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Intervening in the Brain: Ethics and Neurosurgery

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FROM THE EDITOR
Neuroethics: Perspectives from the Field, Circa 2015

Neurosurgery is among the newest of surgical disciplines, appearing in its modern incarnation at the dawn of the twentieth century with the work of Harvey Cushing and his contemporaries. It is also the most fraught. Neurosurgeons alone have the training and education to operate on the organ that constitutes the locus of humankind's consciousness, emotion, and intelligence. The ethical dilemmas inherent in acting upon the nervous system have long been apparent within our community and are compounded by the moral questions common to all medical fields [1, 2]. Ultimately, neurosurgical ethics involves the challenges of manipulating the anatomical locus of human identity and the concerns of surgeons and patients who find themselves bound together in that venture.

In recent years, neurosurgery ethics has taken on greater relevance as changes in society and technology have brought novel questions into sharp focus. The former changes—a global movement toward patient-centered surgery, evidence-based medicine, and cost-effective care—have prompted us to reconsider the relationship between neurosurgery and societal aims. The latter changes—an expanded armamentarium of techniques for interfacing with the human brain and spine—demand that we use philosophical reasoning to assess the merits of technical innovations.

This issue of *Virtual Mentor* features an array of perspectives from remarkable people working at the intersection of neurosurgery and practical ethics. Rather than a scholarly exercise, we have sought to create a living showcase of the most important ethical issues in neurosurgery circa 2015. Our goal is to provide useful guideposts for the practicing neurosurgeon as well as to inspire the coming generation of neurosurgeons and neuro-ethicists.

Our case studies, inspired by actual events, highlight key dilemmas that neurosurgeons may face in the clinical environment. The first case commentary, written by Michael Kelly, MD, MA, uses the example of elective cerebral aneurysm surgery to analyze the challenges of risk perception in the informed consent process. In the second case commentary, Bryn Esplin, JD, Andre G. Machado, MD, PhD, Paul Ford, PhD, and Kara Beasley, DO, MBe, take up the process of patient selection for neuromodulation, concluding that a blind attachment to "least invasive" treatments may not actually minimize harm.

Taken as a whole, the neurosurgery community might be placed near the left-hand portion of Everett Rogers's famous innovation adoption curve [3], as an

unambiguous "early adopter." Perhaps owing to the treacherousness of operating on the human brain and spine, considered unassailable domains for most of medical history, neurosurgeons have, since the mid-twentieth century, adopted new technological ideas—including intracranial pressure monitoring, stereotaxis, microscopy, radiofrequency energy, lasers, computers, endovascular therapy, neuroimaging, endoscopy, neuromodulation, surgical simulation, and molecular biology—with astonishing rapidity and varying success. In their history of medicine piece, Jayant Menon, MD, MEng, and Daniel J. Riskin, MD, MBA, consider the social and moral questions that accompany surgical innovation. By contrast, Brett E. Youngerman, MD, and Guy M. McKhann II, MD, ask how the increasingly ubiquitous standards of evidence-based medicine, with their emphasis on double-blind, randomized controlled trials can be applied to neurosurgery. In his piece, Marwan Hariz, MD, PhD, suggests that those advocating neuromodulation as a cognitive enhancement for normal persons may have been carried too far by exuberance about this technology.

Ethical considerations also arise in the training of neurosurgeons. In response to our third case, which was inspired by the ongoing debate surrounding the justification of resident duty-hour exceptions in neurosurgery, Nathan R. Selden, MD, PhD, and Michael M. Haglund, MD, PhD, offer solutions neurosurgery residency programs can pursue to balance patient care and educational training for residents. In this issue's medical education article, Brian D. Rothstein, MD, MS, and Warren R. Selman, MD, build on their experience with neurosurgical simulation technology to consider the unresolved questions that may accompany its widespread use in training. In a piece that is especially relevant to trainees and young surgeons, neuro-ethicist John Banja, PhD, argues for the disclosure of the surgeon's experience level as a risk factor in informed consent for neurosurgery.

For neurosurgeons, both training and practice require constant vigilance, attention to the needs of patients, and the maintenance of one's skills. In this issue, however, we turn our spotlight to several issues that require the neurosurgeon to assess his or her broader relationship to society. Jonathan Riley, MD, and Jessica Emery contribute a thoughtful review of the 2014 report of the Presidential Commission for the Study of Bioethical Issues concerning how the integration of ethics with neuroscience education and research at all levels will lay an ethical foundation for neuroscience research that may have far-reaching societal implications. While acknowledging the admirable leadership of neurosurgery organizations in expanding global access to neurosurgery care, George M. Ibrahim MD, PhD, and Michael Bernstein, MD, MHSc, discuss possible ethical pitfalls in certain common types of neurosurgery international aid missions. In this month's medicine and society piece, James Giordano, PhD, MPhil, advocates for a preparatory, rather than a precautionary or post hoc, approach to ethical analysis of neurotechnological advances, embracing innovation and anticipating and mitigating problems rather than trying to prevent use of new technologies in the name of risk reduction.

This issue's podcast features an interview with Paul Root Wolpe, PhD—whose

efforts have played a significant role in establishing neuroethics as a scholarly discipline—about emerging ethical issues affecting the field of neurosurgery. We hope you will enjoy the conversation with Dr. Wolpe as much as we did.

We are pleased to note that this is the first time *Virtual Mentor* has devoted an issue to the ethical dimensions of neurosurgery. As we continually push the boundaries of current technology and technique in the service of our patients, neurosurgeons have the best view of the accompanying ethical challenges. This month's issue should provide confidence in our community's ability to engage those challenges and perhaps a sketch of things to come. We invite you to join us on that journey.

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ETHICS CASE
Risk Perception, Bias, and the Role of the Patient-Doctor Relationship in Decision Making about Cerebral Aneurysm Surgery
Commentary by Michael L. Kelly, MD, MA

Dr. Swan, a young neurosurgeon, felt a nearly palpable anxiety in the air as he entered the examination room to see Mrs. Jones.

Mrs. Jones had been diagnosed with an unruptured cerebral aneurysm and referred to Dr. Swan. Her primary care physician had ordered an MRI scan of her head to work up her recurrent headaches, which were, ultimately, diagnosed as tension headaches. However, her workup incidentally revealed a moderate-sized aneurysm of the right posterior communicating artery.

In her initial visit, Dr. Swan had counseled Mrs. Jones that her aneurysm carried a roughly 1 percent annual risk of rupture and that a rupture carried a roughly two-thirds chance of neurologic disability or death. After conferring with his partners in interventional neuroradiology, Dr. Swan and his team recommended craniotomy on the basis of the characteristics of her aneurysm. In response to Mrs. Jones'ss questions about the danger of the surgery, he said, "If everything goes well, you could be out of the hospital three days after your craniotomy and the aneurysm will be gone. However, all surgeries have risk and this one is a complicated, delicate procedure. In my experience, you would have a roughly 15 percent risk of suffering a stroke or neurological deficit from surgery. The risk of wound infection, which could potentially result in a washout surgery, is about 5-8 percent. The surgery could also result in death, although this is rare, less than 1 percent of the time. Of course, every patient is different and no one has ever done a study on you, but this is what our experience tells us." Momentarily overwhelmed, Mrs. Jones asked to postpone treatment and think it over.

Dr. Swan reassured Mrs. Jones that, although hers was not an emergency, delaying treatment would result in no benefit and would yet expose her to a continued risk of neurologic catastrophe.

Several weeks later, Mrs. Jones returned to Dr. Swan's clinic for a followup visit. Dr. Swan scrutinized the new angiogram study he had ordered as part of her preoperative workup. To his concern, the aneurysm appeared to have subtly increased in size. Mrs. Jones, however, was not ready to provide consent for a craniotomy. She told Dr. Swan: "I have been thinking about all those risks you mentioned, like disability from stroke, and I wouldn't want my children to see me like that. I'm a gambler. At

my age, I might just take my chances with a tiny annual risk rather than the known risks of going under the knife."

Dr. Swan was taken aback. Although he had recommended surgery, he was determined to respect his patient's wishes. Mrs. Jones appeared to understand the details of her medical condition and the risks and benefits of Dr. Swan's treatment recommendation. However, she decided not to pursue treatment because of her age and her own self-described "gambler" disposition in the face of personal risk.

Dr. Swan was reminded of a popular magazine article he had seen, describing the follies and errors of human risk perception in behavioral economics, especially those risks that are rare, unfamiliar, or emotionally clouded. He wondered how informed consent could be preserved amidst these confounding factors and biases.

Commentary

A traditional ethical analysis of this case would point out that preservation of patient autonomy in the informed consent process is the paramount objective [1]. Mrs. Jones must be informed of all the pertinent risks, benefits, and alternatives to the treatment recommendation in order to make a fully informed and independent choice. A traditional approach might simply advise that, as an adult patient with decision-making capacity, Mrs. Jones has the right to refuse medical care even against the recommendations of the treating physician and family members [1].

Informed Consent and the Problem of Bias

However, informed consent and decision making are influenced by underlying cognitive processes, which may interefere with rational judgment. Under stressful and uncertain conditions, risk information is often misunderstood, and rational judgment can be obscured. Cognitive tendencies, limitations, and even errors can often influence judgment inappropriately, a problem known as "bias" [2, 3]. A growing body of literature suggests that cognitive biases and decision-making heuristics strongly influence decision making for both patients and physicians [2, 3]. Several types of bias may negatively impact a decision or outcome, particularly when the stakes are high and the risks uncertain.

Informational bias. To begin with, medical information can include implicit biases that often go unacknowledged but influence treatment decision making. Clinical studies may compare treatment modalities or select outcome measures or time points based on unjustified value assumptions [4]. For example, "unfavorable" neurological outcomes are traditionally designated in research studies by a Modified Rankin Score (mRS) greater than three, but whether or not individual patients define "unfavorable" in that way is unknown [5]. Studies that dichotomize results in this way may reflect research priorities rather than patient or clinician preferences. Moreover, academic medical centers are commonly the main sites for clinical research investigations and treatment recommendations, and this context may not reflect outcomes or available treatment options in nonacademic or community practice settings [6].

The effects of framing bias—including emphasizing only negative outcomes, focusing on the impact of disability, and selectively providing details about treatment options—have also been shown to influence patient decision making [7, 8]. Studies demonstrate that patient perception of prognostic information strongly influences decision making. Factors include the order in which negative information is presented, the time frame used for outcome assessment, the use of relative versus absolute risk reduction, the use of proportions instead of probabilities, and the inclusion of graphical materials [9, 10]. Poor statistical literacy among patients and physicians has also been reported as a barrier to the informed consent process [11].

The case scenario provides several examples of informational bias. Dr. Swan emphasized the risks of intervention (e.g., 15 percent chance of neurologic deficit, risk of death less than 1 percent) without ever reframing these statistics in more positive terms (e.g., 85 percent chance of no neurologic deficit, greater than 99 percent chance of survival after surgery). He also described the annual risk of aneurysmal rupture (i.e., 1 percent) without mentioning the much higher cumulative risk over Mrs. Jones's lifetime. In the case, Mrs. Jones actually refuses surgery based upon the risk of neurological deficit associated with surgical intervention. Her perception of neurological risk might have changed had Dr. Swan presented the information differently.

Geographic bias. Geographic studies suggest that institutional factors and the local culture of clinical practice strongly influence physicians' practice patterns. For example, the work of the Dartmouth Atlas group demonstrates wide geographic variation in procedural rates for hip and knee replacements, tonsillectomy, prostatectomy, cardiac surgery, and back surgery [12-15]. These variations appear to be associated with local physician supply and opinion and regional infrastructure and remain unexplained by patient-reported preferences for surgery or the prevalence of disease in a population [16].

This phenomenon has been observed in the treatment of cerebral aneurysms. Nonsurgical endovascular techniques for the treatment of cerebral aneurysms, developed over the past two decades, demonstrate similar efficacy and safety profiles as standard surgical approaches [17]. However, studies report wide institutional and regional variations in rates of endovascular procedures, with some regions reporting that they are used for 30 percent of all treated aneurysms and other regions reporting rates greater than 90 percent [18]. Much of the variation appears to be related to institutional factors such as physician expertise, equipment availability, and referral patterns between surgeon and nonsurgeon endovascular specialists [18].

In the case scenario, Dr. Swan consults the interventional neuroradiology team for nonsurgical treatment options but apparently does not mention to Mrs. Jones that the recommendation for surgical treatment involved other clinicians. He does not discuss the institutional factors and regional biases that structure his treatment decision and may even be unaware of the regional practice customs that influence his decision making. Dr. Swan's own lack of endovascular expertise, the existing institutional

referral patterns between neurosurgeons and neurointerventionalists, and regional practice patterns may all affect his treatment recommendation. In turn, Mrs. Jones's limited knowledge of surgical and nonsurgical treatment techniques and outcomes influences her appraisal of the treatment recommendations. These factors may subtly influence the discussion of treatment options and risk perception in this case.

Individual bias. The presence of individual biases in medical decision making may seem particularly obvious and unremarkable. However, individual biases have been associated with very specific practice patterns, some related to life and death decisions. A study by Garland et al. [19] showed that decisions to limit life support were more strongly associated with the individual treating physician than with the patient's comorbid conditions, diagnostic category, and source of ICU admission. Several studies demonstrate associations between a physician's years in practice, attitudes toward medical care, and religious beliefs with a willingness to offer treatment or to withdraw care [20-22]. Clinicians also have professional biases. For example, prognostic accuracy is often influenced by patients' conditions [23, 24], and the use of tests and procedures is associated with financial incentives [25]. Both patients and clinicians tend to focus on how life changes after a major health event without acknowledging aspects that remain unchanged, a cognitive bias known as the "focusing illusion" [23, 26, 27].

In the case scenario, little personal information is exchanged between Dr. Swan and Mrs. Jones that could help explain how indvidual biases might be influencing decision making and the informed consent process. What is Mrs. Jones's understanding of neurologic deficits and the potential for rehabilitation when she says, "I wouldn't want my children to see me like that"? The effect of a focusing illusion may be driving Mrs. Jones's mostly negative perception of what her life would be like in the event of a neurological deficit after surgery. Moreover, Dr. Swan may be too focused on treating the aneurysm and preventing a rupture event, rather than appreciating Mrs. Jones's concerns about neurological disability.

Relationship and the Limits of Autonomy

At its core, the problem raised by the case scenario has much to do with how we have come to model the informed consent process in medicine today. Under the current paradigm, the competent patient is considered an autonomous decision maker who must be provided with the relevant information and make an independent choice [28]. Whether or not the patient's decision is in accord with the physician's recommendation is largely irrelevant. The patient-physician relationship today is more contractual than fiduciary, more a matter of disclosure and fair exchange than trust.

However, our brief survey of the possible impact of bias on the informed consent process suggests that the expectation of completely autonomous decision making is somewhat unrealistic. From the moment a patient and physician meet, a torrent of cognitive, geographic, and personal factors surface that can confound risk perception and independent rational decision making. Mrs. Jones decides against treatment,

focusing on the immediate risks of neurologic complications associated with surgical treatment. Dr. Swan emphasizes the potentially "catastrophic" risks of not treating the aneurysm. Doctor and patient interpret the same risk information from different perspectives and in different ways. Dr. Swan is committed to respecting Mrs. Jones's wishes but remains concerned about her clinical benefit.

