Value-based neurosurgery: measuring and reducing the cost of microvascular decompression surgery

Clinical article

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Object. Care providers have put significant effort into optimizing patient safety and quality of care. Value, defined as meaningful outcomes achieved per dollar spent, is emerging as a promising framework to redesign health care. Scarce data exist regarding cost measurement and containment for episodes of neurosurgical care. The authors assessed how cost measurement and strategic containment could be used to optimize the value of delivered care after the implementation and maturation of quality improvement initiatives.

Methods. A retrospective study of consecutive patients undergoing microvascular decompression was performed. Group 1 comprised patients treated prior to the implementation of quality improvement interventions, and Group 2 consisted of those treated after the implementation and maturation of quality improvement processes. A third group, Group 3, represented a contemporary group studied after the implementation of cost containment interventions targeting the three most expensive activities: pre-incision time in the operating room (OR) and total OR time, intraoperative neuromonitoring (IOM), and bed assignment (and overall length of stay [LOS]). The value of care was assessed for all three groups.

Results. Forty-four patients were included in the study. Average preparation time pre-incision decreased from 73 to 65 to 45 minutes in Groups 1, 2, and 3, respectively. The average total OR time and OR cost were 434 minutes and $8513 in Group 1; 348 minutes and $7592 in Group 2; and 407 minutes and $8333 in Group 3. The average cost for IOM, excluding electrode needles, was $1557, $1585, and $1263, respectively, in Groups 1, 2, and 3. Average total cost for bed assignment was $5747, $5198, and $4535, respectively, in Groups 1, 2, and 3. The average total LOS decreased from 3.16 days in Group 1 to 2.14 days in Group 3. Complete relief of or a significant decrease in preoperative symptomatology was achieved in 42 of the 44 patients, respectively. Overall, the average cost of a surgical care episode (index hospitalization + readmission/reoperation) decreased 25% from Group 1 to 3.

Conclusions. Linking cost-containment and cost-reduction strategies to ongoing outcome improvement measures is an important step toward the optimization of value-based delivery of care.

(http://thejns.org/doi/abs/10.3171/2014.5.JNS131996)

Key Words • microvascular decompression • value • outcome • cost • surgical complication • readmission • intraoperative monitoring

Health care expenditures in the US continue to rise annually, faster than the national income. In 2010, health spending exceeded 17% of the nation’s gross domestic product. Numerous elements of national health reform are aimed at cost containment. Importantly, “bending the cost curve” refers most commonly to the government or insurers’ payment to providers. However, reducing reimbursements does not decrease the cost of care delivery. The critical issue is how to deliver improved outcomes at the lowest cost and achieve the highest value of care. Although health care providers have put significant effort into the quality and safety of care delivered in the past decade, little attention has been focused on cost measurement and even less on cost containment. This oversight stems from the fact that health systems, departments, and individual physicians misunderstand the costs related to the care they deliver.

Early in 2009, the Department of Neurosurgery at our institution, aiming to improve the delivery of neurosurgical care, launched a Clinical Quality Program. Numerous improvement processes aimed at optimizing preoperative, intraoperative, and postoperative patient care were implemented by the third quarter of 2009. Previously, we assessed whether the multidisciplinary and multifaceted efforts instituted in 2009 succeeded in improving our delivery of value-based neurosurgery. For that initial case study, patients undergoing microvascular decompression (MVD) performed by one neurosurgeon (N.A.M.) was the proposed model given that the surgical technique was standard, anticipated operative risks were relatively predictable, and perioperative care was relatively similar between cases. We documented a favorable impact from...
the improvement processes, especially in the recovery process and the sustainability of health—Tiers 2 and 3, respectively, of the outcome hierarchy proposed by Porter. The effect of outcome optimization on health care cost was unknown. Furthermore, the possibility of integrating cost-containment and -reduction strategies into this optimized outcome protocol remained to be investigated.

In this paper, we describe how total and detailed cost assessment enabled us to further optimize the value of delivered neurosurgical care by maintaining outcome improvement and targeting cost containment and reduction. We discuss the challenges of the cost assessment process, the importance of linking cost-containment and -reduction strategies to ongoing outcome improvement measures, and the future opportunities for such strategies as health care economics evolve.

