The persistent value of lesions in psychiatric neurosurgery

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Neurosurgery for intractable psychiatric conditions has seen a resurgence with the increasing use of deep brain stimulation (DBS). Although DBS promises reversible neuromodulation and has become more popular than older lesioning methods, lesioning might still be preferred in specific cases. Here, we review the evidence for DBS and lesions in the treatment of intractable neuropsychiatric conditions and consider the factors that favour the continued use of lesioning procedures in appropriately selected cases. Broadly, systemic factors including comparative effectiveness, cost, and ethical arguments support an ongoing role for lesioning. Such a role is also supported by practical considerations including patient experiences of this type of therapy, the relative intensity of follow-up care, access to sparse or specialised follow-up care, and relative infection risk. Overall, we argue that neurosurgical lesion procedures remain an important alternative to DBS and their continued availability is necessary to fulfil the imperatives of mental health parity and enhance access to effective mental health treatments. Nonetheless, the efficacy of DBS and recent advances in closed-loop stimulation and remote programming might provide solutions to some of the challenges associated with wider use of electrical neuromodulation. Concerns about the scarcity of high-level evidence for the efficacy of lesioning procedures as well as the potential irreversible adverse effects of lesioning remain to be addressed.

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Introduction

Psychiatric illnesses remain a leading cause of disability worldwide.[1] Although most patients can be successfully managed with pharmacotherapy and psychotherapy, a small minority are severely debilitated and have illness that is refractory to intensive conventional treatments; such patients are potential candidates for procedural intervention.[2,3] The use of non-invasive interventions such as electroconvulsive therapy and transcranial magnetic stimulation, as well as neurosurgical interventions, reflects a growing circuit-based understanding of psychiatric illnesses that increasingly renders them amenable to neuromodulation targeted anatomically rather than just pharmacologically.[4]

Surgical intervention for psychiatric illness has gone through multiple eras of transformation and has had its share of innovations, breakthroughs, promising results, and controversies. Psychosurgery can be traced back to Gottlieb Burckhart's first topectomy in 1888, which considerably pre-dates the use of pharmacological therapy for these conditions.[5] The understanding of the link between neural anatomy and behaviour was poor at the time of these procedures, which were described as trepanations and resections. Since the 20th century, advancements in neurophysiology, stereotaxis, and electrical stimulation have led to a narrowing of the scope and purpose of psychiatric neurosurgery from maximally invasive and morbid procedures, such as the frontal lobectomy, to more selective lesioning procedures, such as anterior cingulotomy and anterior capsulotomy.[6] However, unlike lesioning techniques, deep brain stimulation (DBS) offers the prospect of variable neuromodulation. Once the DBS system is implanted, a multidisciplinary team can adjust its settings to maximise therapeutic benefit while minimising side-effects. More recently, the possibility of regulating stimulation in real time based on neurophysiological feedback has gained increasing attention and is a promising avenue of research.[7,8] Such closed-loop neuromodulation systems have the potential to deliver more efficacious treatment due to their ability to sense and record neurophysiological signals that might be associated with specific psychological states and respond by delivering stimulation accordingly. These advances in the technology will, hopefully, prove beneficial for both patients with psychiatric illness and their providers, who can find it challenging to select effective stimulation parameters.[9] Given this potential for adjustable and dynamic stimulation and the perception of reversibility, DBS for psychiatric illness has become increasingly favoured over lesioning procedures.[10]

Circuit-specific intervention is especially appealing in the patient with refractory illness who might have few options for additional medications, with diminishing returns. Medications are only as specific as the targets in the brain with which they interact. Given the highly polygenic nature of mental illness and the important role of environmental and epigenetic factors, psychiatric illnesses might not map easily onto a circuit that colocalises neatly with a molecular drug target.[11–13] Therefore, to best address neuropathology that has as its basis a dysfunctional circuit (rather than a dysfunctional molecule or metabolic pathway), anatomically targeted approaches such as electrical neuromodulation and structural ablation or disconnection might prove beneficial for some patients. Such anatomical approaches hold the promise of precise treatment of cognitive, affective, and behavioural aspects of neuropsychiatric illness by modulating the brain circuits directly responsible for them.