In this case scenario, the goal is to ensure that Mrs. Jones's decision be informed and autonomous. But treatment decisions, particularly in high-risk situations, require more than simply exchanging information or eliciting preferences. A recent study by Sulmasy et al. demonstrated that patients with serious illnesses prefer a model of shared decision making, in which patient preferences and clinician recommendations carry equal weight in making a treatment decision [29]. Treatment decisions in high-risk situations require a dynamic relationship between doctor and patient in which patient preferences and clinician recommendations can interact equally to help shape a final treatment decision.

Mrs. Jones's refusal of treatment is then not the endpoint of the case. The goal is to promote a shared decision between Dr. Swan and Mrs. Jones, in which Mrs. Jones continues to follow-up with Dr. Swan and discuss treatment options and goals of care. Dr. Swan should acknowledge the geographic and individual biases at work in his own treatment recommendation insofar as he is aware of them and provide risk information framed both positively and negatively. He might also provide graphical depictions of the medical risks in the form of bar or pie charts or icon-based pictographs to help Mrs. Jones understand such abstract information. If Mrs. Jones remains opposed to surgery, Dr. Swan should share his concern about that decision with her and ask her to return soon for more discussion. He cannot override her refusal and must avoid making Mrs. Jones feel that she is being coerced. If he believes that Mrs. Jones exposes herself to greater risk by doing nothing, he must hope that his routine followup and discussions with her—perhaps with new evidence of the aneurysm's change—will cause her to reconsider her decision.

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ETHICS CASE

Applying Guidelines to Individual Patients: Deep Brain Stimulation for Early-Stage Parkinson Disease

Commentary by Bryn Esplin, JD, Andre G. Machado, MD, PhD, Paul J. Ford, PhD, and Kara Beasley, DO, MBe

As 39-year-old Sam Ruffini sat confidently in the clinic chair, his hand tremor would have been noticeable only to a trained expert. The other signs of Parkinson disease, however, were unmistakable, such as the once-spry man's shuffling gait. Mr. Ruffini had come to see Dr. Blue, a neurosurgeon renowned for treatment of functional nervous system disorders.

"I simply don't want to suffer through years of trial and error with medications and their side effects. I'm a young, active guy. I can handle a surgery. If this can be improved with a one-time procedure, even if it's brain surgery, I'd rather do that now and not wait until I've suffered through years of disability."

Dr. Blue faced a dilemma. In previous years, he would have politely dismissed Mr. Ruffini and referred him back to the neurology department, since deep brain stimulation (DBS) surgery for Parkinson was still a measure of last resort for patients whose conditions had become refractory to best medical therapy. Mr. Ruffini had responded fairly well to levodopa and other standard medications for Parkinson, and he continued to function in his job as an investment banker. Although he complained about fatigue and other side effects of the medications, these did not seem to be disabling.

On the other hand, Dr. Blue had recently read about a clinical trial showing good results for patients who received DBS in the early stages of their disease, before their level of disability had progressed to the point of being "medically refractory." He wondered if this foretold a new paradigm in thinking about proactive surgical interventions for neural disorders, including not only Parkinson but also essential tremor, depression, chronic pain, and others. In some cases, the stipulation that a patient's condition be "medically refractory" prior to contemplation of surgery seemed to be a holdover from the era when that procedure was experimental and particularly risky. Dr. Blue's rate of serious complications with DBS had become so low (less than 5 percent) that, depending on the patient's preferences, he believed it could be a viable alternative to medical therapy even when the latter hadn't failed.

When he met with the interdisciplinary DBS committee that week, Dr. Blue floated the idea of doing DBS for Mr. Ruffini. This idea was met with acrimonious objections from the neurologists and psychiatrists in the room. Based on the standard

of care, they argued, Mr. Ruffini should be treated with medications, which were noninvasive and well understood, and must exhaust all reasonable nonsurgical therapies prior to being offered an invasive brain surgery.

Commentary 1
by Bryn Esplin, JD, Andre G. Machado, MD, PhD, and Paul J. Ford, PhD
Proper selection of patients who will reliably benefit from treatment is critical to the successful outcome of deep brain stimulation (DBS). The ethical duties of the clinicians in this case involve careful balancing of a variety of interests of the patient, society, and their own practices. They need to create fair systems based on the best available research that allow individualized decisions for each patient and assess the likelihood of harm and benefit. In doing so, each clinician should be cognizant of whether decisional elements are merely a matter of tradition, rely on outmoded data, or are based on unwarranted assumptions.

In the current case, the surgeon needs to evaluate carefully which model of the patient-physician relationship is appropriate to apply, based on the facts' relationship to the models. In particular, the surgeon must consider the role of informational vulnerability, paternalism, and an obligation to improve practice for all patients. This is no doubt a complex task because how various subjective values are balanced could lead to different conclusions. Acceptable solutions must be based on a clear ethical justification according to the values at stake.

The proper selection of a model for physician-patient relationship provides structure, security, and transparency to the relationship through designated roles and mutual obligations. A classic 1992 article by Ezekiel A. Emanuel and Linda L. Emanuel highlights four distinct models of relationships physicians may adopt, two of which, the interpretive and paternal models, are relevant here [1].

In the interpretive model, the physician aims to elucidate the patient's values and assists him or her in choosing the available medical treatment that best preserves those values. By the surgeon's account, Mr. Ruffini's hand tremor is "mild," his shuffling gait is becoming more pronounced—a marked change from his once-spry self—and he complains of fatigue and other side effects of medications that "did not seem to be disabling." But the patient's illness experience is also crucial. What may be described as a "mild" hand tremor by a physician may have a severe impact on a patient's everyday life. Categorizing things like disability as mild, moderate, or severe may yield more disagreement and confusion than clarity; quality-of-life assessments are value-based and vary from patient to patient. A patient's perception of disability is critical to evaluating whether his or her expectations about potential benefits correspond to realistic outcomes of the procedure.

The interpretive model anticipates that a patient's values may not be known or fixed, and so the physician helps the patient articulate goals, aspirations, and commitments and provides clear guidance about which treatment plan best balances these values [1]. This model allows the patient to come to know more clearly his own identity and

how various treatment options may bear upon that identity, a proposition particularly important when treating a neural disorder that, by its very nature, transforms and may largely dictate the lived experience of the body.

For example, Mr. Ruffini, valuing his active lifestyle, may be feeling anxious that his PD will slowly rob him of agency, and thus intervening before he has "suffer[ed] through years of trial-and-error with medications and their side effects" is reasonable. Additionally, Mr. Ruffini states, "If this can be improved with a one-time procedure, even if it's brain surgery, I'd rather do it now and not wait until I've suffered through years of disability."

However, it is vital to be aware that the procedures of implanting and stimulating the electrodes are brain-invasive and entail significant risks. Although the paternalistic model has fallen out of favor as a default standard model, there are instances where elements of it should still be employed. This model calls for the physician to act in the patient's best interest based on what he or she knows of the patient. In particular, when clinicians encounter a patient with significant vulnerabilities, they incur a greater obligation to protect that patient's interest. Besides a patient's usual medical vulnerability, Mr. Ruffini's lack of understanding of DBS constitutes an informational vulnerability [2]. First, Mr. Ruffini believes that DBS is a one-time procedure. However, once implanted, the system may become infected, parts may wear through the skin, and the lead or lead/extension connector may move [3]. Additionally, systems require battery changes throughout the life of the technologies and need ongoing monitoring and programming. A DBS procedure is not like a traditional ablative procedure in which a lesion is made and then the intervention is complete.

Informed consent in this case involves more than understanding the expected good and bad short-term outcomes; it involves understanding the ongoing burdens of the technology. Mr. Ruffini's informational vulnerability results not only from a lack of specialized knowledge but also from misinformation. Patients often come to DBS with an informational vulnerability, having received misleading information or skewed portrayals of outcomes from the media and other forms of public discourse that occur outside the clinical encounter. Studies have pointed to overwhelmingly positive reporting of neuromodulation, heralding the arrival of the future and prominently featuring "miracle stories" [4]. Reports tend to showcase only the spectacular while obscuring the spectrum of all possible outcomes. Patients' susceptibility to this type of informational vulnerability may justify or, perhaps, obligate the team to respond more paternalistically and protectively. Physicians seeking to protect patients must do their best to overcome patient misunderstandings caused by inaccurate or sensationalized accounts from the media or other discourses and must be careful to address assumptions that may not be correct—particularly that "less invasive" always means "less harm."

In this particular case, though, the team members' attempt to prioritize protection over self-determination may not be ethically justified, because the criterion they are

relying on to determine harm may not make sense. The traditional proposition that the least invasive intervention is always preferable can serve the purpose of limiting harm associated with overambitious goals. However, this obvious-sounding proposition is dubious in this instance. The faulty premise here is equating "more invasive than medications" with "more dangerous in the long term than medications." Medications to treat PD are associated with not only fatigue but also a variety of neuropsychiatric symptoms, including depression, apathy, anxiety, obsessive behaviors, impulse-control disorders, hallucinations, and delusions that are difficult to treat, cause great disability, and can distress both patient and family [5]. Social and physical harms associated with uncontrolled side effects of medications that will ultimately fail to manage PD symptoms create a new dynamic.

While the long-term efficacy and safety of DBS implemented early in the course of the disease is uncertain [6], DBS can result in significant improvement in many of the motor symptoms while also decreasing the need for PD medications and improving overall quality of life [3]. An emphasis on long-term benefit might indeed lead to a preference for DBS in this case.

Ultimately, it is the patient's assessment of risks and benefits that should guide deliberation. A recent article evaluating EARLYSTIM has argued that the appropriate time for surgery is when the needs and expected benefits outweigh the risks for a patient who has received objective and comprehensive information about individualized risks and benefits of the DBS [7]. In the current case, the goals that Mr. Ruffini wants to accomplish are not disclosed, but the metric still needs to be about the likelihood of achieving those goals with DBS. Whether using a paternalistic or interpretive model, the calculus should not be about a simplistic change in physical symptoms, but rather the functional impact the changes may make for the patient.

Despite cognizable risks, patients may remain steadfast in their desire to move forward with treatment. Even when patients aggressively advocate for procedures, there are limits on patient-centered care, including internal and professional limits, such as the institution's standard of care provision. While these limits are important safeguards, their appropriateness should be reassessed if there is proof of advances in treatment. The interdisciplinary DBS committee needs to give clear reasons why this specific patient should not receive DBS at this time. If the patient's centrally important goals could be reached and due diligence has been undertaken to offset vulnerability and collaborate on proper consent, there is ample justification for this team to offer DBS—provided it carefully monitors and collects information in a systematic manner for this patient.

Offering DBS to Mr. Ruffini could be undertaken based on several different models, all of which should reinforce that the surgeon's obligations to provide high-quality care to all his patients remain the same. If the team decides to pursue DBS for Mr. Ruffini, there are two main options for offering it. First, the patient could be offered the procedure as "off-label" use. In this instance, Dr. Blue still has an obligation to

collect information to ensure best outcomes for this patient and for his future practice. Dr. Blue could either review the case series in the future or contribute to a national registry. However, the amount of data would be modest, and many people could be put at risk before an unknown negative consequence became apparent.

The other option is to offer DBS only as part of a well-controlled research study. Although this option increases burdens for the patient and the clinicians, it is least likely to cause harm to future patients and protects this patient through the careful oversight afforded research participants. Offering this procedure as part of a research protocol would be the ideal, but many practicalities of our current medical system pose barriers to doing so [8]. Moreover, by the time a research study was funded and approved by the regulatory bodies, Mr. Ruffini's condition could have already advanced to a severity level that he is attempting to avoid through early DBS, which, worse yet, could make him a "standard" DBS candidate and preclude his inclusion in the study. Too little information is provided in the current case to give a definitive opinion as to whether it is obligatory to offer DBS, but the option of offering the procedure to Mr. Ruffini is ethically supportable if proper safeguards are put into place and robust outcomes information is collected.

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Disclosure
AGM may in future receive distributions for intellectual property from Cardionomics, ATI, and Enspire (all Cleveland Clinic spin-off companies).

Commentary 2
by Kara Beasley, DO, MBe

The ethical issues and treatment options that must be considered in this case can be framed by considering the interests of the involved stakeholders and what they might, potentially, have to lose. This technique was developed by Paul Ford and has shown itself extremely valuable in teaching ethical analysis to students and residents.

The Stakeholders
The clinical team. Evaluation of patients for DBS ideally occurs through a process employing a multidisciplinary team that includes neurosurgeons, neurologists, neuropsychologists, and psychiatrists. As Paul Ford and Cynthia Kubu argue, "an ongoing multidisciplinary conversation around patient selection and care provides an important avenue for establishing good practice" [1]. The first group of stakeholders we will consider are the members of the interdisciplinary team. With the exception of Dr. Blue, they are conservative in nature and have strictly applied the criterion of "medication-refractory" disease. They are not without good reasons.

Firstly, there is sound clinical reasoning for their position. Clinicians traditionally consider the ideal DBS patient to be one in whom there is a 30 percent reduction in the United Parkinson's Disease (UPDRS) rating scale motor subsection in response to levodopa, motor fluctuations, or troubling side effects caused by medication and no significant cognitive impairment. The rationale behind the typical protocol, in which DBS is offered four to five years after onset of symptoms, is that waiting helps ensure that patients truly have idiopathic Parkinson disease (PD), rather than

Parkinsonism associated with other disease entities that could be negatively affected by DBS. While DBS is not a cure, there is evidence to indicate that DBS remains effective for the motor symptoms of PD despite clinical progression [2].

Furthermore, the team's interest in professionalism and high-quality care could also call for caution. There are strong arguments for judicious use of new technology; examples of indiscriminate use of procedures such as frontal lobotomy have colored the history of elective intracranial surgery for decades. Furthermore, invasive procedures should be offered based upon high-quality evidence, which in this case is lackluster. While there are studies that indicate that DBS is safer when used earlier in the disease [3, 4], the most compelling study only includes 30 patients.

Society and medicine. A second group of stakeholders might also have reasons for concern about offering DBS to Mr. Ruffini—society and the profession of medicine. Should Mr. Ruffini have a poor outcome, it might cost the public a great deal economically in terms of care for his complications. Poor outcomes in early uses could also hamper further adoption of the technology and hence access to DBS.

The patient. Mr. Ruffini, of course, is the other important stakeholder in this situation. His request is not unreasonable. Evidence indicates that, with the subthalamic nucleus target (STN), patients can typically reduce their medication burden by 50 percent. In their multicenter randomized trial of DBS versus best medical therapy, Weaver at al. concluded that "deep brain stimulation was more effective than best medical therapy in alleviating disability in patients with moderate to severe PD with motor complications responsive to levodopa and no significant cognitive impairment" [5]. Thus the treatment Mr. Ruffini seeks is effective for his condition and within therapeutic goals. He is a well-educated and highly functional patient who is informed about the risks, benefits, and alternatives of the procedure as well as the conventional indications. He is aware of the low complication rate of his selected surgeon, Dr. Blue, and he would elect to move forward if offered surgery.

To consider Mr. Ruffini's interests in this situation is to consider the fact that Mr. Ruffini is the only person who can truly determine what facets of his disease and his treatment negatively affect his quality of life and whether other possibilities, like medication trials, would be overly burdensome to him. An overly paternalistic decision would obviously conflict with his self-determination and right to direct his course of care in an informed fashion. The team may correctly argue that he does not meet the established criteria and does not have the right to demand a therapy that, in their expertise, they have deemed inappropriate at this time. But such a decision, while consistent with the medical and surgical guidelines routinely practiced, could have the consequence of leaving Mr. Ruffini feeling that he had no voice in the decision making about his care.

