Pursuing Excellence in Healthcare Delivery: American Neurosurgery

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The field of healthcare delivery is a large one, and neurosurgical health services research can be said to have only just begun. This chapter briefly addresses 3 components of excellence in health care delivery—quality, access, and cost—from a neurosurgical perspective.

Excellence in healthcare delivery has always been a primary aim for clinical physicians, although they have not given the concept such a formal name until quite recently. But since the beginning of recorded medical history,[1] neurosurgeons have always aimed to provide the best outcomes possible for each patient, a goal consistent with medical codes of ethics since at least the time of Hippocrates. This emphasis on quality of healthcare delivery forms the first and oldest part of a useful triad[2] of concepts that cover much of what we mean by good healthcare delivery. The second part of the triad, access, and the third part, cost, reflect 2 additional goals of healthcare delivery that are manifest increasingly today in medicine's interaction with society as a whole. Quality of care (good outcomes for each patient, within the limitations of current medical knowledge) at the level of individual patients or small groups of patients has been the focus of much neurosurgical research and publication since before Harvey Cushing's time, although in the last 2 decades new emphasis has been placed on measuring quality at the level of the practitioner (individual surgeon or hospital). Access and cost have received much less attention in the neurosurgical literature, although this is beginning to change. The US government has devoted much attention to healthcare delivery initiatives since the 2008 general presidential election, and one state (Massachusetts) has already enacted significant healthcare reform,[3] making this topic a particularly germane one for discussion today.

The branch of the US government most directly tasked with ensuring quality in healthcare delivery, the Agency for Healthcare Research and Quality (AHRQ), uses 6 distinct criteria to define successful healthcare delivery: (1) effectiveness, (2) safety, (3) timeliness, (4) patient-centeredness, (5) equity, and (6) efficiency.[4,5] Because of the limited scope of the present discussion, I will combine the first 4 goals under the label of "quality." "Access" will be used to cover the AHRQ concept of equity and "cost" to address the AHRQ concept of efficiency.

QUALITY OF NEUROSURGICAL HEALTH CARE

The history of neurosurgery (like any branch of medicine) has been a constant search for better quality of care. Novel neurosurgical treatments that hold the potential to improve outcomes are continually being developed, tested, and sometimes discarded through the normal process of clinical research, dissemination through meetings and print journals, and peer review. Formal healthcare delivery studies intended to improve the quality of neurosurgical care began only recently and used different tools, chosen to be appropriate for studying characteristics of neurosurgical care not in individual patients but at the surgeon-specific or hospital-specific levels, in entire healthcare systems, or for a nation as a whole.

Any study of the quality of neurosurgical care first demands appropriate metrics. Neurosurgeons are more or less familiar with a long list of ways of measuring the success of neurosurgical treatment, and appropriate metrics are chosen, depending on the specific condition being treated and even on the specific procedure used. Examples of neurosurgical metrics that are applicable to many different conditions include mortality[6] (which can be measured as in-hospital mortality or 30-day mortality for nearly all neurosurgical procedures or as long-term survival when the procedure is intended to have a long-term effect on the disease process), measures of treatment-related morbidity (such as discharge other than directly home for conditions that are usually minimally symptomatic before treatment), quality of life (for which both overall and disease-specific metrics are often available), and measures of treatment cost (such as hospital costs or charges).[7]

The usefulness of a given end point for measuring quality of healthcare delivery often varies with the size of the population being studied. For example, in acoustic neuroma surgery, single-institution case series would be expected to report results in terms of operative mortality, rates of complete tumor resection, facial nerve results and hearing results at certain times after operation, and other complication rates. Administrative databases that would be useful in studying this operation would probably contain in-hospital mortality, length

of stay (LOS), and hospital discharge disposition, but rates of complete resection and detailed facial nerve function results are not available, and hearing loss codes, in addition to probably being significantly underreported, do not distinguish complications of surgery from the presenting symptoms of the tumor.[8] In general, administrative databases contain information on large numbers of treated patients (even for relatively uncommon diseases or procedures) but offer little clinical detail, compared with prospective trials or even with case registries that have been designed to study a given type of surgical procedure or diagnosis. One registry that has been useful in studying surgical outcomes in great detail is the Society for Thoracic Surgeons database, which has been used to derive robust risk adjustment models for coronary artery bypass surgery.[9,10] Examples with neurosurgical relevance include procedure-specific registries such as the Ontario Carotid Endarterectomy registry,[11] diagnosis-specific registries such as the National Traumatic Coma Data Bank,[12] and some device-specific registries that follow patients in whom specific medical devices or classes of devices (such as lumbar disk prostheses[13] or cerebrospinal fluid shunts[14]) have been implanted.

