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Efficient Surgery/Neurosurgery: Cutting Costs and Cutting Time Without Cutting Corners

Russell J Andrews [1,2]

[1]Editor, Newsletter, World Federation of Neurosurgical Societies
[2]Advisor, Nanotechnology & Smart Systems, NASA Ames Research Center, USA

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Corresponding author:

RUSSELL J ANDREWS

Editor, Newsletter, World Federation of Neurosurgical Societies
Advisor, Nanotechnology & Smart Systems, NASA Ames Research Center, USA
E-mail: *rja@russelljandrews.org*

Short summary: "There is a severe shortage of surgical resources globally. Improving surgeon productivity through evidence-based techniques will address this need more rapidly than simply training more surgeons."

Key words: Efficient surgery, evidence-based surgery, global surgery, surgical productivity

Abstract

Objective: One-third of all deaths worldwide are due to conditions requiring surgical intervention. To address this surgical deficit, some have advocated the answer is training more surgeons. Using the example of neurosurgery (where the deficit would need nearly 50% more neurosurgeons worldwide), the objective is to demonstrate that making the surgeon more efficient can address much of this surgical deficit more quickly than relying solely on training more surgeons.

Methods: The factors that affect a neurosurgeon's productivity can be divided into two categories: (1) those factors that the neurosurgeon himself/herself has control over; (2) those factors that require the neurosurgeon to interact with others in the healthcare team (from hospital administrators to ministries of health). This report considers primarily the first set of factors.

Results: Improving surgeon efficiency results from either the surgeon being more efficient in conducting surgery or the surgical infrastructure being improved so the surgeon will be more productive. Techniques by which a neurosurgeon can be more efficient include: not shaving preoperatively, careful planning of incisions, more efficient anesthesia (laryngeal mask anesthesia, spinal or local anesthesia etc., where feasible), choosing the most efficient surgery (evidence-based) for the condition being addressed. Examples of choosing the most appropriate surgery are given for epidural hematoma and hydrocephalus.

Conclusions: By performing surgery efficiently – based on the evidence rather than one's habits or traditions – many modest improvements can add up to make the surgeon much more productive. Together with improvements in the surgical infrastructure and more equitable distribution of surgeons around the world, the global surgical deficit can be much more quickly addressed by increased productivity than by relying solely on training more surgeons.

Key words: Efficient surgery, evidence-based surgery, global surgery, surgical productivity

Introduction

In 2015 the Lancet Commission on Global Surgery 2030 estimated that one-third of all deaths globally were associated with conditions that required surgery.[1] The total number of deaths due to malaria, tuberculosis, and HIV/AIDS combined is less than one fourth of the number due to lack of surgery.[1] With regard to neurosurgery, it has been estimated that more than 5 million essential neurosurgery procedures are not performed each year due to a lack of neurosurgeons.[2] There are approximately 50,000 neurosurgeons worldwide at present; roughly a 50% increase is needed (23,300) in the number of neurosurgeons to perform those 5 million essential neurosurgical cases each year.

In 2009 the European Union of Medical Specialists (UEMS) Section of Neurosurgery published statistics for countries in the European Union (EU) on the number of neurosurgeons per capita, the number of neurosurgical procedures performed annually per million population, and the number of neurosurgical procedures performed annually per neurosurgeon.[3] The results were remarkable for the variation among the countries of the EU:[3]

Although the UK had the most productive neurosurgeons, other EU countries had a number of procedures per neurosurgeon above the mean of 154 per year: two countries had 250 per neurosurgeon (Czech Republic and Netherlands), three countries had 200 per neurosurgeon (Estonia, Israel, and Luxemburg – Israel was included since it has associated status in the UEMA and is a member of the European Association of Neurosurgical Societies - EANS). Five other EU countries had numbers of procedures per neurosurgeon greater than the mean of 154 per year: 167 to 174 procedures per neurosurgeon.

Although no data are likely available regarding global neurosurgical productivity, let us assume that it approximates the EU average, i.e. roughly 150 neurosurgical procedures per year. If that productivity could be raised ½ of the way to the productivity in the UK of 300 procedures per year – to 225 procedures per neurosurgeon per year – we would accomplish the same number of procedures per year globally as training an additional 23,300 neurosurgeons.