Ablative techniques

Gamma knife capsulotomy for obsessive-compulsive disorder is considered the classic ablative intervention for psychiatric illness. This procedure involves affixing the patient's head in a stereotactic head frame using skull pins and obtaining an MRI, which is used for targeting. Gamma radiation is then delivered to an isocentre to create a lesion, with patients typically being discharged the same day. The effects of this treatment are not immediate, given the delayed development of the radionecrosis that creates the lesion.[14] Laser interstitial thermal therapy and radiofrequency ablation both rely on standard stereotactic methods for the direct insertion of a probe into the target structure, but the precise method will vary depending on surgeon preference and available tools. These procedures are generally done under general anaesthesia; however, awake implantation and microelectrode recordings have been described for radiofrequency ablation surgery.[15] In the case of laser ablation, energy delivery is monitored in near real time using magnetic resonance thermometry.[16,17] Focused ultrasound, an emerging technique that is gaining popularity for the treatment of movement disorders, is similar to gamma knife radiosurgery in that it involves attaching a stereotactic frame to the patient's head with skull pins; the frame is, in turn, fixed to the focused ultrasound helmet. Unlike radiosurgery, however, focused ultrasound delivers precise sonication to create an immediate lesion, which is monitored in near real time using magnetic resonance thermometry, similar to laser procedures. Patients undergoing gamma knife radiosurgery or focused ultrasound are typically discharged the same day.[16,18]

Efficacy

The effectiveness of both DBS and lesioning techniques has been shown across various indications within psychiatric illness.[16,19–21] In treatment-resistant obsessive-compulsive disorder, lesioning and DBS have roughly equivalent efficacy,[21] with both interventions targeting the same basic circuit (ventral capsule and ventral striatum for DBS and the anterior–ventral internal capsule for capsulotomy). A meta-analysis of the published literature comparing DBS with lesions found similar efficacy for these techniques in the treatment of refractory obsessive-compulsive disorder, with response rates of 53% and 48% after 12–16 months and 57% and 56% at last follow-up for ablation and DBS, respectively, and large effect sizes in the reduction in Yale-Brown Obsessive Compulsive Scale scores.[22] A more recent-meta analysis, which focused specifically on DBS for refractory obsessive-compulsive disorder and included additional targets, such as the subthalamic nucleus and bed nucleus of the stria terminalis, found a slightly higher response rate with DBS: 66% of patients were full responders, with nearly 50% improvement in symptoms.[23] Additionally, ablative procedures such as radiofrequency and laser ablation can reduce symptoms and improve Yale-Brown Obsessive Compulsive Scale assessment scores immediately after surgery,[24] whereas DBS necessitates programming sessions and adjustments that might take months of optimisation. Stereotactic radiosurgery is similar to DBS in that a longer latency to effect is observed as the radionecrosis develops.[14]

For treatment-resistant major depressive disorder, two randomised controlled trials showed some potential benefit, especially in the short term, but recurrence rates were high.[25,26] Furthermore, the results of a study by Bergfeld and colleagues showed that symptoms responded in 10 of the 25 patients enrolled, with a significant reduction in the 17-item Hamilton Depression Rating Scale; however, this observation was limited by high dropout rates for patients with symptoms that did not respond, which might have led to the true efficacy of this intervention being overestimated.[25] Meanwhile, a multisite, randomised, sham-controlled trial by Holtzheimer and colleagues showed no statistical difference in the antidepressant effect of stimulation versus sham.[26] Thus, further well designed studies are needed to understand the true therapeutic potential of DBS for major depressive disorder.[27–30] Similarly, the data supporting ablation techniques for major depressive disorder are scarce, mostly derived from retrospective and open label studies. Therefore, drawing conclusions regarding the efficacy of neuromodulation versus ablation for major depressive disorder is not yet feasible.[31]