Furthermore—perhaps most importantly—the team is making evaluations and decisions based upon outdated data and in their recommendation should take into consideration the evidence regarding earlier implantation. Two studies—Charles et

al. [3] and Schuepbach et al. [4]—have provided evidence that DBS is safe for much earlier use than has been typical. In the Charles et al. study, 30 patients were randomized to optimal drug therapy (ODT) or ODT plus DBS three years earlier than is conventionally accepted. The authors concluded that DBS is "well tolerated in early PD" [3], and a larger multicenter trial has been approved. The Schuepbach et al. study randomized 251 patients with PD and early motor complications to best medical therapy or DBS plus best medical therapy. Overall, in a two-year period, the DBS plus medication group had a 26 percent improvement in quality of life and improved mobility, suggesting that "instead of waiting for patients to have very marked fluctuations, peaks and very deep valleys, [we can] move in when the peaks and valleys are not that steep" [4].

Four Possible Solutions

There are four possible solutions to this dilemma. The first would be to honor the decision of the multidisciplinary team and deny Mr. Ruffini access to DBS until he has "exhausted all reasonable medical options." Should he choose to pursue DBS in the immediate future, he would need to do so with a different group. The second option would be for Dr. Blue to move forward with surgery based upon his medical judgment, despite the recommendations of the rest of the team. The third is for the team to agree that, while surgery will not be offered at this time, they will reevaluate the evidence and revisit the option of surgery for Mr. Ruffini in three to six months. Finally, the team could agree to consider the patient's treatment wishes in light of the medical and scientific evidence and move forward with implantation so long as true informed consent is obtained.

Analysis of the Solutions

The first solution—to deny surgery based on the multidisciplinary team evaluation—errs on the side of paternalism and disenfranchises the patient. Each patient has a unique set of symptoms, goals for treatment, and family and social support structure. Patients should be considered holistically and not simply subjected to an impersonal checklist. Furthermore, new evidence supporting earlier utilization has emerged, calling into question the rationale behind the standard. The criterion of "medical-refractory" candidacy could allow Mr. Ruffini's PD to jeopardize his perceived quality of life and create despair in an otherwise active and empowered patient. These consequences of withholding DBS far outweigh the risks involved in offering it.

On the other hand, it would not be advisable for Dr. Blue to disregard the recommendations of the team. This would force other team members to provide treatment they were not in agreement with; the neurologist in particular would have to oversee medication management and programming of the device. Such an action could erode future cooperation and professional trust. Strife in the team could limit access to care for other future patients, as team members may be unwilling or unable to continue a professional partnership that would benefit them.

The third solution holds some merit. It gives the team further time for discussion and review of the literature while leaving a window open for implantation in the not-so-distant future. It would ensure, and show, that the patient's unique situation and personal autonomy are being respected without jettisoning standards of care. If the team is unwilling to move forward with the fourth and most ideal solution in this case, then consideration in the immediate future is a concession with minimal downside.

The most ethically justifiable option would be for the team to step away from strict adherence to the "medically refractory" criterion and consider the specific and individual case before them. Not every patient should be offered the surgery this early on, but the aforementioned attributes—the surgeon's low complication rate, the new data supporting earlier utilization of the procedure, the patient's understanding of the risks and benefits and his strong preference to intervene before his condition progresses—make a strong argument for reconsideration and recommendation to offer him surgery in this particular set of circumstances. At the end of the day, patients are people with individual circumstances, goals, and values. They should be treated as such rather than forced to conform to a predetermined set of criteria. Furthermore, as scientific evidence develops, those forming standards and guidelines should stay current and flexible, altering their criteria and evaluations as appropriate.

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Disclosure
Kara Beasley is a consultant for Functional Neuromodulation Ltd. and Medtronic.

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ETHICS CASE
Duty-Hour Exceptions for Neurosurgery Residency Programs
Commentary by Nathan R. Selden, MD, PhD, and Michael M. Haglund, MD, PhD

As neurosurgery residency program director at Cushing Hospital, Dr. Burr was accustomed to balancing the demands of a clinical practice and administrative duties. Never before, however, had he found himself at the center of such keen public scrutiny on the long hours worked by surgery residents.

A letter from a consumer watchdog group had been circulated among the hospital's academic medical leadership. The letter complained that the hospital's surgery residents—particularly those in general surgery, neurosurgery, and cardiothoracic surgery—were working unsafe hours and that patient care at Cushing was suffering due to physician sleep deprivation. The group indicated that they would soon be launching a media campaign about this topic.

Dr. Burr believed that his residents provided excellent care to all patients, and, while he acknowledged that neurosurgery residency required an especially grueling and demanding schedule, his program made every attempt to comply strictly with the Accreditation Council for Graduate Medical Education (ACGME) duty-hour regulations. However, this had become increasingly difficult. As of 2011, first-year residents (previously the backbone of the on-call schedule) could no longer take overnight call without direct supervision. The previous year, one resident had quit for personal reasons, which meant the remaining residents had to pick up the slack. Dr. Burr was grateful that the ACGME had approved his request for a 10 percent increase in duty hours to 88 hours per week. Such requests are granted to a handful of programs, most of them in neurosurgery, based on demonstration of "sound educational rationale." But there was no guarantee this request would be renewed.

In recent weeks, Dr. Burr had come under pressure to defend his duty-hour arrangement from an ethical as well as an educational standpoint. Some of his fellow faculty members, who trained before resident work-hour regulations, believed that the education of future neurosurgeons was suffering and preferred that he publicly fight attempts to further restrict duty hours. They argued that neurosurgery was an exception to the general rule, owing to the long cases, complex anatomy, critically ill patients, small numbers of residents, and stamina of those who self-select as neurosurgery trainees. Other faculty, however, had opined that the danger of errors from overfatigued residents and loss of public trust outweighed the possible educational benefits. Meanwhile, other graduate medical education committee (GMEC) members at Cushing questioned whether the neurosurgery program truly merited an extension to 88 hours per week on educational grounds.

Commentary 1
by Nathan R. Selden, MD, PhD

In the clinical teaching environment, every patient encounter has two equally vital purposes: first, to deliver excellent care to the individual patient and, second, to train a professional, skilled, and ethical clinician who will care independently for thousands of patients during the course of a career (and who may, in turn, become a clinical educator) [1].

In neurological surgery, the technical demands, lengthy duration of interventions, and the extraordinarily high-stakes clinical outcomes demand exceptional focus and personal dedication [2]. Hence, the contemporary practice of neurological surgery is not compatible with the rigid duty-hour limits applied to current ACGME trainees. It is therefore axiomatic that one goal of training must be to prepare neurological surgeons to practice safely and effectively within a realistic duty-hour schedule before they practice without supervision. This training must build stamina, as well as provide the experience, judgment, and professionalism necessary to self-regulate fatigue, triage urgent clinical problems, and function effectively in a complex interdisciplinary care environment [3].

Without duty-hour exceptions, we have a system in which senior residents, typically in their mid-thirties, practice for years under artificial duty-hour restrictions and then, on a single day, are withdrawn from formal supervision and required to self-regulate. Alternatively, a carefully designed, focused, and specialty-specific duty-hour exception program can allow high-stakes and high-demand disciplines, such as neurological surgery, to prepare residents in graded fashion, under supervision, to cope with realistic practice environments.

The ACGME has created clear and compelling standards for the consideration of duty-hour exceptions for both entire specialties and individual programs. These exceptions should enhance the educational environment and improve educational outcomes. Moreover, exceptions may not compromise safe practice and excellent patient outcomes (and in fact should directly or indirectly promote them). Exceptions should be continuously monitored and systematically re-evaluated.

The 10 percent (88-hour) exception rule is specific to individual rotations within a residency program based on an educational rationale. It allows residents to participate in the longitudinal care of patients with evolving, complex neurological problems requiring surveillance, decision making, and sustained or prolonged intervention (a common experience in practice that residents might otherwise be deprived of). It also allows residents to engage fully in the live clinical environment without sacrificing participation in didactic and case-based conferences that provide the critical framework for experiential learning.

The ACGME has made other exceptions in the duty-hour regulations in order to promote professionalism and effective, safe learning in the clinical environment [4]. For example, final-year trainees (who have extensive experience with high-level

performance and fatigue monitoring and mitigation) may exceed single-shift duty limits to care for a patient with a rare disease or condition, the management of which is necessary for their training. Each episode must be justified and tracked in writing.

The case scenario reveals problems, not with the conception or value of duty-hour exceptions, but with their implementation. First, the scenario identifies various manpower pressures on the clinical neurosurgery service at the academic hospital in question, arising from the resignation of one program trainee and from modifications to the ACGME duty-hour regulations in 2011. Manpower needs in general, and a failure to design duty and rotation schedules compliant with the core 2011 regulations, are not valid justifications for exceptions.

It is possible to create program-specific call and duty schedules that comply with the 2011 regulations and also maintain educational quality and operative case volumes. For example, our program at Oregon Health and Science University in Portland succeeded in eliminating chronic compliance problems by shifting to a three-person night float system specifically for neurological surgery residency [5]. Any further restriction in duty hours that reduces the overall engagement of residents with clinical care, however, would not only restrict their individual experiences but also fundamentally alter the central role of residents in the care delivery process (which is the heart of their professional education).

Responding to manpower needs unrelated to the education and training mission through the addition of midlevel practitioners (physician assistants and nurse practitioners) should be the responsibility of academic hospital leadership. Because graduate medical education dollars flow through academic hospital administrations, the decision makers for educational program resources and clinical program support should, in theory, be closely linked and aligned in providing these resources. In practice, this linkage remains inconsistent at best. In the case scenario, conflict among program faculty about the wisdom and necessity of effective duty-hour compliance also reveals a failure, at least in part, of the departmental and program leadership in managing change.

The duty-hour debate is far too frequently divided into extreme perspectives. Some experts and educators believe stricter regulations and broader interventions are always better. Unfortunately, there is little evidence that even the current standards have improved clinical outcomes and some evidence that they have reduced both readiness to practice and academic productivity in trainees [6, 7]. Furthermore, indirect evidence garnered from administrative databases suggests that, in some specialties, including neurological surgery, the implementation of duty-hour restrictions may have worsened clinical outcomes, presumably due to reduced continuity of care and increased handoff errors [8].

By contrast, many traditionalists eschew any limits on or standards for resident duty hours. This position ignores not only well-recognized safety problems of severe fatigue [9, 10] but also the terrible toll on surgery trainees that can result from

excessive stress and unreasonable, extreme duty shift lengths. This toll includes broken marriages, impaired parenting, fatigue-related medical and vehicular injuries, and suicide [11]. These considerations are not hypothetical and are known to virtually every trainee of my own generation. As an "intern" on a subspecialty surgical service in the early 1990s, while near the end of a 136-hour week of nearly continuous in-hospital duty, I made a simple and entirely fatigue-related error that nearly caused a catastrophic outcome in a young child. That and similar experiences of friends and colleagues inform my own perspective on duty hours. As surgery educators and mentors, we must find a reasonable and sustainable middle ground to improve our specialty and serve the trainees entrusted to us.

There is accumulating evidence in favor of reasonable, tested, and—where possible—evidence-based regulations that reflect legitimate differences between stages of training and specialties. Such regulations should be clear and enforceable to avoid a slippery slope and cynical abuse by a small minority of programs that might jeopardize the overall enterprise. For practical reasons, some quantifiable metrics such as hours spent doing a particular activity are likely to remain part of the regulations. Wherever possible, however, regulations should be closely linked to more intrinsically important measures, such as patient safety and clinical outcomes [12]. The widespread engagement of US hospitals in the quality movement may provide data and opportunities to design more meaningful duty, supervision, and professionalism standards for graduate medical education [13, 14].

Ultimately, I believe duty-hour exceptions should be maintained and rationally expanded. The principal problems with the exceptions today are their narrow scope and their underutilization. Currently, fewer than 10 percent of neurological surgery programs have active duty-hour exceptions (unpublished data, Accreditation Council for Graduate Medical Education neurological surgery residency review committee, 2014). Given the potential of approved duty-hours exceptions to promote professionalism in practice, all programs should attempt to rigorously comply with the basic duty-hour regulations in order to become eligible for meaningful and educationally focused exceptions.

Finally, the limited existing duty-hour exceptions are misnamed. Rather than "exceptions," we should describe them as desired "enhancements" to a system designed to promote excellence in a cohort of highly capable and talented adult learners. The duty-hour regulations and approved exceptions to them should embody fundamental principles of professionalism and personal accountability, drive independence, and help create a self-regulating, self-improving, and excellence-seeking generation of physicians and surgeons.

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Commentary 2
by Michael M. Haglund, MD, PhD

As program directors (PDs) in neurological surgery, Dr. Burr, Dr. Selden, and I are responsible for ensuring that the care provided to our patients is excellent and, at the same time, for creating an environment that prepares our residents for independent practice. In this hypothetical case, Dr. Burr faces criticism and pressure from a watchdog group focusing on fatigued residents and disagreement among his own neurosurgery faculty about whether to even have the duty-hour exception. The competing pressures to provide coverage for the neurosurgical service and to create the right educational environment for trainees frequently result in an impossible situation. In this case, Dr. Burr has put himself in a precarious position.

Dr. Burr stated that, when his resident resigned abruptly, his program's duty-hour exception allowed him to stay at least within reach of the duty-hour restrictions by having the other residents provide the extra coverage required. The loss of the single resident, however, meant 4,224 hours (48 weeks at 88 hours per week) needed to be covered by the remaining residents during the upcoming year. It appears that, even with the exception, his residents would have to violate the duty-hour maximum of 88 hours per week to cover that time.

Furthermore, Dr. Burr must justify his duty-hour exception, which is only granted to a small number of programs in neurological surgery. To complicate matters, the percentage of programs in neurological surgery with duty-hour exceptions has steadily declined from 40 percent to 8 percent in the last seven years [1], due to pressures from institutional graduate medical education committee (GMEC) members whose programs do not have the duty-hour exception and the neurosurgery residency review committee (RRC) that requires clear justification for the eight extra hours. The Accreditation Council for Graduate Medical Education (ACGME) clearly states that before the RRC can allow a duty-hour exception it must first be approved by the sponsoring GMEC [2]. The ACGME also requires that the 10 percent exception in duty hours "must be based on sound educational justification" [2], meaning that Dr. Burr must demonstrate that "there is a very high likelihood that this will improve residents' educational experiences. This requires that all hours in the extended work week contribute to resident education" [2].

Dr. Burr is using these extended hours to cover for new intern duty-hour reductions and the missing resident. With the apparently unsupportive GMEC awaiting his presentation, he will have to somehow claim to be prioritizing resident education

over service when it appears at first glance the opposite is occurring. The pressure to deal with "education over service" for the entire program will make for a painful discussion at the GMEC meeting.

Furthermore, alongside all these pressures, program directors like Dr. Burr have the additional responsibility for increasing outpatient clinic experience so the residents can better understand patient selection, preoperative counseling, the informed consent process, and postoperative care. In the past, resident attendance in the outpatient clinic has been sacrificed to inpatient care and the operating room.