Training a neurosurgeon takes upwards of a decade – assuming there are qualified individuals wishing to become neurosurgeons, as well as programs to train them. Training neurosurgeons to be more productive can be accomplished much more quickly – through online presentations, for example. Most neurosurgeons enjoy operating (hopefully!) – and most would enjoy doing more procedures in the same amount of time.

This short review explores some ways to increase the productivity of neurosurgeons.

Methods

The factors that affect a neurosurgeon's productivity can be divided into two categories: (1) those factors that the neurosurgeon himself/herself has control over; (2) those factors that require the neurosurgeon to interact with others in the healthcare team (from hospital administrators to ministries of health).

The former factors involve the actual procedure itself: Is the proposed operation the most efficient treatment for the condition at hand? Are there ways the procedure can be done more efficiently? Am I guided by personal habit rather than by the evidence when deciding which procedure to perform and how to perform it?

Table 1: Statistics about neurosurgical resources and utilization in Europe

Topic	Low	High	Mean
Neurosurgeons per capita	39,800 (Greece)	294,000 (UK)	99,000
Procedures per million population	770 (Poland)	3,600 (Luxemburg)	1,642
Procedures per neurosurgeon	56 (Greece)	300 (UK)	154

The latter factors might be called the "surgical infrastructure". Must I perform a suboptimal procedure due to lack of equipment, implants, etc.? Are there deficiencies in support, e.g. operating room time, anesthesia, nursing support, etc.? These factors require the neurosurgeon to be diplomatic but effective in interacting with colleagues and healthcare administrators to improve the resources available.

This report considers primarily the first set of factors. Two excellent examples of neurosurgeons making dramatic improvement in neurosurgical care through infrastructure improvements, thanks in both instances to their dedication and entrepreneurial attitude, has been published recently.[4]

Results

Shaving

Perhaps the clearest example of habit trumping evidence is the negative effects of shaving preoperatively. It was shown over 50 years ago for surgery in general, and over 30 years ago for neurosurgery in particular, that shaving the incision site is associated with a higher risk of infection than if the incision site is prepped without shaving.[5-7] Not shaving reduces the odds of a wound infection – an infection which can result in (at best) a course of antibiotics or (at worst) another operation with marked delay in full recovery (at best) and death of the patient (at worst).

There are several additional advantages to not shaving:

- The time spent shaving is obviated. Once the region is prepped (chlorhexidine being preferable to betadine, being both as a better antiseptic and better at combing the hair away from the incision), the incision is ready to be made.

- The time spent applying a major dressing post-operatively is obviated. Skin that is not traumatized by shaving bleeds much less post-operatively. A minimal dressing is all that is needed for incision where pressure or contact with clothes is likely, e.g. thoracolumbar spine. No dressing is needed for cranial incisions if the wound is closed effectively.

- The benefits of not shaving the scalp go far beyond reduced risk of infection and shorter time in the operating room. The patient looks (and feels) more "normal" than if the head is shaved and a large dressing/turban applied. The patient is more eager to get out of bed and resume normal activities; the nursing staff also is more aggressive with mobilization. Minimally invasive scalp incisions are not particularly painful; patients who have not been shaved require less postoperative pain medication as well.

The statements in the previous paragraph are based on personal experience over decades – and discussions with colleagues. Although there may not be Class I evidence from randomized control trials (not very feasible when dressings are considered), the findings from experience are logical and not surprising.

Incisions

It is a basic concept but one that bears emphasizing: incisions that avoid major skin/scalp arteries are preferable.[8] For craniotomies, incisions parallel to the scalp vasculature (primarily medial-lateral rather than anterior-posterior – unless midline over the superior sagittal sinus) are preferable. The scalp innervation is also less likely to be interrupted. Vertical (medial-lateral) scalp incisions can be exposed with Weitlaner retractors, obviating the need (and expense) of applying Raney clips. Maintaining the blood supply to the scalp is especially important where reoperation is anticipated or if the patient has increased risk of infection or breakdown due to radiation, chemotherapy, diabetes, etc.[9]

Image guidance – for those sites that can afford the cost of equipment – can make many neurosurgical procedures more efficient. Once the team is experienced in making the setup brief, the savings during the procedure in more ideally placed (i.e. smaller) craniotomies are apparent.

