Original Study

Non-home discharge disposition after posterior spinal fusion in neuromuscular scoliosis—an analysis of the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) Pediatric database

Jae Baek, Azeem Tariq Malik, Robert Tamer, Elizabeth Yu, Jeffery Kim, Safdar N. Khan

The Ohio State University Wexner Medical Center, Columbus, Ohio, USA

Contributions: (I) Conception and design: AT Malik; (II) Administrative support: SN Khan; (III) Provision of study materials or patients: AT Malik; (IV) Collection and assembly of data: AT Malik; (V) Data analysis and interpretation: AT Malik, J Baek; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Safdar N. Khan, MD. The Benjamin R. and Helen Slack Wiltberger Endowed Chair in Orthopaedic Spine Surgery, Associate Professor and Chief, Division of Spine Surgery, Department of Orthopaedics, Adjunct Associate Professor, Department of Integrated Systems Engineering, Clinical Faculty, Spine Research Institute (https://spine.osu.edu/about/our-team), Wexner Medical Center at The Ohio State University, Columbus, OH, USA. Email: Safdar.Khan@osumc.edu.

Background: Despite an increasing trend of corrective surgery in patients with neuromuscular scoliosis, evidence regarding risk factors associated with non-home discharge destination following surgery remains limited.

Methods: The 2012–2016 American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) Pediatric database was queried using Current Procedural Terminology codes for patients undergoing posterior spinal fusion (22802, 22804 and 22808) for neuromuscular scoliosis. Non-home discharge was defined as discharge to a skilled nursing facility, rehabilitation facility and/or separate acute care unit. Patients who expired during inpatient stay were excluded from the study sample. Only patients aged 2–18 years with a primary diagnosis of neuromuscular scoliosis were included in the final cohort.

Results: Out of a total of 1,269 patients, 76 (6.0%) had a non-home discharge disposition. Following adjustment for baseline clinical characteristics, patients lying in the age bracket of 15–17 years {odds ratio (OR) 2.27 [95% confidence interval (CI): 1.01–5.08]; P=0.047} or >17 years [OR 2.29 (95% CI: 1.10–4.79); P=0.027], male gender [OR 1.75 (95% CI: 1.06–2.89); P=0.029], having structural pulmonary abnormality at time of surgery [OR 2.01 (95% CI: 1.17–3.43); P=0.011], a length of stay >4 days [OR 2.29 (95% CI: 1.15–4.55); P=0.018] and having a past history of childhood cancer [OR 4.50 (95% CI: 1.15–17.61); P=0.031] were significant independent predictors associated with a non-home discharge.

Conclusions: Providers can utilize these data to pre-operatively identify patients who might require continued high-level/inpatient care in a facility, and subsequently expedite discharge and reduce costs associated with a prolonged inpatient stay.

Keywords: Neuromuscular scoliosis; non-home discharge; risk factors; predictors; American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP); pediatric; scoliosis

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Introduction

Scoliosis, defined by a spine curvature of more than 10 degrees, can be a result of various congenital, idiopathic, and neuromuscular causes (1). Unlike congenital and idiopathic scoliosis, neuromuscular scoliosis secondary to diseases such as cerebral palsy, spina bifida, Duchenne muscular dystrophy (DMD), and spinal muscular atrophy can progress past puberty (2). As a result, patients without proper treatment may lose the ability to walk and experience severe pulmonary difficulties due to decreased space in the chest cavity which can severely decrease their quality of life (3,4).

There are nonoperative management therapies that currently exist for patients with neuromuscular scoliosis. Properly fitted braces have been shown to delay the worsening of the curvature and prevent related complications (2,5). In most cases, however, the use of a brace only delays the need for surgery, and many patients still undergo spinal fusion in order to restore correct spine positioning (2,6). From a value-based approach, this can significantly accrue costs over time.

Between 2002 and 2011, the cost of spinal fusion for pediatric neuromuscular scoliosis has increased nearly 75% (7). One reason for this could be that surgical techniques are continuously improving so that patients with more severe scoliosis and multiple co-morbidities can undergo more extensive surgical treatment options than were available in the pas (7,8). According to a recent report, the total cost of neuromuscular scoliosis surgery is around $50,096±23,998, with an average hospitalization length of around 8 days (9). Following the cost of the implants themselves, the second major contributor of the cost was due to inpatient stay and ICU admissions (9). As health-care systems begin to adopt value-based approaches towards care, identifying areas of health-care resource utilization will be of utmost important in order to launch appropriate cost-reduction strategies. By understanding patient-level and procedure-level predictors of a non-home discharge, health care providers can determine a better postoperative care plan with a potentially shorter length of stay in the hospital before discharge to facility, significantly reducing costs for the patient. To help aid in this decision making, this study was designed to examine the percentage as well as to determine the independent predictors of a non-home discharge following posterior spinal fusion for neuromuscular scoliosis.

