Value-based neurosurgery: the example of microvascular decompression surgery

Clinical article

NANCY McLAUGHLIN, M.D., PH.D., F.R.C.S.C., FARZAD BUXEY, M.Sc., KAREN CHAW, AND NEIL A. MARTIN, M.D.

Department of Neurosurgery, David Geffen School of Medicine at UCLA, Los Angeles, California

Object. Value of care is emerging as a promising framework to restructure health care, emphasizing the importance of reporting multiple outcomes that encompass the entire care episode instead of isolated outcomes specific to care points during a patient’s care. The authors assessed the impact of coordinated implementation of processes across the episode of surgical care on value of neurosurgical care, using microvascular decompression (MVD) as an example.

Methods. This study is a retrospective review of consecutive cases involving patients with either trigeminal neuralgia or hemifacial spasm undergoing first-time MVD. Patients were divided into 2 groups: Group 1 included patients who underwent surgery between February 2008 and November 2009 and Group 2 included those who underwent surgery between January 2011 and October 2012. The authors collected data on outcome measures spanning the entire surgical episode of care according to the Outcome Measures Hierarchy.

Results. Forty-nine patients were included: 20 patients in Group 1 and 29 patients in Group 2. Thirty-one patients underwent MVD for trigeminal neuralgia and 18 for hemifacial spasm. A zero mortality rate and high degree of symptom resolution were achieved in both groups. Group 2 benefited from a reduction in the average total operating room time, a decrease in the mean and median postoperative length of hospital stay, a decrease in the mean length of stay on the floor, and a reduction in the rates of complications and readmissions.

Conclusions. Comprehensive implementation of improvement processes throughout the continuum of care resulted in improved global outcome and greater value of delivered care. Enhanced-recovery perioperative protocols and diagnosis-specific clinical pathways are two avenues built around global care delivery that can help achieve an “optimal episode of surgical care” in every case.

Key words • value • outcome • episode of care • length of stay • operating room • complication • readmission

In light of the current challenging economic status and the need for a comprehensive health care reform, value (quality divided by cost) is emerging as a concept that the vast majority of stakeholders in health care embrace. Leaders in the field of health economics have proposed that the central focus should be to increase the value of care, with value being equated to the meaningful outcomes delivered to the patient per dollar spent. Porter states, “the only way to truly contain costs in health care is to improve outcomes: in a value-based system, achieving and maintaining good health is inherently less costly than dealing with poor health.” Importantly, the goal of the “value of care” framework is to create a context for improvement that encompasses an entire care episode and considers clinical results (for example, symptom relief, complications), efficiency of care delivery, resource use, and cost (for example, bed assignment, length of stay [LOS], and readmission rate). In the framework proposed by Porter, the outcomes for any medical condition or care episode can be organized in a 3-tier hierarchy. Focusing on a single outcome, such as relief of facial pain or spasm for patients undergoing microvascular decompression (MVD), is not sufficient to define completely the value of care delivered to patients. Value of care is assessed by reporting the multiple outcomes that encompass the entire surgical care episode.

In February 2009, the Department of Neurosurgery at the University of California, Los Angeles (UCLA), launched the “Clinical Quality Program: Enhancing Quality Safety and Efficiency.” The department lead-
Value-based neurosurgery

ership worked with the UCLA Medical Center to align mutual quality improvement priorities, ultimately aiming to improve the value of neurosurgical care. The Clinical Quality Program inspired a culture that encouraged change and progress, while developing an infrastructure to implement new processes designed to achieve and sustain performance improvement. This initiative began in the third quarter of 2009. Monthly review of quantitative performance metrics, in a Neurosurgery Quality Dashboard, by the Quality and Care Coordination Committee helped monitor the impact of applied interventions and identify new opportunities for improvement.31

Since the launch of the Clinical Quality Program, the impact of interventions has been tracked for the Department of Neurosurgery as a whole, including urgent and elective patient admissions, with all neurosurgical subspecialties combined. However, the impact of a comprehensive bundle of improvement interventions for all 3 tiers of outcome, for a specific pathology with a relatively standard surgical care episode, was unknown.32 Given that the anticipated operative risks are relatively predictable and that the perioperative care is relatively similar among patients undergoing a MVD, this surgical procedure was proposed as a study model. The goal of this study was not primarily to report surgical success rates following MVD procedures at our institution, but rather to assess the impact of implementing a comprehensive bundle of perioperative and intraoperative care improvement processes on the overall clinical value of MVD. Specifically we asked: did the multidisciplinary and multifaceted improvement efforts, deployed in 2009 and thereafter sustained, succeed in improving the value of care received by this patient population if one considers the entire episode of surgical care, encompassing all care points from the initial neurosurgical consultation to the last postoperative encounter? We assessed, before and after the implementation of the improvement processes, the quality measures in each tier of outcome assessment, including the specific dimensions related to each tier.32 This study is unique as it integrates the most complete concepts of outcome assessment in health care, provides a concrete example of quantitatively measured assessment of the value of care delivered in neurosurgery, and determines the effect of a comprehensive surgical care improvement initiative.20,31,32 We discuss the strategies and tactics that can be used to optimize value-based delivery of health care for neurosurgical patients, using the MVD patient population as a model.