Methods

Patient Populations

Our local institutional review board approved this research. For this study we considered all patients who had undergone first-time surgery performed by the senior author (N.A.M.) for either trigeminal neuralgia (TN) or hemifacial spasm (HFS) between June 2008 and February 2013. Of importance, UCLA Health has undergone two major changes within the last 5 years. First, its main medical center completed its move to the Ronald Reagan UCLA Medical Center (RRMC), a new state-of-the-art academic facility, in June 2008. Second, in March 2013, UCLA Health implemented an integrated electronic health record system. To ensure the stability of clinical pathways and cost-reporting systems, the study time intervals were guided by these two major events. The patient population was divided into three groups. Group 1 included all consecutive patients who had undergone surgery between July 2008 and November 2009 (16 months). The following 12 consecutive months were exempted from patient review given that this time was allocated to implementing the improvement processes and optimizing their compliance throughout the Department of Neurosurgery. This group represents the era prior to the implementation of improvement interventions. Group 2, which included all consecutive patients treated between January 2011 and May 2012 (16 months), represents the era following the implementations and maturation of the improvement interventions that spanned the entire phase of care, that is, pre-, intra-, and postoperative. Group 3 represents a contemporary set of patients, including all who were treated over a 6-month period after the integration of the cost-containment interventions to the clinical pathway.

Cost-Containment and Cost-Reduction Initiatives

After reviewing total and detailed costs of the surgical care episodes in Groups 1 and 2, the high-yield opportunities for cost containment and reduction were identified. The three most expensive items in the surgical care episode for patients undergoing an MVD were targeted: the operating room (OR), intraoperative neuromonitoring (IOM), and bed assignment (Fig. 1). Modifications to the clinical pathway were evidence based and cost conscious. To address OR cost, parallel instead of sequential teamwork was encouraged and emphasized to decrease time spent in the OR from the time the patient entered the operating theater to the time of incision. For the IOM cost, brainstem auditory evoked potentials (BAEPs) monitoring and facial nerve electromyography were removed from the standard monitoring protocol for TN. Experts in the field of MVD have recognized that once surgeons show proficiency in the technique, BAEPs monitoring can be withdrawn from “standard practice.” Moreover, IOM would cease after dural closure instead of continuing up to the time of stapling. For bed assignment cost, patients with an age ≤ 65 years, with no cardiorespiratory comorbidities, and with an intact neurological exam in the recovery room were transported directly to the regular ward.

Clinical Data Collection

Patient hospital records from the RRMC were reviewed, including clinical notes (outpatient and inpatient), radiographic images, and operative notes. Outcome measures spanning the entire surgical care episode were collected according to the three-tier outcome hierarchy of Porter, and key outcome measures were reported for each group. Health status achieved (Tier 1) included resolution of preoperative symptoms and survival (mortality). Recovery process (Tier 2) included outcomes related to care cycle, namely duration of pre-incisional preparation time, duration of surgical procedure, recovery room length of stay (LOS), intensive care unit (ICU) LOS, regular ward LOS, and total LOS. Disutility of the care or treatment process is also included in the outcomes of Tier 2; the need for intraoperative blood transfusions, the occurrence of surgery-related complications, and readmission and/or reoperation rates within 30 days of surgery were identified through the operative reports and postoperative clinical notes. Since patients in Group 3 have not yet had a 12-month follow-up, evaluation of Tier 3 outcomes, related to sustainability of health, was deferred; however, we did tabulate the extent of symptom improvement or recurrence at the 1-month postoperative follow-up.

