Costs and complications of increased length of stay following adolescent idiopathic scoliosis surgery

Matthew R. Boylan[a], Aldo M. Riesgo[a], Alice Chu[a], Carl B. Paulino[b] and David S. Feldman[a,c]

Accelerated discharge protocols for scoliosis surgery have recently been described in the literature. There are limited data describing the association of length of stay (LOS) during the index admission with postoperative outcomes. We sought to define the economic and clinical implications of an additional 1 day in the hospital for scoliosis surgery. The Statewide Planning and Research Cooperative System database was used to identify patients with adolescent idiopathic scoliosis who underwent spinal fusion from 1 October 2007 to 30 September 2012 at high-volume institutions (>20 cases/year) in the state of New York. Regression models were adjusted for age, sex, race, insurance, comorbidity score, and perioperative complications during the index admission. Among the 1286 patients with AIS who underwent spinal fusion, the mean LOS was 4.90 days [95% confidence interval (CI) = 4.84–4.97; SD = 1.19]. In the perioperative period, 605 (47.05%) underwent transfusion and 202 (15.71%) had problems with pain control. An additional 1 day in the hospital was associated with $11 033 (95% CI = 7162–14 904; $P < 0.001$) in insurance charges, $5198 (95% CI = 4144–6252; $P < 0.001$) in hospital costs, 28% increased risk (odds ratio = 1.28; 95% CI = 1.01–1.63; $P = 0.041$) of all-cause 90-day readmission, and a 57% increased risk (odds ratio = 1.57; 95% CI = 1.13–2.17; $P = 0.007$) of returning to the operating room within 90 days. Increased LOS during the index admission scoliosis surgery is associated with higher costs and an increased risk of 90-day postoperative complications. Protocols to decrease LOS for this surgery have potential benefits to patients, hospitals, and insurers. Level of Evidence: Level III, retrospective comparative study. *J Pediatr Orthop B* **28:27–31**

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[a]Department of Orthopaedic Surgery, NYU Hospital for Joint Diseases, New York, [b]Department of Orthopaedic Surgery, SUNY Downstate Medical Center, Brooklyn, New York and [c]Division of Spine Surgery, Paley Orthopedic and Spine Institute, West Palm Beach, Florida, USA

Correspondence to David S. Feldman, MD, Paley Institute, 901 45th Street, Kimmel Building, West Palm Beach, FL 33407, USA
Tel: +1 561 844 5255 x310; fax: +1 561 844 5245;
e-mail: dfeldman@paleyinstitute.org

Introduction

Adolescent idiopathic scoliosis (AIS) is the most common indication for surgery on the spine in adolescents and young adults in the USA. Although most AIS patients are otherwise healthy, with good physiologic reserve, they typically require hospitalization for 4–9 days for surgery and postoperative medical stabilization [1,2]. Over the past decade, however, a number of studies have investigated the safety and efficacy of accelerated discharge protocols for common surgical procedures. In 1999, Healy *et al.* [3] reported on a clinical pathway for total hip arthroplasty that was associated with decreased length of stay (LOS) and lower hospital costs, with no difference in functional outcomes, patient satisfaction, or surgical complications. Several other studies have reported on the efficacy of accelerated discharge protocols, showing safety, cost efficiency, and improved quality [4–6].

With the Centers for Medicare and Medicaid Services implementing bundled payment initiatives for common medical and surgical conditions [7–9], there is increased interest in improving the quality and cost efficiency of common orthopedic procedures, including spinal fusion for AIS. Over the past decade, the hospital costs associated with AIS treatment have increased, whereas the incidence of and treatments for AIS have remained relatively constant [10,11].

Currently, however, there are limited data describing the association of LOS with outcomes of scoliosis surgery. To address this, we identified patients with AIS who underwent spinal fusion surgery in a large, multihospital, statewide healthcare database. Among this cohort, we assessed the following: (a) LOS for the primary surgical admission; (b) insurance charges and hospital costs associated with longer LOS; and (c) 90-day complications associated with longer LOS.

Patients and methods

Database

The New York Statewide Planning and Research Cooperative System (SPARCS) is a comprehensive healthcare data reporting system established by the New York State Department of Health (*https://www.health.ny.gov/statistics/sparcs/*). This database contains a census of all

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hospital admissions performed in the state of New York annually. Each record includes data on patient demographics, medical diagnoses, and surgical procedures. Hospital admissions utilize International Classification of Diseases, 9th revision (ICD-9, clinical modification) codes for both diagnoses and procedures. The database includes a unique encrypted identification code for each patient, which allows researchers to track patients across multiple encounters. Our version of the database did not contain any patient identifiers or protected health information, and therefore, this study was given an exemption from institutional review.