Methods

Patient Population

All consecutive first-operation MVD procedures performed by the senior author (N.A.M.) for either trigeminal neuralgia or hemifacial spasm between January 2008 and October 2012 were identified. Patients who underwent a repeat MVD procedure for either trigeminal neuralgia or hemifacial spasm were excluded as reoperations may pose higher risks to cranial nerves than a first MVD.31 During the study period, 3 patients were referred for treatment because of recurrent symptoms and underwent repeat MVD; they were excluded from this study. The patient population was divided into two groups. Group 1 included all consecutive patients operated on from beginning 2008, from February 2008 to November 2009. This group represents the era prior to the implementation of improvement processes. Group 2 included all consecutive patients operated on from beginning 2011, from January 2011 to October 2012. This group represents the era following the implementation and maturation of the improvement measures. This research was approved by our local institutional review board.

Process Improvement Interventions Initiated After Group 1

Perioperative Performance Improvement Processes. Table 1 summarizes the comprehensive bundle of improvement processes that were implemented, including numerous processes in the preoperative and postoperative phases of care, to optimize the value of care delivered to patients undergoing an MVD procedure. At the time of initial consultation and throughout the preoperative outpatient medical clearance workup, physicians and nurses prepared patients to expect a shorter hospital stay (1 or 2 days after surgery, depending on service lines). For the postoperative phase of care, a communication template was established. Based on this template, physicians and nurses discussed the daily care plan and plan for discharge during the morning multidisciplinary rounds. Afternoon rounds were specifically focused on identifying patients ready to be discharged the following day, enabling discharge teaching and arranging of transportation. The discharge process was standardized, and the interns and residents received education on the specific instructions, steroid taper protocol, and follow-up appointments.

Intraoperative Performance Improvement Processes. Table 1 also summarizes processes implemented to improve the value of delivered care from the moment a patient enters the operating room to when he/she leaves.

Before Incision. In preparing a patient for surgery, multidisciplinary teamwork was emphasized so that teams could work in parallel, rather than sequentially, for such tasks as intravenous and intra-arterial line placement, intubation, Foley catheter placement, and insertion of needles on extremities for intraoperative monitoring. Introducing a comprehensive time-out, with an official team pause, team member introductions, review of the surgical safety checklist, and a team safety statement, represented a major change in culture and practice at UCLA.23

Surgical Technique. All surgical procedures were performed by a single surgeon (N.A.M.) in an academic institution. Standard microsurgical technique was used for the decompression of the involved cranial nerve by the offending vessel.34 A PTFE felt pledget (Bard Peripheral Vascular) was inserted between the involved cranial nerve and the dissected vessel. A partial selective rhizotomy of the mandibular division of the trigeminal nerve was performed in a minority of cases if no vessel was found to be obviously distorting the root entry zone of the trigeminal nerve. The closure technique in Group 1 consisted of interrupted dural sutures covered by a single disk of gelatin.
TABLE 1: Summary of improvement processes undertaken in the UCLA Department of Neurosurgery since the launch of the Clinical Quality Program*  

<table>
<thead>
<tr>
<th>Phase of Care</th>
<th>Improvement Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>preoperative</td>
<td>description of expected postop course, w/ duration of stay in each location; discussion of expected goals for hydration/nutrition, elimination, mobilization, management of postop pain, nausea, vomiting; discussion of the expected postop LOS (1–2 days), depending on service lines†</td>
</tr>
<tr>
<td>intraoperative</td>
<td>multidisciplinary efforts for parallel pt preparation; introduction of a comprehensive timeout; reflective analysis of OR team’s performance; numerous technical improvements (see text for details)</td>
</tr>
<tr>
<td>postoperative</td>
<td>creating a template for communication (HPT); modifying the focus of the afternoon rounds: identification of pts ready to be discharged &amp; initiating discharge preparation; revising the postop order sets, standardizing elements of care; standardization of discharge criteria; standardization of discharge instruction sheets, steroid taper, suture removal, &amp; FU appointment; reviewing each discharge at the daily morning multidisciplinary rounds</td>
</tr>
</tbody>
</table>

* FU = follow-up; HTP = Hospitalization plan, Present day plan, Transition/Transfer plan; pt = patient.
† For the MVD patient population, an expected LOS of 2 days was established and discussed with patients.

