MEDICAL organizations, subspecialties, and the federal government are placing increasing emphasis on quality control initiatives to improve patient care.4 Many of the outcome measures used to measure quality are derived from administrative, billing, and clinical databases. These databases are useful because they contain a large quantity of clinical and socioeconomic determinants, which have long been recognized to be relevant to outcome. They also allow quick access to information for a large number of patients, allowing for relatively convenient statistical analysis. However, no matter how comprehensive a database is, it almost always fails to capture all possible clinical scenarios where medical treatment and outcome may vary widely. For example, even if all patients in a series have "hydrocephalus," the etiology and management may differ widely between patients. Therefore, physician participation in quality measure development and utilization remains essential to ensure the accuracy and relevance of these quality measures.

Herein, we report our experience in establishing a quality measure for cases involving patients undergoing pediatric neurosurgical procedures. Specifically, we return to system within 30 days of pediatric neurosurgery

Clinical article

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Object. Quality assessment measures have not been well developed for pediatric neurosurgical patients. This report documents the authors' experience in extracting information from an administrative database to establish the rate of return to system within 30 days of pediatric neurosurgical procedures.

Methods. Demographic, socioeconomic, and clinical characteristics were prospectively collected in administrative, business, and operating room databases. The primary end point was an unexpected return to the hospital system within 30 days from the date of a pediatric neurosurgical procedure. Statistical methods were used to identify clinical and demographic factors associated with the primary end point.

Results. There were 1358 pediatric neurosurgical procedures performed in the Children's Healthcare of Atlanta operating rooms in 2012, with 37.4% of these surgeries being preceded by admissions through the emergency department. Medicare or Medicaid was the payer for 54.9% of surgeries, and 37.6% of surgeries were shunt related. There were 148 unexpected returns to the system within 30 days after surgery, and in 109 of these cases, the patient had a presenting complaint that was attributable to the index surgery (related returns). The most common complaints were headache, nausea, vomiting, or seizure after shunt revision or cranial procedures (n = 62). The next most common reason for re-presentation was for wound concerns (n = 30). Thirty-seven of the 109 related returns resulted in a re-operation. The monthly rate of related returns was 8.1% ± 2.5% over the 12-month study period. When using related returns as the dependent variable, the authors found that patients who underwent a shunt-related surgery were both more likely to unexpectedly return to the system (OR 1.86, p = 0.008) and to require surgery upon readmission (OR 3.28, p = 0.004). Because an extended hospitalization shortened the window of time for readmission after surgery, extended length of stay was protective against return to system within 30 days of surgery. Importantly, if related and unrelated returns were analyzed together as the dependent variable (n = 148), no independent clinical and demographic risk factor could be identified.

Conclusions. Quality assessment measures need to be clearly and carefully defined, as the definition itself will impact the analytical results. Clinicians must play a leading role in the development of these measures to ensure their clinical meaningfulness.

Abbreviations used in this paper: ACS = American College of Surgeons; CPT = Current Procedural Terminology; ICD-9 = International Classification of Diseases, Ninth Revision; ICU = intensive care unit; NSQIP = National Surgical Quality Improvement Program.

Key Words • hospital readmission • pediatric neurosurgery • quality control • administrative claims data
evaluate the measurement of returning to system within 30 days of surgery. This is a measure that was developed and used by the pediatric version of the American College of Surgeons National Surgical Quality Improvement Program (ACS NSQIP Pediatric). We identified and defined necessary elements within our administrative database to establish this measurement. Statistical analysis was used to identify clinical and demographic risk factors associated with an unexpected return. Important lessons were learned in the process and are discussed.

Methods

Study Population

Pediatric Neurosurgical Associates at Children’s Healthcare of Atlanta serves the Atlanta metropolitan area of 4.5 million residents. In 2012, 1358 procedures in 996 patients were performed in the operating rooms by 5 fellowship-trained pediatric neurosurgeons and 2 pediatric neurosurgical fellows. Data related to patient demographics, clinical characteristics, surgery, and emergency room visits were prospectively captured in various Epic applications (Epic Systems Corp.). Specific Epic products included ASAP (emergency department application), Op-Time (surgical application), EpicCare Inpatient (universal hospital system), EpicCare Ambulatory (outpatient medical record application), and ADT (inpatient and outpatient admission-discharge-transfer application). Data from the above individual databases was then merged into a single operational database on an Oracle platform (Oracle 11g).