Cases

The study cohort consisted of 1286 patients who underwent scoliosis surgery in New York between 1 October 2007 and 30 September 2012. We initially identified 1871 patients between the ages of 10 and 21 years with a primary ICD-9 diagnosis code for adolescent idiopathic scoliosis (737.30) with a primary ICD-9 procedure code of spinal fusion surgery (81.00, 81.04, 81.05, 81.06, 81.07, 81.63, 81.64). We excluded 31 patients with a LOS less than 3 days, 94 patients with a LOS greater than 8 days, and 159 patients with an unknown number of levels fused. Some patients accounted for multiple exclusions; hence, this left the cohort with 1595 patients. As quality improvement protocols are more impactful at higher volume institutions, we then excluded 309 patients who had their surgery performed at a hospital with less than 100 cases during the 5-year study period (<20 cases/year), leaving the final cohort with 1286 patients.

Using ICD-9 procedure codes, we classified the number of levels fused as 4–8 (81.63) or 9 or more (81.64). We identified patients who underwent perioperative autologous transfusion (ICD-9 procedure 99.02) or allogeneic packed red blood cell transfusion (ICD-9 procedure 99.04). We also identified patients with problems with pain control (ICD-9 diagnosis 338.18). Medical complication included patients with cardiac (ICD-9 diagnoses 785.0, 458.29, 997.1, 458.9, 78.02, 998.0), pulmonary (ICD-9 diagnoses 518.0, 512.1, 511.9, 518.5, 997.39, 486, 799.02, 518.82, 507.0, 518.4, 786.03, 786.09, 786.1), gastrointestinal (ICD-9 diagnoses 560.1, 564.00, 997.4, 787.02, 564.09, 787.01, 787.03), and/or genitourinary (ICD-9 diagnoses 599.0, 788.20, 997.5, 788.30), or electrolyte (ICD-9 diagnoses 276.1, 276.2, 276.8, 275.41, 276.52) abnormalities.

Charges and costs

We extracted the charges billed by the hospital to the patient's insurance company for each admission. We adjusted all charges to 2015 US dollars using inflation rates provided by the Consumer Price Index. Hospital costs for each admission were derived using hospital inpatient cost transparency data provided by the New York State Department of Health. The cost-to-charge ratio was defined as the mean cost divided by the mean charge for each combination of patient-refined diagnosis-related group and severity of illness codes at each hospital in a given year. Cost-to-charge ratios were only available for the years 2009, 2010, and 2011; thus, we applied 2009 ratios to admissions in 2007 and 2008 and 2011 ratios to admissions in 2012.

Complications

Using the patient identification code, we then followed patients for 90 days after the date of discharge for their scoliosis surgery admission. Outcomes included all-cause readmission and return to the operating room. Primary ICD-9 diagnosis codes were used to identify patients with a readmitting diagnosis of hardware complication (996.49, 996.67, 996.78, 997.09) or wound complication (349.39, 998.12, 998.13, 998.32, 998.51, 998.59). A patient was only classified as returning to the operating room if he or she had a primary ICD-9 procedure code related to spinal fusion (03.02, 03.09, 03.59, 77.39, 77.69, 78.69, 81.00, 81.05, 81.07, 81.08, 81.37, 84.81, 86.74) or wound care (83.32, 83.39, 83.45, 86.04, 86.05, 86.22, 86.28).

Demographic covariates

Demographic variables for each admission, including age (in years), sex (male, female), race (white, nonwhite), insurance (private, other), and year of admission (2007–2012), were extracted. A composite comorbidity score was calculated using the Charlson and Deyo scoring method for ICD-9 coding.

Statistical analysis

We used means with 95% confidence intervals (CIs) and SD as well as medians with interquartile ranges (IQR) to describe the distribution of LOS, insurance charges, and hospital costs for admission for scoliosis surgery. Frequency tables and means were used to describe patient demographics and perioperative complications. We used linear regression modeling to determine the charges and costs associated with a 1-day increase in LOS for the primary admission. Charge and cost values in dollars were defined using the parameter estimate and 95% CI. We used logistic regression modeling to determine the risk of complication associated with a 1-day increase in LOS for the primary admission. Risk was defined by the odds ratio (OR) and 95% CI of readmission and return to the operating room. All regression models were controlled for age, sex, race, insurance, Charlson score, perioperative blood transfusion, perioperative pain, other perioperative complication, number of levels fused, and year of admission.

All statistical analyses were carried out using SAS version 9.4 (SAS Institute Inc., Cary, North Carolina, USA). All P values were two-tailed, and P value less than 0.05 was considered to be statistically significant.