Surgical Performance Improvement Processes. Technical modifications were part of the comprehensive bundle of improvement processes. The size of the craniectomy was standardized to a smaller diameter, from 30 mm in Group 1 to 18–22 mm in Group 2. The mastoid bone drilling technique was modified to leave a short shelf of inner and outer table after exposing the venous sinus margin. This created a concave profile to the craniectomy edge along the mastoid air cells, which would better hold bone wax. The arachnoid mater was carefully dissected from the petrosal vein to enable stretching and avoidance of coagulation, preserving the vein. Blood loss and blood spillage into the subarachnoid space was meticulously avoided, and thorough irrigation of the surgical cavity was performed multiple times during each case. Fixed cerebellar retraction was not used. A no-touch technique was adhered to during the preparation of the PTFE felt pledgets and their insertion. The dural closure was reinforced and sealed by interweaving strips of gelatin sponge between the interrupted dural sutures. A multilayer onlay (gelatin sponge, collagen sponge [Helistat, Integra LifeSciences Corp.], gelatin sponge) was systematically applied on the dura with a thin film of tissue glue between each layers. The muscles and galea were closed in a multilayer fashion as usual. Last, horizontal Vicryl (Ethicon) sutures were placed in the dermis to secure the skin closure and provide precise coaptation and a watertight seal that would endure after skin staple removal. A surgical safety checklist was also introduced and a formal pre-incision timeout instituted, with reliable administration of antibiotic agents within 60 minutes before incision.

Data Collection

Patient clinical notes, radiographic images, and operative notes were reviewed. Duration of surgery, recovery room LOS, intensive care unit (ICU) LOS, floor LOS, and readmission data were extracted from the electronic medical records by 2 different persons (N.M. and K.C.) to ensure consistency of values. Outcome measures were organized using Porter’s 3-tier Outcome Measures Hierarchy [32] (Table 2).

Tier 1 Outcome Measure—Health Status Achieved or Retained. The two outcome dimensions within this tier are survival and degree of health or recovery. Survival is accounted by perioperative mortality rate, defined as death within 30 days of surgery. For trigeminal neuralgia, the degree of recovery was assessed using the Barrow Neurological Institute (BNI) pain intensity scale and described as complete pain relief with no need for pain medication (a score of I); partial pain relief—either occasional pain not requiring medication or pain that is adequately controlled with medication (scores of II and III, respectively); some pain not adequately controlled by medication or severe pain with medication providing no relief (scores of IV and V).13,35 Recurrence of pain was defined as a BNI pain intensity score of II–V if complete pain relief had been achieved. For hemifacial spasm, there is no corresponding scale that allows grading of the intensity of hemifacial spasm throughout the patient’s care. With analogy to the BNI intensity scale for facial pain, we classified the degree of recovery following an MVD for hemifacial spasm in a similar fashion: complete cessation of spasm (a score of I); partial decrease of the frequency and/or distribution of the spasm (II–III); little to no improvement of the spasm pattern (IV–V). The early postoperative degree of recovery was evaluated at the initial follow-up visit 1 month after surgery by a neurosurgical nurse practitioner and the treating surgeon.

Tier 2 Outcome Measures—the Process of Recovery. The first outcome dimension in this tier comprises the time to recovery and time to return to normal activities. Measurements of time needed to complete various phases of care are considered as outcomes, as their reduction can improve patient functionality and reduce complications.32 Outcome measures (influencing the recovery process) related to the operative phase of care include: time in the operating room (OR), pre-incisional preparation time, and surgical procedure time. Time in the OR is defined as the time interval between the patient’s arrival in the OR and departure for the recovery room. The pre-incisional preparation time spans the period from the patient’s arrival in the OR to the time of incision. This time interval takes into consideration time required for anesthesia preparation, insertion of electrodes for neuromonitoring, pinning...
TABLE 2: Outcome Measures Hierarchy as applied to MVD for trigeminal neuralgia or hemifacial spasm

<table>
<thead>
<tr>
<th>Tier</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. health status achieved or retained</td>
<td>survival: mortality rate; degree of health of recovery; relief of pain for TN or spasm for HFS; return home after op</td>
</tr>
<tr>
<td>2. process of recovery</td>
<td>cycle time of surgery; time to recovery; time to return to work; prep activities</td>
</tr>
<tr>
<td>3. sustainability of health</td>
<td>disutility of care of treatment: need for blood transfusion, new neurological deficit, duration of op, LOS, infection, CSF leak, need for wound revision</td>
</tr>
</tbody>
</table>

* Based on Outcome Measures Hierarchy as presented by Porter. HFS = hemifacial spasm; TN = trigeminal neuralgia.