The Merits of Restrictions

The reduction in duty hours has generated an outpouring of studies looking at patient safety, resident education, resident satisfaction, and operative experience. The results of the studies have been mixed. Caruso's extensive review of the impact of duty-hour restrictions on patient safety found 4 studies showing a negative effect, 17 studies showing no change, and 27 studies showing a positive effect [3]. A multivariate analysis of harms to patients from ten North Carolina hospitals showed no significant reduction in the overall rate of patient harms between 2002, the year before the duty-hour restrictions were implemented, and 2007 [4]. Our recent studies at the Duke University Neurosurgery program using the Nationwide Inpatient Sample for both cranial and spine surgery patients showed that, after institution of the duty-hour restrictions in 2003, there were worse outcomes for patients in teaching than in nonteaching hospitals [5, 6]. Although the results are mixed for patient safety, the patient and public to whom we are ultimately responsible have said that they no longer accept longer working hours if it leads to fatigued physicians. We have to move on and get more out of the hours the residents work, focusing those hours more on education than on service.

Resident education in neurological surgery appears to have been negatively impacted by the restrictions. A detailed study of neurosurgery residents' overall American Board of Neurological Surgeons (ABNS) primary exam scores before and after institution of the duty-hour restrictions found that junior residents' scores dropped by 16 percent, even though the USMLE Part 1 scores were increasing for incoming neurosurgery residents [7]. Scholarly activity has also declined, with 7 percent fewer abstracts published by residents at the annual neurosurgical meeting (unpublished data). Recent pushes for more time for scholarly activity have led our neurosurgery training program at Duke, like several other programs around the country, to institute a weekly full-length "academic day" to improve resident education and time for scholarly activity (unpublished data).

Dr. Burr's Course of Action

For the duty-hour extension to continue, Dr. Burr must have a comprehensive plan that addresses all the issues detailed here. The encouraging news is that there are data and possible solutions to his problems that don't require sacrificing resident education to service, which is his current predicament.

He will need to enlist his program chair to advocate for changes at multiple levels to avoid negative reviews from his institutional GMEC and the neurosurgery RRC. First, by voluntarily relinquishing the duty-hour exception and at the same time improving the balance of resident education and service, he will be able to get the support of the health system and the GMEC. After unsuccessfully trying to convince the GMEC of the importance of the duty-hour exception, we at Duke made the decision to drop the case for the exception in favor of major program alterations that would benefit the residency education process and improve patient care and safety. First, after careful review of our need for patient care, the program chair and I advocated for an increase in our complement of midlevel practitioners. Providing more complete midlevel coverage has been shown to improve patient and resident satisfaction by enhancing continuity [8]. At that time, we had three midlevel practitioners covering the cranial, spine, and pediatric floors. To provide adequate coverage and institute the weekly academic day plus one day per week in the outpatient setting for our junior residents required doubling the number of midlevel positions. The hospital was persuaded by our chair to pay the majority of the cost for the increased complement.

Secondly, innovative resident scheduling with night floats, as demonstrated by my fellow commentator, Dr. Selden, can improve resident satisfaction and reduce duty-hour violations while avoiding a decrease in resident time in the operating room [9]. Finally, the decrease in operating room experience after the duty-hour restrictions is a complicated subject; the literature is all over the map. Some surgery specialties have shown no change in operating room time, while one of the most respected neurosurgery programs in the country at the University of Virginia found that the institution of duty-hour restrictions was associated with an increase in on-call hours and a significant decrease (39 percent) in educational and operating room time. At the University of Virginia neurosurgery program, the time in the operating room decreased from 64 to 41 hours per week (35 percent) [7]. Duke's program is similar for our junior residents, who deal with the majority of the pressure to cover in-house call, recording a 31 percent decrease in operative case volume in the last several years (unpublished data).

For the psychomotor and technical skills of the residents to reach adequate levels, they must spend time in the operating room and make that time as efficient and deliberate as possible. One possible solution comes from social learning theory, which focuses on teaching in the resident's "zone of proximal development" [10]. Residents specifically identify what they want to learn from a given case and, after approval from the faculty surgeon, they are taught in that small zone that stretches their knowledge and technical base. This is believed to allow them to integrate the cognitive and psychomotor skills necessary to take the next step in their learning process. The idea is that adhering to social learning principles improves the knowledge, skills, attitudes, and motivation of residents involved in a collaborative clinical education environment. They gain technical competence more efficiently and quickly if their passion for learning and teaching is maximized in the operating room.

Conclusion

Unfortunately for Dr. Burr, the attitude that prevailed during most of our generation's training—that "being on call every other night meant missing half the good cases"—no longer applies. The public demands rested physicians at their peak of performance to maximize patient care and safety, and the governing bodies of resident education demand fewer hours spent in the hospital, focusing primarily on education. We can help our residents to develop the cognitive and psychomotor skills necessary for competent independent practice without duty-hour exceptions by increasing the complement of midlevel practitioners, implementing innovative resident scheduling, and using social learning techniques to increase efficiency.

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MEDICAL EDUCATION

Evaluating Simulation as a Teaching Tool in Neurosurgery

Brian D. Rothstein, MD, MS, and Warren R. Selman, MD

The term "simulation" is not foreign to the medical community. For decades, medical students, residents, and practicing physicians have all had the opportunity to hone their skills using medical simulation [1]. Whether it be simulated office visits with "standardized patients" or the cutting-edge technology of virtual reality simulators, the medical field has not only welcomed but relied on simulation for physician training in its ever-present goal of providing high-quality, cost-effective, and efficient care.

Key initiatives have noted the benefits of simulation in surgical training, most specifically general surgery [2]. Neurosurgery has lagged somewhat behind. Given the complexity of the anatomy of the central nervous system and the correspondingly complex nature of the procedures performed, simulation has not yet found a niche in training for neurosurgical procedures [3, 4].

There are numerous options for use of simulated neurosurgery [4-6]. Here we hope to highlight important ethical and institutional questions regarding the use of simulators. We've identified two sets of considerations for discussion. The first relates to the evaluation of neurosurgeons who use simulators and how it pertains to the expected outcomes for procedures performed after simulation has been completed. The second relates to access to simulators and institutional policies regarding their use. We believe that, with the advancement of simulation technology and adequate means for evaluating competency and outcomes, simulators will prove beneficial for neurosurgery training.

Data from many disciplines has demonstrated that simulation can be an effective educational tool [1, 7-12]. Neurosurgery must determine how to evaluate simulation's effectiveness in our field: first, does the use of a simulator provide a false sense of security for an ill-prepared or under-experienced surgeon? And second, do successful outcomes in a simulation prove competency?

A major distinction between medicine and other fields such as flight instruction that use simulation in training is the predictability of circumstances and consequences [13]. Consider, for example, intracranial aneurysm treatment. Aneurysms of the same size, configuration, and location can have different susceptibilities to rupture during a procedure. With available imaging technology it is impossible to predict and recreate the exact wall strength of an aneurysm for a specific patient. Hence wall strength cannot be modeled in the patient-specific manner necessary for realistic

rehearsal. Thus success in simulated surgery may lead to a false sense of security, a fact that has been noted in other surgical fields [14, 15].

Defining competency is another challenge. Simulators are being evaluated for their ability to provide an experience as close to reality as possible, but the metrics by which "competency" is defined must also be further refined if we are to equate simulator proficiency with actual surgical capability [16]. The American College of Surgeons now uses simulation as a tool for competency assessments before surgeons are permitted to perform laparoscopic surgery on patients [17, 18]. Stefanidis and colleagues agree and suggest that training to expertise, rather than just competency, should be the standard for all simulation efforts [18]. Establishing objective standards for competence or expertise will no doubt be valuable in the training and continuing education of neurosurgeons, but thoughtful crafting of these standards will be necessary to their success. It is likely that the critical factors for success differ, for example, in laparoscopic procedures and in the microsurgical clipping of an intracranial aneurysm. Current laparoscopic simulation tools may be able to assess competency in general, rather than enable patient-specific rehearsal, but the validity of competency assessment with aneurysm clipping requires further evaluation. This is not to say that simulation is unnecessary in neurosurgical training, but rather to highlight the need for continued evaluation of competency-based, patient-specific simulation.

The second set of questions pertains to the institutional cost of and access to simulators. In theory, all institutions should ensure that every surgeon has access to the best training tools available. By providing these instruments, the institutions further the agenda of high-quality, cutting-edge care. But the investment necessary is costly in both dollars and time and resources. Will an institution be expected or mandated to incur these training costs? Should patients or their insurance companies be billed for the use of simulators? These critical areas of concern need to be carefully evaluated before requiring simulation as a training modality in neurosurgery.

For over a century now, surgeons have acquired their skills through apprentice-based mentoring in residency programs based on Halstedian principles [19]. This has produced generations of skilled surgeons. Now, in an era of consumer-driven care, we must consider whether patients have the right to expect that their surgeon has had access to a simulator to rehearse their surgery before performing it on them. Although there is no clear consensus regarding outcomes associated with the use of neurosurgery simulators [20], we remain vigilant in our efforts to advance the technology and the science by which we evaluate their use. Currently, the Congress of Neurological Surgeons Bootcamp for young neurosurgeons [21] and many medical centers like ours are making the investment in model-based simulation for residency training because we believe in its potential. Given the history of the success of simulation across other disciplines, we know it holds value [1, 2]. Bob Dylan may have said it best: "you don't need a weatherman to know which way the wind blows" [22].

As stated above, in numerous disciplines simulators have been shown to improve end-user skills and are now considered standard in training. The best-documented example is in pilot training with flight simulators [12]. Every passenger expects that his or her pilot has flown a simulator successfully. Patients should have the same expectations, and therefore simulators in neurosurgery should strive to satisfy these same standards of effectiveness and usefulness. So, although the wind is clearly blowing, and we have seen early adoption, we owe it to our specialty, our patients, and ourselves to strive to document effectiveness in skill acquisition and outcome, so that we can better understand the true professional and institutional impact of simulators in neurosurgical training and practice.

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IN THE LITERATURE

Integrating Ethics into Science Education and Research: Report of the Presidential Commission for the Study of Bioethical Issues

Jonathan Riley, MD, and Jessica Emery

***Gray Matters: Integrative Approaches for Neuroscience, Ethics, and Society*. Presidential Commission for the Study of Bioethical Issues; 2014. Vol. 1. http://www.bioethics.gov/sites/default/files/Gray%20Matters%20Vol%201.pdf. National Institutes of Health; 2013. Accessed November 25, 2014.**

The BRAIN Research Initiative

There is this enormous mystery waiting to be unlocked, and the BRAIN initiative will change that by giving scientists the tools they need to get a dynamic picture of the brain in action and better understand how we think and how we learn and how we remember. And that knowledge could be—will be—transformative.
President Barack Obama, April 2, 2013 [1]

On April 2, 2013, President Obama introduced an ambitious and far-reaching scientific vision prescribing a directed evolution of and funded mandate for future neuroscience research in the United States [1, 2]. In this speech, the president used contemporary and historical examples of how Americans have come together, both through private enterprise and governmentally supported programs, to tackle the large problems of the day. In this way, he made the case that investment in innovation has kept the United States at the forefront of worldwide scientific progress, supported a "feed-forward" process of innovation, increased domestic prosperity, and benefited citizens worldwide.

The Brain Research through Advancing Innovative Technologies (BRAIN) Initiative was developed in recognition that neuroscience research is in a period of transition. The approaches of modern molecular neuroscience research, developed over the past century, have provided the current foundational understanding of neural structure, function, and connectivity of the brain. This knowledge has provided a perspective for understanding many pathologic neural processes resulting from disordered function at the level of neural networks of activity. The BRAIN Initiative recognizes that a comprehensive investigation of neural function and dysfunction at a network level will require investment in the development of a new array of investigative tools. Historical precedent indicates that this comprehensive investment will result in far-reaching advances, some predicted and many more unforeseen. The National Institutes of Health (NIH), National Science Foundation (NSF), Defense Advanced Research Projects Agency (DARPA), Food and Drug Administration (FDA), and Intelligence Advanced Research Projects Activity (IARPA) are involved in the

BRAIN Initiative. Each is approaching the aims of the initiative through the perspective of its individual agency mandates [3]. Additionally, companies, collaborative research consortiums, and numerous academic institutions have aligned their research priorities with BRAIN Initiative goals [3].

Before Adhering to a Standard, You Must Define It

I want to ensure that researchers maintain the highest ethical standards as the field of neuroscience continues to progress. As part of this commitment, we must ensure that neuroscientific investigational methods, technologies, and protocols are consistent with sound ethical principles and practices.
President Barack Obama, July 1, 2013 [4]

In his rollout of the BRAIN Initiative, the president specifically addressed the need for such research to be conducted in a responsible manner. To accomplish this, he indicated that guidance would be sought from the Presidential Commission for the Study of Bioethical Issues to identify a set of best ethical practices. This was followed up with a letter to the commission on July 1, 2013, requesting that the committee engage the scientific community and the general public to guide the conduct of BRAIN Initiative-related research. In part, this request was designed to consider the potential societal and ethical implications associated with these studies and interpretation of their results. *Gray Matters* is the first of the commission's two planned reports on this topic.

Completion of this report followed two public meetings in which comment was obtained from thought leaders from a broad array of disciplines. In addition, public comment was solicited. The report sets forth specific recommendations to support integration of bioethics training and considerations throughout all levels of scientific inquiry [4]. A follow-up report will explore mechanisms to implement these recommendations [5]. Published in May 2014, *Gray Matters* highlights four guiding recommendations that should be implemented. These include:

1. Integrate ethics early and explicitly throughout research [6].
2. Evaluate existing and innovative approaches to ethics integration [7].
3. Integrate ethics and science through education at all levels [8].
4. Explicitly include ethical perspectives in advisory and review bodies [9].

Creating a Culture of Ethical Cognizance

The four primary recommendations set forth by the committee represent a concise schema for promoting a pervasive culture of ethical cognizance within the scientific community by emphasizing ethics integration into all levels of biomedical research. While a second volume of *Gray Matters* is intended to explore specific mechanisms of integration in detail, the authors of the first report provide some thoughts on achieving this goal. Specifically, they recommend a commitment of "financial resources, human capital, and expertise" [10], indicating a recognition that dedicated funding will only be helpful in a broader context.

In scientific education, ethics-related studies are primarily emphasized beginning at the graduate level. The authors stress that ethics training should be more broadly integrated well before the graduate level and continue throughout the researcher's professional career.

Similarly, they recommend that evidence of ethics integration into the scientific process be sought at the stages of hypothesis design and grant application. They recommend that funding agencies acquire the expertise to assess whether ethical considerations have been built into proposed research agendas when reviewing applications for funds.

Incorporation of these and other such changes are intended to ensure that: (a) the ethical implications of a line of scientific inquiry are considered at the earliest stages, (b) scientists approach hypothesis generation with fluency in ethical analysis and reflection, and (c) ethicists and ethics-related perspectives are solicited and mobilized throughout the entire scientific process. Discourse between ethicists and scientists at earlier stages of hypothesis generation and encouraging scientists to cultivate a greater fluency in ethical analysis may, in turn, improve ethicists' understanding of relevant scientific concepts at a more granular level. Proactive attempts to achieve improved ethical cognizance and ethical integration are crucially important: the results of future neuroscience-related research may have far-reaching personal, societal, and legal implications that can now only be poorly predicted.

