the reporting can be criticised as lacking independence and a structured approach.
2. Undoubtedly, modern NMD does not carry the grave risks that older operations had, although the types of risks remain similar
3. Close scrutiny of the data suggests that although some centres have reported low levels of adverse effects, this is variable (in the international context) and different operations may confer different risk profiles (e.g. weight gain and capsulotomy).
4. Tertiary referral centres may lose contact with patients and therefore lose data about longer-term adverse effects.
5. There are specific gaps in the reported UK data – notably the effect of subcaudate tractotomy on personality change.

Implications

1. The NAC has a key role in collating data about adverse effects.
2. Data collection should be standardised across UK centres, and structured.
3. The use of specific psychometric tools for the assessment of personality change (such as that quoted by Sachdev & Hay (1995)) should be considered.
4. There is a need for further neuropsychological research.
5. Long-term contact with patients post-operatively needs to be encouraged to get more accurate data about adverse effects, especially the incidence of epilepsy.

6. International context

Neurosurgery for mental disorder has always had an international context to it. Having originated in Portugal in the mid-1930s, the practice was rapidly developed and disseminated from the USA prior to becoming established in the UK in the early 1940s.

Some countries have always had a practice of NMD, but the variable degrees of censure expressed about NMD and other factors has meant that only a handful of countries have NMD programmes. These currently include the UK, USA, Australia, Sweden, and Hungary. Up until the 1980s, operations were also being performed in Holland and Spain. However, at the time of writing, we are unable to confirm whether or not these are continuing.

Some countries have banned the practice of NMD outright on the grounds that it is of unproven efficacy and is likely to confer harm on patients rather than benefit. Other countries have placed significant restrictions on the practice, so in reality no activities take place (e.g. Canada).

In all contemporary centres of NMD, referrals are organised at tertiary level and services are vulnerable to changes in key personnel. This has been the case, for example, in Sweden after the death of Professor Mindus in December 1998 and in the UK after the retirement of key personnel at the Brook Hospital in London and in Leeds.

Contemporary practice

Sweden

Operations have been conducted in Sweden since the 1940s. Sweden has a long history of innovative development and the current practice at the Karolinska Institute in Stockholm is to use the capsulotomy procedure – either as thermal lesion or by the use of gamma irradiation. The other distinguishing feature of the Swedish practice is that in recent years they have used the operation almost exclusively for anxiety disorders or OCD. There have been no operations done in the first half of 1999 following the death of Professor Mindus, however, they expect the NMD programme to pick up in the near future.

Australia

There has been a long history of NMD in the states of Victoria and New South Wales. The most active centre was in Sydney, but funding was withdrawn from the Psychosurgery Review Board, which has effectively meant the closure of the service. There are now plans for a national centre for psychosurgery based at the

Melbourne Neuroscience Centre at the Royal Melbourne Hospital under the directorship of Dr John Lloyd. He anticipates that 2–3 operations may be carried out per annum but estimates that he would see 3–4 times this number for professional assessment and work-up. They usually admit the patient for a couple of weeks in order to conduct neuropsychological and psychological assessment. There is then an application made to a Psychosurgery Review Board, who may decide whether an operation can proceed and, if so, determine within what time frame (usually a month or so) (Rosenfeld & Lloyd, 1999).

Hungary

There are proposals to develop a service in Budapest at the Arato Clinic. As of May 1999, they have six patients with OCD for whom thermo-capsulotomy is proposed, pending permission from the ethical committee of the Ministry of Health. The technique has been studied by Hungarian neurosurgeons at the Karolinska Institute in Stockholm. These patients are deemed to have failed all previous treatments, and Professor Arato is developing appropriate medico-legal protocols.

United States of America

The only centres for NMD in the USA that are active, and that the authors of this report can find, are in Massachusetts. Dr Steve Rasmussen has been collaborating with the Swedish centre at the Karolinska Institute to conduct a randomised double-blind trial of the gamma-capsulotomy method for the treatment of OCD. The results of this trial are still pending.

Russia

A series of 18 patients has been stereotactically operated on at the Bechterev Psychoneurological Research Institute in St Petersburg (Korzenev *et al*, 1997). This group has used a variety of different surgical target sites for the treatment of OCD depending on whether or not there are other comorbid conditions. For example, if an OCD patient suffers from depression, they suggest cingulotomy innominatotomy. This operation is probably not dissimilar to the limbic leucotomy.

Brazil

Stereotactic neurosurgery for mental disorder has been carried out on patients suffering from DSM–III/DSM–IV-defined schizophrenia, certainly up until the mid-1990s. DaCosta (1977) reports on 16 patients who had stereotactic operations between 1985 and 1996. All patients had cingulotomies, but lesions were also made in the postero-medial hypothalamus in three-quarters of the patients, and

the other quarter had lesions in the fundus striaterminalis. All the patients had structured symptomatic rating scales used, neuropsychology and CT scans. All the patients had a history of dangerous, aggressive behaviour and/or self-harm. It was these aspects of their clinical picture that seemed to have been considered to be the target symptoms. In this respect, DaCosta claimed that 14 of the patients were significantly better and none were worse. These patients were personally followed-up from the author's private clinical practice and he suggests that NMD should be considered in certain cases of schizophrenia.