Studies that attempt to compare quality of care across different providers (surgeons or hospitals) face certain common problems. First, because such studies rarely randomize patients among providers, accurate risk adjustment models are necessary to prevent, for example, clustering of sicker patients with certain providers being misinterpreted as poorer quality of care.[9] Such risk adjustment models are rarely available, and for many neurosurgical procedures, the risk factors for poor outcome are not well defined. Second, statistical power in comparing outcomes across providers is a significant challenge. In one study, only coronary artery bypass graft surgery was sufficiently common and had high enough mortality to allow reliable comparisons across US hospitals; craniotomy mortality rates were considered reliably enough measured at only 33% of hospitals performing craniotomies to provide the needed statistical power to detect a doubling of mortality risk over expected.[15] This result is particularly disappointing because it is compounded by a lack of adequate risk adjustment models for craniotomy.[11,16]

One observation about quality of care that has been consistent across many studies of varied procedures in many surgical disciplines is called the volume-outcome effect. This is the observation that patients who receive care from high-volume providers often are observed to have better outcomes than those treated by low-volume providers.[17,18] The volume-outcome effect was first observed in neurosurgery in relation to aneurysm care[19,20] and has been subsequently confirmed for many other types of neurosurgical procedures.[21-28] The volume-outcome effect has been explained as a result of the well-established existence of a learning curve for most surgical procedures (''practice makes perfect''),[29-33] as well as from the systematization of care in the form of formal checklists or less

formal habits that accompany any frequent activity.[34] Other explanations include ''structural'' factors describing hospital resources such as dedicated intensive care units and intensivists, number and level of training of nurses, presence of advanced operating room technology, and 24-hour resident coverage.[35-37] Finally, the ''perfect makes practice'' or ''selective referral'' effect describes the ability of established high-volume centers to attract good-prognosis patients from a broad catchment area, whereas lower-volume hospitals are more likely to receive the sickest, most emergent patients with a given diagnosis.[38] For example, lower-volume acoustic neuroma centers treat a higher proportion of patients with hydrocephalus at presentation and with emergent presentation (although conversely, complex patients with neurofibromatosis 2 tend to receive care at high-volume referral centers).[23]

Recent neurosurgical research has identified surgeon-specific factors that help to explain the volume-outcome effect. Integrated medical learning results from the 2007 Congress of Neurological Surgeons (CNS) meeting demonstrated that surgeons with higher-volume cerebrovascular practices had greater subject-specific knowledge about current neurovascular literature in premeeting surveys,[39] and surgeons with high-volume tumor practices similarly displayed greater knowledge about current neuro-oncology publications.[40] High-volume cerebrovascular surgeons were also more likely to use advanced technological adjuncts to their surgical practice, such as computed tomography angiography for operative planning and intraoperative angiography and microvascular Doppler use, and were more likely to have personal expertise in endovascular practice.[39]

What can be done to use the consistently observed volume-outcome effect as a tool for improving the quality of care in a population? Most answers to this question take 1 of 2 forms. First, demonstration of a volume-outcome effect for a certain procedure is often followed by a call to ''regionalize'' the procedure, by restricting its performance to high-volume centers only.[41,42] Such initiatives have been carried out by government mandate for certain expensive, high-risk procedures, with mixed results.[43-46] Disadvantages to regionalization include increased travel time for patients, more difficulty coordinating care with local primary providers, and the general deterioration of skills in the general community when emergency care is necessary without transfer to regional centers; in addition, some patients simply prefer to receive care close to home.[47-50] Careful study of unintended consequences is necessary before imposing a top-down mandate for regionalization of a procedure.[51] That said, spontaneous regionalization of some neurosurgical procedures seems to already be taking place in the United States, following trends in other major surgical procedures such as cancer surgery.[52,53] Between 2000 and 2006, for example, the number of US nonfederal hospitals at which intracranial aneurysms were clipped or coiled decreased by almost a third; the number of low-volume