Beginning with the End in Mind

Published only three years after the Presidential Commission for the Study of Bioethical Issues defended the adequacy of current safeguards to mitigate risk to research participants—in a report that revealed the US Public Health Service's support for unethical research activities in Guatemala between 1946 and 1948 [11]—*Gray Matters* represents a proactive approach to developing both a durable ethical foundation and a new paradigm for neuroscience-related research. In this way, a path is being laid for future best practices toward systematic ethics integration beginning with initial benchside hypothesis generation and persisting through bedside clinical investigation. It is very possible that the first innovation born of the BRAIN Initiative may be the development of an improved ethical foundation from which to conduct all future biomedical scientific research.

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STATE OF THE ART AND SCIENCE

Innovation in Surgery and Evidence Development: Can We Have Both at Once?

Brett E. Youngerman, MD, and Guy M. McKhann II, MD

Surgical innovation has long enjoyed a privileged status in the evolving evidence-based medicine (EBM) paradigm. Since surgery is often considered to be as much an art as a science, many aspects of surgical practice have remained beyond the reach of formal evaluation. The culture of the surgical specialties, too, has traditionally valued innovation above standardization or external assessment. The success of this culture in producing rapid innovation over the last century has perhaps overshadowed surgery's collective missteps and allowed it to largely escape the purview of EBM and its proponents in government and industry. However, as gains slow and innovations raise costs without clear benefits, scrutiny has grown. There is now a concerted effort among patient groups, government, and private payers, as well as surgeons themselves, to bring surgery more fully into the evidence-based fold. Yet, for all these efforts, surgery's unique characteristics continue to present a number of challenges to the methods of EBM.

Innovation in Surgery

In the early days of surgery, patients desperate for a chance at a cure for dire or difficult-to-treat ailments sought out those offering the latest techniques. The landmark surgeons of the past were known for challenging the common perception about where in the body, whether it was the heart or the brain, it was possible to go safely and what was technically possible, from endoscopic surgery to transplantation.

Modern surgery has perpetuated a culture of innovation. Patients still equate the newest with the best and often seek it out [1], and surgeons and hospitals promote themselves by offering novel techniques. Surgery departments, societies, and journals reward innovation with career advancement, awards, and publications.

History is, of course, riddled with examples of excess exuberance in surgical innovation. Perhaps there is no better example than neurosurgery's enthusiastic adoption of prefrontal leucotomy for a wide range of psychiatric disorders in the 1940s. The only neurosurgical innovation to be recognized with a Nobel Prize, leucotomy was a highly valued treatment option at a time when there were few, if any, viable alternatives. However, leucotomy is remembered largely with condemnation because it was performed on tens of thousands of vulnerable patients without a clear understanding of its effects or appropriate standards of informed consent [2].

In more subtle ways, surgical innovation continues to blur the line between research and clinical practice. The 1979 Belmont Report attempted to distinguish research from innovative practice, based on the intended beneficiary [3]. According to the report, which forms the basis for current federal guidelines, practice is intended to benefit the individual patient and research is intended to test a hypothesis and produce generalizable knowledge. The report attempted to define the degree of innovation that marked a departure from standard clinical practice but nonetheless left a large gray area [4]. Institutional review boards are left to adjudicate individual cases, but, in surgery, innovation is a constant and iterative process in which many incremental changes can lead to a novel procedure before it is ever formally proposed for experimental evaluation [5, 6]. The decision to classify use of a new technique as research often falls to individual surgeons, and patients may be left without many of the systemic protections that we generally assume are in place in clinical care. The blurred boundary between research and innovative clinical practice in surgery highlights both ethical issues and the potential difficulty of applying EBM principles.

Evidence-Based Medicine (EBM)

The definition of EBM is constantly evolving and can vary, but its general principles are at the foundation of modern medicine and, properly implemented, should be congruent with the goal of innovation in surgery. One widely accepted, if nonspecific, definition of EBM is "a systematic approach to clinical problem solving which allows the integration of the best available research evidence with clinical expertise and patient values" [7]. The idea is that, by drawing continuously updated conclusions from unbiased and reliable evidence, medicine will weed out false notions and identify beneficial and efficacious innovations.

Most of the surgical subspecialty societies have endorsed the broad outlines of EBM, and many have developed resources, training grants, and prestigious awards and positions to recognize and promote it [8]. However, skepticism about its implementation remains, and its current use in surgical practice is limited. The frequency of randomized controlled trials, the highest level of evidence in the EBM hierarchy, has remained low in surgical specialties [9]. Most of the recommendations that compose the countless surgical practice guidelines in the literature are based on low grades of evidence, at times little more than the personal experience of experts, and thus can be only weakly "endorsed" [10].

What Makes Surgery Different?

Surgical interventions have a number of characteristics that make them more difficult to evaluate in a formal and reproducible way than other medical interventions. None of these features is unique to surgery, but their frequent appearance together collectively makes surgical interventions challenging for the EBM model.

First, surgical procedures are not a single entity but rather a complex series of interventions, the outcomes of which depend on operator, team, and setting and may vary over time [11]. The risk-benefit profile of a procedure often varies from one

surgeon to another based on numerous and sometimes difficult-to-measure factors such as their technical skill, choice of technique, judgment, training, experience, or even something as vague as demeanor [12]. Factors beyond the individual surgeon's control such as anesthesia, support staff, hospital protocols, and pre- and postoperative care also play a role and are difficult to account for even in the largest multicenter trials. To further complicate matters, none of these unmeasured variables is static. Experience in particular has been shown time and again to play an important role in outcomes, both for an individual surgeon performing a given procedure and for that procedure more broadly as the field adopts it, and levels of experience change with time and exposure [13]. A procedure may also evolve so rapidly that by the time it is evaluated it bears only a distant resemblance to what is currently popular in practice. All of these variables make it difficult to formulate practice guidelines on the basis of evaluations of a surgical intervention.

A randomized trial of unruptured brain ateriovenous malformations (ARUBA) [14] exemplifies the difficulty of standardizing the study intervention in a surgical trial. The trial was conducted at 39 centers in 9 countries to increase enrollment and, it was hoped, to randomize variables related to setting. However, to accommodate the variability in practice at the time, the treatment arm included surgery, interventional embolization, and stereotactic radiosurgery, alone or in combination, without descriptions of how any of the procedures were performed at specific sites by particular surgeons [15]. In the end, the study had limited impact on practice because it was difficult for neurosurgeons to know if the results applied to their specific treatment algorithms.

Second, blinding, one of the hallmarks of high quality clinical trials, is often difficult or impossible in surgical trials. A surgeon knows whether he or she performed the trial surgery or placebo or sham surgery. Attempts to use placebos are ethically fraught because patients in the placebo arm must be exposed to considerable risk with no promise of potential benefit, and equipoise is necessarily lost [16]. Sham surgeries have been used when they could be performed with minimal risk, such as in the case of a high-profile trial of stem cell transplantation for Parkinson disease, in which the placebo consisted of a small incision and partial-thickness burr hole in the skull [17]. A later randomized trial of implantable deep brain stimulation electrodes for Parkinson disease took advantage of the "on-off" nature of the technology, giving all patients implants but placing some patients in a temporary placebo group by leaving theirs turned off and only later turning them on in an open-label arm of the trial [18]. However, sham surgery of any kind remains controversial and cases that afford opportunity for placebo control are the exception rather than the rule.

Third, surgical clinical trials tend to suffer from low enrollment, high crossover between the control and experimental groups, and poorly defined equipoise. Since there is no regulation restricting the availability of experimental surgical procedures to the trial setting, patients can often obtain them without participating in a trial. Strong surgeon and participant preferences have significant influence on the validity of clinical trials. For participants, the invasive and risky nature of surgery may

contribute to strong preferences, which may be amplified if the alternative is nonsurgical management or a placebo. Surgeons, for their part, may be less tolerant of uncertainty than their medical counterparts [19]. They may also feel greater accountability or have stronger opinions about the procedures they perform than physicians prescribing study drugs. Decisions of equipoise must be left to individual surgeons, and crossover between experimental and control groups must be permitted to avoid interfering with what an individual surgeon judges to be in the best interest of a given patient. All this can mean that it is difficult to recruit patients for randomized surgical trials, and the assignments individual participants do receive are often discarded, which makes analysis of the results extremely difficult.

In the expensive and highly anticipated Spine Patient Outcomes Research Trial (SPORT), which compared surgical and nonsurgical management of lumbar disc herniation, only about 50 percent of the patients assigned to receive surgery did so within the study period and 30 percent of those assigned to receive nonoperative management went on to receive surgery [20]. Due to the high rate of crossover, the authors could not draw any conclusions about the superiority of the treatments based on the intention-to-treat analysis.

Due to low enrollment, many surgical trials never even reach completion. The Early Randomized Surgery Epilepsy Trial (ERSET) [21] was halted after enrolling only 38 of 200 needed participants. Although the results of this limited study indicated that surgical treatment was superior to the best medical therapy for patients with newly diagnosed, intractable temporal lobe epilepsy, the study will be remembered more for its enrollment difficulties. Similarly, recruitment for the Radiosurgery or Open Surgery for Epilepsy (ROSE) Trial [22] was recently discontinued due to inability to enroll a sufficient number of participants with temporal lobe epilepsy who were willing to be randomized to radiosurgery versus temporal lobectomy.

EBM's Implications for Surgical Innovation

Given the limitations of evidence-based medicine in surgery, there is appropriate concern among surgeons that the rising use of available evidence to make coverage and reimbursement decisions could result in problematic requirements or guidelines. The Leapfrog Group, an independent group of corporations and public agencies that provide health benefits for their employees, and private insurers have begun to use evidence-based guidelines to assess the quality of care offered by clinicians [23]. The Centers for Medicare and Medicaid Services (CMS) is linking a portion of reimbursement to performance on evidence-based quality measures [24]. Current efforts are focused on simple, well-studied, primarily perioperative practices like use of antibiotics or beta blockers. Overly prescriptive attempts to further standardize surgical practice based on the limited body of evidence, however, are likely to be met with resistance. If only those procedures meeting excessively high evidentiary standards were to be covered by insurers, this would have serious consequences for care quality and surgical innovation.

The demand for better evidence is likely to continue growing, however. Numerous prestigious groups have outlined paths forward [25, 26]; the common emerging theme is a more concerted effort at developing evidence without stifling innovation.

There is a need for both improved observational and experimental evidence. For observational data, single-center cases series are being replaced by audited national registries with standardized definitions of variables, outcomes, and complications [27, 28]. Such registries, while administratively burdensome and not immune to the biases inherent in observational data (i.e., selection bias, information bias, and confounding), can vastly improve the available evidence in surgical specialties at a fraction of the cost of clinical trials. Ongoing, large-scale data collection is changing the way new statistical information is incorporated into evidence-based decision making [29]. CMS has demonstrated willingness to allow participation in these databases, designed by surgical subspecialty societies, to meet its national quality reporting requirements [30].

Experimental methods are constantly evolving to meet the realities of surgical practice. Randomized controlled trials will remain the gold standard of evidence, but new trial designs are being attempted that can incorporate learning curves and patient and physician preferences [26]. Financial incentives that encourage evidence development rather than simply denying payment for unproven techniques will also be critical. There are substantial new government funding streams directed at answering clinical questions, such as the Patient Centered Outcomes Research Institute (PCORI) [31]. Innovative coverage schemes, like Medicare's coverage with evidence development [32] and reimbursement for the routine costs of clinical trials [33], aim to encourage the collection of data as innovation occurs rather than mandating burdensome levels of evidence collection before new ideas can receive financial support.

Conclusions

Innovation is at the heart of surgery's culture and mission. The growing demand for evidence in support of clinical practice poses significant challenges for surgery. Given that surgical interventions depend significantly on the surgeon, patient, and setting, attempts to measure outcomes and standardize decision making are difficult to integrate and, not surprisingly, viewed unfavorably [4]. Nonetheless, the goals of evidence-based medicine are ultimately supportive of innovation that aims to maximize patient well-being. With prudent observational and experimental research designs and thoughtful financial and policy support it should be possible to simultaneously promote innovation and evidence development.

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POLICY FORUM

Models of Neurosurgery International Aid and their Potential Ethical Pitfalls

George M. Ibrahim, MD, PhD, and Mark Bernstein, MD, MHSc

Introduction

The magnitude of unmet need for neurosurgery in the developing world is staggering. It is estimated that 2 billion people worldwide lack adequate access to basic surgical care [1], and access to neurosurgical care is even more restricted. For example, the ratio of neurosurgeons to population is 1 to 62,500 in the United States and 1 to 6.4 million in sub-Saharan Africa [2, 3]. In many low- and middle-income countries (LMICs) with some capacity to provide neurosurgical care, subspecialized neurosurgery—such as vascular, functional, epilepsy, and pediatric—is altogether unavailable, and regional disparities may prevent most citizens from accessing available services. Diseases treatable with neurosurgery may be associated with considerable disability and the consequent social stigma [4, 5], robbing individuals and communities of years of productive livelihood. It is not surprising, therefore, that surgical care is increasingly understood to represent a critical component of primary care in LMICs [6-8] and to augment multiple domains of health care [9].

Various models of international aid have been proposed to address the large unmet need for neurosurgical care on the part of the planet's most vulnerable citizens. We categorize the extant models of neurosurgical international aid on the basis of two components: the depth of the commitment and the breadth of applications provided to the LMIC (see figure 1).

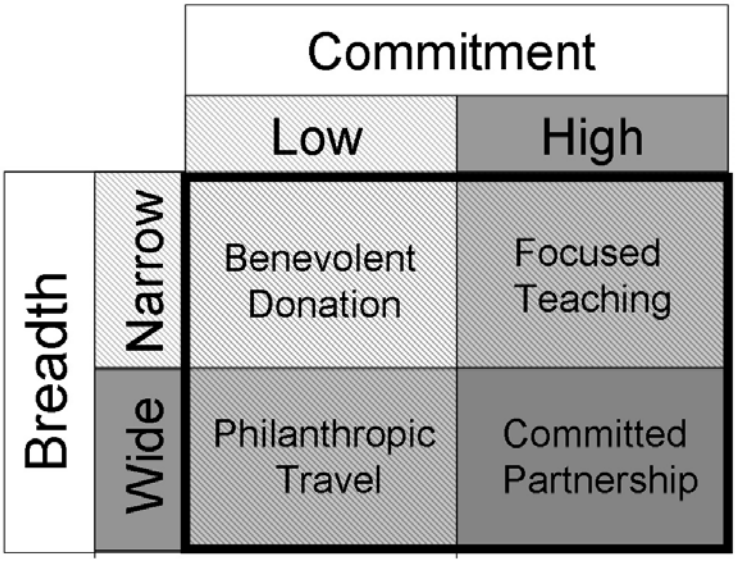

Figure 1. Types of neurosurgery international aid.

The first model, benevolent donation, refers to the giving of material goods to LMICs; little commitment is involved and the uses of the equipment of goods are often narrowly specific. The second model, philanthropic travel, is characterized by a higher, though still limited, commitment: individuals or groups make short trips to one or more countries to perform or teach as many kinds of neurosurgery as possible; the breadth of skills and applications covered is wide. The third model, focused teaching, describes the making of (typically, but not necessarily, repeated) trips to LMICs to teach a single skill set; the commitment is high and the breadth is narrow. Finally, the fourth model, committed partnership, consists of long-term institutional collaborations between centers in developed countries and LMICs; both the level of commitment and the breadth of applications are high. Here, we summarize these models of providing neurosurgical care in LMICs and discuss ethical challenges and pitfalls associated with each.