Patient visits to the hospital system were represented in a sequential manner in the database. The database was queried for the next hospital visit after a pediatric neurosurgical procedure. Data fields related to the index surgery and the next hospital visit were then gathered for correlation analysis.

Data Field Definitions

“Visit” was defined as a single span of time that a patient is at the hospital system. It may encompass several departments of contacts or multiple hospital accounts.

“Index surgery” was defined as a procedure performed within the operating room at Children’s Healthcare of Atlanta in 2012. Every index surgery is captured as a visit to the hospital system and as an entry to the operating room database. Procedures that occurred outside of the operating room were not included.

“First department” was defined as the patient’s first department during their visit. Examples include emergency, surgery, or radiology departments.

“Financial class” was defined as the financial class of the hospital account. This specifies whether a hospital account is a Medicare or Medicaid or managed care account.

“Procedure comments” refers to comments from a surgeon’s description of the procedure entered into a free text section in the operating room database. In our database, this section is never left blank.

“Return to system within 30 days of procedure” indicates a return visit to the hospital system within 30 days from the date of index surgery. This includes both planned and unplanned admissions.

“Cranial procedure” represents an index surgery for which a text search of Current Procedural Terminology (CPT) code descriptions or procedure comments for “craniotomy,” “craniectomy,” or “cranioplasty” yields a positive identification.

“Shunt-related procedure” refers to an index surgery for which text search of CPT code descriptions or procedure comments for “shunt” yields a positive identification.

“Length of stay” was calculated from visit start and stop dates and times. An outpatient surgery patient would have a length of stay of 1 day.

“Chief complaint” refers to a free text description of the patient’s chief complaint entered by the triage nurse when the patient first presented to the emergency department or urgent care center.

Statistical Method

The statistical analysis was performed using IBM SPSS Statistics version 20. Associations between dichotomous variables were analyzed by means of Fisher exact test. Binary logistic regression analysis was used to assess whether significant risk factors identified from univariate analysis independently contributed to the increased hazard of dependent variables. A tolerance statistic below 0.20 was considered to reflect colinearity. A 2-tailed p value less than 0.05 was considered statistically significant.

Results

Baseline Characteristics of the Procedures

There were 1358 neurosurgical procedures performed in the operating theater in 2012 (excluding 14 procedures in 11 patients who died prior to discharge). Five hundred eight surgeries (37.4%) occurred after the patient was admitted through the emergency department. Medicare or Medicaid was the payor for 745 surgeries (54.9%). In 167 admissions, patients underwent more than 1 surgical procedure during the admission. Six hundred seventy-five surgeries (49.7%) were associated with admissions to an intensive care unit (ICU) (including neonatal, cardiac, and pediatric ICUs) either before or after the surgery. Patients remained intubated after 278 surgeries.

The length of hospital stay followed an exponential distribution with a long tail. The mean hospital stay was 12.1 days, but the median length of stay was 3 days. The length of stay for 532 (39.2%) of the 1358 surgeries was 2 days or less. Two hundred fifty-five surgeries (16.6%) were associated with a length of stay of 14 days or longer. Similarly, the length of ICU stay followed an exponential distribution. The average ICU stay was 2 days or less in 308 of the 675 surgeries, and 140 surgeries were associated with a stay of 14 days or more.

The 10 most common ICD-9 (International Classification of Diseases, Ninth Revision) codes associated with the index surgery are listed in Table 1. These 10 codes accounted for only 687 (50.6%) of the 1358 admissions. Mechanical complication of nervous system device, implant, and graft (996.2) was by far the most commonly used code (n = 330), followed by obstructive hydrocephalus (351.4, n = 72).

Two methods were devised to identify patients who evaluated return to system.
underwent shunt-related surgery without resorting to manually reviewing each operative report. In one method, patients with CPT codes between 62190 and 62258 were flagged as having undergone shunt-related surgeries. In the other, the surgery was flagged as shunt related when a text search of CPT code description or procedure comments for “shunt” yielded a positive result. The 2 methods agreed in 84.8% of cases as shown in Table 2.

Unexpected Return Visits Related to Neurosurgical Issues

There were 148 unexpected returns to the system within 30 days of the index surgery. Most of the unexpected returns were evaluated in the emergency department, but they also included inpatient transfers from another hospital and admissions from the clinic during postoperative follow-up visits. Not all visits to the emergency department resulted in admissions to the hospital.