Value-based neurosurgery

Definition of “Optimal Surgery”

We defined an “optimal surgical care episode” as satisfying the following criteria: 1) resolution of symptoms; 2) duration of surgery within 20% (± 20%) of the group average; 3) discharge within 2 postoperative days; 4) discharge by noon; 5) discharged home; 6) no postoperative complication; 7) no readmission; 8) no reoperation; 9) no mortality. Although we recognize there is no evidence-based literature allowing us to establish the targets for the proposed criteria defining “optimal surgery,” we have used our local targets established by historical comparison.

Statistical Analysis

Statistical analyses were performed with the Prism 5.0 GraphPad Software. Between-groups comparison of percentages of patients were performed using Fisher’s exact test. A p value < 0.05 was considered significant.

Results

Demographic Characteristics of the Study Population

The patient population consisted of 20 patients in Group 1 and 29 patients in Group 2. Overall, 36 of the 49 patients were women and 13 were men. The patients’ mean age was 56 years (range 26–83). Thirty-one patients underwent MVD for treatment of trigeminal neuralgia and 18 for treatment of hemifacial spasm. A culprit vessel was found in all patients with hemifacial spasm. In 11 cases of trigeminal neuralgia, a partial rhizotomy was performed (in 2 cases in Group 1 and 9 in Group 2). Table 3 summarizes the demographic characteristics of the two groups.

Tier 1 Outcome Results—Health Status Achieved or Retained

In this series, there was no perioperative mortality. Among the 49 patients in the study population, 3 had no documents (either written or electronic) summarizing the 1-month postoperative follow-up visit, including 2 with trigeminal neuralgia and 1 with hemifacial spasm.

Regarding patients who underwent surgery for trigeminal neuralgia, 24 of 29 reported complete relief of facial pain and were no longer taking any of their preoperative medication for trigeminal neuralgia at the time of their 1-month follow-up visit. An additional 4 patients reported a significant decrease in pain and had reduced or completely discontinued their preoperative medication for trigeminal neuralgia. Therefore, 28 of 29 patients had either complete relief or significant decrease in pain as of the 1-month follow-up visit.

Regarding patients who underwent surgery for hemifacial spasm, 13 of 17 reported complete cessation of facial spasms at the 1-month follow-up visit. An additional...
4 reported significant reduction in facial spasm. Therefore, all patients had either complete cessation of or significant reduction in facial spasm 1 month after surgery.

Tier 2 Outcome Measures—Process of Recovery

The average total time in the OR was 455 minutes (range 283–589 minutes) in Group 1 and 357 minutes (range 216–533 minutes) in Group 2 (p = 0.00001). The average pre-incisional preparation time was 145 minutes in Group 1 and 115 minutes in Group 2 (p = 0.00017). The average surgical procedure time was 300 minutes in Group 1 and 230 minutes in Group 2 (p = 0.078). Figure 1 illustrates the trend of these time intervals in both groups.