Cost Data Collection

Cost data were obtained in collaboration with the finance department. Data were extracted from the EPSi Decision Support (Enterprise Performance Systems Inc.). This accounting system enables activity-based costing (ABC). Total charges and total costs were retrieved for each patient, as were detailed charges and costs for individual elements of care, including but not limited to 1) total cost for bed assignment, incorporating nursing and support personnel time and bed facility base for ICU and floor unit but excluding other activity costs such as pharmacy, imaging, laboratories, and so forth; 2) total OR cost, incorporating OR team, OR facility base, and anesthesia; 3) total IOM-related costs, depending on the specific type of monitoring requested, that is, base rates for each of the following: electroencephalography, somatosensory evoked potentials monitoring, BAEPs monitoring, and monitoring of cranial nerves V and VII (hourly cost of IOM and cost of electrode needles); 4) cost of disposable

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supplies used in the OR; 5) pharmacy cost; 6) imaging cost; 7) laboratory cost; and 8) costs of physical and occupational therapy evaluations and services. Importantly, physicians’ professional fees were not included in this ABC system.

As recommended in other cost models, total cost was used in the present study.\(^2^3\) As an example, the top three overhead allocations rolled into the total cost of the OR are employee benefits, central sterile processing, and interns and residents. The top three overhead allocations rolled into the total cost of the neurocritical care unit bed assignment are employee benefits, interns and residents, and amortization of buildings and improvements. The top three overhead allocations rolled into the total cost of the neuroscience floor unit bed assignment are employee benefits, nutrition and operations, and case management. Of note, the values used were actual cost values, not estimates of cost. The absolute percentage reduction in cost was calculated using the following formula: \(100 - \frac{\text{cost of Group 3}}{\text{cost of Group 1}} \times 100\).

**Statistical Analysis**

Statistical analyses were performed with the GraphPad Prism 5.0 software. Fisher’s exact test and Student t-test were used to compare data between Groups 1 and 3. A p value < 0.05 was considered significant.

**Results**

**Demographics of the Study Population**

Overall, this study included 44 patients, 32 women and 12 men, with a mean age of 57 years (range 26–77 years). All three groups were composed of consecutive unselected patients. Group 1 comprised 12 patients; Group 2, 25 patients; and Group 3, 7 patients. Microvascular decompression was performed for the treatment of TN in 28 patients and for HFS in 16 patients.

**Value of Recovery Process: Intraoperative Time Cycles and Supportive Services**

The average pre-incisional preparation time, surgical procedure time, total OR time, and total OR cost for all three groups are summarized in Table 1. The pre-incisional preparation time decreased between Groups 1 and 2 and also between Groups 2 and 3. Although the surgical procedure time decreased between Groups 1 and 2, it returned to baseline in Group 3. Total OR time and total OR cost decreased between Groups 1 and 2 but then increased between Groups 2 and 3 without returning to the initial level in Group 1. The average total cost of IOM as an intraoperative support service during the MVD procedure increased 6% from Group 1 to Group 2 (Table 1). The integration of a revised IOM protocol in Group 3 re-
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resulted in a 5% decrease in the average total IOM cost from Group 2.\textsuperscript{3,42}

**Value of Recovery Process: Postoperative Recovery Time Cycles**

Average total LOS, median LOS, postoperative ICU bed allocation cost, percentage of patients discharged before noon, and average cost for bed assignment are summarized in Table 1. In Group 2, two patients were identified as outliers, with a hospital course lasting 7 or more days. One patient was surgically treated for TN and experienced complete resolution of her pain; however, unstable angina developed following surgery, and she remained hospitalized for 11 days for medical management. The other patient was surgically treated for HFS and experienced decreased hearing and transient facial weakness. She remained hospitalized for 14 days after surgery for close monitoring. With the exception of these two patients, all others were discharged home. After the implementation of improvement interventions and cost-containment initiatives, the average total cost for bed assignment was $4535, representing an 21% reduction between Groups 1 and 3. Of note, the cost for a 24-hour stay in the ICU was $2235, $2434, and $2597, respectively, in Groups 1, 2, and 3. The cost for a 24-hour stay on the floor was $1512, $1651, and $1615, respectively, in Groups 1, 2, and 3. Therefore, despite the increase in unit bed location cost, a cost reduction was achieved in Group 3 with sustained outcome improvements.