Results

Among the 1286 patients in the cohort, the mean age was 14.53 years (95% CI = 14.41–14.66; SD = 2.25), 942 (73.25%) patients were female, 682 (53.03%) patients were nonwhite, and 1160 (90.20%) patients had private insurance. The mean Charlson comorbidity score was 0.17 (95% CI = 0.15–0.19; SD = 0.39). The number of levels fused was 9 or more for 828 (64.39%) patients and 4–8 for 458 (35.61%) patients. During admission, 605 (47.05%) patients underwent blood transfusion, 202 (15.71%) patients had problems with pain control, and 661 (51.40%) patients had a medical complication.

The mean LOS was 4.90 days (95% CI = 4.84–4.97; SD = 1.19) and the median LOS was 5.0 days (IQR = 4.0–6.0). Discharge occurred on day 3 for 95 (7.39%) patients, day 4 for 465 (36.16%) patients, day 5 for 386 (30.02%) patients, day 6 for 197 (15.32%) patients, day 7 for 99 (7.70%) patients, and day 8 for 44 (3.42%) patients.

The mean charges were \$162 815 (95% CI = 158 218–167 412; SD = 84 023) and the median charges were \$145 611 (IQR = 103 993–203 518). The mean costs were \$54 083 (95% CI = 52 942–55 224; SD = 20 861) and the median costs were \$49 990 (IQR = 40 870–64 618). Figure 1 for the mean charge and cost values according to the day of discharge. In regression models, an additional 1 day in the hospital was associated with \$11 033 (95% CI = 7162–14 904; $P < 0.001$) in charges and \$5198 (95% CI = 4144–6252; $P < 0.001$) in costs.

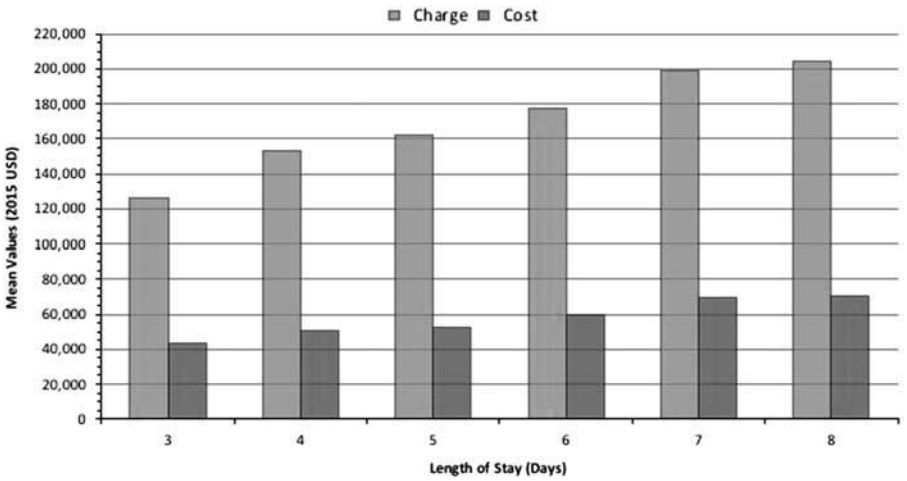
All-cause readmission within 90 days was recorded for 44 (3.42%) patients. The primary admitting diagnosis was hardware complication for seven (0.54%) patients and wound complication for 19 (1.48%) patients. In regression models, an additional 1 day in the hospital was associated with a 28% increased risk (OR = 1.28; 95% CI = 1.01–1.63; $P = 0.041$) of all-cause readmission. There were 22 (1.71%) patients who returned to the operating room within 90 days. The procedure was hardware related for 10 (0.78%) patients and wound related for 12 (0.93%) patients. In regression models, an additional 1 day in the hospital was associated with a 57% increased risk (OR = 1.57; 95% CI = 1.13–2.17; $P = 0.007$) of returning to the operating room (Fig. 2).

Discussion

For patients with severe adolescent idiopathic scoliosis, spinal fusion has low complication rates and good functional outcomes [12], although there is no consensus on perioperative management and goals for hospital discharge day. To our knowledge, no previous study has evaluated the association between LOS and perioperative outcomes of scoliosis surgery. Therefore, using a large sample of patients with AIS who underwent surgery at high-volume institutions in the state of New York over a 5-year period, we found that longer LOS was associated with higher costs and an increased risk of 90-day postoperative complications.