For Group 1, the average overall LOS was 3.25 days (median 3 days). For Group 2, the average overall LOS was 3.27 days (median 2 days). Three patients were identified as outliers, with a hospital course lasting 7 days or greater. In Group 1, a patient who underwent surgery for hemifacial spasm and had decreased hearing postoperatively remained hospitalized for 7 days for close monitoring. In Group 2, a patient who underwent surgery for hemifacial spasm had decreased hearing and transient facial weakness and remained hospitalized for 11 days for close monitoring. Also in Group 2, a patient who underwent surgery for trigeminal neuralgia with complete resolution of her pain developed unstable angina following surgery and remained hospitalized for 14 days for medical management. All but these two last patients were discharged home. After excluding the 3 outliers, the average overall LOS was 3.05 days for Group 1 and 2.59 days for Group 2 (p = 0.041) (Table 4). The average LOS in recovery was 3 hours for Group 1 and 5 hours for Group 2 (p = 0.273). In Group 1, one patient remained in the recovery room for 26 hours because no bed was available in the hospital. The average LOS in the ICU was 26 hours for Group 1 and 33 hours for Group 2 (0.179). In Group 2, one patient remained in the ICU for 117 hours. This patient underwent an uneventful right-sided MVD for trigeminal neuralgia, awoke neurologically intact from surgery. After a 3-hour stay in recovery she was transferred to the ICU. In the evening, she developed swelling of the left side of her face and neck and stridor with difficulty breathing, requiring reintubation. She was diagnosed with acute parotiditis and remained intubated for 3 days. After 24 hours of observation following extubation, the patient was discharged home directly from the ICU. The average LOS on the floor was 41 hours for Group 1 and 24 hours for Group 2 (p = 0.0005). In addition to the patient described above, 3 other patients were discharged directly from the ICU without having transitioned to the floor, all in Group 2. Each had a total postoperative LOS of 2 days. Figure 2 illustrates the trend of LOS in the recovery room, the ICU, and the floor for both groups. The percentage of patients discharged before noon was 47% in Group 1 and 66% in Group 2. In Group 1, 5% of patients met both targets (discharge by postoperative Day 2 and prior to noon) versus 37% in Group 2 (Fig. 3). A total of 47 patients (96%) were discharged home.

Blood loss was minimal in all patients, and no blood transfusion was performed in any patient in either groups. No stroke, surgical site infection, or bacterial meningitis occurred in this series. Among all patients who underwent MVD for trigeminal neuralgia, 4 had a procedure-related complication: 3 patients in Group 1 with a CSF leak and 1 patient in Group 2 with chemical meningitis (Table 5). Of these, the 3 patients with a CSF leak required a readmission and a return to the operating theater for wound revision and insertion of a lumbar drain. Among all patients who underwent MVD for hemifacial spasm, 4 had a procedure-related complication: 2 patients in Group 1 (1 with decreased hearing and 2 with transient facial weakness) and 2 patients in Group 2 (1 with decreased hearing and transient facial weakness and 1 with a CSF leak) (Table 5). Of these, the patient with a CSF leak was readmitted for insertion of a lumbar drain. Overall, 3 patients in Group 1 required readmission. Length of stay of readmissions was 5 days for each patient. Only one patient of Group 2 required a readmission that lasted 6 days.

Tier 3 Outcome Measures—Sustainability of Health

Long-term follow-up data were available for 46 patients, the same patients for whom 1-month follow-up data were also available (Table 6). At 6 months after surgery, 24 of 29 patients maintained complete relief of facial pain and 14 of 17 experienced complete cessation of facial spasm. Therefore, within this follow-up period, no patient had recurrence of symptoms and 1 patient’s condition improved from significant spasm reduction to complete cessation of spasm. No patient reported any adverse event related to the surgical episode of care between 1 and 6 months’ follow-up. We recognize that long-term recovery will need to continue to be monitored, but the 6-month postoperative evaluation enabled assessment of sustainability of health following the surgical care episode and subsequently delivery of value-based care.

Optimal Surgical Care Episode

In the present series, only 1 patient (5%) of Group
I met all criteria for “optimum surgery.” However, in Group 2, 9 patients (31%) met all of the criteria for an optimal surgical care episode as described in the Methods (p = 0.034).

Discussion

Redesigning Care Delivery

The Clinical Quality Program of the Department of Neurosurgery set a clear goal: to improve the value of care of all patients. The strategy was to identify an ensemble of key outcomes that matter to patients and commit to measuring and reporting them (Neurosurgery Clinical Dashboard).23 After opportunities for improvements were identified, we planned the program’s tactics, by mapping out various processes, elaborating and implementing interventions, and measuring their results with respect to outcome. The Clinical Quality Program’s operation logistics included building a team, identifying a driving leader,

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>total postop LOS in hospital (in days)</td>
<td>3.05</td>
<td>2.59</td>
</tr>
<tr>
<td>median</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>LOS in recovery room (in hrs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>median</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>LOS in ICU (in hrs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>26</td>
<td>33</td>
</tr>
<tr>
<td>median</td>
<td>24</td>
<td>23</td>
</tr>
<tr>
<td>LOS on floor (in hrs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>41</td>
<td>24</td>
</tr>
<tr>
<td>median</td>
<td>45</td>
<td>22</td>
</tr>
<tr>
<td>no. of pts discharged before noon</td>
<td>9/19 (47%)</td>
<td>18/27 (66%)</td>
</tr>
</tbody>
</table>
empowering team members, and coordinating recurrent meetings (Care Coordination Committee). This framework for care redesign described by Lee enabled us to pave a durable path forward for future quality improvement work within our institution.19

Summary of Comprehensive Processes Implemented After Group 1

An overview of the improvement processes undertaken in the UCLA Department of Neurosurgery since the launch of the Clinical Quality Program is presented in Table 1.