An additional comment regarding bone flap replacement in craniotomies is warranted. Rather than using titanium plates to secure the bone flap, non-absorbable (e.g. nylon) sutures provide an alternative that is as quick if not quicker than titanium plates – and certainly more cost-effective. The lack of artifact on postoperative MRI or CT scan is another advantage.

Perioperative Patient Management and Anesthesia

Indwelling Urinary Catheter (IUC)

With regard to IUC, a large (> 5000 patients) study has recently been published.[10] Over 90% of the procedures were General, ENT, or Orthopedic surgery, with 2863 patients in the IUC group and 2249 patients in the control (no urinary catheter) group. Although the incidence of urinary tract infection was minimal in both groups (IUC 2, control 0), the duration of surgery was much shorter in the control group (83 versus 131 min), post-operative altered mental status (AMS) less frequent in the control group (1.8% versus 4.9%), and the hospital stay shorter in the control group (mean of 5 days versus 7 days). One can therefore argue that an IUC should only be placed when the length of the surgical/neurosurgical procedure would exceed 4-5 hours or other factors indicated an IUC should be placed. In developed countries especially, the cost of an IUC (device and labor for placement and removal) can be substantial – in addition to the benefits regarding duration of surgery, AMS, and length of hospital stay.

Laryngeal Mask Anesthesia (LMA) and Spinal Aesthesia (SA)

Two recent studies in the thoracic surgery literature have addressed LMA compared with endotracheal anesthesia (ETT).[11,12] One study compared patients undergoing thoracoscopic pulmonary wedge resection, 53 patients in the LMA group and 54 patients in the ETT group.[10] The LMA group had significantly less hoarseness/pharyngeal discomfort, less post-operative pain, and shorter hospital stay than the ETT group. The second study considered the enhanced recovery after surgery (ERAS) protocol for pectus excavatum patients undergoing the Nuss procedure.[12] The primary aspects of ERAS were the use of LMA rather than ETT and not placing an IUC. There were 75 patients in the traditional group and 73 in the ERAS group. The major significant findings were (1) shorter mean duration of surgery time in the ERAS group (66 versus 84 min); (2) shorter mean post-operative hospital stay (5 days versus 7.7 days).

Although lumboperitoneal shunt (LPS) surgery has usually been performed under ETT GA, it has been performed under both LMA as well as high-flow nasal cannula and propofol anesthesia.[13] Another option for LPS surgery (and other surgery in the lumbar region and more caudally) is spinal anesthesia (SA).[14] Seventy-nine patients undergoing LPS surgery for idiopathic normal pressure hydrocephalus (iNPH) – 43 under GA and 36 under SA – showed no statistical difference in any criteria (e.g. length of surgery) but the GA group had a slightly longer post-operative hospital stay (median 11 versus 10 days) and two cases of aspiration pneumonia (versus none in the SA group).[14]

Local Anesthesia (LA) versus General Anesthesia (GA)

Regarding surgery for chronic subdural hematoma (CSDH) evacuation, one report documents the benefits of LA over GA in 45 patients over 70 years old – a population that is rapidly growing with the aging global population and the widespread availability of CT imaging.[15] The 22 LA patients versus the 23 GA patients revealed the following statistically significant differences: shorter operative time in the LA group (mean 38 versus 76 min), lower overall complication rate in the LA group, higher Glasgow Coma Scale score on post-operative day 1 in the LA group, shorter mean hospital stay in the LA group (4.3 versus 6.6 days).

