

Clinical Study

Risk factors for nonroutine discharge in adult spinal deformity surgery

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Abstract

BACKGROUND CONTEXT: Surgery for adult spinal deformity (ASD) is increasingly common. Although outcomes of ASD surgery have been studied extensively, to our knowledge, no data exist regarding factors predicting nonroutine discharge in this population. Nonroutine discharge is defined as discharge to a health care facility after surgery rather than to home.

PURPOSE: To determine which patient and surgical factors predict nonroutine discharge after ASD surgery.

DESIGN: This is a retrospective study.

PATIENTS SAMPLE: We conducted a retrospective single-center study of 303 patients who underwent arthrodesis of five or more spinal levels to treat ASD between 2009 and 2014.

OUTCOME MEASURES: Patients were stratified into two groups according to discharge disposition: home or nonroutine.

METHODS: Objective preoperative characteristics, intraoperative course, and postoperative recovery were analyzed to identify pre- and perioperative factors associated with nonroutine discharge. Univariate analysis was performed first. All factors with P values < .2 on univariate analysis were included in a logistic regression model. Additionally, to understand the relationship between subjective patient-reported outcome measures and nonroutine discharge, we compared the two groups with respect to mean Oswestry Disability Index and Scoliosis Research Society-22r domains using Student t-tests.

RESULTS: On univariate analysis, objective measures that differed significantly ($P < .05$) between the two cohorts were age (≥ 65 years), osteoporosis, Charlson Comorbidity Index score of ≥ 2 , prolonged hospital stay (> 8 days), and blood transfusion. Given the above logistic regression inclusion criteria, we controlled for the performance, and type, of osteotomy ($P = .055$). On multivariate analysis, older age, osteoporosis, prolonged hospital stay, blood transfusion, and 3-column osteotomy were independently associated with nonroutine discharge. Subjective patient-reported outcome measures, including Oswestry Disability Index and Scoliosis Research Society-22r physical function and pain domain scores, were significantly worse in the nonroutine discharge cohort ($P < .05$).

FDA device/drug status: not applicable

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CONCLUSION: To our knowledge, this is the first study to evaluate pre- and perioperative factors associated with nonroutine discharge after ASD surgery. Elderly patients who undergo complex surgery and receive blood transfusions are at particularly high risk of nonroutine discharge. Surgeons should consider these factors during surgical planning and preoperative patient counseling. © 2018 Elsevier Inc. All rights reserved.

Keywords: 3-column osteotomy; Adult spinal deformity; Blood transfusion; Charlson Comorbidity Index; Osteoporosis; Spinal arthrodesis.

Introduction

Surgical intervention is an increasingly common tool used to reduce the pain and functional limitations associated with adult spinal deformity (ASD) [1]. To achieve maximal benefit, appropriate postoperative rehabilitation is necessary. For some patients, this requires discharge to rehabilitation facilities. Unlike other spine surgeries that have protocol-driven postoperative pathways, ASD surgery does not have standard inpatient treatment and discharge recommendations [2].

An understanding of factors predicting discharge disposition of ASD patients is critical in an era of medical cost containment, emphasis on shorter hospitalization, and efficient discharge planning [3]. Though research suggests that rehabilitation is associated with improved short-term functional outcomes and decreased 30-day readmission rates, nonroutine discharge (to rehabilitation facilities rather than home) stresses limited medical resources [4]. Recent data show that ASD surgery, on average, incurs costs far exceeding diagnosis-related group Medicare reimbursement [5].

An equally important reason to understand the causes of nonroutine discharge after ASD surgery is to address patient expectations. This is a critical issue to discuss preoperatively as family involvement in patient care has been shown to decrease costs and demands on health care resources [6]. Family involvement has been shown to increase patient activity activation scores, lessening the need for the level of care provided by physical therapists [7,8]. Early acknowledgement of the need for rehabilitation due to limited mobility may allow family members to adequately prepare the home environment for earlier postoperative return to home. Furthermore, data on which patients are at high risk of nonroutine discharge can be shared with patients during preoperative consent and can be provided as unbiased information to patients when discussing their suitability for discharge [9].