More recently, studies have evaluated the possible role of focused ultrasound to treat depression and obsessive-compulsive disorder, with an early case series suggesting clinically significant improvements for some patients might be possible.[32,33] Low-intensity focused ultrasound is also being evaluated for its potential to produce reversible neuromodulatory effects in precisely targeted anatomical regions that are relevant to the expression or treatment of psychiatric symptoms. Low-intensity focused ultrasound might provide a means to probe these neural circuits and thereby identify, for each individual, what types of network modulation might be most effective, potentially leading to more optimal selection of targets for lesioning or DBS. Low-intensity focused ultrasound might also itself be a therapeutic modality when designed to promote circuit plasticity and, perhaps, combined with appropriate behavioural or pharmacological interventions.[34] Compared with high-intensity focused ultrasound, low-intensity focused ultrasound provides an even less invasive neuro-modulatory modality as it does not require placing the patient in a fixed head frame with pins.[34] Thus, given these various modalities and mechanisms of action, this technology has considerable potential to enhance the understanding and treatment of otherwise intractable psychiatric illness.

Irreversibility

The notion of irreversibility pertains to the concern that ablations and disconnections might, even if they ameliorate specific aspects of the neuropsychiatric illness, produce some negative consequences that can never be undone. However, whether there are indeed irreversible and functionally meaningful adverse cognitive changes in patients who undergo lesion

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procedures is not yet clear. A meta-analysis of long-term deficits after ablative procedures for major depressive disorder, for example, was limited by the paucity of randomised controlled data.[31] Many of the studies included were small institutional case series, and these showed that most postoperative deficits, including apathy, subjective memory loss, or concentration problems were temporary, with some patients having reported seizures, motor weakness, or urinary incontinence.[31] Similarly, ablative procedures for obsessive-compulsive disorder might have temporary postoperative side-effects, including, most notably, apathy following the capsulotomy procedure, but no clear evidence to date suggests irreversible cognitive or affective symptoms are prominent or common. For example, a randomised controlled trial of gamma knife capsulotomy with 16 patients showed no long-term deficits.[14] Other studies reporting long-term adverse events in ablation for obsessive-compulsive disorder are limited by small numbers of patients as well as a scarcity of formal objective neuropsychological testing, both preoperatively and postoperatively.[35,36] Although the evidence regarding cognitive changes after these procedures is far from conclusive, there are hints that lesions might in some ways augment, rather than irreversibly compromise, cognitive function. This outcome is not unlike the occasional improvement in memory observed after ablative, highly selective temporal lobe procedures for epilepsy;[37] the intuitive explanation for such effects is that the ongoing disruptive influence of abnormal activity in the affected region was more harmful than the loss of the involved structures. These effects might not be unique to epilepsy surgery. For example, one study that undertook detailed presurgical and postsurgical neuropsychological assessments of patients undergoing anterior capsulotomy for obsessive-compulsive disorder found grossly stable or even improved cognitive outcomes in several domains, although there were also potentially concurrent adverse effects on particular language and attention measures.[38] Therefore, although irreversible adverse effects created by lesions have been reported and remain concerning for patients and providers,[39] there are likely to be mixed effects. Further research into the characteristics of lesions and the risks associated with different ablative modalities is needed to aid in the appropriate counselling of patients.

Patients might also develop affective changes after DBS surgery. For instance, hypomania (20%), worsened anxiety (22%), and disinhibition (6%) have been reported after DBS for obsessive-compulsive disorder.[40] However, the vast majority of these adverse effects are temporary or can be reversed with iterative programming adjustments.[23] Neuropsychological assessments of patients with DBS in the nucleus accumbens for obsessive-compulsive disorder have shown mildly decreased or stable cognitive outcomes after surgery.[41] Of note, DBS placement might result in microlesions at target sites and gliosis along lead trajectories,[42] but the long-term sequelae of these changes, independent of ongoing stimulation, are not fully known.