Holland/Belgium

Between 1971 and 1991, 111 patients were referred to the Committee on Psychosurgery in the Netherlands and Belgium, of whom 79 subsequently had a stereotactic operation. Most of these patients suffered from OCD. A variety of different operations were used, including anterior capsulotomy and subcaudate tractotomy. The Dutch subcaudate tractotomy technique was similar to the revamped British subcaudate tractotomy lesion in that thermocoagulation was used rather than yttrium rods. This group also used multifocal leucocoagulation, but abandoned it since it conferred no extra clinical benefit and proved to be more technically complex. This series also included 28 patients operated on because of aggressive behaviour, using amygdalotomy or thalamotomy (Cosyns *et al*, 1994).

Denmark

There has been an active psychosurgical centre at the University Clinic in Copenhagen, and results from 1965–1974 have been published by Hansen *et al* (1982). Their initial review suggested that the operations were carried out prematurely in a number of cases, and 42% had serious somatic complications. They conclude that psychosurgery must be considered a last and dubious resort. We are unclear as to whether or not there is still a Danish NMD service.

7. Current practice in the UK

There have been major changes in the practice of NMD in the UK over the past 10 years. Several centres have closed (Leeds, Bristol and Birmingham), two new centres have opened in Dundee and Cardiff, and the centre that in the past did by far the most operations, the Brook Hospital, has relocated to the Maudsley Hospital. This centre now uses a different operation. The situation up until 1995 is summarised in the Table 1.

Current practice

There are now three main centres in the UK performing NMD.

Cardiff: University Hospital of Wales

This is the newest of the centres. It has carried out 34 operations in the past 5 years. The majority have been on affective disorders, with seven for OCD and one for another anxiety disorder.

The operation that is performed is bilateral stereotactic anterior capsulotomy using radio frequency lesion. The two key personnel that have been involved have been Roger Thomas, consultant psychiatrist, and Brian Simpson, consultant neurosurgeon. Patients receive a multi-disciplinary assessment involving psychiatrists, neurosurgeons, psychologists, anaesthetists, a radiographer and nursing staff. Follow-ups occur routinely at 4 weeks, 3, 6, and 12 months, with an MRI scan being performed at 6 months' follow-up.

A small number of patients (five in total) have received second operations. This is usually when there has been a relapse after a promising earlier response, and when MRI scans show inadequate lesions.

London: Institute of Psychiatry and King's Hospital

This centre performs stereotactic subcaudate tractotomy, and this involves a bilateral subcaudate radio frequency lesion to the white matter in the orbital part of the frontal lobes.

Twenty-three operations have been performed in the last 5 years. Twenty of these were for affective disorder, and three were for OCD. Very detailed and comprehensive protocols for all aspects of the treatment were provided by the team.

The key personnel involved are Professor Stuart Checkley, consultant psychiatrist, Professor C. Polkey, consultant neurosurgeon, and Dr Lang, clinical psychologist.

The centre has not performed any second operations in the past 5 years.

Table 1. Total number of NMD operations carried out in UK (1979–1995)

	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95	Total
Brook Hospital	47	50	42	35	28	7	16	11	12	20	18	20	15	22	13	11	0	367
Atkinson Morley's, London	-	-	-	-	-	-	5	5	4	3	5	7	0	1	2	3	1	36
Pinderfields, Wakefield/Leeds	-	-	-	-	-	-	1	1	0	1	0	1	1	2	1	0	1	9
Birmingham	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	0	1
Bristol	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	0	1
Dundee	-	-	-	-	-	-	-	-	-	-	-	-	-	1	6	4	3	14
Cardiff	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	3	7
Not specified	23	12	16	3	9	3	-	-	-	-	-	-	-	-	-	-	-	66
Total	70	62	58	38	37	10	22	17	16	26	23	28	16	26	24	20	8	501
% of operations per- formed by Brook	67	81	72	92	76	70	73	65	75	77	78	71	94	85	54	55	-	73

Source: CRAG Working Group on Mental Illness (1996) *Neurosurgery for Mental Disorder*

Table 2. Total number of NMD operations carried out in Wales (1994 to date)

	1994	1995	1996	1997	1998	1999 to date	Total
<i>Cardiff</i>							
Depressive disorder	2	1	9	3	4	3	22
Bipolar affective disorder	–	2	1	–	1	–	4
OCD	–	–	–	2	2	3	7
Other anxiety disorder	–	–	–	–	–	1	1
Other diagnoses	–	–	–	–	–	–	–
No. of second operations	–	–	2	2	0	1	5
Total NMD operations, Cardiff							39

Table 3. Total number of NMD operations carried out in England (1994 to date)

	1994	1995	1996	1997	1998	1999 to date	Total
<i>The Maudsley/King's College</i>							
Depressive disorder	5	–	3	4	2	–	14
Bipolar affective disorder	4	–	2	–	–	–	6
OCD	1	–	2	–	–	–	3
Other anxiety disorder	–	–	–	–	–	–	0
Other diagnoses	–	–	–	–	–	–	0
No. of second operations	–	–	–	–	–	–	0
Total NMD operations, Maudsley							23

Table 4. Total number of NMD operations carried out at Atkinson Morley's, London (1994 to date)