hospitals (5 or fewer aneurysms per year) decreased by about 50%; and the number treating 50 or more aneurysms per year roughly tripled (unpublished data from Nationwide Inpatient Sample, Healthcare Cost and Utilization Project, AHRQ, Rockville, MD, 2009). Similar spontaneous centralization (ie, not in response to government mandate) took place in the United States between 1988 and 2000 for pediatric tumor craniotomies[27] and craniotomies for adult primary brain tumor and meningioma.[54,55] For the United States as a whole, models showed that the number of hospitals capable of admitting patients for all nontraumatic craniotomies shrank significantly between 1988 and 2000, whereas the highest-volume craniotomy centers increased dramatically in number during this period.[56] The forces causing these shifts in practice are open to speculation.

The other general way to use the volume-outcome effect to improve care is to study processes of care that characterize high-volume centers and care delivered by specialists[57] and use them to improve care at low-volume centers.[58,59] This is sometimes called ''floating all boats.'' At the individual-practitioner level, a parallel is the high-quality care delivered by low-volume surgeons who have participated in a formal credentialing process, as in the context of a clinical trial.[60-63] The difficulty in applying this strategy to neurosurgery specifically is the comparatively large number of different procedures a neurosurgeon in general practice is called on to perform: vascular, tumor, spine, pediatric, functional, trauma, and peripheral nerve. It is difficult to envision a formal effort to apply high-volume center processes of care to each one of the many different and relatively infrequent operations that make up general neurosurgical practice. It might make more sense to concentrate these knowledge-transfer strategies on conditions for which timely transfer of care to regional centers would be difficult or impossible to implement. It is possible that the periodic published reports of ''good outcomes at low-volume aneurysm centers''[64-67] may result from conscious or unconscious applications of this strategy.

ACCESS TO NEUROSURGICAL CARE

As effective interventions become available to cure or alleviate disease, it is fair to ask whether all members of a given society enjoy equal ability to take advantage of the intervention. It is one of the major accomplishments of health services research in the last 2 decades that we now have overwhelming evidence that this is not true for American society. Copious research has established beyond any reasonable doubt that some Americans who belong to certain socially defined groups (such as by racial, ethnic, or socioeconomic characteristics, or primary language) have less chance of receiving many effective medical interventions and, as a result, have poorer outcomes.[68] Neurosurgery has been rather late to the table in investigating these questions, but there is now

mounting evidence that what is true for American medicine as a whole is also true for American neurosurgery in particular.

As an example, we consider patterns of care in the United States for acoustic neuroma.[69,70] Evidence suggests that small, relatively asymptomatic acoustic neuromas may be underdiagnosed in black persons and persons with low socioeconomic position because of less access to imaging studies. The observational epidemiology of acoustic neuromas strongly reflects the distribution of medical imaging devices and the distribution of wealth.[69] In Denmark, the incidence of acoustic neuromas increased about 2.5-fold between 1976 to 1983 and 1996 to 2001, a finding the authors attributed to increased availability of brain imaging, especially magnetic resonance imaging, during the interval.[71] The average size of acoustic neuromas at discovery in this study decreased from 35 mm in the earlier interval to 10 mm in the later interval. Compared with modern Denmark residents, whose incidence rates are comparable to those of contemporary Americans,[72] a 3-fold higher incidence of acoustic neuromas was documented in residents of Beverly Hills, California (a very wealthy area of the United States); half of these patients had normal audiograms at the time of discovery.[73] Inskip et al[74] used 3 urban US hospital case series from 1994 to 1998 in a case-control study of incidence of gliomas, meningiomas, and acoustic neuromas. Patients with higher socioeconomic status had a significantly higher incidence of acoustic neuromas and low-grade gliomas and meningiomas, whereas the incidence of high-grade gliomas was the same at all socioeconomic levels. Other studies have shown 3-fold higher incidence of diagnosed acoustic neuromas in US white residents from 2000 to 2004 compared with black residents.[72]