Importantly, not all lesions are created equal, so considering the modality of the lesion technique might be important to understand the precise benefits and limitations of this general approach, especially for comparison with DBS. Thermal lesions produced by radiofrequency ablation, laser interstitial thermal therapy, or focused ultrasound are generally more immediate and more predictable than those produced by radiosurgery.[17] For example, approximately 7% of patients who underwent gamma knife thalamotomy for essential tremor in a single series[43] developed neurological side-effects secondary to unexpectedly large lesion volumes 6–12 months after procedures, and delayed formation of cysts (20 months after the procedure) has been observed in gamma knife radiosurgery for obsessive-compulsive disorder.[44] Even among the thermal lesion modalities, laser thermal lesions have a more defined border due to the optical tissue boundaries encountered by photons, whereas radiofrequency lesions generally show a more graded transition to normal tissue.[15] The morphology of focused ultrasound lesions is influenced by the characteristics of the skull and might show unanticipated tails extending from the isocentre.[45]

Different lesioning methods entail different degrees of procedural intensity and risk. Most thermal lesions, whether produced by radiofrequency emitter or laser, require the insertion of a probe or fibre-optic catheter directly into the brain. Here, laser ablation and focused ultrasound have the advantage of online monitoring of the procedure's progress using near-real-time MRI thermography. Radiosurgical lesioning techniques such as gamma knife require high doses of ionising radiation but are less invasive, at least in the immediately tangible sense. However, higher doses of radiation have been associated with a higher rate of adverse events, including executive dysfunction, disinhibition, and apathy.[46] These outcomes have led some groups to propose a limit for radiation doses delivered during gamma knife capsulotomy, for example.[14] High-intensity focused ultrasound, the newest lesioning tool, combines the advantages of a less invasive, non-ionising surgical technique with the high predictability of a thermal mechanism; nonetheless, this approach is still hindered by the limitations of individual bony structure and addressable neuroanatomy (ie, restrictions on lesion size and ability to deliver energy at particular angles and depth).[47] Therefore, considering all these differences, the terms ablation and lesion procedure can refer to very different operative realities.

Mental health parity

The US Mental Health Parity and Addiction Equity Act of 2008 and subsequent extensions by the Affordable

Care Act prohibit the use of different standards in the provision of mental health care. However, discrepancies between the law and the application of insurance benefits to patients with mental health conditions have persisted. For example, Davis and colleagues argue that providing insurance coverage for DBS to treat dystonia while excluding coverage for DBS to treat obsessive-compulsive disorder (despite both indications being supported by similar levels of evidence and government approval) is a violation of parity.[48] Applying evidentiary standards more stringently to mental health benefits (eg, in the treatment of obsessive-compulsive disorder) than to medical benefits (eg, in the treatment of dystonia) should be regarded as discriminatory.[48] Furthermore, in cases of severe and intractable mental illness such as obsessive-compulsive disorder, withholding necessary care could lead to long-term disability or death.[49]

Although DBS for neurological versus psychiatric illness has been regarded inequitably, there is generally greater acceptance of ablative and resective techniques in other contexts. In epilepsy, despite the advent of neuromodulatory techniques such as anterior thalamic DBS and responsive neurostimulation, procedures such as lobectomy, ablation, and even hemispherectomy or hemispherotomy remain widely accepted options.[50] Furthermore, in many epilepsy cases, the extent of tissue ablation or resection is far larger and can be more cognitively and affectively impactful than the typically much smaller lesions created for psychiatric conditions.[51] Yet there is comparatively less concern voiced over the aggressiveness of such destructive procedures in the epilepsy setting when weighed against the potential benefits for seizure reduction. This incongruity is more startling when one compares the overall morbidity and mortality of severe psychiatric illness and epilepsy. There were nearly 50 000 deaths from suicide alone in the USA in 2018 (15 per 100 000 population),[52] and individuals with severe psychiatric illness generally have their life expectancy shortened by 13–30 years.[53] Sudden unexpected death in epilepsy has an estimated overall crude annual incidence rate of 0·81 cases per 100 000 population, and the life expectancy of patients with epilepsy has been reported to be shorter by 8–10 years, on average.[54]