**Value of Recovery Process: Disutility of Care or Treatment**

In this study, no patient required blood transfusion, as blood loss was minimal in all surgeries. No stroke, no bacterial meningitis, and no surgical site infection requiring wound washout was encountered in this series. In Group 1, three patients experienced a postoperative procedure-related complication that became manifest after discharge. One patient presented with Bell’s palsy and was treated with steroids and acyclovir as an outpatient. Cerebrospinal fluid leak occurred in two patients, both requiring a readmission (LOS 5 days for each patient) and return to the OR for wound revision and insertion of a lumbar drain. In Group 2, one patient demonstrated transient facial weakness and loss of hearing and possible rhinorrhea that prompted close follow-up (LOS 11 days). A second patient experienced acute respiratory distress syndrome due to swelling of the parotid glands, requiring reintubation and close monitoring in the ICU for 3 days as the swelling came down (LOS 5 days). A third patient had an uneventful surgery, but unstable angina developed after surgery, and she underwent detailed examination and close medical observation (LOS 14 days). The average total cost for the index hospitalization among these three patients was $40,747, as compared with $22,838 for each of the rest of the patients in Group 2. A fourth patient demonstrated chemical meningitis 2 weeks postoperatively and was treated with steroids as an outpatient. In Group 3, there were no postoperative complications. The average total cost for the index hospital stay due to postoperative events either related or unrelated to the surgical procedure was $0 in Group 1, $40,747 in Group 2, and $0 in Group 3. The total cost for readmissions and reoperations at RRMC was $47,472 in Group 1 and $0 in Groups 2 and 3.

**Value of Health Achieved and Sustained**

Among the entire study population, 42 of 44 patients experienced either complete relief (35 of 44) or a significant decrease (7 of 44) in their preoperative symptom-

**TABLE 1: Summary of data related to cost containment and reduction initiatives**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>p Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>average prep post-incision time in OR (Groups 2 &amp; 3)</td>
<td>73</td>
<td>65</td>
<td>45</td>
<td>0.111</td>
</tr>
<tr>
<td>average surgical procedure time in min</td>
<td>360</td>
<td>286</td>
<td>362</td>
<td>0.940</td>
</tr>
<tr>
<td>average total OR time in min</td>
<td>434</td>
<td>348</td>
<td>407</td>
<td>0.452</td>
</tr>
<tr>
<td>average total OR cost in US$</td>
<td>8513</td>
<td>7592</td>
<td>8333</td>
<td>0.631</td>
</tr>
<tr>
<td>average cost of IOM, excluding electrode needles, in US$</td>
<td>1557</td>
<td>1585</td>
<td>1263</td>
<td>0.165</td>
</tr>
<tr>
<td>average cost of IOM needle in US$</td>
<td>729</td>
<td>835</td>
<td>1028</td>
<td>0.093</td>
</tr>
<tr>
<td>% of patients w/ no ICU bed assignment</td>
<td>0 (0/12)</td>
<td>8 (2/25)</td>
<td>43 (3/7)</td>
<td>0.0361</td>
</tr>
<tr>
<td>average cost for ICU bed assignment in US$</td>
<td>2618</td>
<td>2414</td>
<td>1855</td>
<td>0.349</td>
</tr>
<tr>
<td>average postop LOS in days</td>
<td>3.16</td>
<td>3.27‡</td>
<td>2.14</td>
<td>0.001</td>
</tr>
<tr>
<td>median postop LOS in days</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>NA</td>
</tr>
<tr>
<td>% of patients discharged by noon</td>
<td>41.6</td>
<td>60</td>
<td>71.4</td>
<td>0.367</td>
</tr>
<tr>
<td>average total cost for bed assignment in US$</td>
<td>5747</td>
<td>5198</td>
<td>4535</td>
<td>0.019</td>
</tr>
</tbody>
</table>

* NA = not applicable; PO = postoperative; prep = preparation.
† The p value was calculated between Groups 1 and 3. Values in boldface type are significant.
‡ Average postoperative LOS in Group 2 without the outliers is 2.65 days.
Global Cost of the Surgical Care Episode

Total costs for the surgical episode of care take into consideration the costs of the index hospitalization as well as the costs incurred by readmissions and/or reoperations. For Group 1, the average total cost for the surgical care episode was $24,771. The average total cost for the surgical care episode decreased to $23,161 in Group 2. For Group 3, after the implementation of cost-containment measures, the average total cost for the surgical care episode decreased to $18,480, representing a 25% reduction as compared with costs in Group 1.