Several studies have evaluated preoperative factors associated with postoperative discharge to rehabilitation facilities after nondeformity spine surgery [3,6,10–12]. However, most of these studies used large national databases that lack the granularity necessary to isolate detailed risk factors. To our knowledge, no data have been published regarding factors predicting nonroutine discharge after ASD surgery [1,13].

Our goal was to identify the patient characteristics, surgical factors, and postoperative course associated with nonroutine discharge after ASD surgery. We hypothesized that older age, blood transfusion, and 3-column osteotomy would predict discharge to rehabilitation facilities.

Patients and methods

This study was conducted using the Strengthening the Reporting of Observational Studies in Epidemiology guidelines. Before data collection, the study was approved by our center's institutional review board. Given that this study was a retrospective chart review, patient consent was not required. We analyzed a surgical registry of patients who underwent corrective surgery for ASD by the senior author at our academic tertiary referral center. Patients were stratified into two groups according to discharge disposition: home or nonroutine (location other than home, which included long-term, acute, and subacute rehabilitation facilities). We identified 338 patients who underwent arthrodesis of 5 or more levels between 2009 and 2014 and were also identified by the primary surgeon in the operative note as spinal deformity patients. We excluded 35 patients because of incomplete records, leaving 303 patients (90%) in our analysis.

The decision about where to discharge a patient is multifactorial and is formulated by the treating surgeon, the patient, patient's family, and the other providers involved in the patient's care, such as physical therapists and social workers. Typical factors considered when planning for discharge include the patient's level of function, the degree of support at home, financial and insurance considerations, and patient preferences. However, many of these variables are subjective and difficult to analyze.

We evaluated preoperative patient characteristics, including age group (<65, 65–74, ≥75 years), body mass index category (<30, 30–34.9, ≥35), sex, and osteoporosis. Charlson Comorbidity Index (CCI) score was evaluated as an indicator of health status. Operative details included primary versus revision surgery, number of spinal levels fused, and performance of an osteotomy. Postoperative variables included length of stay (LOS), major organ system perioperative complications (respiratory, cardiovascular, and thrombotic), and perioperative blood transfusion (Table 1). We used a cutoff of >75th percentile to define “prolonged” LOS, which agrees with a published study that

Table 1

Risk factor analysis for discharge to rehabilitation facility after adult spinal deformity surgery in 303 Patients, 2009 to 2014

Variable	No. (%) of patients		P
	Discharged to home (n = 176)	Discharged to rehabilitation facility (n = 127)	
<i>Patient factors</i>			
Female sex	128 (73)	94 (74)	.803
Smoking	9 (5)	6 (5)	.878
Age category (y)			
<65	128 (73)	50 (40)	<.0001
65–74	42 (23)	60 (47)	
≥75	6 (6)	17 (13)	
Body mass index category			
<20	7 (6)	6 (6)	.716
20–24.9	40 (31)	26 (25)	
25–29.9	26 (20)	26 (25)	
≥30	55 (43)	45 (44)	
Missing	48	24	
Osteoporosis	30 (17)	43 (34)	.001
CCI score ≥2	40 (23)	45 (35)	.015
<i>Preoperative laboratory values</i>			
Hemoglobin concentration (g/dL)	13 (1.6)*	13 (1.7)*	.133
International normalized ratio	1.0 (0.2)*	1.1 (0.3)*	.31
Platelet count per L	246 × 10 ⁹ (84 × 10 ⁹)*	241 × 10 ⁹ (97 × 10 ⁹)*	.667
<i>Surgical course</i>			
No. of levels fused	8.8 (2.9)*	9.2 (3.2)*	.290
<i>Osteotomy</i>			
No osteotomy	62 (35)	37 (29)	.055
Posterior column osteotomy	48 (27)	25 (20)	
3-column osteotomy	66 (38)	65 (51)	
Revision surgery	91 (52)	66 (52)	.964
<i>Inpatient hospital course</i>			
Blood transfusion	111 (63)	98 (77)	.009
Cardiovascular complication	2 (1.1)	3 (2.4)	.409
Hospital stay >8 d	27 (15)	54 (43)	<.0001
Respiratory complication	3 (1.7)	1 (0.8)	.490
Thrombotic complication	6 (3.4)	4 (3.1)	.901

CCI, Charlson Comorbidity Index.