Methods

Database and patient selection

The 2012–2016 American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) Pediatric database used for this study collects more than 120 variables relating to preoperative, intraoperative, and 30-day postoperative risks. The ACS-NSQIP Pediatric database ensures data quality through certified clinical reviewers (SCR) as well as inter-rater reliability (IRR) audits and reports an overall disagreement rate of approximately 2% for all variables. A disagreement rate of 5% or less was determined by ACS-NSQIP Pediatric to be acceptable. Detailed information about how the data are collected can be found on the official ACS-NSQIP website (10).

The ACS-NSQIP Pediatric database was queried using Current Procedural Terminology (CPT) codes for patients aged 2–18 years with a primary diagnosis of neuromuscular scoliosis undergoing posterior spinal fusion (22802, 22804, 22808). Patients who expired during inpatient stay were excluded from the study. Discharge was separated into home and non-home, with non-home discharge being defined as discharge to a skilled nursing facility, rehabilitation facility, and/or separate acute care unit.

The data collected for this study were divided into preoperative, operative, and postoperative factors. Preoperative data consisted of baseline demographics (age, sex, gender, race, body mass index) and co-morbidities. Operative data included total operative time, fusion length, type of procedure (primary *vs.* revision surgery), as well as the use of osteotomy, pelvic fixation, and the use of intervertebral biomechanical devices. Postoperative factors included length of stay in the hospital and occurrence of any pre-discharge complications including but not limited to surgical site infections, wound dehiscence, pneumonia, unplanned intubation, pulmonary embolism, venous thromboembolism, progressive renal insufficiency, acute renal failure, urinary tract infection, coma, stroke, seizure, neurologic deficits from surgical positioning, cardiac arrest, graft failure, sepsis, and central-line associated infections.

Statistical analysis

The Pearson-chi square test univariate analysis was used to identify significant association between, preoperative, operative, and postoperative factors and discharge

destinations. Multivariate analysis was also used by including all variables in a backward elimination logistic regression model, with entry at P=0.05 and removal at P=0.1, to identify independent predictors of a non-home discharge. Results from the analysis are reported as an adjusted odds ratio (OR) with 95% confidence intervals (CI) and P values. For this study, a P value less than 0.05 was considered statistically significant. All statistical analysis was carried out using SPSS v24 (IBM, Armonk, NY).

Results

After filtering the database using the various inclusion/exclusion criteria, the final study population included 1,269 neuromuscular scoliosis patients out of which 76 (6.0%) had a non-home discharge. There were significant baseline differences using unadjusted analysis (*Table 1*). Patients who were discharged to a non-home destination were more likely to be 15 years or older, male, exhibit comorbidities [specifically relating to chronic lung disease, structural pulmonary abnormalities, and central nervous system (CNS) abnormalities], underwent pelvic fixations, and had a postoperative hospital stay lasting longer than 4 days. *Table 1* shows a complete list of the baseline clinical characteristics of the study population.

Adjustments using multivariate backward elimination logistic regression model found that significant independent predictors associated with a non-home discharge, in decreasing order of effect size, were having a past history of childhood cancer [OR 4.50 (95% CI: 1.15–17.61); P=0.031], a hospital length of stay >4 days [OR 2.29 (95% CI: 1.15–4.55); P=0.018], patients >17 years [OR 2.29 (95% CI: 1.10–4.79); P=0.027] or lying in the age bracket of 15–17 years [OR 2.27 (95% CI: 1.01–5.08); P=0.047], having structural pulmonary abnormality at time of surgery [OR 2.01 (95% CI: 1.17–3.43); P=0.011], and belonging to male gender [OR 1.75 (95% CI: 1.06–2.89); P=0.029] (*Table 2*).