Benevolent Donation

The first model of neurosurgery as international aid is the donation of material goods, mainly equipment, to LMICs with variable follow-up and support. This model has been adopted by numerous national and supranational organizations. For example, The United States Agency for International Development (USAID) donated a computed tomography scanner to the CURE Children's Hospital of Uganda in 2004 [10]. This donation allowed clinicians at the hospital to identify and treat previously undiagnosed diseases amenable to neurosurgical treatment. Such an important basic tool is a rare commodity]; there were only three CT scanners outside Uganda's capital city as recently as 2011 [10].

Although there is clearly a role for this model of international aid, its limitations are self-evident and raise ethical questions. Do such contributions actually do good? In the aforementioned example, the donation allowed CURE Children's Hospital of Uganda to expand its capacity and operations by more rapidly diagnosing conditions and expediting appropriate treatments. There are numerous other examples, however, of material donations that are inappropriate for the resource-limited settings, e.g., because they are costly to repair or their use is prohibitively expensive for the local population. In the former circumstance, if equipment breaks down, possibly futile efforts to fix it can drain already quite limited resources. In the latter circumstance, a $60 CT scan, for example, may be beyond the means of the majority of citizens in LMICs [10]. Well-intentioned donations of goods therefore may not actually increase access to health care. A thorough assessment of the sustainability and overall impact of material goods must be performed prior to donation.

Philanthropic Travel

The second, classic model of neurosurgery-related international aid is one in which surgeons or surgical teams make short trips to perform surgery and teach techniques to local surgeons [11-13]. In some cases, participants visit the same location multiple times, which has the added advantage of longitudinal follow-up and monitoring of the initiative's impact.

There are ethical challenges inherent to this model. Sustainability is a major issue. Some initiatives do not include teaching; merely performing occasional operations on citizens of LMICs does little to improve the overall state of public health and may even lead to poor clinical outcomes [14]. Even if the initiative includes teaching, will the local team be able to perform the procedures independently after the visitors leave [15]? Contributing to these problems is the lack of coordination among international neurosurgical initiatives, of which there are an increasing number. There should be continuity of teaching aided by documentation of accomplishments and challenges at each center so that vital resources are not wasted on redundant or unnecessary teaching.

Other ethical challenges of this model have been categorized loosely as related to the venue and the visitor [15]. The former include the possible diversion of resources from other local priorities, choosing a location that mitigates regional disparities in access to care, and difficulties in ensuring proper informed consent. Among the most important resources in LMICs are highly trained local physicians. By involving them in specific projects related to neurosurgery during a philanthropic visit, one may inadvertently divert their attention from other worthwhile priorities, such as treatment of diseases that do not require surgery. The choice of location is also an important consideration given that certain subpopulations in LMICs, including those in rural areas, are disproportionately affected by disparities in access to surgical care. The location of the mission should aim to mitigate local inequities in access to health care rather than reinforce them. Finally, while a thorough discussion of informed consent in LMICs is beyond the scope of the current article, it is necessary to appreciate that cultural and social factors and resource constraints may modify the three elements of informed consent—voluntariness, capacity, and lack of undue influence.

The latter ethical challenges include the choice of team members (for instance, whether to include allied health professionals such as physiotherapists as part of the mission) and conflicts of interest that may arise if the visit is sponsored by organizations with financial, social, or political interests. While surgery is important, patients with diseases treatable with neurosurgery often also require prolonged follow-up and rehabilitation. It may be ethically dubious—and indeed a disservice to patients—to facilitate the provision of neurosurgery without augmenting the capacity to care for patients following it. The incorporation of a multidisciplinary team as part of the international mission can bridge such gaps in patient care and improve overall patient outcomes. In order to mitigate many of these challenges, an "ethical checklist" has been proposed that gives *a priori* consideration to them [15].

Focused Teaching

The third model is a variant of philanthropic travel in which surgeons travel to LMICs to teach a narrow, specific skill set. A prime example is teaching local surgeons in developing countries how to perform awake craniotomy [11]. The purposes of this specific skill set are to decrease reliance on intensive care beds and general anaesthesia and to improve patient safety in resource-poor settings [16].

Teaching a narrow (as opposed to a broad) skill set is associated with specific ethical advantages and pitfalls. One significant advantage is the ability to rapidly expand capacity and to perform a particular procedure more efficiently. This may result in decreased morbidity and increased access to care. This is evident in Uganda, where the CURE Children's Hospital has become a regional referral center for childhood hydrocephalus and has seen greatly improved outcomes, expanded access, and long-term postoperative follow-up of patients [17, 18].

The most significant ethical challenge is prioritizing a small subset of diseases for neurosurgical treatment in settings where there is great need for generalized care. Patients whose need for neurosurgical attention is emergent (for example in the setting of trauma or other life-threatening conditions) may require care that the center is unable—or lacks the funding—to provide it. To overcome these challenges, some surgeons focus on narrow, specific skill sets with broad applications, such as the aforementioned awake craniotomy.

In addition, a comprehensive analysis must be performed to ensure that the intervention is appropriate, sustainable, and desired by the local surgeons. One successful implementation of this strategy was the teaching of endoscopic third ventriculostomy and choroid plexus cauterization (ETV/CPC) for cases of childhood hydrocephalus in Uganda [17, 18]. Prospective databases and outcome recording established that this intervention was indeed beneficial and resulted in greater overall good than harm [17, 18]. The result of this endeavor is a reverse innovation phenomenon whereby the procedure is now gaining greater prominence in the developed world [19].

Committed Partnership

The final model, partnerships between surgical centers in developed countries and LMICs, involves a very significant commitment to a broad group of goals. One example of such a consensual partnership is the East African Neurosurgical Research Cooperative, which was formed by regional centers to advance global health development in neurosurgery [20]. The “twinning” of individual centers in developed countries and LMICs involves continuous support and outcome evaluation and monitoring [21].

This is an excellent model, doing much more than the others to develop and ensure sustainability, but it may have its own ethical challenges. First, it can be unclear what both parties’ responsibilities are if the relationship becomes ineffective or conflicts arise. Such agreements typically also include provisions for the education of surgeons from LMICs in the developed world, which may be associated with specific challenges concerning the appropriateness of certain skills for a given context. For example, microsurgical clipping of an aneurysm may not be relevant in certain LMICs where patients with ruptured aneurysms cannot be treated due to the lack of intensive care expertise, diagnostic equipment such as angiography suites, and equipment such as an operating microscope or microinstruments.

Furthermore, the roles of sponsors and conflicts of interest must also be clearly examined at the onset of the partnership. Typically, committed partnerships are resource-intensive. Their ultimate goal is to allow the local centers in LMICs to become self-sufficient, which may not be achievable if all the funding stems from sponsors in the developed world. Additionally, any perceived conflicts of interest—for instance, from the involvement of pharmaceutical or biomedical companies—will undermine the trust that is necessary to establish such a partnership. Both parties must be aware of and agree to how funds will be generated and consider the long-term sustainability of the endeavor as well as find ways to empower the LMIC center to advance and grow until it becomes self-sufficient.

Discussion and Conclusions

An important consideration for all models is their impact. At present, there are no accepted guidelines or metrics to monitor and evaluate the impact of international neurosurgical initiatives. While the response to the neurosurgical needs of LMICs through various models of international aid is gaining momentum, it is increasingly important to audit and review the results of those initiatives to foster accountability to local surgeons, funding agencies, and visiting teams. At the very least, visiting surgeons must be aware of the potential ethical pitfalls inherent in their chosen paradigm of surgical aid and strive to resolve them to improve access, equity, sustainability, and informed consent processes.

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MEDICINE AND SOCIETY

A Preparatory Neuroethical Approach to Assessing Developments in Neurotechnology

James Giordano, PhD, MPhil

Incising the Brain, Mind, and Self

The intricate—and still not fully understood—relationship of the structures and functions of the brain to the properties of consciousness, cognition, emotion, and behavior that define what it is to be a human person represents an important philosophical and pragmatic construct of neurosurgery. Of course, any surgical intervention involves possibilities of changing the physical structure of the body to alter some subjective or objective qualities that are regarded to represent "the self" (one need only consider cosmetic surgery, perhaps the most obvious example). And, like all forms of surgery, neurosurgery possesses certain inherent risks (e.g., infection, hemorrhage), which are of concern when balancing benefits, burdens, and harms. Increasingly, neurosurgical intervention is being regarded as a valid, viable, and valuable option for the treatment of a number of neurological disorders and psychiatric conditions [1-4].

Yet, there is something about incising the brain and the relationship of brain-to-mind-to-self that conjures concerns of a more profound sort. There is disquiet about using neurosurgery to change thoughts and emotions, if not what is considered by many to be the "essence" of the "self" [5]. Perhaps it is that consciousness is wholly subjective and internal, and thus there is something almost sanctified—and inviolable—about that space where consciousness, thought, feeling, and the ability to experience and exercise the qualities that define the "me-ness of me" are generated, or at least focused. For over 100 years, neurosurgery has crossed that threshold of inviolability with ever-improving finesse. In this essay, I first discuss the concerns raised by these interventions and then introduce a comprehensive framework for identifying and addressing ethical issues in neurosurgery.

Altering Behavior and Thought with Neurosurgical Techniques and Technologies

Attempts at cutting the brain to alter the mind and self are not new, and history reveals similar concerns about the prior use of techniques, such as leucotomy and lobotomy, that were "state-of-the-science" at the time [6]. Retrospection now enables us to view such techniques as relatively crude. With this in mind, I look to the current palette of neurotechnologically enabled neurosurgical interventions with enthusiasm—and apprehension. The newest methods evoke imaginings that border on the science-fictional, and fictionalized accounts and the fears they evoke should

not be taken lightly: they tend to reveal important dimensions of public perception and emotion [7].

Arguably, the use of novel neurosurgical techniques and technologies to alter behavior (e.g., impulse control disorders), cognition and emotion (e.g., depressive disorders, posttraumatic stress disorder), and memories (e.g., restoring function following brain insult, mitigating memories of traumatic events) could all be regarded positively as therapeutic. There are near-term possibilities of utilizing neurosurgery-dependent neurotechnologic approaches to treat personality disorders, reduce criminal behavior, and augment specific dimensions of cognitive performance [8, 9]. Yet, these very same approaches could be employed as means to ends that are more controversial: e.g., to enforce social norms or "public safety" [10]. To what extent can—and should—these interventions be used to alter human thought, intellect, mood, personality, belief, and actions? And how do we know whether to categorize these interventions as treatments of "abnormalities" (particularly if said norms are neuroscientifically defined), enhancements (and how far can and should brain functions and human performance be enhanced?), or "enablements" (e.g., to promote qualities deemed desirable in certain public servants and professionals such as peace officers, fire fighters, soldiers, or even physicians) [11-14]? What will this portend for the practice—and ethics—of neurosurgery?

Much of this remains something of a brave new world, as many of the mechanisms and effects of these novel techniques remain unknown precisely because they are, in fact, new. Thus, ongoing research is important to establish and clarify the possible benefits, burdens, risks, and harms. Since many of the more controversial aspects of these approaches are related to control of human cognition, emotion, and behavior, animal research alone will not suffice [15]. At this stage—and in the near future—much of clinical neurosurgery that employs advanced technology will likely be regarded as a research endeavor. Given that any such intervention is exploring uncharted interactions between a novel neurotechnology and its effect upon the brain, the possibility arises of neurosurgery having unanticipated outcomes and unintended consequences as well as its being used to enforce social norms.

Toward a Preparatory Neuroethical Framework: A Twelve-Step Approach

In many ways, ethical issues in neurosurgery overlap with those of surgery and medicine in general. Surgical intervention must always regard relative risks, harms, gains, and losses; well-informed patients must completely and genuinely consent to the treatment(s) offered; and equitable allocation and distribution of services, resources, and goods must be considered [16]. However, these ethical issues are amplified in neurosurgery given the unknowns of the brain-mind relationship, the novelty of neurologic techniques and technologies, and uncertainties arising from their intersection [17]. As a result, actual benefits and harms can be misperceived or misrepresented, available science and technology can be over- and underused, and the extent of care can be inadequate to provide and sustain meaningful good to patients and society at-large—all of which can impact the current and near-future practice of neurosurgery. Such issues are the domain of the field of neuroethics.

We have called for a preparatory neuroethical posture [18], which (a) realistically appraises the actual capabilities and limitations of the tools and techniques at hand; (b) works to define the domains and dimensions that new techniques and technologies will influence; (c) employs qualitative and quantitative modeling to plot benefits, burdens, and risks as accurately as possible; and (d) addresses what can and should be done to mitigate risks and harms while maximizing benefits [19].

A first step in this process is to characterize and parse neuroethical issues into six essential questions:

1. *What* types of techniques and technologies are available for current use, and what are their defined benefits and known and potential burdens and risks?
2. *Why* are specific techniques and technologies being considered or advocated for use, and why and how can technical capabilities affect identified substrates of neurological and psychiatric disorders and conditions that require treatment?
3. *Who* will receive these neurosurgically administered interventions (i.e., which disorders and conditions are to be targeted, which specific patients will be candidates for such interventions)?
4. *When* will neurosurgically administered interventions such as deep brain stimulation (DBS) be considered within a therapeutic algorithm or protocol? Will (and how will) factors such as age and comorbidities be considered in making such decisions?
5. *Where* will these techniques be practiced (e.g., large medical center "hubs," private practice clinics, specified research-based trials)?
6. *Which* funding mechanisms will be employed to subsidize equitable provision of resources and services necessary for both the intervention and any subsequent care that may be required?

These questions (the "six Ws") can be seen as serial and interrelated, yielding a detailed description and definition of the ethical problems in neurosurgery that are—and will soon be—generated by new developments in neuroscience and neurotechnology.

From this point, the six W questions listed above should be framed and informed by considering the "six Cs" (expanding upon initial work by William Casebeer [20]):

1. *Capacities* and limitations of the neurotechnology and neurosurgical intervention in question [16],
2. *Consequences* that will be incurred by patients, patients' families, and society as a result of the intervention in the short, intermediate, and long-term,
3. *Character* of the patient (e.g., patterns of cognition, emotion, and behavior) that could be affected by the intervention,
4. *Continuity of clinical care* for any and all adverse or undesirable effects and manifestations of the intervention (including multidisciplinary approaches, or repeated neurosurgery to alter or reverse the initial treatment) [15],
5. *Consent* based upon the provision of the greatest extent of information possible [20],

6. *Contexts* of culture and circumstances that may affect the aforementioned variables [21].

These lists of considerations for addressing, analyzing, and answering neuroethics questions can be used together with a general approach to ethical reasoning (as shown in table 1) to formulate a decision and actions.

Table 1. Using the six Ws and six Cs in a typical ethical reasoning process

Step	
1	Gather and assess all relevant facts (i.e., the six Ws).
2	Identify the circumstances of the case (i.e., what, who, when, where).
3	Identify the agents involved and their respective roles.
4	Identify the nature of the ethical issue, question, or problem (i.e., the six Ws) and if/how these relate to capacities, consequences, character, or contexts (4 of the Cs).
5	Plot possible actions toward resolving the issue or problem and offer a grounding rationale for each (considering the six Ws).
6	Identify potential trajectories, outcomes, and effects of each possible action (considering the six Cs).
7	Discern what should be done and why (to maximize beneficial consequences in particular contexts).