Because lesioning is an efficacious treatment for severe, refractory psychiatric illnesses, particularly obsessive-compulsive disorder, and perhaps treatment-resistant major depressive disorder, a failure to recognise the value of this treatment option when indicated might reflect a bias against the organic nature of mental illness and also contravenes mental health parity. Such biases manifest at various levels of psychiatric and medical care. Prevailing stigma around psychiatric illness as being less deserving of surgical treatment probably influences public perceptions of treatment options and clinicians' trust in the data regarding the efficacy of various neurosurgical interventions for psychiatric illness.[55] The views of both the public and medical providers about psychiatric neurosurgery and lesioning procedures in particular are likely to be influenced by negative perceptions of historical procedures such as lobotomy and a scarcity of collaboration and knowledge dissemination about the current safety and effectiveness of neurosurgery for psychiatric disorders.[56] Expanding awareness of and access to surgical treatments for severe psychiatric illness will require changing the understanding of both providers and patients. Specifically, it will be necessary to reinforce the notion that lesion-based treatments, although destructive in nature, are effective and might offer the potential for overall positive functional outcomes. Nonetheless, however strongly one agrees with these ethical arguments supporting the continued use of lesion techniques in psychiatric neurosurgery, there are additional, practical considerations that might also favour lesioning approaches in appropriately selected cases.

Practical arguments in favour of lesion procedures

Access

Despite its approval by the US Food and Drug Administration in 2009, DBS of the anterior limb of the internal capsule for the treatment of obsessive-compulsive disorder remains underused.[57] Barriers to access are multiple, with geographical limitations representing a considerable hindrance for patients seeking a centre that not only has experienced clinicians and services for implantation but also the resources to coordinate a multidisciplinary approach for care.[3] Subsequent follow-up and programming might prove challenging for patients who must travel long distances for this procedure. For patients with implanted DBS systems, regular access to specialised neuropsychiatric follow-up is required for the optimisation of settings and identification of hardware issues.[3,58,59] For a given system, various settings, including choice of active contact, stimulation frequency, and voltage, can be changed and in many circumstances are changed frequently to optimise patient benefits. However, there are no guidelines to assist providers with adjustments to DBS settings for a given set of symptoms or side-effects. Providers with experience programming DBS for a given indication might lack the relevant expertise to programme DBS for other indications;[60] few psychiatrists are as familiar or experienced with DBS as a typical movement disorders neurologist. In Parkinson's disease, in-person evaluation by a neurologist who specialises in both movement disorders and DBS programming can result in improved treatment outcomes.[61] In obsessive-compulsive disorder, data are much scarcer.[62]

Poor access to appropriate follow-up (either as a result of geographical distance or lack of local expertise) accounts for a substantial number of patients referred for DBS failure to specialised movement disorder centres.[63] In the psychiatric domain, the consequences of unrecognised hardware failure can be serious: both lead disconnections and battery depletions can be associated with abrupt worsening of psychiatric illness. Recent advances in telemedicine and remote DBS programming technology, such as the US Food and Drug Administration-approved remotely programmable Abbott device, might mitigate the need to travel long distances for follow-up.[64] The effectiveness and utility of this option, however, remain largely unknown at this point. Ablative procedures can be an option for patients who are faced with challenges regarding follow-up and programming, but efforts to provide education and experience to providers and empower them to take part in increasing access to surgical treatments for psychiatric disorders remain necessary. In fact, increasing access to both neuromodulation and ablation is necessary for all patients, to allow them to select the therapy that meets their needs and expectations.