	1994	1995	1996	1997	1998	1999 to date	Total
<i>Atkinson Morley's</i>							
Depressive disorder	–	–	1	–	–	–	1
Bipolar affective disorder	–	–	–	–	–	–	0
OCD	–	–	–	–	–	1	1
Other anxiety disorder	–	–	–	–	–	–	0
Other diagnoses	–	–	–	–	–	–	0
No. of second operations	–	–	–	–	–	–	0
Total NMD operations							2

Table 5. Total number of NMD operations carried out at other centres (1995 to date)

1995–2000	
London, Brook	No further operations carried out
Leeds, Pinderfields	No further operations carried out
Birmingham	No further operations carried out
Bristol	No further operations carried out
Dundee	No information available on current activity

Table 6. Assessments per year

	Detained	Informal	Total
1993/4	2	0	2
1994/5	2*	4*	6
1995/6	0	1	1
1996/7	0	4	4
1997/8	3*	3	6
1998/9	2	5	7
Total to date	9	17	26

* One patient in each category was assessed twice in the year

Dundee, Scotland: Ninewells Hospital, Dundee & Dundee Royal Infirmary

This centre began operating in 1992 under the direction of Professor George Fenton, psychiatrist and Mr Varma, neurosurgeon.

The operation carried out is a bilateral stereotactic anterior capsulotomy. The current key personnel are Professor Keith Matthews, psychiatrist, and Mr Eljamel, neurosurgeon. No further details were supplied to us. However, for a number of years, under a voluntary agreement with the treatment centre in Dundee, the Mental Welfare Commission for Scotland has also been involved in assessing informal patients. A pool of six commissioners is used to provide three people for each assessment. The group meets 6-monthly to review assessments carried out and discuss other relevant issues

Over the last year, seven patients have been assessed by commission representatives, three women and four men. Two were detained patients and

five informal. Two were referred from England, and one from the republic of Ireland; the remainder were from within Scotland. One detained English patient had been assessed in her hospital in England in 1997–1998 and had to be assessed again once her liability to detention had been transferred to Dundee and the appropriate form could be issued under Scottish law. The other English patient had also been seen before in 1997–1998 and it was felt at that time that other treatments had not yet been exhausted. One of the Scottish patients also had been seen in 1997–1998 and at that time was not able to give informed consent. All seven assessments in 1998–1999 led to a decision that the patient was consenting and the operation was appropriate.

Summary from 1993–1999*

To date, 26 assessments have been carried out on 18 individuals.

One informal patient seen in 1994–1995 was seen again in 1996–1997, and one detained patient in 1994–1995 was seen again as an informal patient in 1997–1998. Both of these patients were seen twice in 1994–1995, one detained patient was seen twice in 1997–1998, and three patients seen in 1997–1998 (one detained and two informal) were reassessed in 1998–1999. Hence, 26 assessments have been done on 18 individuals. There were 13 women and five men, aged 34–61 years (mean age 44 years).

One informal patient had had a previous but different operation in London. One Scottish patient was operated on in 1995 when detained and in 1997 underwent a second and slightly different operation when informal. Treatment-resistant depressive symptoms had returned after a spell of 3–4 months after the first operation in which she had been very well. Three informal and two detained patients were resident in England at the time of their assessments and the Mental Health Act Commission was given anonymised information on them. One informal patient was resident in the Irish republic.

The Mental Welfare Commission seeks follow-up reports 1 year following operation. A rough categorisation of these shows that out of 12 operations, two were associated with no improvement, four with some improvement or marked improvement followed by relapse, and six showed marked improvement.

Procedures and sites for neurosurgery for mental disorder

Stereotactic subcaudate tractotomy

Target site: Orbitomedial quadrants of the frontal lobes
Practitioners: Professor Stuart Checkley & Professor Polkey
The Maudsley/King's College, London

* Information taken from the Mental Welfare Commission's 1998–1999 Annual Report

Stereotactic anterior capsulotomy

Target site: Anterior capsular radiation
Practitioners: Dr P. Mindus & Dr B. A. Meyerson, Sweden
Professor Keith Matthews & Mr Eljamel, Dundee
Dr Roger Thomas & Mr Brian Simpson, Cardiff

Stereotactic limbic leucotomy

Target site: Combination of orbitomedial and cingulate lesions
Practitioners: Dr D. Kelly & Mr H. Marsh, Atkinson Morley's Hospital,
London

Stereotactic anterior cingulotomy

Target site: Cingulate tracts
Practitioners: Dr S. Rasmussen & Dr N.T. Ballantine, USA

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Appendix 1. Outcome data from stereotactic neurosurgery for affective disorders

Author	No. in series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Ballantine <i>et al</i> (1987)	106 (273)	Cingulotomy	Unipolar depression (<i>n</i> =83) Bipolar depression (<i>n</i> =23) DSM-III criteria used retrospectively	8.6 year average. Retrospective	6-point Global Scale	41% either well or well and on treatment. 24% considerably improved. 2% worse. 12% suicide	No differences between diagnostic groups. Outcome data includes 14 patients with schizoaffective disorder
Bartlett & Bridges (1977)	6 (8)	Extended subcaudate tractotomy	"Mixed depression and anxiety or depression and personality disorder"	1 year. Retrospective	5-point Global Scale	3 moderately improved. 2 slightly improved. 1 no change	Possibly part of Goktepe series
Corkin <i>et al</i> (1979)	20 (42)	Cingulotomy	"Depression or probable depression"	1 year. Prospective	4-point Global Scale Cognitive tests	37% markedly better. 21% moderately better. 16% slightly better. 21% not better. 5% undetermined	Possibly part of Ballantine's series. Some patients had multiple operations. 1 patient was lost to follow-up