These findings must be suspected to be largely an artifact of greater tumor discovery in whites and wealthier persons, especially smaller tumors. Black patients, who compose about 12% of the US population, accounted for only 3% of acoustic neuromas treated with craniotomy in the United States from 1993 to 2002; they were 4.6 times as likely to present for operation emergently and twice as likely as white patients to present with hydrocephalus.[70] Outcomes were correspondingly poorer for black patients after acoustic neuroma surgery: the risk of in-hospital mortality was >10 times higher for black patients compared with white patients, and any discharge disposition other than directly home was 1.7 times more frequent in blacks. Although the disparities were less marked than for acoustic neuroma surgery, blacks also had more severe disease at presentation and poorer outcomes after surgery for 3 other types of brain tumor surgery (primary malignant gliomas, metastases, and meningiomas).[70] Similar findings have been reported in studies of outcomes after other neurosurgical procedures such as carotid endarterectomy,[75,76] unruptured aneurysm clipping,[77] and extracranial-to-intracranial bypass.[21]

As a second example of possible disparities in US neuro-surgical care, we consider surgical treatment of Parkinson

disease (thalamotomy, pallidotomy, or neurostimulator implantation).[78] Although black patients comprise 12% of the US population, before Medicare began to reimburse for neurostimulator devices (ie, 1995-2003), only 0.7% of surgically treated Parkinson disease patients in the United States were black. After reimbursement (2004-2007), the proportion of black patients did not increase significantly (0.9%). Black Parkinson disease patients were just as likely as white patients to receive gastrostomy during inpatient admissions, suggesting that a lack of preference for invasive treatment did not explain the finding. Patients with Medicaid insurance were also significantly less likely than those with private or Medicare insurance to receive surgical Parkinson disease treatment in the United States during the same interval.

Inequalities in healthcare outcomes such as the ones we observed seem to arise from a complex combination of causes.[68] Different clinical appropriateness and need, patient choices, access to health care at every step of the surgical process, poor success in navigating complex systems of health care, and lack of trust in medical providers could all contribute to our results. Research shows, however, that access to care (including insurance status and ability to pay) is consistently the most important predictor of the quality of healthcare across racial and ethnic groups,[68] and in systems without such barriers (such as US Veterans Administration hospitals), observed disparities are markedly reduced or no longer found.[79-82]

How can access to neurosurgical care be improved? A multifactorial approach to this complex problem offers the only realistic hope for an eventual solution.[70] Institutions that treat disproportionate numbers of patients from disadvantaged populations could be targeted for quality improvement efforts. For some such centers, partnering with nearby high-volume centers could offer the possibility of mutual advantage. Mistrust in the healthcare system and in healthcare providers could be addressed on many levels. Minority physicians currently make up a tiny fraction of American neurosurgeons; organized neurosurgery could help to establish special interest groups[83] to address underrepresentation and lack of visibility within the profession. Individual institutions could establish better ties with community providers, provide patient navigators to assist with complex treatment choices and completing complex treatment plans, and foster links to patient advocacy groups. Finally, extra effort on the part of individual surgeons to gain trust from patients who belong to disadvantaged groups should be practiced and, when possible, rewarded.

COST OF NEUROSURGICAL HEALTH CARE

Healthcare costs and their relentless increase are currently receiving urgent attention in the United States.[84,85] The cost of much neurosurgical care is thought to be quite high. For example, 5-year costs for brain tumor patients are among the highest for any type of cancer, and much of the cost is driven by inpatient treatment, including surgery.[86] Although insurance and other economic pressures caused progressive decreases in LOS for neurosurgical craniotomy admissions during the late 1980s and 1990s, from a mean LOS of 17 to about 8 days, the decreasing trend had stopped by about 1998. In the 1980s and early 1990s, the average LOS was much longer in certain parts of the United States, with the longest LOS in the northeast and the shortest in the west, but by 2000, LOS was much shorter in all regions of the United States, and much of the previous variation in LOS was no longer present.[56] This suggests that further economies by reducing LOS for neurosurgical inpatients are likely to be difficult to achieve. Although for certain neurosurgical conditions high-volume centers have been reported to deliver care at lower costs,[23,87,88] some of this effect is probably due to a more elective case mix at these centers, and care is not always cheaper at such centers.[54,77,89-92] Still, the rapid growth of healthcare costs in the United States has led many observers to label current trends as unsustainable, and it is likely that the relatively near future will bring increasing pressure to cut costs. How should neurosurgeons proceed in this environment?