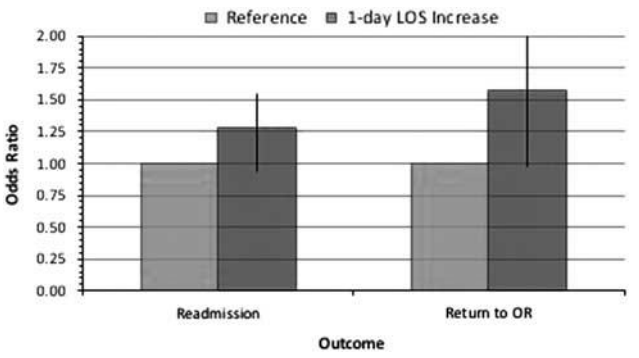
This study has several limitations that must be acknowledged. First, there are inherent limitations in using administratively coded data for outcome studies. We could not account for clinical variables including the specific number of levels fused, the indication for perioperative blood transfusion, and the perioperative pain management and physical therapy protocols used. We also could not identify the subset of patients undergoing revision fusion or two-stage procedures, or stratify according to potential confounders including patient BMI and pulmonary function. Second, cost values were derived from cost-to-charge ratios, and we lacked an

Fig. 1



The cost and charges of admission for scoliosis surgery are shown according to the patient's length of stay.

Fig. 2



For a 1-day increase in length of stay (LOS) during the index admission for scoliosis surgery, the odds ratio of 90-day readmission and return to the operating room (OR) is shown.

itemized bill of both costs and charges for the hospitalization. Third, we were only able to identify patients admitted within 90 days to a hospital in the state of New York. At the high-volume institutions that we investigated, patients often travel from outside states and countries for the primary surgery, and may be admitted to an outside hospital upon their return home. Fourth, we lacked data on the specific indication for reoperation and the severity of each complication. Finally, although LOS may directly increase the risk of perioperative complications such as wound infection, we suspect that this relationship is more complex and that LOS may serve as a marker of poorer patient medical condition before discharge.

In this study, the mean LOS was 4.90 days. The cohort in our study represents a diverse, yet representative sample of the pediatric population undergoing surgery for AIS, with a low Charlson comorbidity score, and the majority undergoing fusion of more than nine levels. The mean LOS is comparable to other previous studies [1,2,13].

An additional day in the hospital was associated with more than $11 000 of insurance charges and $5000 of hospital costs. Compared with the mean charges of $162 815 and the mean costs of $54 083, an early discharge by 1 day represented nearly 10% savings in total hospital costs. Although economic outcomes are not currently tied to reimbursement in the pediatric population, the changing focus in all of healthcare to provide value-based treatments will make our findings increasingly relevant to clinical practice.

Readmission is increasingly being used as an indicator for the quality of care that patients receive in the hospital and during the short-term postdischarge period [14,15]. We found that increased LOS during the index admission was associated with an increased risk of all-cause readmission and return to the operating room, even after adjusting for patient comorbidities and complications during the index hospitalization. Our overall readmission rate of 3.4% for scoliosis surgery is comparable to previous studies [13,16]. Furthermore, the most common cause of readmission was wound complication, which is also comparable to recently published studies [11,16]. Although wound complications and infection are multifactorial in etiology, they represent an attractive target to reduce readmissions, with the potential for significant cost savings. Previous studies have shown that LOS is associated directly with an increased risk of spinal infections and nosocomial infections, particularly in ICU [17–19]. With no increase in adverse outcomes or complications associated with earlier discharge, the ability to limit time spent in hospital has potential benefits related to nosocomial infections and related complications.

A recent single-institution study by Fletcher *et al.* [20] on discharge protocols for scoliosis surgery showed a 48% shorter LOS for patients in the accelerated pathway compared with the control group in the standard pathway. The rate of overall complications was significantly lower among the accelerated pathway patients (7.6 vs. 20.0%) and the rate of wound complications was also lower in the accelerated pathway (1.1 vs. 2.2%), although this difference did not reach statistical significance. These findings are generally consistent with our study [21], and the larger sample size of our study may account for differences in the significance of wound-related complications.

Conclusion

Orthopedic surgeons should be aware of the higher costs and increased risk of 90-day postoperative complications associated with an increased LOS following scoliosis surgery. Institutional protocols to decrease LOS have potential benefits to patients, hospitals, and insurers. In fact, a recent study on accelerated discharge pathways in AIS showed a decrease in hospital LOS and costs by one-third, without an increase in early complication rate [12]. Moving forward, prospective studies with large sample sizes and extended follow-up will be needed to comprehensively evaluate the risks and benefits of accelerated discharge from the hospital following scoliosis surgery.

Acknowledgements

Conflicts of interest

Dr Feldman serves as a paid consultant for Ortho-Pediatrics. Dr Paulino is a paid speaker for Depuy and Ethicon. For the remaining authors there are no conflicts of interest.

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