Discussion

The goal of this study was to examine the overall percentage of non-home discharges and determine the independent predictors of non-home discharges for pediatric patients with neuromuscular scoliosis undergoing posterior spinal fusion using a national pediatric surgical database. The estimated non-home discharge rate following corrective neuromuscular scoliosis surgery was 6.0%, much higher than the 1.1% non-home discharge rate of patients undergoing spinal fusion for adolescent idiopathic scoliosis (AIS) (11). Independent predictors associated with a non-home discharge were a past history of cancer, a hospital stay longer than 4 days, concurrent structural pulmonary abnormalities at time of presentation, age between 15–17 years or older than 17 years, and belonged to male gender.

Past cancer history was shown to be the highest independent predictor of a non-home discharge. This may be due to several reasons. Recent evidence has found that parents of children with past history of cancer had increased levels of anxiety and depression than parents of healthy children and expressed other emotional symptoms often related to posttraumatic stress (12). This may cause these parents to become overly cautious and request a non-home discharge at rates higher than usual, to allow their children to recuperate in a more supervised environment as compared to home. In addition, children with prior history of cancer tend to have a higher incidence of other illnesses potentially due to secondary effects experienced from prior radiation and chemotherapy treatment (13). The prolonged length of inpatient stay seen in patients going to a facility could be a result of post-operative complications taking place during the stay, or could also be due to improper discharge planning and/or insurance approvals for a facility-discharge requiring patients to stay in the hospital for unnecessary prolonged time while appropriate paperwork is sorted out.

Males also had an increased risk of a non-home discharge. The prevalence of DMD may be a contributing factor. Of the different types of muscular dystrophies that can lead to neuromuscular scoliosis, DMD is the most common (14). Scoliosis can affect up to 90% of DMD patients (15). Because DMD is an X-linked disease (16), there may inherently be a higher male population undergoing posterior spinal fusions for neuromuscular scoliosis leading to the increased odds ratio seen in this study especially since DMD is the second most common cause of neuromuscular scoliosis after cerebral palsy (17). It would be interesting to note whether the exact cause of the neuromuscular scoliosis played a role in determining discharge destination, but unfortunately due to coding practices this is not routinely reported as part of the surgical database.

Patients with structural pulmonary abnormalities at the time of surgery were also shown to have a higher rate of a non-home discharge. Studies have already shown that lung function, measured by pulmonary function tests, are decreased immediately after scoliosis surgery and do not return to preoperative levels until at least 1 to 2 months

Table 1 Baseline clinical characteristics of the study population

Characteristic	Home, n (%)	Non-home, n (%)	P value
Number (N)	1,193 (94.0)	76 (6.0)	–
Demographics			
Age (years)			0.044
<12	290 (24.3)	11 (14.5)	
12–14	301 (25.2)	14 (18.4)	
15–17	239 (20.0)	20 (26.3)	
>17	363 (30.4)	31 (40.8)	
Gender			0.007
Male	579 (48.5)	49 (64.5)	
Female	614 (51.5)	27 (35.5)	
Race			0.134
White	861 (72.2)	45 (59.2)	
Black/African-American	179 (15.0)	14 (18.4)	
Asian	41 (3.4)	4 (5.3)	
American Indian or Alaska Native	4 (0.3)	1 (1.3)	
Native Hawaiian or Pacific Islander	2 (0.2)	0 (0)	
Other/unknown/not reported	106 (8.9)	12 (15.8)	
Weight (as per 95th CDC centiles)			0.316
Normal (5th to <85th percentile)	646 (54.1)	37 (48.7)	
Underweight (<5th percentile)	260 (21.8)	19 (25.0)	
Overweight (85th to <95th percentile)	138 (11.6)	6 (7.9)	
Obese (≥95th percentile)	149 (12.5)	14 (18.4)	
Co-morbidities			
Chronic steroid use	38 (3.2)	5 (6.6)	0.113
Ventilator dependence	150 (12.6)	15 (19.7)	0.072
Asthma	209 (17.5)	15 (19.7)	0.623
Bronchopulmonary dysplasia/chronic lung disease	181 (15.2)	18 (23.7)	0.048
Oxygen support requirement	75 (6.3)	6 (7.9)	0.578
Tracheostomy	87 (7.3)	10 (13.2)	0.062
Structural pulmonary abnormality	206 (17.3)	23 (30.3)	0.004
Esophageal disorders	418 (35.0)	33 (43.4)	0.139
Prior history of cardiac surgery	64 (5.4)	6 (7.9)	0.349
Developmental delay	821 (68.8)	54 (71.1)	0.683
Seizure disorder	482 (40.4)	34 (44.7)	0.456
Cerebral palsy	539 (45.2)	34 (44.7)	0.94