In the 1930s, Archie Cochrane, who later became famous as an early exponent of evidence-based medicine and after whom the Cochrane Collaboration is named, adopted the personal slogan, ''All effective care must be free.''[93] This was a radical position in the pre–National Health Service United Kingdom and still would be today in the United States,[94] although not in most other industrialized countries. The general principle of reducing health care costs by avoiding ineffective care,[2,95,96] however, remains attractive in every healthcare system, and when there are 2 competing treatments for the same condition, even if both are equally effective, one will usually be less costly. When there is disagreement among practitioners about competing treatments, if neurosurgeons can establish the better treatment option, it is likely to improve the overall cost-effectiveness of their healthcare system.

Significant interpractitioner variation in treatment recommendations appears to exist for many common neurosurgical conditions.[39,40,97-109] This variation suggests a lack of consensus on what constitutes best clinical care and offers an opportunity to potentially identify care that is ineffective or, at best, less cost-effective. Interpractitioner variation in care can be identified by surveys,[39,104,108,109] by small-area variation studies that examine use of procedures in relatively small geographic regions,[110-114] or by studies using large administrative databases. For example, in the United States from 1996 to 1997, the percentage of lumbar stenosis operations that included a fusion varied from a low of 4.4% in Shreveport, Louisiana, to a high of 56% in Columbia, Missouri.[115] Such extreme variation is unlikely to arise from differences in patient characteristics or from technical factors such as undercoding. Spine surgery shows more geographic variation than many other procedures,

but other neurosurgical examples exist such as carotid endarterectomy. For this procedure, the annual rate per 1000 Medicare enrollees varies from 1.1 in Idaho Falls, Idaho, and Honolulu, Hawaii, to 7.6 in Houma, Louisiana.[115]

Presently, there is much variation in the proportion of intracranial aneurysms treated by clipping or coiling in the United States. This interpractitioner variation was formally studied in the 2007 CNS Annual Meeting integrated medical learning program.[39] Of 8 cases of ruptured aneurysm presented at the CNS plenary session for voting on clipping or coiling for treatment, the number that individual surgeons stated they would clip varied between 1 and 8. In a premeeting survey, the strongest apparent predictor of clipping or coiling of a single hypothetical case (7-mm unruptured posterior communicating artery aneurysm with limited mass effect) was higher annual volume of either clipping or coiling in the surgeon's individual practice. For the group of 328 neurosurgeons voting at the meeting, recommendations for the 8 cases ranged from 26% clipping to 85% clipping. Community practice for the United States as a whole reflects this individual-level variation. Although the overall trend in aneurysm treatment has changed progressively, from about 90% clipping in 2000 to about 50% clipping in 2006, practice at individual large hospitals (those with 50 or more cases treated per year) ranged between 0% clipping and about 70% clipping (unpublished data from Nationwide Inpatient Sample, 2009).

These data indicate substantial uncertainty in the US neurosurgical community about the best treatment for intracranial aneurysms. Unfortunately, data on usage rates do not translate directly into knowledge about what the appropriate, or ideal, usage rate should be. High rates of inappropriate procedures have been found in low-usage areas as well as in high-usage areas. The true ideal rate of usage can be found only through an understanding of the effectiveness of the procedure in relation to population incidence factors, not by choosing the highest or lowest observed usage rates or even the median usage.