Discussion

Summary of Contemporary Financial Data on the Treatment of Microvascular Compression Syndromes

To our knowledge, three groups have reported financial data (cost and/or charge) for the treatment of TN. In 2003, using the Nationwide Inpatient Sample (NIS) database, Kalkanis and colleagues performed a retrospective study of patients undergoing MVD for TN, HFS, or glossopharyngeal neuralgia between 1996 and 2000. Among the short-term end points assessed, hospital charge data were captured from the NIS and were analyzed using a logarithmic transform. The authors reported that the hospital charges increased significantly between 1996 and 2000, from a median of $15,600 to $20,100.

In 2005, Pollock and Ecker evaluated the relative cost effectiveness of three commonly performed interventions to treat TN, namely MVD, glycerol rhizotomy, and stereotactic radiosurgery. They used their administration decision support system cost data and calculated the costs per procedure by including uncomplicated procedure cost plus the average cost of complications plus the costs associated with additional procedures performed for persistent or recurrent facial pain. Specifically for MVDs, the average uncomplicated procedure-related cost was $13,403, the average morbidity cost was $1026, and the average additional procedure cost was $857. The total procedure-related cost for an MVD was $15,286 for patients treated more than 12 years ago.

In 2008, Fric-Shamji and Shamji assessed the impact of US state government Certificate of Need (CON) laws on patient access to elective surgical care. Data on six elective surgical procedures, including MVD for TN, were collected from the State Inpatient Databases of the Healthcare Cost and Utilization Project. The authors reported that the median procedure-related charges for MVD were $37,741 among the 5 states without CON legislation versus $27,729 among the 21 states with CON legislation.

Specifically, average procedure-related costs or median procedure-related charges for treatments adminis- tered between 1996 and 2000 are documented in the first study above; between 1999 and 2001, in the second study; and between 2004 and 2005, in the third study. Given the different care pathways, treatment protocols, costing methodologies, and several other factors not reported, comparison between these three historical studies and the current case study is not warranted. Our descriptive report is unique, as it demonstrates that cost analysis can be directly applied to clinical care 1) by contemporary costing of all activities occurring during the surgical care episode for an MVD and 2) by identifying the most frequent and most expensive costs incurred in the care pathway.

New Responsibility for Physicians, Health Systems, and National Organizations

Across the globe, there is growing concern about the fiscal sustainability of current health systems. In the US, health care spending is increasing yearly, with estimated 4%–6% increases per year. Not only are physicians and organizations expected to deliver the best quality of care in the safest environment, they are also being asked to practice cost-conscious medicine. Although approximately 60% of health care costs are determined or influenced by physicians, the majority of them have received little, if any, education on resource management and health economics. Despite the fact that physicians have positively responded to the call for improvements in safety, quality, and outcomes, their involvement in cost containment or cost reduction is scant. Realistically, the most that physicians engage with charge and cost data is through the calculation of their relative value units (RVUs), which serve as a means of determining the level of reimbursement awarded to a physician in exchange for services rendered by most health insurance providers.

Furthermore, outside influences, such as legal incentives to practice defensive medicine and economic incentives of the fee-for-service payment structures, may have swayed health care providers toward overutilization. Since the Patient Protection and Affordable Care Act (Public Law 111-148) was enacted in 2010, the US health care system has been incentivized to reward better delivery of high-value care, where value is measured in terms of patient outcomes achieved per dollar spent. Value-based reimbursement and cost-containment and cost-reduction strategies are being piloted throughout the nation.