Author	No. in series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Goktepe <i>et al</i> (1975)	78 (134)	Subcaudate tractotomy	"Chronic depression" (<i>n</i> =67) "Recurrent depression" (<i>n</i> =10)	2.5–4.5 years. Retro-spective	5 point Global Scale. "Work capacity". Wakefield Depression and Taylor Manifest Anxiety Scores in minority	35% well, no treatment. 33% much improved. 21% slight improvement. 11% no change. None worse	13 suicides in this group, but fewer attempts in best outcome group
Hansen <i>et al</i> (1982)	10 (65)	Mixed (cingulotomy and/or orbito-frontal lesion)	"Manic depressive psychosis"	1–7 years. Retro-spective	4-point Global Scale. Cognitive tests	3 "better". 3 "worse". 2 "ambiguous". 1 "same". 1 "no information"	High % institutionalised pre-operation. 60% previously operated on using non-stereotactic technique
Herner (1961)	19 116	Thermo-capsulotomy	"Depression"	24–80 months. Prospective.	6 point Global Scale. Work assessment. Subjective assessment by patients. Neuropsychology	16% symptom-free. 32% marked improvement. 16% moderate improvement 10% no improvement/unchanged. 21% worse	Weight gain of 13%. Diagnostic criteria uncertain
Hodgkiss <i>et al</i> (1995)	183 249	Subcaudate tractotomy	"Depression"	1 year. Retro-spective	Conflated 5-point Global Scale	34% completely or substantially better (<i>n</i> =58). 31% worse or same (<i>n</i> =57)	Conflated measures. No symptom measures. No personality tests

Author	No. in series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Hodgkiss <i>et al</i> (1995)	44 (249)	Subcaudate tractotomy	"Bipolar mood disorder"	1 year. Retro-spective	Conflated 5-point Global Scale	Approximately 32% completely better. 38% slightly better. 13% same or worse	Conflated measures. Results include 3 individuals without a clear diagnosis
Kelly (1980) Mitchell-Heggs <i>et al</i> (1979)	36 (148)	Limbic leucotomy	"Psychotic and neurotic depression"	20 months. Prospective	5-point Global Scale. HDRS and BDI. Personality scales. WAIS. Neurophysiology	19% symptom-free. 19% much improved. 22% slight improvement. 31% no change. 8% worse	Rater bias possible. No diagnostic criteria given
Lovett & Shaw (1987)	9 (9)	Subcaudate tractotomy	Bipolar affective disorder	1-5 years. Retro-spective	Global reports and case descriptions.	"All patients report reduced frequency and severity of episodes, especially hypomanic ones"	Case reports only
Lovett <i>et al</i> (1989)	15 (15)	Subcaudate tractotomy	Unipolar affective disorder	69 months. (16 months-10 years range). Retro-spective	Measure of frequency and severity of further episodes by case notes or interview	2/3 benefited by reduced severity of episodes. 1/3 benefited by series.	1/3 had died by follow-up. Possibly in Hodgkiss series. 1/3 had deterioration in personality

Author	No. in series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Martin <i>et al</i> (1977)	31 (68)	Cingulotomy	"Neurotic depression" (<i>n</i> =27) "Psychotic" (<i>n</i> =4)	4 years+ Prospective.	4-point Global Outcome. MMPI. Cognitive tests.	Excellent 11 Moderate 7 Slight 3 None 0	No diagnostic criteria given. Rater bias possible.
Snaith <i>et al</i> (1997)	2 (7)	Orbito-medial lesion	Severe depressive disorder (<i>n</i> =1) recurrent depressive disorder (<i>n</i> =1)	1 year. Prospective.	GAF. CPRS. HADS.	GAF score improved. 25 → 90 4 → 70 CPRS and HADS scores improved significantly	Independent clinical assessment post-operation
Strom-Olsen & Carlisle (1971)	75 (210)	Subcaudate tractotomy	"Recurrent depression" (<i>n</i> =45). "Involuntional depression" (<i>n</i> =6). "others" (<i>n</i> =24) (others = hypochondriasis, "others" (<i>n</i> =24) thoughts, etc.)	16 months to 8 years. Retrospective	5-point Global Scale. Working capacity. Post-operative treatment usage	Symp-tom-free 20 Marked improvement 5 Slight improvement 2 None 1 Worse 0	Rater bias possible. No patient had "real manic episodes" pre-operation but modern diagnostic criteria for bipolar disorder may be difficult to exclude

		Outcome					
Author	No. in series	Surgery	Diagnosis	Follow-up	measures	Results	Comments
Winston (1979)	7 (7)	Cingulotomy	"Depression"	6 months-3.5 years. Prospective	4-point Global Scale	2 patients asymptomatic with no post-operative treatment. 1 patient asymptomatic with treatment. 2 much improved. 2 unchanged	No worse category. 1 patient had hypomanic episode post-operation

GAF, Global Assessment of Functioning (ref); HADS, Hospital Anxiety and Depression Scale (ref); N, neurotic; P, psychotic; R, recurrent; I, involuntal; O, other.