Preoperative Measures. In-depth discussion of the hospitalization process was added as a new key aspect of the initial neurosurgical consultation for patients in Group 2. Although patients in Group 1 were told that they could expect to go from the OR to the recovery room and then to the ICU before going to the floor, the specific time they could expect to spend in each location was not systematically discussed. In Group 2, patients were given a time estimate regarding how much time they were expected to spend in each location. Regarding the overall hospital stay, 10–15 years ago, patients undergoing MVD would be informed that they could expect to spend 5–7 days in the hospital. In 2008 (Group 1), patients were told to expect a 3- to 4-day hospital stay, similar to the average reported LOS following an MVD.16,29 Since 2011 (Group 2), patients have been systematically told to expect a hospital stay of 2 days following surgery. In addition, during the preoperative consultation, the expected goals of hydration and nutrition, mobilization, elimination, and pain and

---

**Fig. 2.** Graphs displaying LOS in the recovery room, ICU, and floor unit. **Upper:** Scatter plot showing the duration for each patient over the course of the study period. **Lower:** Bar graph showing the mean values for each group. Error bars indicate SDs.
Nausea control on postoperative Days 1 and 2 were discussed with patients and their families to demystify the postoperative setting and establish shared expectations.

**Intraoperative Measures.** Engaging the surgical team to revise the surgical technique and determine if any improvements were feasible to achieve better outcomes was an essential step in coordinating the comprehensive bundle of improvement processes. The technical improvements made to the surgical technique were detailed in Methods. The pre-incisional preparation time, the duration of the actual surgical procedure, and the total time in the OR have been identified as an important measures to assess in order to follow OR efficiency in the context of a relatively standard elective procedure.\(^\text{14}\) Surgical preparation time and anesthesia induction duration are known to be increased for neurosurgical procedures.\(^\text{21,27}\) In addition, prolonged surgical duration has been identified as a contributing factor to surgical site infections.\(^\text{15,26}\) Neurosurgery, anesthesia, and nursing leadership stressed the importance of optimizing time spent in the OR, encouraging more efficient communication and parallel instead of sequential work to get patients ready for surgery.\(^\text{14,27}\) Introduction of a comprehensive timeout also enabled the surgical team to have all the instrumentation available from the start.\(^\text{22,23}\) The benefit of practice cannot be overstated. Experience and reflective analysis of a team’s performance, more than simple volume accumulation, enabled the entire OR team to become more familiar with the sequence of tasks to be accomplished and more efficient in performing each task.\(^\text{16}\)

**Postoperative Care Measures.** Multiple interventions were implemented in the postoperative setting to improve

---

**TABLE 5: Complications and readmissions as measures of the process of recovery (Tier 2)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TN</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>chemical meningitis</td>
<td>0</td>
<td>1*</td>
</tr>
<tr>
<td>CSF leak, lumbar drain</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>CSF leak, return to OR</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td><strong>HFS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>chemical meningitis</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>decreased hearing</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>transient facial weakness</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>CSF leak, lumbar drain</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>CSF leak, return to OR</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>readmission</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

* Chemical meningitis manifested 3 weeks postoperatively when steroid therapy was discontinued. It was treated with continuation of steroid therapy for an additional week.

**TABLE 6: Clinical outcome at 6-month postoperative visit as a measure of sustainability of health (Tier 3)**

<table>
<thead>
<tr>
<th>Resolution of Symptoms</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HFS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total no. of pts</td>
<td>6</td>
<td>11</td>
</tr>
<tr>
<td>no spasm</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>significant reduction in spasm</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>no improvement</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>TN</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>total no. of pts</td>
<td>11</td>
<td>18</td>
</tr>
<tr>
<td>no pain</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>significant decrease in pain</td>
<td>0</td>
<td>4*</td>
</tr>
<tr>
<td>moderate improvement</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>no improvement</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* Most of these patients had significant improvement or resolution of the typical electrical pain, but also had a dull atypical pain that improved but was still present.
the process of recovery (Tier 2) and health sustainability (Tier 3) (Table 2). The first step was emphasizing the importance of clear guidance for multidisciplinary communication. For each patient and at each occasion, the treating team reviewed 1) the hospital plan for that admission (H); 2) the present day’s plan (P); 3) the transition/transfer plan (T). The overall plan, incorporating these three phases, is referred to as the HPT plan. As of the third quarter of 2009, the decision for discharges was to be made during the neurosurgery team’s afternoon rounds. The evening nursing staff would assure that discharges were appropriately planned with the patients and their families. The tasks involved include review of discharge handouts, finalizing teaching points, and ensuring coordination of transportation for the following morning. Completion of all these tasks the morning of discharge for all patients being discharged had proven to be challenging in our department, which often resulted in delay of discharge to the afternoon or even the following day in Group 1.