Assessing Cost of Care Delivery

A reliable financial evaluation of delivered care is possible only if the disease- or condition-specific clinical pathway is known in detail. Integrating cost analysis into the assessment of clinical pathways and care processes may reveal expensive steps or activities that do not add value to patient care as well as significant cost differences that could translate into potentially unnecessary process variation. Furthermore, linking cost analysis to the implementation of improvement measures

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and redesign initiatives has become critical to ensure that outcomes are being improved and costs are being simultaneously contained or reduced to optimize the delivery of value-based care.\textsuperscript{23,40,41,45} The time-driven ABC (TD-ABC) method, described by Kaplan and colleagues, has been gaining popularity in health economics as a costing methodology with the potential to support value-optimization initiatives. It integrates the cost of each resource used in the process of performing an activity or service and the amount of time each resource is dedicated to the patient.\textsuperscript{22,23} We are currently experimenting with this costing methodology in our department and assessing how it can be optimally used.

**Strategies to Contain or Reduce the Cost of Care Delivery**

Various strategies either contain or decrease the cost of care delivery: cost reduction, variation containment, and waste reduction. Reducing cost can be achieved by 1) deferring use, for example, reducing the use or complexity of IOM, using no postoperative imaging, and pursuing fewer postoperative labs; 2) shortening cycles, for example, OR time, LOS in the ICU, and so forth; 3) substitutions, for example, favoring disposable supplies and implants with the most value, generic medications, and oral instead of intravenous medications; and 4) reengineering delivery of care, for example, revisiting standard postoperative admission to the ICU and sending selected patients directly to the floor. Minimizing variation in the delivery of care can also decrease the cost of care. Examples include standardizing the number of antibiotic doses administered after an elective cranial surgery (from three postoperative intravenous doses in Group 1 to one dose in Group 3) and aiming for a postoperative stay of 2 days for patients undergoing an MVD. Lastly, waste reduction must be addressed in any strategy, given that resources can be used without any added value to the patient, as occurs in the management of postoperative complications, readmissions, and reoperations. It is critical to understand that although a reduction in the cost of care does not necessarily result in net savings in hospital finances, it does translate into improved value of care when outcomes are either maintained or even improved.

**Targeting OR Costs**

Use of the OR is one of the most expensive care points in a surgical episode of care but is also one of the most important sources of revenue for a hospital.\textsuperscript{28} Therefore, effective utilization of the OR is essential to preventing idle time and overtime. In Group 2, joint efforts by neurosurgery, anesthesia, and nursing leadership stressed the importance of optimizing time spent in the OR. The importance of efficient team communication the day before surgery, at the beginning of a case through a comprehensive time-out, and at the end of a case through a team debrief was emphasized, as was open communication throughout the case.\textsuperscript{33} In Groups 2 and 3, parallel instead of sequential teamwork was encouraged and emphasized to get the patient ready in a timely fashion, as surgical preparation time and anesthesia induction time are longer for neurosurgical procedures.\textsuperscript{33} Our data showed a persistent decrease in the average pre-incisional preparation time from Group 1 (73 minutes) to Groups 2 and 3 (65 and 45 minutes, respectively). We recognize that the overall duration of the operative procedure in all three groups may be longer at our institution, as is the case in other tertiary care centers with residency programs.\textsuperscript{38} Indeed, the duration of surgery can be prolonged by resident participation and direct supervision of an attending in the OR, resulting in additional costs.\textsuperscript{2,20} In Groups 2 and 3, the sequence of surgical steps for exposure, microsurgical decompression, and closure were standardized. Especially for the exposure and closure, the surgical fellow ensured that the resident executed the steps in a similar manner and sequence for every case. Variability in the time to execute each step depends on multiple factors that are challenging to predict and control, including the experience level of the assisting resident, particular anatomical features, delays related to instruments, and so forth. Although the average total OR time for Group 3 increased compared with that for Group 2, it still remained lower than that for Group 1. Importantly, modifications to the surgical technique in Group 2 and maintained in Group 3 allowed us to minimize the incidence of adverse events related to surgery (such events can result in a prolonged LOS or readmissions and reoperations).

