Abstract

Background: Standardized pediatric hospitalist and orthopaedic co-management of spinal fusion patients may improve quality processes and outcomes. This approach has not been studied in a general academic center.

Objective: Estimate relative effects and feasibility of the interventions on quality outcomes, length of stay (LOS), catheter-acquired urinary tract infections (CAUTI), medication errors, and pain scores.

Design and Setting: Retrospective cohort using interrupted time series, analyzing data from 83 patients aged 5 to 18 years admitted for posterior spinal fusion (PSF) in 2009 (N = 27), 2010 (N = 28), and 2011 (N = 28) on a children’s service at a general academic tertiary care center.

Interventions: Multimodal approach to standardizing pediatric PSF postoperative care with interdepartmental development of order sets, clinical care guidelines, and routine pediatric hospitalist co-management of all pediatric PSF patients.

Measurements: Chi-square analysis of order set use, guideline use measured by proxy medication and documentation data. ANOVA for comparison of CAUTI and medication error rate and multivariate linear regression of LOS and pain scores.

Results: Pediatric hospitalist co-management documentation increased from 64% to 80%. Guideline use increased from 40% to 79%, and order set use was < 15%. CAUTI and medication error ratios remained low. Adjusted mean LOS decreased by 0.8 days (p = 0.039, 95% CI 0.7, 1.1). Pain scores did not differ.

Conclusion: Interdisciplinary, clinical guideline development and postoperative co-management significantly decreased hospital LOS in pediatric PSF patients. In a general academic medical center, this change may be attributed to a pediatric hospitalist academic team, a universal co-management process with well-communicated roles, and a pediatric hospital-based physician development of and adherence to standardized practice.

Children and younger adolescents, particularly those with underlying medical conditions, have potential sequelae and protracted recovery patterns from spinal fusion surgery that can differ from adults. Their care is further challenging because while spinal fusion is a common surgery affecting 11,000 children each year, there are no consensus evidence-based guidelines on pediatric postoperative spinal fusion management. In many institutions, the majority of pediatric spinal fusion postoperative management occurs on mixed medical-surgical units, managed by surgical housestaff with varying levels of pediatric skills and knowledge.

Previous studies have suggested that pre- and postoperative medical co-management of high-risk pediatric spinal fusion and other orthopaedic patients improves quality outcomes like length of stay and readmission rates.
There remains a debate about the role of hospitalists in the care of routine elective procedures on otherwise healthy patients. Among elective orthopaedic procedures in adults, medical hospitalist use decreased length of stay (LOS), improved patient satisfaction, and decreased overall complications.6,7

Outside of a children’s hospital, postoperative management with both orthopaedic and pediatric co-management is anecdotally successful, but this practice has yet to be extensively evaluated.8,9

In particular, implementation of a robust, pediatric hospitalist academic team, universal co-management process with written guidelines, collaborative management guidelines, and order set development have not been explored as a comprehensive approach to improving quality process and outcomes for pediatric posterior spinal fusion (PSF) patients.

Prior to September 2009, PSF patients on the medical surgical unit at our academic tertiary care center were managed independently by the orthopaedics service, with pediatric housestaff following PSF patients but without consistent, documented pediatric attending hospitalist supervision. This resulted in variability in frequency and degree of attending pediatric hospitalist involvement as well as strategy, although the pediatric hospitalist service was explicitly consulted if a PSF patient had significant comorbid conditions. For most otherwise healthy, idiopathic PSF patients, there was no consistent approach to postoperative co-management nor was there effective communication of care plans between the pediatric housestaff and attending orthopaedic surgeons or orthopaedic housestaff. Notably, due to the many responsibilities throughout the hospital, it was difficult for orthopaedic housestaff to respond quickly to lower-acuity and routine patient care concerns, although overall care and surgical results were very good.

The goal of the intervention was to collaborate across disciplines to standardize and improve care for PSF patients. We hypothesized that universal, comprehensive pediatric hospitalist and surgical co-management for all pediatric PSF patients would improve quality outcomes, including decreasing LOS, medication error rates and CAUTI, and improving pain management. We also hypothesized that all components of pediatric hospitalist-surgical co-management (order sets; guidelines; or explicit collaboration and communication between services, particularly communication between attending physicians) would be associated with improvements in care.