Table 1 *(continued)*

Table 1 *(continued)*

Characteristic	Home, n (%)	Non-home, n (%)	P value
CNS abnormality	376 (31.5)	33 (43.4)	0.031
Neuromuscular disorder	899 (75.4)	61 (80.3)	0.334
Pre-operative blood transfusion	13 (1.1)	0 (0)	0.36
Cancer			0.114
Current cancer	3 (0.3)	0 (0)	
Past history of cancer	14 (1.2)	3 (3.9)	
Nutritional support requirement	392 (32.9)	29 (38.2)	0.341
Hematologic disorders	42 (3.5)	6 (7.9)	0.053
Inotropic support at time of surgery	25 (2.1)	3 (3.9)	0.287
ASA grade			0.342
I–II	14 (1.2)	0 (0)	
>II	1,179 (98.8)	76 (100)	
Operative factors			
Total operative time (min)			0.827
0–240	248 (20.8)	15 (19.7)	
>240	945 (79.2)	61 (80.3)	
Osteotomy	339 (28.4)	20 (26.3)	0.694
Fixation to pelvis	468 (39.2)	40 (52.6)	0.021
Use of intervertebral biomechanical device	7 (0.6)	0 (0)	0.503
Extent of fusion			0.073
Up to 6 segments	125 (10.5)	8 (10.5)	
7–12 segments	195 (16.3)	5 (6.6)	
>12 segments	873 (73.2)	63 (82.9)	
Revision surgery	42 (3.5)	0 (0)	0.096
Post-operative factors			
Length of stay >4 days	850 (71.2)	66 (86.8)	0.003
Occurrence of any pre-discharge complication	939 (78.7)	61 (80.3)	0.748

after surgery (18). For patients already suffering from structural pulmonary abnormalities, this decrease in lung function from the effects of surgery can be exaggerated. A study examining the predictive risk factors of the use of mechanical ventilation after surgery for neuromuscular scoliosis showed that the only significant predictor of prolonged postoperative mechanical ventilation was a decrease in preoperative pulmonary function (19), which is often associated with structural pulmonary abnormalities. Prolonged mechanical ventilation could extend the length of hospital stay in addition to requiring patients to be discharged to a non-home facility for closer postoperative monitoring.

There are several limitations to this study and areas that need further exploration. The ACS-NSQIP Pediatric database does not report the Cobb angle for the patients so it is not possible to quantify the severity of the scoliosis prior to surgery. There was also no information regarding

Table 2 Independent predictors associated with a non-home discharge, following adjustment in a multi-variate backward elimination logistic regression model

Characteristic	Adjusted OR (95% CI)	P value
Age (years)		
<12	Ref.	–
12–14	1.25 (0.54–2.87)	0.599
15–17	2.27 (1.01–5.08)	0.047
>17	2.29 (1.10–4.79)	0.027
Male gender	1.75 (1.06–2.89)	0.029
Structural pulmonary abnormality	2.01 (1.17–3.43)	0.011
Length of stay >4 days	2.29 (1.15–4.55)	0.018
Cancer		
Current cancer	1	0.999
Past history of cancer	4.50 (1.15–17.61)	0.031
No current or past history	Ref.	–

the use of braces and other non-surgical management tools used before surgical intervention. Conservative treatments are often used first to slow down the progression of the diseases which may impact risk factors for discharge to a non-home facility. Finally, the database lacks granular information about how the long the patients stayed in the facility, which would be useful in further stratifying and identifying patients who may require high-level prolonged continued inpatient care.

Conclusions

Using a national pediatric surgical dataset, the study identifies several key patient-level and procedure-level factors associated with a non-home discharge following posterior spinal fusion for neuromuscular scoliosis. Providers can utilize this data to risk-stratify patients and individualize discharge planning according to every patient's need so as to control costs while providing appropriate quality care.

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None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Disclaimer: The American College of Surgeons National Surgical Quality Improvement Program and the hospitals participating in the ACS NSQIP are the source of the data used herein; they have not verified and are not responsible for the statistical validity of the data analysis or the conclusions derived by the authors.

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