**Targeting Intraoperative Monitoring Costs**

Refined exposure techniques and the introduction of BAEPs monitoring allowed for reductions in the rate of neurological complications, such as hearing loss and facial weakness, to less than 2% in modern series.\textsuperscript{7,47} Masters in the field of MVD have acknowledged that experienced surgeons may revise the need for routine intraoperative BAEPs monitoring in MVD procedures for TN.\textsuperscript{7,8,42,47} Bond and colleagues said, “In the future, shifts in the cost-benefit ratio . . . may favor evidence-based selected deployment of such techniques rather than rigidly designating them as a surgical ‘standard of care.’”\textsuperscript{77} Regarding the cost of IOM, detailing the electrode needle cost and actual monitoring cost revealed that the decrease in the average cost of monitoring (base test rates and hourly intraoperative monitoring cost; $1557 to $1263) was offset by the increase in the average electrode needle cost ($729 to $1028) noted from Group 1 to Group 3. This increase in the cost of needles is explained by the increase in the number of muscle groups monitored, an initiative from the IOM team in patients in Group 3. This example stresses the importance of reviewing cost details, not just the total cost for a specific activity, to capture increases and direct future cost-containment strategies.

**Targeting Bed Assignment**

Routine postoperative ICU admission for patients undergoing an elective craniotomy is a long-established practice.\textsuperscript{26} Recently, studies have documented the safety and feasibility of direct ward admissions for patients undergoing elective craniotomies, reserving ICU admissions for selected patients needing intensive care.\textsuperscript{9,51,54} As ICU resources become more limited, this paradigm change will become more prevalent. In the present study, the care for most patients in the ICU consisted of intense monitoring, not intense care, except for one patient who developed
postoperative parotitis and needed reintubation for airway protection within 4–6 hours after arrival in the ICU. Prospective studies from different practices are needed to establish predictive factors to preoperatively and intraoperatively identify patients who would benefit from selective ICU admission.24 In Group 3 in the present study, safe orientation of selected patients to more cost-efficient bed allocations contributed to significant cost reductions.

Targeting LOS

Length of stay is a universal metric for gauging the success of process improvements. Intuitively, it is thought that reducing the LOS decreases cost.49 However, many variables must be taken into consideration for this belief to become reality. Many studies have shown that patients incur more expenses early in their hospitalization, especially the first 2 days, than at the end of their stay.49 In surgical specialties, the notion that not all hospital days are economically equivalent is even more valid. The financial impact of a decreased LOS varies depending on the overall length of the hospitalization. For longer hospitalizations, the cost attributed to the last day of the hospital stay may be a minor component of the total cost of the care episode.50 Reducing LOS may result in accelerating some care points and delivering others in an outside patient setting, leading to a shift in cost more than an actual cost reduction for the whole episode of surgical care. Delivering certain elements of care in an outpatient setting instead of an inpatient setting may remain cost efficient overall.50 Recently, multidisciplinary perioperative protocols that enhance recovery after surgery by implementing evidence-based best practices throughout a patient’s entire care episode have been shown to improve outcome and decrease the cost of care.6,10,16,27,35,37 In the present study, in addition to revisiting postoperative bed assignment, we achieved a more reproducible and predictable discharge by postoperative Day 2.

Targeting Cost of Medical and Surgical Complications

Postoperative complications related or unrelated to the procedure always reduce the value of care delivered either by resulting in a less than optimal outcome or by incurring a greater total cost of care.1,52 Most often, complications are associated with an increase in the hospitalization stay and/or readmissions.15 As shown in this study as well as others, the average cost of care with major postoperative complications is greater than that without complications.2,52 A comprehensive assessment of perioperative health status, based on evidence-based recommendations and a detailed workup in selected patients using a risk stratification methodology, can be just as effective in reducing intraoperative or postoperative adverse medical events as a routine workup.24 In the present study, all patients underwent preoperative stratification and clearance by their primary care physician and were preoperatively verified by the anesthesia team before admission to the OR. Such approaches have been shown to be cost effective.24 The only patient who presented with a medical complication (unstable angina) after surgery had been stratified at a low cardiac risk preoperatively. The implementation of the Surgical Care Improvement Project (SCIP) has also led to reductions in perioperative complications by tackling surgical site infection prevention, venous thromboembolism prevention, use of perioperative beta-blockers, serum glucose level monitoring, normothermia, and use of clippers for hair removal.53 Other initiatives to improve and standardize perioperative care include the Enhanced Recovery After Surgery (ERAS) program and fast-track protocols, which combine, in the manner of a mega-surgical bundle, multimodal evidence-based elements guiding the perioperative management of patients.51,53,54 Such initiatives, spanning the entire continuum of surgical care, have led to an improved value of delivered care.46 Lastly, the importance of the surgical team always seeking to improve its technique cannot be overstated.