**Methods**

**Design and Population**

To examine the effects of any potential intervention on improving quality of care, we used retrospective cohort using interrupted time series10 to examine successive annual cohorts of pediatric patients aged 5 to 18 years old undergoing PSF at a general academic tertiary care center during May to September who received care on the pediatric medical-surgical floor. Subjects were identified based on admission diagnosis (*International Classification of Disease, 9th Revision, Clinical Modification* 737.x or 743.x). We excluded patients who were admitted for any reason other than primary PSF. This study was approved by New York University (NYU) School of Medicine Institutional Review Board. The need for informed consent was waived.

**Setting**

NYU Langone Medical Center’s Tisch Hospital is a 705-bed urban academic hospital with a 32-bed pediatric medical-surgical unit caring for patients younger than 19 years old. Most postoperative pediatric spinal fusion patients are initially admitted to the pediatric intensive unit and, depending on disposition and bed availability, are subsequently transferred to the medical-surgical floor as a primary patient of either the pediatric orthopaedics or orthopaedics-spine service. Prior to October 2009, there was as-needed co-management by the pediatric hospitalist and housestaff. Pediatric hospitalists are in-house during the day. The hospitalist group includes two hospitalists who cover the unit 75% of the time, with four others providing the remaining coverage throughout the year. The pediatric department floor team consists of the hospitalist, a third-year pediatric resident, two pediatric first year residents, and three to four medical students. Orthopaedics attending and housestaff round on pediatric patients twice daily, but the majority of their obligations are on other floors or in the operating room.

**Planning and Implementing the Intervention**

The pediatric hospitalist service, consisting of a pediatric hospitalist and pediatric housestaff, began co-management of PSF patients in September 2009 (Fig. 1). In 2010, orthopaedics division chiefs, Department of Pediatrics leadership, pediatric intensivists, and pediatric hospitalists had formal discussions as well as development of formal written guidelines codifying the implementation of universal co-management roles and responsibilities. By May 2010, co-management by surgical and hospitalist teams was universal with clearly defined roles and responsibilities. The orthopaedics team was responsible for all direct wound and rehabilitation-related issues, such as wound care, drains, and physical therapy orders. The pediatric hospitalist service was responsible for all other medical needs, including pain management, bowel regimen, and management of underlying comorbid medical conditions. Decisions regarding fever evaluation, severe anemia, and ketorolac use were jointly discussed, but the orthopaedics, as the primary service, remained responsible for the ultimate decision.

Those interdepartmental discussions led to development of postoperative spinal fusion guidelines and an electronic medical record order set to standardize postoperative care across orthopaedic services. These admission order sets would be used by the orthopaedics as the primary service. Pediatric hospitalists, intensivists, critical care, and floor
nursing leadership reviewed and contributed to these guidelines and order sets, in conjunction with two different orthopaedic divisions. Based on the literature and consensus exert opinion, pediatric physicians agreed to use daily polyethylene glycol for bowel regimen with or without docusate or senna.

Guidelines and order sets were rolled out among the orthopaedic housestaff by orthopaedic faculty in 2010 via personal communication. Order sets were listed under “pediatric orthopaedics.” These were reinforced in didactic format in October 2010 and July 2011 by pediatric hospitalist faculty. Simultaneously, these guidelines were introduced among pediatric housestaff in lecture format in October 2010, posted on the online learning portal, and reinforced during bedside rounds on the medical-surgical unit by pediatric hospitalist and pediatric intensivist attending physicians. Nurses in both the pediatric intensive care and medical-surgical units were provided with in-service training about the order sets and guidelines.

Neither housestaff nor attending physicians received personal incentives to improve throughput during the study period.

Methods of Evaluation
Process Outcomes
Change in collaborative relationship between orthopaedic and pediatric services was assessed qualitatively by written agreements and ongoing nursing report of collaboration. Quantitative process outcome was measured by orthopaedic housestaff order set use in 2010 and 2011. Proxy for guideline use was timing and presence of polyethylene glycol order. Pediatric hospitalist co-management was measured by clinical documentation, defined by either attending progress note or co-signing a pediatric housestaff progress note on over 75% of inpatient days, excluding day of transfer and discharge.