N.B. An Australian series has also been reported but is not technically stereotactic (cingulotomy); Bailey *et al*, 1977) and there is a small Spanish series of subcaudate tractotomy patients not amenable to this sort of tabulation (Broseta *et al*, 1977). Other reports are believed to be contained in the data outlined above (e.g. Hussain *et al*, 1988).

Appendix 2. Outcome data from stereotactic neurosurgery for obsessive-compulsive disorder

Author	No. in series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Baer <i>et al</i> (1995)	18 (18)	Cingulotomy	OCD (DSM-III-R defined by SCID)	26.5 months average (at 6-month intervals). Prospective	Y-BOCS, BDI. Clinical Global Impression Sickness impact profile. Side-effects measures	28% had >35% fall in Y-BOCS scores. 50% no response. Improvement of Y-BOCS correlated with other depression and anxiety scores	Data via telephone contact and local psychiatrist report. All comorbid for major depression. Many comorbid for social phobia
Ballantine <i>et al</i> (1987)	32 (273)	Cingulotomy	OCD (retrospectively defined on DSM-III criteria from notes	8.6 years. Retrospective	6-point Global Scale. WAIS	25% either well or on maintenance treatment only. 56% within top improvement ratings	Information from notes, questionnaires, out-patient contacts. All patients had a marked depressive component. Rater bias possible
Bartlett & Bridges (1977)	2 (8)	Extended subcaudate tractotomy	"Obsessional neurosis with depression"	1 year. Retrospective?	5-point Global Scale	1 case improved with few mild symptoms. 1 case improved with significant residual symptoms	No symptoms measure. Rater bias possible. 1 case transient increased sexual demand

Author	No. in series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Bingley <i>et al</i> (1977)	35 (35)	Thermo- capsulo- tomy	"Typical chronic obsessional neurosis"	35 months (4-55- month range). Prospective	5-point Global Scale. Working capacity measure. Wechsler Bellevue. IQ. MMPI. EPI. (<i>n</i> =9)	42% symptom- free. 24% much improved. None worse. No tendency to relapse. Working capacity improved in third. IQ tended to improve. Anxiety, obsession- ality, neuroticism and introversion tended to decrease	4 cases had previous surgery. Considerable weight gain in some. Measures of global outcome by independent psychiatrist
Burzaco (1981)	85 (85)	Thermo- capsulo- tomy ("Leksell's method")	"Obsessive-com- pulsive neurosis"	1-2 years. Prospective	Global Scale (5 category)	41% symptom- free. 32% much improved. 22% slightly improved. 5% not improved. None worse	17 patients were re- operated on. 17 patient had late improvement (1 year post-operation) Rater bias possible. Telephone, letter or personal contact

Author	No. in series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Corkin <i>et al</i> (1979)	7 (41)	Cingulotomy	"Obsessive-compulsive neurosis"	1 year. Prospective	Global Scale (4 category) WAIS. Non-verbal fluency. Neurological exam. Neuropsychological assessment	57% no improvement (<i>n</i> =4). 29% slight improvement (<i>n</i> =2). 14% moderate improvement (<i>n</i> =1)	Data based on notes, interview, telephone. Possibly part of Ballantine's outcome series. No diagnosis criteria or symptom scale
Cosyns <i>et al</i> (1994) Cosyns & Gybels (1979)	16 (21)	Subcaudate tractotomy. Thermo-lesion (<i>n</i> =9). Multifocal leuco-coagulation (<i>n</i> =7)	OCD (DSM-III defined)	7 years (range 2-9 years). Prospective?	6-point Symptom Scale (four domains). Postal questionnaires (treatment, social support, WAIS, MMPI, neuropsychology).	Significant fall in symptoms pre-/post-operation but not in the coagulation group). None worse. Control group (<i>n</i> =7) unchanged at follow-up. No deterioration in WAIS or MMPI	Questionnaires not validated (postal). Rater bias possible (referrer may be assessor)
Crow (1977)	49 (90)	Multifocal leuco-coagulation	"Obsessional patients"	2-12 years Retrospective	Global Scale (4 category)	29% "complete relief". 26% "near complete relief". 22% "substantial relief"	IQ fall in 19% (rest improved or remained the same). No diagnostic criteria or symptoms measures. Rater bias possible

Author	No. in series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Fodstad <i>et al</i> (1982)	4 (4)	Cingulotomy (n=2). Capsulotomy (n=2) (randomised)	"Chronic obsessive-compulsive neurosis"	12-34 months. Prospective	Global Scale (5 category) CPRS. Hamilton & Vikki Scale Neuropsychological battery	50% marked improvement. 50% slight improvement. Significant fall in C.P.R.S. scores in 50%	Personal contact for follow-up. Capsulotomy may be superior, but small sample
Goktepe <i>et al</i> (1975)	18 (208)	Subcaudate tractotomy	"Obsessional neurosis"	30 months minimum. Retrospective	Global Scale (conflated 5 category). Work and marital adjustment. Post-operation admission data. Taylor Manifest Anxiety and Wakefield Depression Scores	50% either symptom free or marked improvement. 33.3% slight improvement. 16.7% unchanged	Only 64% fully assessed. Rater bias possible. Undesirable but slight personality traits in 6.7%. No cognitive or personality tests