A more stepwise simplification in anesthesia technique over the years has been seen in carpal tunnel syndrome (CTS) surgery. GA continues to be used by many neurosurgeons even though a study involving nearly 9,000 patients in New York State (USA) from 2016 to 2017 found that hospital charges were significantly higher for the roughly one-third of cases that were performed under GA than those performed under regional anesthesia (RA) or LA.[16] RA (Bier block) involves application of a tourniquet to the arm in order to minimize the systemic spread of the intravenous short-acting local anesthetic (e.g. lidocaine). This provides pain control during CTS surgery for up to 45 minutes plus a relatively bloodless field. However, sedation may be required due to patient discomfort during RA. More recently a wide-awake local anesthesia, no tourniquet (WALANT) technique has been advocated for hand surgery (principally for CTS), based on comparison with RA.[17-21] On a range of measures – length of surgery, need for postoperative pain medications, patient satisfaction, cost – the WALANT technique outperformed RA in randomized studies involving hundreds of patients from Korea, Canada, Brazil, Spain, and Argentina.[17-21]

Specific Disorders – Which Operation to Perform?

Epidural Hematoma (EDH)

EDH is typically treated by craniotomy. However, reports of successful treatment of EDH by burr hole drainage have appeared, either as a temporizing measure before transfer to a neurosurgical center for definitive treatment,[22] or as the primary treatment (with craniotomy being reserved for cases not successfully treated by burr hole alone).[23-25] A burr hole can be performed in about 15 min; a craniotomy may require an hour or longer. Although the ability to treat an EDH rapidly is particularly important under mass casualty conditions,[24] burr hole treatment for EDH has been performed electively to determine if it is a viable option.[23,25] Under a mass casualty situation (earthquake) with 36 EDH patients age 5 to 50 years old – 18 treated the first day, 13 the second day, and 6 the third day – a single burr hole drainage procedure was performed.[24] Thirty-four of the 36 patients recovered with Glasgow Comma Scale (GCS) of 15 on the day of surgery, one required a follow-up craniotomy, and one died on the day of surgery. A study of 13 patients aged 19-46 (not under mass casualty conditions), 11 of 13 were successfully treated by burr hole alone (together with negative pressure drainage); 2 patients required a craniotomy when their level of consciousness failed to improve within 8 hours of surgery and CT scan showed continued presence of the EDH.[23] Another study of 50 pediatric EDH patients (aged 45 days to 12 years) employed burr hole drainage with careful intra-operative suction evacuation but no drain placement.[25] One patient required follow-up repeat burr hole drainage and one patient (GCS 3 pre-operatively) died on the day of surgery; the 48 other patients were discharged with GCS 15.

Hydrocephalus

Traditionally the primary treatment for both obstructive and communicating hydrocephalus has been the ventriculoperitoneal shunt (VPS). The VPS has a significant infection and malfunction rate as well as considerable expense regarding the valve that is required – often now a programmable valve costing thousands of US dollars. The need for revision and reprogramming are severe drawbacks in locations where patient follow-up with the neurosurgeon is difficult.

An "implantable-hardware-free" alternative for obstructive hydrocephalus in particular is endoscopic third ventriculostomy (ETV). ETV can be combined with choroid plexus cauterization (CPC) during the same procedure for reduction of cerebrospinal fluid (CSF) formation. A meta-analysis of randomized controlled trials comparing ETV and VPS for obstructive hydrocephalus in all age groups found a total of six studies (203 patients ETV, 195 VPS).[26] For both post-operative infection and mortality, ETV was superior to VPS (infection 2.5% ETV and 16% VPS; mortality 3.8% ETV and 6.6% VPS). The benefit of ETV/CPC over VPS appears to be true even for the very young (those less than 12 months of age), a group where ETV has traditionally been thought to have a high failure rate.[27] This study examined all infant patients with hydrocephalus (approximately half of them less than 2.5 months of age) treated at a single hospital over nearly 13 years (266 ETV/CPC, 82 VPS). ETV/CPC was found to be more successful for all patients than VPS except those infants less than 2.5 months of age who had severe ventriculomegaly. With regard to cost, a study of all patients less than 14 years of age undergoing either ETV or VPS in a large public hospital in Salvador da Bahia, Brazil, over nearly 7 years documented the greater long-term cost of VPS due to the higher complication rate for VPS than for ETV.[28] Although the initial cost of surgery was higher for ETV than for VPS (US$1100 versus $900), the cumulative cost at 24 months post-operation was much lower for ETV than for VPS (US$1400 versus $2450).