These 148 return visits included both related and unrelated returns (returns for reasons that may or may not be related to the index surgery). All 148 cases were reviewed by a nurse practitioner with 10 years of pediatric neurosurgical experience (C.B.) and an attending physician (J.J.C.). The following guideline was generally, but not strictly, followed. A visit was categorized as a “related” visit when the presenting chief complaint was 1) a complaint of headache, nausea, vomiting, or seizure-like activity after a shunt or craniotomy operation; 2) fever; or 3) any wound-related concern; or 4) if the word “shunt” appeared in the chief complaint portion of the emergency department database.

The chief complaints for related returns are listed in Table 3. Headache, nausea, vomiting, and seizure-like activity were the most commonly reported symptoms. One hundred nine of these visits were deemed to be related to the index surgery (related returns). Planned readmissions (planned by the neurosurgical or other services, n = 21) were considered to be unrelated returns. For example, a child who underwent a previously scheduled tooth extraction within 30 days after a shunt revision was deemed to have an unrelated return. In another example, a failed attempt at baclofen pump implantation was followed by another successful attempt 2 weeks later. This was considered to be unrelated as well. Neurosurgical procedures were required in 37 of the 109 related returns.

Statistical Analysis

All of the index surgeries were considered in the statistical analysis (n = 1358). The rate of return visits was calculated as a monthly rate. The monthly rate of all unexpected returns was 10.9% ± 3.6%, and the monthly rate of related returns was 8.1% ± 2.5%. The monthly rate of return to operating room was 2.8% ± 1.3%.

A contingency table was used to analyze the number of returns for each individual surgeon; no statistically significant difference was observed. Univariate analysis was used to identify risk factors associated with all returns to the system, related returns, or a return to the operating room. Notably, length of stay, craniotomy procedures, and ICU stays were all consistent in exerting a protective effect against unexpected returns (OR < 1.0), while shunt-related procedures, identified through either of the methods described above, correlated with a higher likelihood of returns (Table 4).

Multivariate logistic regression models were constructed based on these 4 factors. When the dependent variable included both related and unrelated return visits to the system, no independent risk factors were identified (Table 5). When the dependent variable was restricted to related returns or reoperations, shunt-related surgery was associated with a higher likelihood of unexpected returns and reoperation. Moreover, length of stay exerted a pro-

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>No. of Admissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>348.0</td>
<td>cerebral cysts</td>
<td>29</td>
</tr>
<tr>
<td>348.4</td>
<td>compression of brain</td>
<td>55</td>
</tr>
<tr>
<td>756.0</td>
<td>congenital anomalies of skull &amp; face bones</td>
<td>53</td>
</tr>
<tr>
<td>V53.09</td>
<td>fitting &amp; adjustment of other devices related to nervous system &amp; special senses</td>
<td>23</td>
</tr>
<tr>
<td>996.63</td>
<td>infection &amp; inflammatory reaction due to nervous system device, implant, &amp; graft</td>
<td>32</td>
</tr>
<tr>
<td>345.41</td>
<td>localization-related (focal) (partial) epilepsy &amp; epileptic syndromes w/ complex partial seizures, w/ intractable epilepsy</td>
<td>25</td>
</tr>
<tr>
<td>996.2</td>
<td>mechanical complication of nervous system device, implant, &amp; graft</td>
<td>330</td>
</tr>
<tr>
<td>331.4</td>
<td>obstructive hydrocephalus</td>
<td>72</td>
</tr>
<tr>
<td>742.59</td>
<td>other specified congenital anomaly of spinal cord</td>
<td>40</td>
</tr>
<tr>
<td>V57.89</td>
<td>other specified rehabilitation procedure</td>
<td>28</td>
</tr>
<tr>
<td>total</td>
<td></td>
<td>687</td>
</tr>
</tbody>
</table>

* Values represent numbers of shunt-related surgeries.
Return to system after surgery

TABLE 3: Chief complaints for the emergency department visit after pediatric neurosurgical procedures

<table>
<thead>
<tr>
<th>Chief Complaint</th>
<th>No. of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>headache/nausea/vomiting/seizure</td>
<td>62</td>
</tr>
<tr>
<td>fever</td>
<td>6</td>
</tr>
<tr>
<td>wound concerns</td>
<td>30</td>
</tr>
<tr>
<td>other</td>
<td>11</td>
</tr>
</tbody>
</table>

tective effect that was independent of ICU stays or craniotomy procedures (Table 5).