Challenges in Using Cost-Containment and Cost-Reduction Strategies to Improve Value of Care

Methodology of Costing. Currently, the lack of a standard methodology to accurately determine the cost of care has limited efforts in this field. Although some groups have tackled cost assessment, cost estimates or total cost data are gathered most often, with limited applicability. The TDABC method has shown potential in initial pilot studies.22,23 Although at first glance this methodology may appear cumbersome and time consuming, from a clinical standpoint it may allow the study of activities that add significant value to a patient’s care yet are not accounted for. A standard methodology will need to be selected to allow comparative analysis between various health centers.

Collaboration Among Clinicians, Financial Officers, and Operational Officers. In this study, a detailed understanding of cost allocation was eye opening: costs were dynamic, with most increasing and few decreasing. Despite all efforts to improve outcome, increases in cost occurred annually, potentially jeopardizing the impact of value of care. Teams engaged in redesigning value-based care need to be aware of these dynamic fluctuations and understand the reasons they occur. Overall, reengineering the delivery of care to achieve optimal value of care requires close collaboration among clinical, operational, and finance teams along with the support of visionary leadership.

Study Limitations and the Future

We recognize that the current study is a pilot study. Although our center is high volume when considering the total annual volume of MDV procedures performed, the absolute total number of cases was not high, limiting our statistical significance testing.21 Basic data analysis using descriptive statistics was used to summarize the main characteristics of the data from each group. Similar analyses are being conducted on other neurosurgical diagnoses occurring in larger volumes, which will enable significance analysis of cost reductions.

We caution readers about comparing the cost of care delivery between institutions. Indeed, numerous variables influence cost, such as human resources, technology, and real estate, precluding accurate comparison between institutions. Most importantly, our study demonstrates how, within one institution, the incorporation of cost assess-
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ment is critical in redesigning the delivery of value-based care.

We used ABC in this study, reporting cost through data extracted from our cost accounting system. We are piloting the TDABC methodology to assess the cost of care delivery and to evaluate how both methodologies may guide toward different, but potentially complementary, strategies to drive cost containment and reduction and ultimately optimal value. Knowing exactly what it costs to deliver an optimal value of care will empower health organizations to negotiate bundle payments with third parties as this payment method becomes reality. This exercise is important for our institution not only to remain profitable as the general cost of care continues to increase, but also to ensure competitiveness.

Conclusions

As a complement to outcome improvement measures, cost assessment is essential to ensure, at a minimum, containment of expenditures. Optimally, sound knowledge of the value stream map for treated conditions enables one to identify opportunities for reducing the cost of care delivery. In the present study, the optimization of teamwork during pre-incision time in the OR, revision of the IOM protocol, revision of “routine” postoperative admission to the ICU, and reduction in the LOS were identified as cost-containment and potentially cost-reduction opportunities. Reductions in the cost of care delivery do not necessarily result in net savings for hospital finances; however, they do translate into improved value of care when outcomes are either maintained or improved. Indeed, cost reductions should never jeopardize clinical outcomes, as demonstrated by the absence of postoperative complications, readmissions, and reoperations in our contemporary group of patients. Physician involvement in the field of health economics will be required as new methods of reimbursement, such as bundled payments, emerge. It will be essential to realize that outcome results and cost data go hand in hand and that both must be tackled simultaneously for optimal and sustained value-based care.

Acknowledgment

We acknowledge the finance department and decision support team for their assistance in extracting data from the EPSi system and for reviewing the cost analysis.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Concept and design: Martin, McLaughlin. Acquisition of data: McLaughlin, Upadhyaya, Buxey. Analysis and interpretation of data: all authors. Drafting the article: McLaughlin. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors: McLaughlin. Administrative/technical/material support: Buxey. Study supervision: Martin, McLaughlin.

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