This approach acknowledges that (a) the most contemporary science and technology represent a "frontier" of possibilities, (b) conditions at the frontier are always somewhat uncertain, and (c) given such uncertainties, things can—and often will—go wrong [11, 16]. Indeed, pressing the boundaries of innovation can sometimes be risky. But risk need not stifle the quest for novel tools and methods. Rather, it's better and far more valuable to pragmatically assess trajectories of effect and recognize, prevent, or mitigate potential problems before they escalate in order to reap the benefits that new techniques and tools may afford [22].

Conclusion

Rapid developments in neuroscience and neurotechnology position neurosurgery to be increasingly employed to treat an expanding range of neurological and psychiatric conditions—and generate a host of ethical concerns about the ways such techniques might be used and misused. Neuroethics provides a set of practices for realistically defining horizons of possibility and pursuing the deliberations necessary to move ahead with prudence [11, 17, 21, 23]. But the field cannot continue to advance without representation in medical education and training at a variety of levels and through a diversity of resources, inclusive of medical curricula, resident training, grand rounds, and case presentations [24]. Such education will ultimately be vital to informing and developing neuroethically sound guidelines and policies to direct the provision and use of clinical resources, goods, and services and to providing public education about the trajectories and implications of employing neuroscientific techniques and neurotechnology in neurology, psychiatry, and neurosurgery.

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HISTORY OF MEDICINE

Technological Innovation and Ethical Response in Neurosurgery

Jayant Menon, MD, MEng, and Daniel J. Riskin, MD, MBA

Introduction

Neurosurgery has a rich tradition of experimentation and innovation. These efforts are stimulated by a human desire to understand our anatomy, our consciousness, and ourselves. Experimentation with our brain and thoughts offers vast opportunity matched by significant ethical and physical risks [1]. In this manuscript, we explore the history of innovation in neurosurgery with a focus on the life cycle of learning, including associated ethical challenges and resolution. Our purpose is to illuminate the intersection of neurosurgery, innovation, and ethics so that history can inform a rational approach to future neurosurgery advances.

A bit of background is needed to properly explain cycles of innovation. In health care, as in other industries, there are periods of technology expansion and periods of technology refinement [2]. The drivers for rapid expansion typically include enabling technologies and societal needs [3]. For example, late in the twentieth century, wide availability of miniaturized processing power, solid-state storage media, and powerful communication infrastructure set the stage for rapid development and adoption of smart mobile phones. Although individuals helped bring these changes about, it was the enabling technology and societal desire for instant and constant access to data and people that created fertile conditions for technological innovation. Similarly, enabling technology and societal need define periods of rapid technology expansion in other fields.

One difficulty in innovation is that periods of technology expansion tend to create or exacerbate ethical challenges. With smart mobile phones, for example, concerns about privacy, unequal access, and censorship have increasingly become global discussions [4]. Ethical challenges are highlighted or precipitated by technological advances, and the path to resolution of those challenges can be slow. Decades into mobile phone availability, efforts to solve ethical and practical challenges require ongoing public and private debate. In health care and the field of neurosurgery, given their direct influence on lives and health, ethical dilemmas are both immediate to the patient and of deep concern to society.

Leveraging the Past to Understand the Present

While it is beyond the scope of this brief article to discuss neurosurgery history and ethics comprehensively, considering two periods of rapid advancement may offer insight into innovation cycles. We will examine the late nineteenth century and mid-

twentieth century periods of rapid technology expansion, how these expansions led to ethical challenges, and how those challenges were addressed.

The late nineteenth century was a period of rapid expansion of medical technology in all specialties, with a great deal of experimentation and innovation in neurosurgery specifically. Factors that contributed to this state of affairs included improved communication facilitated by the industrial printing revolution [5], pain-free operations made possible by the advent of anesthesia [6], and improved surgical safety using antiseptic techniques [7]. These led to robust experimentation and innovation in neurosurgery. Bell and Magendie's experiments in 1868 established the anterior-posterior anatomic relationship of motor and sensory function in the spinal cord and ushered in the modern era of neurophysiology [8, 9]. In 1874, Robert Bartholow conducted a series of controversial experiments on Mary Rafferty, a patient with a cranial defect resulting from an ulcerating tumor that allowed him to perform direct brain stimulation. These experiments confirmed that the parietal lobe was responsible for motor control of the contralateral limb and that seizures came from irritation of the human cortex [10]. But Rafferty's death and ambiguity about informed consent raised questions about the ethical appropriateness of such medical research.

By the end of the nineteenth century, there was a strong populist movement against human experimentation [11]. Topics of global debate included the Neisser syphilis inoculation trial [12], criminalization of physician intervention without consent in some countries, and appropriate experimentation practices [13].

In the mid-twentieth century, another period of rapid neurosurgical advancement and innovation occurred. Enabling technologies included electrocautery, which allowed safe dissection of the scalp and control of intracranial vasculature [14]; roentgenography, which made it possible to image surgical neuroanatomy [15]; and electroencephalography, which provided imaging of functional neurophysiology [16]. Enabling technology coupled with societal drivers led to innovation and experimentation. Nazi Germany is well known for medical research war crimes [17], but ethical lapses in proper consent and insufficient respect for autonomy were pervasive across the globe [18, 19]. From the Tuskegee syphilis experiment to the 22 experiments with no patient benefit highlighted by Henry Beecher [20], intellectual curiosity overwhelmed ethical concerns.

In response to these ethical failures, ethical principles of human experimentation were codified in the Nuremberg Code in 1947 [21], the Helsinki Declaration in 1964 [22], and, in the US, in Henry Beecher's seminal article on pervasive unethical medical practices in 1966 [20] that ultimately led to the 1979 *Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research* [23]. For the first time, a global framework for ethical human experimentation was developed and enforced. This new ethical framework prioritized potential benefit for the individual, rather than the greater good for society [24].

The two periods outlined above exemplify cycles of innovation that included a set of enabling technologies, followed by rapid advances in medical practice, resulting in recognition of new or newly understood ethical challenges, followed by a decades-long struggle to understand, define frameworks for, and implement solutions to those ethical dilemmas.

Looking Toward the Future

The past can serve as a roadmap to the future. History should give pause to the emerging innovator who enters a field during a time of rapid expansion. Based on today's enabling technologies and societal drivers, neurosurgery is very likely entering another such period of rapid expansion. Newly available enabling technologies include devices that capture and store extensive clinical data, vast computational power, and tools to analyze genetics and gene expression. A resurgence of societal support for neurosurgery innovation is underway, with enthusiasm from academics, physicians, and even the federal government in the form of the BRAIN initiative [25]. While the full spectrum of errors we will make can only be conjectured, new ethical dilemmas are certain to come. In this section, we examine a selection of likely neurosurgical innovations. Again, the goal is not to be comprehensive, but rather to share the flavor of the newest cycle of advancements and potential ethical challenges.

One likely advancement is the advent of the clinically effective brain-computer interface (BCI), first discussed in 1991 [26]. Considerable preliminary success has been achieved. Experiments using a penetrating microelectrode array in humans have established control of robotic arm prostheses [27]. Limited motor control of robotic prostheses has been achieved through subdural nonpenetrating electrode arrays that do not damage the cortex [28]. Cognitive prosthetics are being developed that actually improve the ability to encode new memories [29].

As these interventions become increasingly feasible, questions arise about how more sophisticated BCIs will be tested and to what purpose they will be applied. New nanomaterials are making direct connections between single neurons and electronics possible [30]. Would a future direct neuroelectronic interface with neuroanatomic networks that influence our conscious and subconscious minds make us something other than human? On a more practical level, could extension of rudimentary language decoding through brain-computer interfaces [31] be employed to establish autonomy in patients with locked-in syndrome? If such an interface were to decode subconscious thought, how might we preserve privacy and autonomy with these devices? Is it possible to establish decision-making capacity prior to experimentation on those with cognitive BCIs that are partially responsible for the ability to make decisions or create memories? What is the role of the physician in assessing the outcomes of such interventions?

Other ethical issues are raised by restorative neurotherapies that focus on treating disease: stem cell therapy for stroke [32] and neurodegenerative disease [33] and deep brain stimulation for alcohol addiction [34, 35] and obsessive-compulsive

disorder [36]. Rapid expansion of experimentation in an attempt to treat currently incurable diseases will lead to ongoing questions of clinical equipoise and therapeutic access.

These and many other innovations in neurosurgery represent tantalizing but concerning opportunities. Can knowing that there will be ethical challenges help us to foresee problems today and potentially improve the field's approach to a period of rapid technical expansion?

Conclusion

The past is our best guide to understanding future challenges [37]. History teaches us that periods of enabling technologies and societal support stimulate rapid progress that precipitates new moral dilemmas. It seems likely that we are entering such an exciting and ethically challenging period in neurosurgery. The ethical questions of our era will not be the same as those in past history, but common themes abound. We continue to try to understand and define humanity, assure appropriate protections for the vulnerable, and promote broad access to advanced interventions within a financially stratified society.

If history is any indication, today's neurosurgery will be judged as much on its ethical approach as on its clinical success. How can we, today, work to deserve the respect and appreciation of future generations by understanding and incorporating lessons learned from the past?

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Disclosure

Daniel Riskin is CEO of Vanguard Medical Technologies and Founder of Health Fidelity.

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SECOND THOUGHTS
Disclosure of Experience as a Risk Factor in Informed Consent for Neurosurgery: The Case of *Johnson v. Kokemoor*

John D. Banja, PhD

A problem that has bedeviled both medical law and medical ethics for decades concerns the scope of risk-related information that a health professional should provide to patients, especially when that information involves the health professional's experience and success rates with a certain procedure. For example, I take a rather perverse delight in provoking medical students with the following line of questioning:

"How do you determine what risks you're going to disclose to a patient?"

"You should disclose the risks a reasonable patient would most likely want to know about in making a treatment decision."

"So, if I had a piece of information that I thought would be likely to influence a patient's decision one way or another, then you're saying that I should disclose that to the patient?"

"Yes, absolutely."

"How many of you think that a physician's previous experience doing a procedure—as in how many times he or she has performed the procedure, what are his or her comparative outcomes, complication and success rates, etc., etc.—is something that the average patient would likely want to know about?"

Numerous hands go up.

"So, let me ask you this: If you were a patient in a hospital awaiting a procedure, and I was your physician, but I introduced my resident to you and told you that he or she was going to do most of that procedure, how many of you would want to know about this resident's previous experience doing that procedure? In fact, if this resident had never done this procedure before so that you were going to be his or her first patient, how many of you would want to know that?"

At this point, students begin to squirm, chuckle, and look at one another. Some hands hesitantly go up. So as to capitalize on their distress, I drive the question home:

"So, if you say that a health professional's previous experience is something that the average, reasonable patient would want to know about, then isn't the attending physician ethically obliged to disclose to the patient that this will be the resident's first time doing this procedure? Let me see a show of hands. How many of you believe that the attending should straightforwardly tell the patient that this is the resident's first time?"

And, usually, very few hands go up, which I then follow with:

"So, aren't you contradicting yourselves? One the one hand, you say patients have the right to know this information because it would be material to their decision making. But, on the other hand, many of you are now saying that the physician shouldn't disclose it, at least not at the start."

And here, some students will offer a utilitarian argument in their defense: "But students have to be trained. If we routinely disclosed, 'I'm doing this for the first or second time,' patients would refuse to allow us to treat them and we'd never learn." But that response implies that the clinicians' learning needs trump the patient's right to informed consent, which won't do in the patient-centered ethics espoused in the United States. Nevertheless, we simply must train our health professionals as best we can, which leaves my students stewing over this quandary (although I suspect they adapt by ultimately choosing not to think too hard about the patient's right to know). The recent history of neurosurgery provides an illustrative example of the quandary in the case of *Johnson v. Kokemoor*.

Johnson v. Kokemoor

The leading legal case in neurosurgery that addresses this issue is *Johnson v. Kokemoor* [1]. It's an excellent teaching case that involved a patient, Donna Johnson, who underwent a CT scan to determine the cause of her headaches. The scan revealed an enlarging, basilar bifurcating aneurysm, which prompted Ms. Johnson to visit the defendant, Richard Kokemoor, a neurosurgeon practicing in the Chippewa Falls area of Wisconsin. Dr. Kokemoor clipped Ms. Johnson's aneurysm in October of 1990. The operation left her unable to walk or control her bowel and bladder movements, and she experienced some impairment of her vision, speech, and upper body coordination [1].

In her lawsuit, Ms. Johnson did not allege that Dr. Kokemoor was negligent in performing the procedure. Rather, she claimed that she was deceived by his allegedly exaggerating both her need for surgery and his experience in clipping basilar bifurcating aneurysms. Specifically, when Ms. Johnson asked Dr. Kokemoor about his previous experience, "he replied that he had performed the surgery she required 'several' times; asked what he meant by 'several,' the defendant said 'dozens' and 'lots of times'" [2]. In fact, during his residency, Kokemoor had performed 30 aneurysm surgeries, but all of them were anterior circulation aneurysms. Since his residency, Kokemoor had done only two basilar bifurcation aneurysms and had never operated on a large one like Donna Johnson's. Ms. Johnson contended that,

had she known the truth about Dr. Kokemoor's lack of experience performing this procedure, she would have had the surgery done elsewhere and by a more experienced neurosurgeon.

This case was largely about whether or not Wisconsin law allowed Ms. Johnson to introduce evidence at trial that Dr. Kokemoor had violated his informed consent obligations by failing to describe accurately his relative lack of experience with the surgery in question. Dr. Kokemoor argued that the informed consent law in Wisconsin only required the usual listing of risks and benefits, procedural descriptions and explanations, "likely outcomes" as they are nationally known, and so forth. He vehemently contended that no physician, in Wisconsin at least, was obligated to reveal the extent of his or her performance experience as a risk factor associated with a particular treatment.

America is the land of the free and the brave, however, and the Wisconsin Supreme Court saw it Ms. Johnson's way. The court noted that, in Wisconsin as in most states, the standard that physicians must use to determine whether a risk should or shouldn't be disclosed is that of a reasonable person:

> What a physician must disclose is contingent upon what, under the circumstances of a given case, a reasonable person in the patient's position would need to know in order to make an intelligent and informed decision… [3]. A reasonable person in the plaintiff's position would have considered such information (i.e., information relating to provider-specific risk) material in making an intelligent and informed decision about the surgery [4].

And so the ruling was handed down: patients having surgeries performed by physicians licensed in Wisconsin can regard their treating physician's degree of experience as a risk factor like any other risk variable such as the rate of postsurgical infection or exacerbation of a comorbidity. While it's hard to imagine many Wisconsin physicians being thrilled with the court's decision, most surgeons would probably agree that a physician's degree of experience with a complex procedure will inevitably be a correlational, if not a causal, factor in the outcomes of his or her surgeries [5]. As Donna Johnson's expert witnesses opined on her behalf, even the best, most experienced neurosurgeons faced with clipping an aneurysm like hers would anticipate a morbidity and mortality probability of around 10 to 15 percent, while inexperienced physicians like Kokemoor could anticipate a probability of around 20 to 30 percent.

The Lessons of *Kokemoor*

I believe there are a number of points to take from this case. If the informed consent conversations between Ms. Johnson and Dr. Kokemoor really transpired as they were reported in the court's decision, then Kokemoor indeed dissembled or "fudged" when he reported having done "lots" or "dozens" of aneurysm surgeries like hers. But this may not be uncommon. Some clinicians tell me they respond with, "Oh, I've

had lots of experience with that intervention" when asked by patients, even though their "experience" amounts to having observed others doing it. A problem with medical conversations is that there's often too much wiggle room for clinicians to obfuscate or cleverly respond to a patient's queries in self-serving ways.