Discussion

Quality Measure From ACS NSQIP Pediatric

Quality measures are becoming an increasingly important part of modern medicine and are now being used to evaluate the performance of individual physicians, physician groups, and health care systems. While quality measures for pediatric neurosurgical procedures are still under discussion within our professional organizations, the ACS had proposed a system of prospective assessment of specialty-specific surgical outcomes in children. This has been named the “American College of Surgeons National Surgical Quality Improvement Program Pediatric” (ACS NSQIP Pediatric). Phase 1 of the ACS NSQIP Pediatric was implemented in 4 children’s hospitals in 2008, and preliminary results were reported in 2011. In that report, data pertaining to 3315 procedures were collected, including procedures from general surgery, otolaryngology, orthopedics, urology, neurosurgery, and plastic surgery. Postoperative complications occurred in 231 cases (overall complication rate 7.0%). Among the 3315 procedures, 368 were neurosurgical, and 68 of these were associated with complications (18.5%). This complication rate was the highest among all subspecialties, with plastic surgery having the second-highest rate (9.3%). Three of the top 5 most commonly reported CPT codes for neurosurgical procedures were shunt related (CPT codes 62223, 62230, and 62225). These codes accounted for 23.1% of the cases. The data were audited by experts from each field to ensure accuracy.

One of the 32 postoperative variables for which data were collected in ACS NSQIP Pediatric was “readmission for any reasons within 30 days of principal procedure.” Children’s Healthcare of Atlanta is one of the contributing members to the ACS NSQIP Pediatric, and data collection was formally initiated in January 2012. In October 2012, the 5 partners of Pediatric Neurosurgery Associates were asked to review the data with the focus on the readmission rate within 30 days of the procedure.

Improving Upon the ACS NSQIP Data

Several problematic areas were identified after a careful review of our institutional data in the ACS NSQIP Pediatric format. First, a substantial number of patients were admitted for reasons unrelated to the index proce-
Adjudication of Related Versus Unrelated Return

In this study, we manually reviewed neurosurgical patient returns within 30 days of index surgery. As reported in Table 5, we determined that no independent risk factors could be identified when the studied patient population was heterogeneous, without distinction between related and unrelated returns. This is a significant negative finding; it validates the focus of current literature that argues that administrative data without proper review by content experts often overestimate the rate and the significance of returns.1,2,8

For 2 groups of patients, returns were deemed to be “unrelated”: patients who returned for staged surgery and patients whose presenting chief complaint was not neurological in nature. While the former group was relatively easy to identify, the identification of the latter was to some degree subjective (but based on clinical knowledge). For example, a return of a patient who presented to the emergency department with constipation after a tethered cord release was deemed to be “related,” but such a return would be “unrelated” if it occurred after a craniotomy. In this study, we provided a general guideline to determine “relatedness” that encompassed 98 of unexpected 127 returns (Table 3, excluding planned readmission). Therefore, 29 (22%) of 127 cases were disputable, which was not an insignificant proportion. Of these 29 returns, 11 were deemed to be related and 18 not. Obviously, a prospectively determined, comprehensive and easy-to-use set of rules would be desirable, but one can also imagine the difficulty in setting these rules, as there are at least dozens of clinical scenarios that need to be considered.

TABLE 5: Multivariate analysis of risk factors associated with 3 possible outcome measures

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Independent Risk Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>any return (n = 148)</td>
<td>none</td>
</tr>
<tr>
<td>related return (n = 109)</td>
<td>length of stay: 0.002 (OR 0.933, 95% CI 0.893–0.975)</td>
</tr>
<tr>
<td></td>
<td>shunt-related procedure: 0.008 (OR 1.857, 95% CI 1.179–2.924)</td>
</tr>
<tr>
<td>reoperation (n = 37)</td>
<td>length of stay: 0.030 (OR 0.905, 95% CI 0.826–0.980)</td>
</tr>
<tr>
<td></td>
<td>shunt-related procedure: 0.004 (OR 3.276, 95% CI 1.450–7.398)</td>
</tr>
</tbody>
</table>

Conclusions

The monthly rate of return to system within 30 days of surgery was 8.1% ± 2.5%, and the rate of reoperation was 2.8% ± 1.3%. This study demonstrates that return to system after a pediatric neurosurgical procedure is related not only to clinical factors but also to the methodology of data collection and analysis. Although quality measures are an important tool for evaluating quality of care, they must be used judiciously to avoid obtaining misleading results.
Return to system after surgery

rial 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: Chern. Acquisition of data: Riemenschneider, Hirsh. Analysis and interpretation of data: Chern, Riemenschneider, Braender. Drafting the article: Wrubel, Miller. 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: Chern. Statistical analysis: Riemenschneider.

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