Finally, the costs of the DBS procedure and associated follow-up and subsequent procedures are likely to preclude access to care for patients who have insufficient insurance coverage or live in countries in which the procedure is not covered. Even among the insured, battery replacements after DBS might not be covered. Nonetheless, analyses of quality-adjusted life years after neurosurgical intervention have shown a benefit and cost-effectiveness for DBS in the long term compared with treatment as usual.[65] Although there are few studies directly comparing the cost of DBS with that of lesioning, and these studies have been conducted in different economic settings, there is some support for the proposition that lesioning is likely to be more cost-effective than DBS. For example, a study examining the cost-effectiveness of radiosurgery ablation for obsessive-compulsive disorder showed greater cost-effectiveness compared with another study that looked specifically at DBS for obsessive-compulsive disorder.[65,66] More specifically, a cost-effectiveness analysis of DBS (DBS standard care, including implantation of leads and implantable pulse generator changes) versus treatment as usual for obsessive-compulsive disorder was associated with a mean incremental cost per quality-adjusted life year of €144 738·33 (an estimated US$157 000).[65] By contrast, a cost-effectiveness analysis of radiosurgical capsulotomy for obsessive-compulsive disorder showed an estimated mean incremental cost per quality-adjusted life year of US$28 960 (an estimated €26 700).[66] A cost analysis of laser ablation for obsessive-compulsive disorder has not been done, to our knowledge; however, for other indications such as epilepsy and tumours, varying results show levels of incremental cost that are somewhat higher than those associated with radiosurgery but lower than those associated with DBS.[67] At a health-care systems level, therefore, the availability of lesioning procedures might help mitigate economic barriers to appropriate mental health care.

Lower infection risk

In general, a lesion procedure can be conducted with a considerably lower risk of infection to the patient than a DBS procedure. A recent meta-analysis suggested that approximately 4–10% of patients who undergo DBS implantation might at some point develop a surgical site infection, although treatment might not necessarily require hardware removal.[68] Regardless, these risks could be intolerable for patients who are unable to access close, specialised follow-up. If the scope of psychiatric neurosurgery is to be expanded to benefit patients in parts of the world without regular access to neurosurgical follow-up, there might be considerable benefits for surgical interventions that do not involve implantation of hardware.

Patient perspective

Patient experiences and expectations are a crucial determinant of which interventions, if any, are offered. Patients who have illnesses such as major depressive disorder and obsessive-compulsive disorder often view psychiatric neurosurgery as a last resort.[69] Although many patients with obsessive-compulsive disorder are satisfied with their DBS systems, some have noted that having DBS makes them dependent on a device, which can fail, and on local providers, who must have the expertise necessary to manage their DBS systems.[70] Additionally, some psychiatric comorbidities might pose unique challenges relating to wound care and device integrity for patients. As an example, there are cases of patients with diagnoses of obsessive-compulsive disorder who have compulsive skin-picking behaviour, leading to erosion of the skin overlying their DBS hardware, and patients with diagnoses of Tourette syndrome whose tics resulted in a broken connecting wire.[71] In light of these potential challenges and the other factors, offering the choice of either DBS or ablative procedures, when indicated, could be an essential component of consent and patient autonomy.

Interestingly, as the evidence and technology for ablative procedures in epilepsy and movement disorders advance, we have begun to see an increase in popularity for ablative procedures such as laser and focused ultrasound ablation.[72] In psychiatric neurosurgery, the possibility exists that a sizeable proportion of patients would be more interested in ablative procedures if they were given the choice, which agrees with our own institutional experience. Ultimately, ethical considerations and frameworks that involve patients in research and the clinical adoption of different modalities are crucial and necessary to provide treatment options that address the particular needs of those with the lived experience of psychiatric illness.

Advancing our understanding of neural pathways

Finally, the history and successes of ablative neurosurgery have helped to elucidate the neural pathways affected in psychiatric illnesses and to identify targets for DBS, which has theoretical as well as practical value for the design of clinical trials. In a fundamental sense, compared with DBS, lesions are a simpler intervention—basically a circuit disconnection—that sidesteps the complexities and mechanistic uncertainties of electrical neuromodulation. The many permutations of stimulation