Among the improvement measures implemented, the discharge criteria, the discharge instruction sheets, steroid taper protocol, and time frame for suture removal and follow-up appointment were standardized across service lines. In addition to confirming discharges for the day, morning rounds also identified additional patients that may have progressed exceptionally well since the previous afternoon rounds and now satisfied discharge criteria. A daily morning multidisciplinary round was organized to ensure that each patient’s case and the resources required for a safe discharge were discussed. The implementation of these various improvement processes was department-wide and aimed to improve overall value of care for all patients undergoing surgery at UCLA.

In addition to these changes in the daily workflow, other processes were implemented to measure, monitor, and manage the results. The average LOS, the percentage of patients discharged by noon, and readmissions (if any) were reviewed every Monday morning by the department chairman with the residents and interns, the program director, and the director of quality improvement. A root-cause analysis was launched to understand any deviation, bring appropriate corrections, and set the team back on track. Outcome measures were incorporated into a Neurosurgery Clinical Dashboard reviewed monthly by the multidisciplinary Quality and Care Coordination Committee.

Realistic Goal of an “Optimal Surgery” or “Optimal Surgical Episode of Care”

Results reported in this series regarding rate of pain cessation or significant improvement for trigeminal neuralgia and rate of spasm relief or significant improvement for hemifacial spasm compare to those reported in the literature. Indeed, success of MVD for trigeminal neuralgia is often long lived, persevering in approximately 80% of patients at 5 years and 70% of patients at 10 years. Success of MVD for hemifacial spasm at 10 years is even slightly better, with rates approaching 80%–85%. In the modern era, improving the value of an episode of care, for example the surgical treatment of trigeminal neuralgia or hemifacial spasm via MVD, will not only rely on measures to optimize resolution of trigeminal neuralgia or hemifacial spasm with no procedure-related complication (symptomatic or radiographic) or mortality; the capacity of optimizing the value of a surgical care episode will also depend on numerous other factors, such as minimizing the duration of anesthesia, preventing blood transfusion, optimal postoperative pain and nausea management, and early nutrition and ambulation. Length of stay will also be an important measure, as it represents a surrogate marker of multidisciplinary coordinated and organized care as well as a marker of efficient minimally invasive, complication-free surgery. Recent studies have reported average hospital LOS of 3–5 days following an MVD. A shorter LOS may reduce disruption of patients’ lives and the risk of nosocomial infections. Readmission is another example of outcome measure that is notmeticulously reported in surgical series. This outcome is an indicator not only of postoperative complications beyond the surgical hospitalization, but also of meticulous postoperative follow-up and presence (or absence) of disutility of care. Beyond performing on target for every one of these metrics, performing on target for every metric for every patient will become the goal and therefore synonymous with “optimal surgery” or “optimal surgical episode of care.” The Geisinger ProvenCare coronary artery bypass graft program is an example of this concept. Surgeons reviewed societal guidelines and translated them into 40 discrete steps that could be verified throughout the care process. Initially, only 59% of patients received all 40 evidence-based best-practice components. After these steps were embedded into the workflow, with alerts being sent if a step was incomplete, program compliance reached 100%. In the present series, an optimal surgical care episode, with satisfaction of all 9 key outcome measures, was achieved in 5% of patients in Group 1 and 31% of patients in Group 2 (p = 0.034). As noted in various experiences with care-bundle practices and system-wide quality improvement initiatives, “optimal surgical care” is a much more challenging goal than satisfaction of individual criteria.