Another, underdiscussed aspect of this problem is the way a patient's refusing a particular clinician's services because of the latter's lack of experience constitutes a psychological blow to the clinician. The clinician feels rejected; he or she is deemed inadequate by the very person whose trust and respect the clinician craves. So clinicians may be tempted to inflate their experience and confidence to compensate for their insecurities.

Still another problem is that medical training programs don't prepare students for these self-esteem threats, which issue not only from patients' electing to find more experienced clinicians but also from disappointing outcomes, relationally challenging patients, commission of errors, relentless demands to meet productivity quotas, and so on [6].

We may nevertheless be at the beginning of a new era in the evolution of informed consent conversations, in which health professionals can absorb the lessons of *Kokemoor* with greater emotional maturity and a deeper appreciation of the "patient-centered" perspective than ever before. Obviously, we must respect our patients' right to informed consent, while they in turn should respect that health professionals need to learn the art. Indeed, if health professionals, especially during their training years, were reasonably honest with their patients about their lack of experience in performing procedures, they might well find that some patients are not nearly so deterred by that inexperience as one might think, as long as less experienced clinicians are tutored or assisted by more experienced ones. Perhaps Dr. Kokemoor should have availed himself of more experience by assisting more seasoned neurosurgeons in performing bifurcating basilar aneurysms, and certainly he should have done so before representing himself to Donna Johnson as having performed "dozens."

Economists, incidentally, would have a ready solution to this entire problem: the inexperienced surgeon should reveal his inexperience but charge substantially less for the procedure, just the way numerous but inexperienced professionals from other professions do. Although this arrangement may sound like another depressing example of turning the patient-doctor relationship into a marketplace transaction, it is a virtual certainty that various patients and their insurance companies would find it appealing, as exemplified by the phenomenon of medical tourism, in which patients travel to the other side of the world for less expensive medical care. Note, however, that this economic model would nevertheless insist on a truthful disclosure of the physician's level of experience because patients (as buyers) have a right to know the nature of what they are purchasing. Consequently, as the physician's level of experience is a crucial factor in this purchasing decision, he or she would be

obligated to disclose that experience in a way that would inform what patients or their insurers would be willing to pay.

These kinds of musings underline, I think, what informed consent and all the rest of our familiar ethical challenges have always been: social experiments conducted by various groups of human beings in pursuing what they believe to be the best state of affairs reasonably possible. We should remind ourselves that the famous *Schloendorff* decision [7], which began the historical turn toward acknowledging a patient's right to control what happens to him or her in surgery, is now a century old. We continue to grapple with the changes and risks engendered by advanced medical technologies—like the ability to clip large, bifurcating basilar aneurysms. And we continue to witness and treat a more educated and, often, skeptical population of health care consumers, who will be disappointed and angry with physicians who offer less than truthful representations about their conditions and available care. Obviously, our moral intuitions and practices must keep pace with technological progress, and one hopes that cases like *Kokemoor* will inspire students, medical faculty, the medical community, and the general public to strategize ways to accommodate the competing demands of adequately training our future health professionals without sacrificing any of our patient-centered obligations.

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SECOND THOUGHTS

The New Era of Neuromodulation

Marwan Hariz, MD, PhD, and Jordan P. Amadio, MD, MBA

Introduction

Neuromodulation is a branch of functional neurosurgery that aims to treat chronic neurological or psychiatric diseases by surgically targeting deep brain nuclei and pathways involved in the mediation of the symptoms in order to stimulate, inhibit, or otherwise modify, i.e., modulate, pathological activity.

In recent years, the increasing adoption of neuromodulation therapy has led to a general perception that the technique is safe. This has emboldened proponents of its experimental use in a variety of conditions not traditionally under the purview of neurosurgery, including, on a theoretical basis, the enhancement of normal function and capabilities. With a view to the history of neuromodulation ethics and the current state of our knowledge regarding its long-term use, this is an improper application that neglects serious risks and endangers the patients who would otherwise benefit from this technology.

The modern era of neuromodulation started with the publication in 1987 of a paper by Benabid et al. on the use of deep brain stimulation (DBS) for suppressing tremors of Parkinson disease [1], and the field is still dominated by deep brain stimulation (DBS). Thanks to modern imaging, including functional imaging, and improved surgical techniques, neurosurgeons are now able to implant DBS electrodes virtually anywhere in the brain with a high degree of accuracy and relative safety. Increased understanding of the neural circuits involved in various neurological, psychiatric, cognitive, and behavioral disorders makes it tempting to use the nondestructive stereotactic technique of DBS to modulate these circuits in the hope of alleviating symptoms. The success of this approach on the motor symptoms of Parkinson disease (the most common indication for DBS) has led to enthusiasm for applying DBS beyond movement disorders, in the realm of psychiatry, behavior, and cognition.

To date, DBS trials have targeted no fewer than 40 different brain sites for at least 30 clinical indications [2]. The common denominator of these investigational applications of DBS is their intention to treat symptoms of illnesses and diseases that are refractory to nonsurgical management, be they tinnitus or obesity, depression or dementia, epileptic seizures or phantom pain.

The general euphoria surrounding the potential of the technique of neuromodulation can arouse fears of a “slippery slope” in its future use for enhancement of normal

functions or for "indications" beyond disease and illness. The ethics of neuromodulation use in psychiatric and behavioral illnesses is much debated today and the debate now stretches to address potential DBS applications beyond pathology. This paper will review the current ethical issues surrounding DBS and neuromodulation and their evolution, with emphasis on the role that the neurosurgeon should take in relation to trends and possible future uses, keeping in mind his or her role as the final executor of the surgical act, and thus, the one who will have to take full responsibility for its consequences.

Survey of Publications on Ethics of DBS

If 1987 marks the birth of the modern era of DBS use in movement disorders [1], 1999 is the dawn of the modern era of DBS in psychiatry. Indeed, it was the paper by Veerle Vandewalle et al. on DBS for Tourette syndrome published in *The Lancet* in February 1999 [3] and the publication of Nuttin et al. on DBS for obsessive compulsive disorder, also in *The Lancet* in October 1999 [4], that ushered in the current era of DBS in psychiatry. These were clinical discussions, though, so when and how, given the global spread of DBS, did discourse on the *ethics* of using chronically implanted electrodes in deep brain structures to modulate brain circuitries in various diseases arise?

A search of PubMed using the words "deep brain stimulation" and "ethics" provided 148 publications. The oldest paper listed is "Indications and Ethical Considerations of Deep Brain Stimulation" authored by three neurosurgeons and published in 1980 [5], seven years before Benabid et al. published their clinical introduction to DBS. This article by Siegfried et al. is a discussion of the use of DBS exclusively for pain control. Thus, the ethical concerns of the authors are chiefly clinical—might DBS cause brain tissue damage or biochemical modifications? Will the implanted electrodes move? Is the treatment clinically effective?

The next paper on the PubMed list was published in 2000 by ethicist Joseph Fins, who proposed an ethical framework for use of DBS in impaired consciousness, specifically from traumatic brain injury [6]. Fins advocated that investigation of the procedure go forward only in the presence of therapeutic intent—to benefit the participant—and if benefits were proportional to foreseeable risks [7]. Notably, Fins's paper referred to the use of DBS to improve impaired consciousness as "interventional cognitive neuroscience." In 2003, the first paper explicitly discussing the ethics of neuromodulation in psychiatric illness, also by Fins, appeared [8]. Hence, it was only after modern DBS progressed from neurology and movement disorders toward psychiatry in 1999 that nonclinical ethics became a matter of concern. The implication is that, between 1987 and 1999, when modern DBS was used only for Parkinson, tremor, and dystonia, there did not seem to be any ethical considerations worth discussing and publishing.

In 2006, Fins et al. published a paper on the ethics of DBS in psychiatry that explicitly mentions the role of the neurosurgeon [9]. Here, the authors discussed the era of unrestrained lobotomies, reminded the reader of the "abuses of that early era"

[10], and stated, with respect to psychiatric DBS, that "it is ethically untenable for this work to proceed by neurosurgeons in isolation without psychiatrists determining the diagnosis and suitability of patients for treatment" [10]. The "abuses of that earlier era" allude mainly to the unrestricted lobotomies practiced by neurologist Walter Freeman, whose neurosurgeon James Watts abandoned Freeman because of his too liberal uses of lobotomy [11]. It is obvious that the legacy of the Freeman era of mass lobotomies still haunts the practice of surgery for psychiatric illness to this very day, be it stereotactic lesions (capsulotomy, cingulotomy) or DBS.

Fins et al. are rightly adamant that a multidisciplinary team of neurosurgeon(s), neurologist(s), psychiatrist(s), and psychologist(s) is required in any decision on DBS for psychiatric indications. Yet, the September 2009 issue of the *Archives of General Psychiatry* featured an article titled "Scientific and Ethical Issues Related to Deep Brain Stimulation for Disorders of Mood, Behavior, and Thoughts" [12]. This article summarized a two-day conference convened to examine scientific and ethical issues in the application of DBS in psychiatry, the aims of which were to "establish consensus among participants about the design of future clinical trials of deep brain stimulation for disorders of mood, behavior, and thought" and to "develop standards for the protection of human subjects participating in such studies" [13]. Sadly, none of the 30 participants at the meeting, 19 of whom are authors of the article, was a neurosurgeon. This rather undermines the call to a multidisciplinary approach to psychiatric surgery.

Concerning ethical guidelines for DBS in psychiatric indications, PubMed yields more than 25 papers with overlapping and repeated advice and suggestions for proper conduct. The latest published paper on this issue, the initiative behind which was taken by a group of neurosurgeons from the World Society for Stereotactic and Functional Neurosurgery (WSSFN), is entitled "Consensus on Guidelines for Stereotactic Neurosurgery for Psychiatric Disorders" [14]. This paper was authored by a worldwide group of neurosurgeons, psychiatrists, neurologists, and ethicists as well as representatives of various national, regional, and international neurosurgical and psychiatric societies. The paper highlights that DBS for psychiatric illness remains experimental and should be conducted in a multidisciplinary fashion, on patients with documented refractory illnesses who have the capacity to consent, with long-term follow-up using established evaluation scales, and with dissemination of all results, both positive and negative. This latest published consensus statement explicitly states that "neurosurgery for psychiatric disorders should never be performed for political, law enforcement or social purposes, but with therapeutic intent aimed at the restoration of normal function and amelioration of distress and suffering" [15].

DBS for Antisocial Behavior and Morality?

In July 2012, an article entitled "Functional and Clinical Neuroanatomy of Morality" was published in *Brain* [16]. The authors, who are neuroscientists at the University of Milano in Italy, wrote that "understanding the dysfunctional brain structures underlying abnormal moral behavior can lead to specific treatments nowadays using

deep brain stimulation or other new non-invasive neuromodulation techniques" and suggested that "deep brain stimulation might be used in...pathological antisocial behavior or violence...and for shaping individual morality" [17]. The idea of using of DBS for such "indications" may well provoke a sense of déjà vu for those who remember the premodern era of DBS (or "psychosurgery") of the 1960s and early 1970s, when the procedure was suggested for improving social behavior [18] and misused in questionable experiments on humans [19]. Indeed, the DBS practices of that period were subsequently condemned as "dubious and precarious [even] by yesterday's standards" [20].

DBS for Enhancement of "Normal" Cognitive Function?

Many perceive DBS as reversible and almost harmless, disregarding the inherent risks of hemorrhage and neurological deficit and the many side effects of chronic stimulation of various deep brain structures [12]. Notwithstanding the fact that no neuromodulation procedure is as yet "established" as a treatment for any of the multitude of brain targets involved in any psychiatric or behavioral illness (despite 15 years of intense activity in the field [21]), discussion of DBS as a surgical method has undergone a potentially alarming jump: it is being considered for future cognitive enhancement of healthy people. In a survey of North American neurosurgeons published in 2011, 49 percent of those who answered the survey considered that using DBS to provide surgical memory enhancement to healthy people who request it would be unethical at that time [22]. When asked whether they thought DBS would be used for cognitive enhancement in 50 years, 54 percent said "yes" [22].

What Is the Role and the Duty of the Neurosurgeon?

Modulation of pathological neuronal behavior mainly using electrical current delivered by permanently implanted deep brain stimulation electrodes is an exquisite tool that has been used for more than 25 years in more than 120,000 patients worldwide, the overwhelming majority of whom suffered from Parkinson disease, tremor, and dystonia. Yet, access to this therapy for these established neurological indications is still far below demand, partly for economic reasons, but also because debate continues about which brain target—the pallidum internum or subthalamic nucleus—is the more appropriate [23, 24] and what the ideal timing is for offering this therapy to patients [25, 26].

Despite 15 years of frenetic activity, with exploration of no fewer than eight different brain targets for obsessive compulsive disorders (OCD) and nine targets for major depressive disorder (MDD), DBS for psychiatric illnesses is still in its infancy [2, 21]. Two recent randomized controlled trials of DBS for depression, one targeting the ventral caudate and one targeting the subgenual cingulum, failed to show that active stimulation in either target was better than sham stimulation [27]. A survey of the literature of DBS for depression concluded that "DBS for MDD...remains experimental" [28], and one article on DBS for obsessive compulsive disorder (OCD) concluded that "DBS remains an experimental treatment for medication refractory OCD" [29]. A pilot study of DBS for cognitive decline (especially mild

Alzheimer), pioneered by the Toronto group [30], is still far from providing any conclusive data about its efficacy in the long term. There is no available data to support a notion that DBS might be used for treatment of posttraumatic stress disorders, eating disorders, or drug addiction.

The pathological conditions mentioned above affect millions of patients and are exceedingly far from being adequately addressed by neuromodulation, indicating the need for additional rigorous scientific studies to advance our therapeutic armamentarium. At this time, neurosurgeons would do well to oppose, with rational, humane, and ethical arguments, the use of deep brain surgery for anything other than illnesses and diseases. The contemporary neurosurgical community would benefit from reading or rereading the landmark 1977 statement of the US National Commission Report on Psychosurgery:

> The Commission affirms that the use of psychosurgery for any purpose other than to provide treatment to individual patients would be inappropriate and should be prohibited. Accordingly, the Commission is recommending safeguards that should prevent the performance of psychosurgery for purposes of social or institutional control or other such misuse [31].

Given the current state of the field, it is indefensible for neurosurgeons to participate in implanting neuromodulation technology for consumer use or for early-adopter "enhancement" enthusiasts. The matter of chief ethical concern is that so many patients with illnesses potentially treatable by DBS are denied access or referral to that treatment, suggesting that any excess neurosurgery resources be devoted to that end.

Neuromodulation, especially DBS, is a neurosurgical procedure on deep and delicate brain structures that may have deleterious consequences. It should therefore be reserved for those who suffer from otherwise intractable symptoms that are amenable to alleviation by this method. Those who consider its use in anything other than refractory illnesses are acting irresponsibly and may be harming patients who could benefit from the technique. As Rhode Island neurologist Joseph H. Friedman stated in 2004: "Now that DBS means that psychosurgery is reversible, we no longer have to worry about permanent harm. On the other hand, now that psychosurgery could be readily available, potentially for a large number of conditions, we have a lot more to worry about" [32]. The renowned neuroanatomist Malcolm Carpenter provided an apt warning in 1987: "I feel that stereotaxic surgery has much to offer, if properly controlled and used judiciously. Some of the wild things that are done without a scientific rationale jeopardize the entire effort" [33].

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