"Normal" Pressure Hydrocephalus (NPH)

A disorder benefitting from neurosurgical treatment that has a rapidly growing population (due to both the aging global population and greater recognition among the public as well as healthcare professionals) is "normal" pressure hydrocephalus (NPH). Salomon Hakim, in his 1964 doctoral dissertation describing the condition, put "normal" in parentheses because he knew NPH involved a very mild increase in CSF pressure compared with control patients – the modest increase in CSF pressure being documented by others three decades later.[29,30] A meta-analysis comparing VPS and LPS for communicating hydrocephalus (many if not most patients having NPH) found 25 studies with 3654 patients.[31] The total complication rate was 13% for LPS patients and 24% for VPS patients. On all types of complications – malfunction, infection, seizure, hemorrhage – the percentage for LPS versus VPS was at least 50% lower. One of the largest of these 25 studies, limited to NPH patients over a six-year period treated by the same neurosurgeon, matched LPS and VPS patients by age and sex (LPS 96, VPS 192).[32] In the LPS group, the revision, infection, and SDH rate were all 1%. In the VPS group, the rates were: revision 14%, malfunction 7.3%, infection 5.7%, SDH 2.6%.

Despite the evidence supporting LPS as more efficacious than VPS for NPH (and communicating hydrocephalus in general), adoption of LPS rather than VPS to treat NPH has been variable around the world. In Japan a nationwide survey found a nearly 3-fold increase in the use of LPS in 2011 compared with 2007 (846 versus 324 patients) while the use of VPS declined modestly (from 855 to 761 patients).[33] In the US, however, based on the National Inpatient Sample database, adoption of LPS rather than VPS to treat NPH has been much slower: in 2007, 975 VPS patients versus 169 LPS; in 2017, 6265 VPS patients versus 1320 LPS. In 2007, the ratio of VPS to LPS shunts was approximately 6:1; in 2017 the ratio was approximately 5:1.[34] Over the decade from 2007 to 2017 the number of NPH patients treated with either a VPS or a LPS increased nearly 7-fold. The reasons for such a low adoption rate for LPS in the US are likely several:[30] (1) many US neurosurgeons believe that all types of hydrocephalus should be treated by VPS (they are not aware of the advantages of LPS); (2) VPS surgery is reimbursed more highly than LPS surgery by Medicare (the US national insurance coverage for people 65 years old and older) as well as by most private insurance plans that base reimbursement on Medicare schedules; (3) the neurosurgeon is reimbursed every time a programmable valve is interrogated/reprogrammed; (4) the manufacturers of programmable valves have sponsored "vacation" seminars for neurosurgeons, creating a sense of obligation to use programmable valves (which are not needed for LPS); the higher complication (and revision) rate for VPS can provide the neurosurgeon with additional procedures (i.e. income) following VPS surgery.

Conclusions and Relevance

In resource-rich, developed countries, the immediate reaction to a deficit is to throw more resources (money, manpower, etc.) at the deficit. In resource-challenged developing countries, the reaction (out of necessity) is to throw creative ideas at the deficit – "How can we do more with less?" The need for more surgical resources globally can be met – at least in part – by making today's surgeons more efficient. Some of the techniques noted above may save only a few minutes (or a few dollars) on each case intra-operatively. But when repeated over the surgeon's caseload for a year – especially when combined with techniques that allow patients to be discharged sooner – the savings for both the surgeon's time and the healthcare system's resources can be considerable.

When combined with improvements in the efficiency of the "surgical infrastructure" (which requires the surgeon to be both diplomatic and entrepreneurial), the techniques described above can greatly reduce the unmet global surgical need. To address the uneven distribution of surgeons/neurosurgeons globally, twinning programs between surgical training institutions in developed and developing countries can help: in-training (and faculty) surgeons in developed countries (where the clinical volume may be suboptimal) can work together with over-burdened colleagues in developing countries (where the unmet needs are greatest). The in-training personnel from developed countries gain valuable surgical experience while surgeons from both the developed and developing countries gain the benefits of each other's experience.

Addressing both the inefficiencies of surgical procedures and the inequities in distribution of surgeons globally is a win-win situation that can be accomplished quickly. Let's work smarter rather than demand that someone else (i.e. the surgeon we hope to train soon) can allow us to continue to be inefficient surgeons. Our patients deserve surgeons who can work smarter and more productively.

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