	Neuromodulation	Ablation
Efficacy	Studies have estimated 48–66% efficacy for DBS for obsessive-compulsive disorder; inconclusive data regarding efficacy in treatment of major depressive disorder; other indications remain in early stages of investigation[22,23,25,26]	Studies have estimated 61–78% efficacy for laser ablation for obsessive-compulsive disorder; inconclusive data regarding efficacy in treatment of major depressive disorder; other indications remain in early stages of investigation[21,24]
Reversibility	Side-effects mostly reversible, but complications from implantation are potentially irreversible[22,23]	Considered an irreversible intervention with potentially permanent deficits and cognitive changes, but most deficits are temporary[31]
Access and cost	Substantial geographical barriers in terms of access to surgeons and psychiatrists with expertise in DBS and responsive neurostimulation; high economic burden due to expense of hardware and follow-up; increased incremental cost per quality-adjusted life year in comparison with ablative procedures such as radiofrequency ablation[64–69]	Similar challenges to neuromodulation in terms of access to specialised centres, but long-term follow-up and device programming are not needed; considerably more cost-effective per quality-adjusted life year compared with DBS[66,67]
Infection risk	Higher risk of infection and hardware complication (4–10%), potentially requiring hardware removal[68]	No risk for hardware infection or complications; pin site infections can occur but are rare
Research	DBS can be used to study effects of stimulation of different targets and circuits in a blinded manner; responsive neurostimulation offers closed loop stimulation with the possibility of detecting neural signatures of particular disease states	Lesioning can be a simple method for studying specific circuits and the effects of their disruption; low-intensity focused ultrasound can produce reversible lesions to aid in the understanding of the role of particular targets in psychiatric illness[34]

DBS=deep brain stimulation.

***Table:* Summary of differences in selected aspects of neurosurgical interventions for neuromodulatory and ablative procedures**

parameters and the nonlinearities in neural response create an enormous space of neuromodulatory cause-and-effect—ie, there are many combinations of attributes, including electrode location, electrode configuration, stimulation frequency, and stimulation amplitude, that could be crucial to an observed response, and the effects of even a single type of stimulation on different neural elements and pathways are heterogenous.[73] However, with this complexity comes a potential opportunity to design efficacious patient-specific and symptom-specific stimulation protocols. Lesioning is more straightforward to assess and analyse than DBS, but, because a patient might not know whether or not an implanted DBS system is turned on or off, DBS is more conducive to blinded, prospective, randomised study[74] (unless one were to conduct ethically and practically complex sham-surgery controlled trials for ablative psychiatric procedures).

In the context of either DBS or lesions, the importation of stereotactic electroencephalography from the field of epilepsy to obsessive-compulsive disorder and other psychiatric disorders might enable better identification and characterisation of common and patient-specific, illness-related neural pathways, and could allow the design of optimal neuromodulation strategies.[74,75] Nonetheless, lesions might have an important role in the development of such optimal neuromodulatory strategies, given the simpler nature of this intervention that consists of a well defined, one-time, static, structural modification. As the indications and applications of psychiatric neurosurgery continue to expand, a synergistic interplay between these techniques is likely to propel us towards safer and more effective therapies for otherwise intractable psychiatric illness.

Conclusion

Neurosurgical intervention has a potentially valuable role in the management of severe, medically intractable psychiatric illness. Although DBS has emerged fairly recently as an attractive surgical modality for the treatment of psychiatric illness, considerable systematic and patient-specific challenges still prevent its use for a substantial number of patients. Lesion procedures continue to offer some advantages that could bridge the gap in the use of surgical intervention for psychiatric disorders (table). In particular, lesion procedures currently provide comparable outcomes to those of DBS while minimising the risks of hardware complications, substantially reduce the need for specialised, local follow-up, and might be more cost-effective in resource-constrained settings. Meanwhile, insights from lesion procedures continue to help advance our understanding of the neural pathways involved in psychiatric illnesses. Although the sophistication of and indications for DBS will undoubtedly continue to grow, lesion procedures should still have a major role in the management of psychiatric illness as demanded by the ethical notion of mental health parity as well as by practical factors to enable access to the most effective interventions for patients in need.

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HA: investigation, writing—review and editing. APP: investigation, writing—original draft, writing—review and editing. RS: conceptualisation, investigation, writing—original draft, writing—review and editing, project administration. PML: investigation, writing—review and editing. NCRM: writing—review and editing, supervision. WFA: conceptualisation, writing—review and editing, supervision.

Declaration of interests

We declare no competing interests.

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