Avenues for Future Improvement

Enhanced Recovery After Surgery Perioperative Management Protocols. Enhanced recovery after surgery (ERAS) perioperative protocols are multimodal and multidisciplinary perioperative care pathways that establish evidence-based best practices throughout the patients’ entire care episode including preoperative, intraoperative, and postoperative phase of care. The ERAS perioperative protocols, as well as the Fast-track postoperative protocols, combine various anesthesia techniques, minimally invasive techniques, optimal pain and nausea control, and rapid postoperative rehabilitation including enteral hydration, nutrition, and ambulation. Ultimately, all measures aim to achieve a rapid, uncomplicated recovery with minimal stay in the ICU or, if possible, direct transfer to the floor on the same day of surgery if patients satisfy pre-established criteria. Although numerous surgical specialties have adopted ERAS and Fast-track protocols for various ambulatory and inpatient surgeries, the literature
attesting to their current use in an adapted form to neurosurgical cases is scarce.\textsuperscript{3,4,6,10,33} A few studies have reported that outpatient brain tumor surgery, spinal decompression, and carotid endarterectomy are safe and feasible in selected patients.\textsuperscript{3,4,6,10,33} A comprehensive assessment of the applicability of an ERAS-like perioperative protocol for neurosurgical procedures is lacking.

**Diagnosis-Specific Clinical Pathways.** Like other institutions, UCLA has developed and uses standardized order sets for admissions with specific diagnoses (for example, subarachnoid hemorrhage or intracranial hemorrhage) and for postoperative management of patients undergoing elective surgery (for example, postoperative admission to the ICU following a craniotomy). The use of order sets allows standardization of postoperative care for any patient who underwent an elective craniotomy. Clinical pathways, on the other hand, are disease-specific. These care frameworks aim to achieve a specific outcome over a set time period.\textsuperscript{2,7} Any discrepancy between the expected and actual outcome should result in identification of the problem, proposing solutions to remedy the deviation, and resolution of the problem.\textsuperscript{2} The implementation of improvement processes and measuring resultant outcomes throughout the care episode has demonstrated that an “optimal surgery” or “optimal surgical care episode” is an achievable goal in neurosurgery. The next step is to minimize heterogeneity of care and achieve an “optimal surgery” in all patients undergoing MVD. Developing a multidisciplinary and multifaceted clinical pathway specific for patients with trigeminal neuralgia and hemifacial spasm undergoing surgery will establish exactly what is expected for this patient population from the preoperative period through the initial postoperative period (postoperative Days 0–2), to outpatient postoperative follow-up regarding laboratory tests, hydration and nutrition, pain and nausea management, ambulation, elimination, medication education, and so forth. Reviewing the clinical pathway with patients and their families in clinic prior to surgery is important to set postoperative expectations and engage patients in their care.\textsuperscript{28,30,32}

**Conclusions**

In summary, we report how a comprehensive implementation of improvement processes across the episode of surgical care by an engaged multidisciplinary team and meticulous measurement and monitoring of key processes facilitated improvement of the value of care delivered to patients undergoing a neurosurgical procedure, using the MVD as an example in this study. Implementing multiple processes addressing care throughout the continuum of care as well as reviewing opportunities to improve the surgical technique resulted in an improvement of global outcome with maintenance of a zero mortality rate and high degree of symptom resolution, reduction in the average preincisional preparation time, decrease in the average surgical procedure time, decrease in the average total OR time, decrease in the mean and median overall LOS, decrease in the mean LOS on the floor, and reduction of complications and the number of readmissions. We propose to evaluate the adaptability of the ERAS perioperative protocols to neurosurgery and elaborate diagnosis-specific clinical pathways as next steps to achieve an “optimal surgical episode of care” and optimal care value in every case. Delivering better health is inherently cost-effective. Potential cost savings related to these outcome improvements will be important to monitor as insurance reimbursement will reward practices that deliver the best care value.

**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. Conception and design: Martin, McLaughlin. Acquisition of data: McLaughlin, Buxey, Chaw. Analysis and interpretation of data: Martin, McLaughlin, Buxey. Drafting the article: McLaughlin, Buxey. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Administrative/technical/material support: Buxey, Chaw. Study supervision: Martin.

**References**

experience at the Barrow Neurological Institute. Stereotact Funct Neurosurg 73:131–133, 1999


29. Pollock BE, Stein JK: Surgical management of trigeminal neuralgia patients with recurrent or persistent pain despite three or more prior operations. World Neurosurg 73:523–528, 2010


Manuscript submitted April 2, 2013.
Accepted September 30, 2013.
Please include this information when citing this paper: published online November 29, 2013; DOI: 10.3171/2013.3.JNS13663.
Address correspondence to: Neil A. Martin, M.D., Department of Neurosurgery, David Geffen School of Medicine at UCLA, Ronald Reagan UCLA Medical Center, 757 Westwood Plaza, Ste. 6236, Los Angeles, CA 90095-7436. email: neilmartin@mednet.ucla.edu.

N. McLaughlin et al.