Author	No. in series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Hay <i>et al</i> (1993)	26 (26)	Cingulotomy only (<i>n</i> =6). Orbito-medial lesion only (<i>n</i> =3). Combined (<i>n</i> =17). (Controlled)	OCD (DSM-III-R criteria)	10 years. Retrospective	Global Scale (6 category). Semi-structured interview (HRSD, HAS, BDI, Y-BOCS (17-point), EPI WAIS, neuro-psychological and work capacity	38% "obvious improvement". 23% "mild or doubtful". 23% "no change". 15% "worse". no controls in remission for >6 months, whereas 30% of treatment group had remission at >6 months	Only 18 patients were interviewed fully (17 full data). Change in obsessive compulsive symptoms independent of anxiety and depression. Cingulate lesion only did worst
Herner (1961)	18 (116)	Thermocapsulotomy	"Obsessional neurosis"	24-80 months. Prospective	Global Scale (6 category). Work assessment. Subjective patient assessment. Neuropsychology	39% "symptom-free". 11% "marked improvement". 22% "moderate improvement". 11% "no improvement". 17% "worse". IQ preserved. 75 patients institutionalised pre-operation, 44 patients post-operation	Weight gain 13%. 53% had transient and mild emotional/volitional changes. Diagnostic criteria uncertain

Author	No. in series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Irlé <i>et al</i> (1998)	16 (62)	Ventromedial (<i>n</i> =6). Ventrostriatal and ventromedial (<i>n</i> =5). Dorsal extension and ventromedial (<i>n</i> =5)	OCD DSM-III-R	16-22 years Retrospective	Y-BOCS Self report measures. Neuropsychology tests. MMPI	70% of patients estimated 50% improvement in symptoms	Ventrostriatal lesions associated with addiction. All groups show perseverative changes. Recommend ventromedial lesions only
Kullberg (1977)	10 (24)	Thermocapsulotomy (8 ops). Cingulotomy (3 ops)	"Obsessive compulsive neurosis"	3 years (range 1-9 years). Prospective	General improvement scale 5 point. Social functioning scale 5 point	Excellent Good Moderate Slight None	CPCI 1 0 2 0 2 0 1 1 2 2 Non-standard diagnoses. No "worse" category used. Rater bias possible. Confusion and personality change especially capsulotomy patients
Mei & Yan (1991)	23 (?)	Cingulotomy	OCD	1 year. Prospective	Y-BOCS. MOCI. CPRS-OC	42% "a beneficial response"	No severe adverse consequences noted. Study quoted by Mindus (1994)

Author	No. in series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Mindus (1991)	10 (24)	Thermocapsulotomy	OCD (DSM-III-R criteria)	8 years. prospective	Global Scale (conflated 5 category) Personality assessment (KSP). Symptoms measures (CPRS). Axis V Rorshach tests (Exner, 1986)	60% in symptom-free or marked improvement category. Axis V pre-operation, post-operation 4. KSP tends to normalise scores post-operation	Rater bias possible. 1 suicide. 50% showed severation on lab tests. 29% were tired. 16% subjects had poor memory with weight gain usual. 33% had further episodes of depression
Mindus <i>et al</i> (1994a)	22 (same series)	Thermocapsulotomy	OCD (DSM-III-R criteria)	8 years. Prospective	Global Scale (as above). CPRS	77% had decreased CPRS scores compared with pre-operation (23% increased). No significant differences in outcome measures at 8 years <i>v.</i> 1 year	2 patients lost to follow-up. No further information.
Meyer <i>et al</i> (1973)	3 (75)	Cingulotomy	"Obsessive-compulsive patients"	18 months average (5-54 month range). Prospective.	6-point Global Scale. Neuropsychological tests. MMPI IQ	67% well or marked improvement. 33% slight improvement.	"Worthwhile improvement" in further 11/16 patients with obsessional-compulsive symptoms. Stimulation experiments

Author	No. in series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Rylander (1979)	7 (14)	Gamma-capsulotomy	"Obsessive-compulsive state with anxiety"	9–26 months. Prospective	4 point Global Scale. Multicomponent anxiety measure. IQ EPI	29% symptom-free ($n=2$). 29% much improved ($n=2$). 29% slight improvement ($n=2$). 13% unchanged ($n=1$)	Mixed diagnoses (all had phobic symptoms). Rater bias possible. Slight indication of reduction of initiative and tiredness
Rylander (1979)	38 (38)	Thermocapsulotomy	"Obsessive-compulsive state with anxiety"	21 months–8 years. Retrospective.	5-point Global Scale	50% symptom-free ($n=19$). 21% much improved ($n=8$). 26% slight improvement ($n=10$). 5% unchanged ($n=1$)	Rater bias possible. No undesirable personality change. No intellectual change
Snaith <i>et al</i> (1997)	5 (7)	Stereotactic orbitomedial lesion	OCD	1 year. Prospective	GAF CPRS HADS Psychometric battery (inc. IQ). Visual analogue scale (by referring psychiatrist)	GAF rating pre-operation range 5–35, post-operation 30–65 (none worse). CPRS scores improved (average 2.6 points)	Independent assessor post-operation