Clinical Outcomes
Measurement of clinical outcomes potentially affected by these interventions was conducted by retrospective data collection. Data was collected from charts of guideline-eligible pediatric patients between 5 and 18 years of age with a procedure code of spinal fusion in June 2009 to September 2009 and were compared with those patients who met the same criteria in June to September periods in 2010 and 2011. This time interval was chosen because it oversamples otherwise healthy patients with idiopathic scoliosis. Data collectors were two trained pediatric housestaff using a standardized data extraction tool. Data quality was assured by pediatric faculty supervisor (RR) who reviewed 50% of total charts for accuracy of diagnosis and hospitalist involvement. Secondary outcomes included medication error rates; mean pain scores POD2 and POD3, and catheter acquired urinary tract infection (CAUTI).

Medication errors were defined as weight-based opiate or antibiotic dosing ± 10% recommended standard dosing.
per Lexi-Comp. A pediatric clinical pharmacist reviewed all orders for these medications. Medication error rates were errors per order per patient.

Pain scores (Wong-Baker FACES, FLACC, or numeric, as per institutional protocol) were collected from the nursing flowsheet with pain scores averaged for each patient for the 24 h to 48 h postoperative period in 2009 and 2011, such that postoperative day 2 was the second 24 h after close of case. Data was available for 23/27 (85%) and 26/28 (26%) of patients, respectively. Median number of data points for each patient was 2 for POD2 and POD3.

CAUTI were assigned based on review of all laboratory results with symptoms for each patient as defined by Centers for Disease Control. Demographic variables collected included age, gender, and race and ethnicity. Other variables included body mass index, number of vertebrae fused, etiology of scoliosis (idiopathic, neuromuscular, or other), and number of comorbidities, which were categorized as none, 1, or > 2.

**Statistical Analysis**

Cohort implementation sample characteristics were compared using Student’s t-tests for continuous variables and χ² analyses with Fisher’s exact test for categorical variables. Bivariate analyses were conducted between independent variables and outcomes using χ² analysis and MANOVA. Multivariate linear regression of log-transformed LOS was used to adjust for a priori dependent variables age, gender, and comorbidity.

**Results**

The 27 patients enrolled in 2009 were not significantly different from the 28 patients enrolled in 2010 or 2011 (Table 1) in age, sex, etiology of scoliosis, comorbidity status, body mass index, or vertebrae fused.

**Process Outcomes**

Among the three aspects of care improvement, both pediatric hospitalist co-management and pediatric-orthopaedist communication were reinforced with written agreements and facilitation of best means of communication between services by June 2010. There was more medical-surgical as well as medical-nursing collaboration and satisfaction anecdotaly reported by nursing management with explicit and well-defined involvement of the pediatric team for postoperative spinal fusion patients, rather than only specific patients. Uptake of order sets was low (Table 2). Pediatric hospitalist documentation increased from 64% to nearly 80% by 2011. Orders for polyethylene glycol, the proxy for guideline adherence, increased from 40% to 80%.

**Clinical Outcomes**

Mean and median LOS significantly decreased from 2009 to 2011 (Table 3). Cohen’s d comparing mean LOS for 2009

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographic and Clinical Data on Postoperative Spinal Fusion Pediatric Patients, June-September 2009-2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohort Year/Phase</td>
<td>2009</td>
</tr>
<tr>
<td>Total N</td>
<td>27</td>
</tr>
<tr>
<td>Female</td>
<td>77.8%</td>
</tr>
<tr>
<td>Average Age, Years (SD)</td>
<td>13.8 (2.7)</td>
</tr>
<tr>
<td>Race</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>44.4%</td>
</tr>
<tr>
<td>Black</td>
<td>37.0%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>14.8%</td>
</tr>
<tr>
<td>Other/Unknown</td>
<td>3.7%</td>
</tr>
<tr>
<td>Body mass index, kg/m² (SD)</td>
<td>21.8 (5.9)</td>
</tr>
<tr>
<td>Number of comorbidities</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>51.9%</td>
</tr>
<tr>
<td>1</td>
<td>18.5%</td>
</tr>
<tr>
<td>≥ 2</td>
<td>29.6%</td>
</tr>
<tr>
<td>Scoliosis etiology</td>
<td></td>
</tr>
<tr>
<td>Idiopathic</td>
<td>67.7%</td>
</tr>
<tr>
<td>Neuromuscular/Congenital</td>
<td>33.3%</td>
</tr>
<tr>
<td>Spinal Fusion</td>
<td></td>
</tr>
<tr>
<td>Mean number of vertebrae fused (SD)</td>
<td>11.0 (2.8)</td>
</tr>
</tbody>
</table>