In the absence of good evidence for best treatment, it sometimes seems that surgeons' decisions may be influenced by financial considerations.[116] For example, there is good evidence from randomized clinical trials (RCTs) that patient survival is extended by radiosurgery treatment of single brain metastases,[117,118] and a single small RCT suggested that radiosurgery treatment of up to 4 metastases might extend survival.[118] However, when the audience at the 2007 CNS tumor integrated medical learning session was polled on the question, ''What is the maximum number of brain metastases you are willing to treat with radiosurgery at a single session?'', one-third of the audience chose ''5,'' an answer for which there is no published support.[40] Many payers, however, will reimburse for a maximum of 5 metastases treated at a single session, suggesting that in the absence of good evidence to guide care, financial interest may pose a conflict.

Financial pressures within the US economy, in which >16% of the gross national product already represents healthcare costs, are increasingly going to mandate proof that expensive medical care is cost-effective. Although the proportion of neurosurgical clinical decisions that have good evidence as underpinning is not known, the number of RCTs in neurosurgical journals (about 1% of articles)[119] closely resembles pediatric surgery, a field in which only about 11% of interventions have RCT support.[120] The proportion of articles in general surgical journals and medicine journals that are RCTs is higher (6% and 12%, respectively),[121,122] and about 25% of general surgical decisions[123] and 50% of inpatient medicine decisions[124-126] have RCT support. This analogy suggests that much of modern neurosurgical practice currently lacks a solid foundation in proof of efficacy, a contention that has been advanced, for example, for many common head trauma interventions.[127,128] External examination of neurosurgical practice will probably begin with the aspects of neurosurgical care that are most costly to society, ie, spine care.[71] In fact, of the 100 comparative effectiveness ''priority topics'' identified by the Institute of Medicine in 2009,[129-131] 3 relate to spine care, and no others address decisions typically made primarily by neurosurgeons.

In this context, how can neurosurgeons deliver cost-effective care? Unfortunately, for many common conditions, neurosurgeons currently lack the needed evidence to answer this question. There is an urgent need for high-quality clinical trials addressing many common neurosurgical questions, yet comparatively few prospective trials are completed or in development. Rigorous, prospective evaluation of neurosurgical care is critical to proving that what we do actually benefits patients.[131] When clinical trials are designed by trialists who are not neurosurgeons, it is less likely that their conclusions will suit neurosurgeons' needs. For example, industry-supported trials are likely to test devices rather than procedures, and the bias of published industry-supported trials toward results favoring the sponsors' product is well known.[133-135] The prospective Spine Patient Outcomes Research Trial (SPORT) of lumbar diskectomy,[136] which was designed largely by nonneurosurgeons, was broadly criticized by neurosurgeons both before and after publication of early results.[136,138] Most parts of the US healthcare system presently lack incentives or mandates for providers to choose cost-effective treatment options, but it is likely with time that surgeons will find their practice increasingly constrained in the absence of good evidence supporting surgical treatments.

The first important steps toward modern neurosurgery were taken when Harvey Cushing pointed out that neurosurgeons should become masters of neurological diagnosis[139]; before this, surgeons ''cut on the dotted line'' drawn by neurologists who chose the patient and the procedure. After Cushing, neurosurgeons made their own diagnoses and bore the responsibility of choosing treatment. Today's neurosurgeons

should master the complexities of clinical research methodology[140-142] in the same way that Cushing mastered neurodiagnostics and for the same reason: so we can continue to define ourselves the role our procedures will play in the care of patients with neurosurgical disorders, rather than waiting for others to do so on our behalf. Neurosurgeons today typically have little or no formal training in the design, conduct, and interpretation of clinical trials and only limited exposure to informal trials.[143,144] Taking control of the neurosurgical clinical trials enterprise will require ongoing training for neurosurgeons at all stages of their careers, but adding formal training to the resident curriculum should be an early step in the process.

CONCLUSIONS

The field of healthcare delivery is a large one, and neurosurgical health services research can be said to have only just begun. This chapter has briefly addressed 3 components of excellence in healthcare delivery—quality, access, and cost—from a neurosurgical perspective. Modern neurosurgery is a high-cost, high-technology specialty; thus, it is likely to come under close scrutiny in an era of ever-increasing economic pressures. Much research in this field is necessary before neurosurgeons are fully prepared to meet that scrutiny.

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