Author	No. in series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Strom-Olsen & Carlisle (1971)	20 (210)	Subcaudate tractotomy	"Obsessional neurosis"	16 months-8 years. Retrospective	5 point Global Scale. Working capacity. Capacity for pleasure. Post-operation treatments	35% symptom-free (<i>n</i> =7). 20% marked improvement (<i>n</i> =3). 20% slight improvement (<i>n</i> =3). 30% unchanged (<i>n</i> =6). 5% worse (<i>n</i> =1). 50% relapse rate (<i>n</i> =12).	21% tiredness. 14% personality change. 50% recovered within 5 months. No symptom measures. 20% of total sample set incomplete
Tippin & Henn (1982)	5 (5)	Cingulotomy	OCD (defined by RDC criteria)	1-7 years. Prospective.	5 point Global Scale. MMPI Wechsler Memory Scale	20% symptom-free (<i>n</i> =1.) 60% marked improvement (<i>n</i> =3). 20% slight improvement (<i>n</i> =1). MMPI scores tended to 'normalise'. IQ scores tended to increase	Patients not treated pre-operation with clomipramine

SCID, Structured Clinical Interview for Diagnosis (ref); CP, capsulotomy; CI, cingulotomy

Appendix 3. Outcome data from stereotactic neurosurgery for non-OCD anxiety

No. in Author	series	Surgery	Diagnosis	Outcome Follow-up	measures	Results	Comments
Ballantine (1987)	14 (273)	Cingulotomy	"Phobic or generalised anxiety"	8.5 years (2-22 years range). Retrospective	Global Scale. WAIS	50% "fully or markedly improved"	Rater bias possible. Only 73% fully assessed out of total. Retrospective. No symptom measures. 1% epilepsy, <0.03% hemiplegia
Corkin <i>et al</i> (1979)	3 (41)	Cingulotomy	"Anxiety neurosis or probable anxiety neurosis"	12 months. Prospective	Global Scale. WAIS Non-verbal fluency. Neurological examination	67% "moderate improvement" (<i>n</i> =2). 33% "undetermined" (<i>n</i> =1)	No diagnostic criteria. No symptom scale. 26% of whole series re-operated on (<i>n</i> =41)
Crow (1977)	41 (41)	Multi-focal leucotomy	"Severe anxiety" (mean duration 14.8 years)	2-12 years Retrospective	Global scale (4 category)	36% "complete relief". 31% "near complete relief". 16% "little or no benefit"	Rater bias possible. Diagnostic criteria unclear. No symptom measure

Author	series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Goktepe <i>et al</i> (1975)	24 (208)	Subcaudate tractotomy	"Chronic tension and anxiety. Phobic anxiety"	30-54 months Retro- spective	Global scale. Taylor Manifest Anxiety Scale. Social work interview	62.5% improved "fully" or "markedly" Phobics did better.	Only 64% fully assessed. Retrospective. No cognitive or personality tests. 6.7% showed personality change. 2.2% epilepsy
Herner (1961)	15 (116)	Thermo- capsulo- tomy	"Anxiety neurosis"	24-80 months. Prospective	Global scale. Cognitive battery. Symptom measures in sub- sample	20% "good". 40% "fair". 33% "poor". IQ preserved	Diagnostic criteria uncertain. Weight gain 13%. 53% transient and mild emotional/ volitional changes
Hodgkiss <i>et al</i> (1995)	4 (286)	Subcaudate tractotomy	"Anxiety"	12 months. Retro- spective	Global scale only.	25% "complete or marked relief" (<i>n</i> =1). 50% "moderaterelief" (<i>n</i> =2). 25% "slight or no relief" (<i>n</i> =1)	Diagnostic criteria? 88% patients traced. No interviews – results based on notes only
Kelly (1980) Mitchell- Heggs <i>et al</i> (1976)	27 (148)	Limbic leuco- tomy	"Chronic anxiety (free floating or phobic)"	6 weeks and 20 months. Prospective	Global scale. Taylor Manifest Anxiety Scale. HAS. MPI. WAIS. Physiological measures	28% "fully or markedly improved". 35% in part on Global scale. 7% worse. Significant improvement on symptom scores	Drug or alcohol misuse in some patients pre- operatively. Rater bias not eliminated. Diagnostic criteria? "mild lethargy, slight outspokenness occasionally"

Author	series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Kihlstrom <i>et al</i> (1995)	6 (11)	Gama capsulo- tomy	Phobic disorders Generalised anxiety disorder (DSM-III-R)	1-5 years. Prospective	"Established rating scale". MRI and CT measures	"Unsatisfactory results in patients with non-OCD"	Not concerned with psychiatric outcome. 33% fatigue. 33% frontal lobe syndrome. "Tissue reaction (un)predictable"
Kullberg (1977)	13 (26)	Thermo- capsulo- tomy (5 ops). Cingulo- tomy (15 ops)	"Anxiety neurosis"	1-9 years (3 years median). Prospective	Global scales. "Level of social functioning". "General improvement"	2 patients had both operations. 23% excellent. 8% good. 23% moderate	Non standard diagnoses. Rater bias possible. Confusion in some patients and some personality change (especially capsulotomy)
Mindus (1991)	14 (24)	Thermo- capsulo- tomy	Agarophobia. Social phobia. Generalised anxiety disorder. (DSM-III-R)	12 months. Prospective	Global Scale. CPRS. GAF. KSP	93% "fully or markedly improved" on Global Scale. 50% symptom- free. KSP score more normal post- operatively	Uncontrolled. 50% showed persev- eration on lab tests. 29% tired. 16% subjects had poor memory. Weight gain "usual". 33% further episodes of depression