*Incomplete self-identified race data.*
and 2011 data was 0.67, suggesting a medium effect size. Median LOS decreased from 5 d (IQR 3, 10) to 4 d (IQR 2, 8), p = 0.013. In multivariate linear regression of log-transformed LOS, adjusting for age, sex, and comorbidity, there was a significant decrease in LOS between 2011 and 2009 by 0.8 days, p = 0.039 (95% CI 0.7, 1.1) (Table 3).

Unadjusted mean pain scores on POD2 and POD3 were similar in 2009 and 2011 with Student’s t-test p = 0.071 (95% CI -0.8, 1.1) for POD2 and p = 0.972 (95% CI -1.35, 1.31) for POD 3.

Rates of CAUTI (0/1000 line days) and medication error (< 2%) were low in all three time periods and not statistically different.

**Discussion**

Our study demonstrates that pediatric hospitalist team co-management decreases LOS for PSF patients in a multidisciplinary, academic medical center. This quality improvement in hospital-based care can be accomplished with formal collaboration that includes explicit definition of role and responsibilities for all PSF patients, increased and consistent pediatric housestaff supervision by a pediatric hospitalist, and adherence to practice guidelines.

Previous studies evaluating pediatric hospitalist-surgical co-management have reported decreased LOS in PSF patients admitted to children’s hospitals as part of a comprehensive perioperative evaluation program for high-risk patients, with LOS improvements likely driven by tighter management of complex medical needs and issues.\(^5\) Our intervention focused on the postoperative medical management of spinal fusion as well as the stabilization of chronic medical problems. Medical care goals, which included the transition to oral pain management and optimization of bowel regimen, were emphasized in the guidelines as part of the pediatric hospitalist’s responsibilities and expertise. In contrast, surgical care goals, including assessment of safe ambulation and wound care, were constant pre- and post-guidelines, thus suggesting that the reduced LOS was mainly impacted by the medical care goals.

This study expands on previous work by demonstrating reduced LOS resulting from universal pediatric hospitalist service co-management of predominantly healthy SF patients in a general academic center. In this setting, there is variability in orthopaedic housestaff, pediatric experience and availability due to logistics, and the nature of residency training. Orthopaedic attending surgeons supported pediatric hospitalist team co-management. Role definitions, standards, and “backup” by supervising hospitalists may have contributed to more empowerment of the pediatric housestaff to address concerns raised by nursing, patients, and families, ultimately leading to expedited care.

In addition, in our setting, pediatric HS and pediatric

### Table 2

<table>
<thead>
<tr>
<th>Process</th>
<th>Metric</th>
<th>2009</th>
<th>Transition 2010</th>
<th>Ongoing 2011</th>
<th>Fisher’s exact test*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order set use</td>
<td>Percentage use for pediatric spinal fusions patients</td>
<td>N/A</td>
<td>9</td>
<td>13</td>
<td>ns</td>
</tr>
<tr>
<td>Guideline use</td>
<td>Percentage of patients with polyethylene glycol orders by POD 2</td>
<td>40.0</td>
<td>84.0</td>
<td>78.6</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Pediatric hospitalist team co-management</td>
<td>Proportion of patients with daily progress notes written or signed by pediatric attending &gt; 80% floor admission days</td>
<td>64.3</td>
<td>89.2</td>
<td>78.6</td>
<td>p &lt; 0.001</td>
</tr>
</tbody>
</table>

*Comparing 2009 to 2011.

### Table 3

<table>
<thead>
<tr>
<th>Process</th>
<th>Pre Transition</th>
<th>Ongoing</th>
<th>Unadjusted difference LOS, in d (95% CI)</th>
<th>p-value</th>
<th>Adjusted* difference LOS, in d (95% CI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>2009 27 Pre</td>
<td>Transition 2010 28</td>
<td>Ongoing 2011 28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean LOS, in d</td>
<td>-1.1 (-0.8, -1.1)</td>
<td>p-value</td>
<td>-0.9 (-0.8, 1.1)</td>
<td>p-value</td>
<td></td>
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<tr>
<td></td>
<td>unadjusted</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>(SD) 5.6 (1.6)</td>
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</tbody>
</table>

*LOS, independent variable, log-transformed for analysis then back-transformed for ease of interpretation, adjusted for patient age, sex, and comorbidity.
nurses have ongoing relationships as well as continual floor presence. Nurses can get a more rapid response and in-person assessments by physicians with whom they are familiar and who are readily available. In larger academic settings, nursing staff may prefer pediatric housestaff and hospitalist co-management models for surgical patients for these reasons.13

We had also hypothesized that all aspects of a multimodal approach, including order sets,14 would be successfully adopted and contribute to quality outcomes15: standardization of care, universal hospitalist co-management, and qualitatively improved collaboration. Minimal order set use, despite the labor intensive development and rollout process, likely reflects the technical shortfalls, including lack of appreciation for the end-user experience and lack of comprehensive involvement in the orthopaedic housestaff level. In particular, the technical decision to list the electronic order set in a pathway not typically used by orthopaedics rendered the order set less accessible. The pediatric hospitalist group was invested in developing the guidelines; subsequent consistent bedside teaching may explain why lack of explicit order set use, nevertheless, resulted in guideline adherence.

Other hospitalist-surgical co-management effectiveness research has been criticized for study design and emphasis on LOS without focus on other process and outcome measures.16 In this study, we attempted to evaluate both process and multiple outcomes, including CAUTI, medication error, and pain scores, and did not find significant differences over time, likely due to the low incidence of medication errors and CAUTI in this sample. Lack of improvement in pain scores was surprising but may in part reflect a methodological challenge in the retrospective collection of sufficient and standardized data points to accurately reflect a dynamic variable, such as pain. Further prospective research on postoperative pain control is needed.

Like many efforts to improve quality using interrupted time series design, it was not practically feasible in our small setting with a global intervention to randomize patients to a non-intervention arm.10,17 However, because we examined the data before, during, and after the transition, we are confident that at least some of the changes are due to the intervention and not exclusively due to unmeasured secular changes. We cannot exclude that changes in the orthopaedic outpatient management impacted LOS in some way, but pre-admission process in all three time periods did not change. Nationally, there has been a trend toward slightly shorter LOS (mean 6.8 to 6.5 days) from 2000 to 2009, but national data overlapping this study’s timeframe is not yet available.2

This study is the first to demonstrate the positive impact of pediatric hospitalist co-management of surgical patients (even for low-risk, healthy patients) in a general academic medical center. This is especially important as approximately 30% of children have surgery outside of children’s hospitals.2 We acknowledge that these findings may not be generalizable to all healthcare settings, and that freestanding children’s hospitals and non-academic medical centers may have different effects.

Pediatric hospitalist medicine is the fastest-growing field within pediatrics.18 There are ongoing debates about the role of pediatric hospitalists with surgical patients, and these roles vary based on the type of hosped and breadth and depth of pediatric care. Cost-effectiveness of pediatric hospitalist co-management for surgical patients merits further evaluation and specificity, given the various setting and responsibilities of hospitalists and the impact on quality measures. Nonetheless, reduced LOS translates into financial advantages for healthcare institutions, especially given a median national charge of $126,000 for spinal fusion in 2009 (mean cost = $50,000).2 Since more than 60% of children over 10 years of age are not admitted to children’s hospitals,2 further research regarding the relevance of pediatric hospitalist co-management of patients admitted outside of a specialized pediatric setting is warranted.

We conclude that co-management of postoperative PSF patients by pediatric hospitalist and orthopaedic teams reduces length of stay in both idiopathic and neuromuscular scoliosis patients, while maintaining low-to-negligible medication error and CAUTI rates in a multidisciplinary, academic medical center. Pediatric hospitalist supervision, interdisciplinary collaboration, and adherence to consensus guidelines improve quality outcomes for this population.

Disclosure Statement
None of the authors have a financial or proprietary interest in the subject matter or materials discussed, including, but not limited to, employment, consultancies, stock ownership, honoraria, and paid expert testimony.

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References