Author	series	Surgery	Diagnosis	Follow-up	Outcome measures	Results	Comments
Mindus & Bergstrom (1987)	7 (8)	Gamma-capsulotomy	Agarophobia. Social phobia. Generalised anxiety disorder. (DSM-III-R)	7 years. Retrospective	Global Scale. CPRS. GAF	71% "fully or markedly improved" on Global Scale. CPRS scores significantly better	Retrospective. Variable radiation doses given. Asymmetrical lesions in 2 cases
Rylander (1979)	7 (14)	Gamma-capsulotomy	"Phobias"	9-26 months. Retrospective	Global Scale. "Multicomponent anxiety measure". IQ. EPI	57% "symptom-free". 29% "much improved". 14% "unchanged"	Rater bias possible. Diagnostic criteria uncertain. "Slight indication of reduction of initiative and tiredness"
Strom-Olsen & Carlisle (1971)	46 (210)	Subcaudate tractotomy	"Anxiety state (including neurotic depression)"	16 months minimum (80% between 16 months and 4 years). Retrospective	Global Scale. "Capacity for pleasure and work". Post-operative treatments	41% complete or marked improvement. 24% some improvement. None worse	No symptom measures. 20% of total sample set incomplete. 14% of total had personality change. 7% had weight gain. 21% had tiredness

Appendix 4. Consultation prior to report

We took evidence from the following individuals and groups. We are most grateful to all of those below who gave up their time to come and speak to us. Many of the points that were made to us have been incorporated in this report.

It is important to note that the evidence we received from MIND was that there was absolutely and emphatically no place for neurosurgery in the treatment of mental disorder. The inclusion of their name below does not in any way mean that they endorse this report.

Dr William Barker	Consultant Psychiatrist Hadrian Clinic Newcastle upon Tyne
William Bingley	Chief Executive Mental Health Act Commission Maid Marian House 56 Hounds Gate Nottingham NG1 6BG
Dr Paul Bridges	Consultant Psychiatrist Maudsley/Kings College Hospital London E5 9RS
Professor Stuart Checkley	Consultant Psychiatrist Maudsley/Kings College Hospital London FE5 9RS
Alison Cobb	Policy Officer MIND 15–19 Broadway London E15 4BQ
Dr Desmond Dunleavy	Section 57 Panel Member Mental Health Act Commission Maid Marian House 56 Hounds Gate Nottingham NG1 6BG

Dr George Fenton	Department of Psychiatry Ninewells Hospital Dundee DD1 9SY
Dr June Gilchrist	Clinical Neuropsychologist Dundee Neurosurgery Team Dundee Royal Infirmary
David Guinness	Manic Depression Fellowship 7 Woodside Crescent Glasgow G3 7UL
Dr John Gray	Neuropsychologist Hadrian Clinic Newcastle upon Tyne
Dr Max Harper	Chairman to Consent to Treatment Group Mental Health Act Commission Maid Marian House 56 Hounds Gate Nottingham NG1 6BG
Dr Robert Howard	Senior Lecturer in the Psychiatry of Old Age Section of Old Age Psychiatry Institute of Psychiatry Camberwell London SE5 8AF
Professor R. J. McClelland	Professor of Mental Health The Queen's University of Belfast The Whitla Medical Building 97 Lisburn Road Belfast BT9 7BL
Professor Per Mindus	Dept. of Clinical Neurosciences Karolinska Hospital & Institute S-171 76 Stockholm Sweden
Professor Karel de Pauw	Pinderfields General Hospital Aberford Road Wakefield WF1 4DG

Appendix 5. National survey of neurosurgery for mental disorder

Dear ...

The last national survey of neurosurgery for mental disorder was conducted Twenty years ago (Barraclough & Mitchell-Heggs, 1978). A working party of the Research Committee of the Royal College of Psychiatrists is compiling a report about contemporary practice in the UK in this field. The intention is to produce a report later this year that reviews the current system of care for this group of patients and will aim to evaluate the wider clinical framework (e.g. by making a comprehensive literature review of efficacy and adverse effects).

Information about current activity is therefore vital to our task. Could you fill in the following short questionnaire and return it to us within the next few weeks?

1. What operation(s) are performed at your Centre? (Please state the name of the procedure, the exact target site and the method of lesioning.)

2. Could you fill in the following table about recent activity? (i.e. no. of cases)

Year	Depressive disorder	Bipolar affective disorder	Obsessive–compulsive disorder	Other anxiety disorder	Other diagnoses (Please state)
1994					
1995					
1996					
1997					
1998					
1999 to date					

3. What is the procedure for referral?

4. What is the procedure used for pre-operative assessment? (Please enclose any protocol or give information about psychometric and clinical assessments, etc.)

5. What is the procedure used in post-operative assessment? (Please enclose any protocol as above).

6. Which personnel are involved in the service you provide?

7. Do you have a protocol for reoperating (second operations)? If so, please specify.

8. Number of second operations per year?

Many thanks for completing this questionnaire.

Yours sincerely

Dr Chris Freeman , consultant psychiatrist, Chair of Neurosurgery Working Group,
Royal College of Psychiatrists
Dr David Crossley, SPR in Psychiatry

Appendix 6. Saggital section of brain showing sites of four main neurosurgical operations for mental disorder