*Expressed as mean (standard deviation).

used a large spine deformity database [1]. To understand the relationship between subjective patient-reported outcome (PRO) measures and nonroutine discharge, we compared the Oswestry Disability Index (ODI) and the Scoliosis Research Society Questionnaire 22r (SRS-22r) between the two groups.

We used 2-sample *t* tests to perform univariate analysis of continuous variables. Categorical variables were analyzed using χ^2 tests. To increase sensitivity, we used a P value cutoff of .2 to identify objective factors to include in multivariate analysis. All analyses were performed using Stata, version 14, software (StataCorp LP, College Station, TX). Alpha level was set at 0.05.

Results

Patient population

Preoperative patient characteristics are shown in Table 1. Of the 303 patients included in the study, 176 (58%) were

discharged to home versus 127 (42%) discharged to rehabilitation facilities (nonroutine group). Overall 73% of patients were women, 24% had a diagnosis of osteoporosis, and 28% had a CCI score of ≥2. The mean (± standard deviation) preoperative hemoglobin concentration was 12.9 ± 0.1 g/dL, the mean international normalized ratio was 1.05 ± 0.01, and the mean platelet count was 244 × 10⁹/L ± 5.2. The mean age of the population was 59 ± 14 years. However, a larger proportion of the home-discharge group was younger than 65 years (73%) compared with the nonroutine discharge group (39%) (P < .001).

Univariate analysis

Objective patient-specific

On univariate analysis, older age, osteoporosis, and CCI score of ≥2 were significantly associated with nonroutine discharge. The proportion of patients discharged to a rehabilitation facility varied significantly between the three age groups, whereby 28% of patients aged <65 years were

discharged to rehabilitation facilities compared with 59% of patients aged 65 to 74 years and 74% of patients aged ≥ 75 years ($P < .001$). A higher proportion of patients with known osteoporosis were discharged to a rehabilitation facility compared with patients without osteoporosis (58.9% vs. 36.5%, $P = .001$). Fifty-three percent of patients with CCI scores of ≥ 2 were discharged to rehabilitation facilities compared with 38% with CCI scores of 0 ($P = .015$). Distribution of patients within body mass index categories of < 20 , 20 to 24.9, 25 to 29.9, and ≥ 30 did not differ between the home and nonroutine discharge groups ($P = .716$), and body mass index was not predictive of nonroutine discharge. Similarly, smoking status was not associated with a particular discharge status ($P = .878$). Preoperative hematologic parameters, including hemoglobin concentration ($P = .133$), international normalized ratio ($P = .31$), and platelet count ($P = .667$) were not predictive of nonroutine discharge.

Surgery-specific

Surgery-specific factors are also shown in Table 1. Twenty-four percent of patients underwent posterior column osteotomy, and 43% underwent 3-CO. The performance, and type, of osteotomy had a P value of $< .2$ and was included in the logistic regression model ($P = .055$). Primary versus revision surgery (48% vs. 52%, $P = .964$), and mean number of spinal levels fused (8.8 vs. 9.2, $P = .29$) were not predictive of nonroutine discharge.

Hospitalization-specific

Inpatient hospitalization course is also reported in Table 1. Overall, 27% of patients had LOS greater than the 75th percentile (ie, ≥ 8 days; herein, prolonged LOS), and 69% of patients received blood transfusions. Sixty-seven percent of patients who had prolonged LOS were in the nonroutine discharge group compared with 33% of patients with less than eight days LOS ($P = .0001$). A total of 47% of patients who received blood transfusions had nonroutine discharge compared with 31% of patients who did not receive transfusions ($P = .009$). Among the entire cohort, the rates of inpatient thrombotic, vascular, and respiratory complications were 3.3%, 1.7%, and 1.3%, respectively. The rates of thrombotic ($P = .901$), vascular ($P = .409$), and respiratory ($P = .490$) complications did not differ significantly between the home and nonroutine discharge groups.

Patient-reported outcomes

Of the 303 patients, 241 (80%) had complete preoperative PROs. The two patient groups differed significantly with respect to several PRO domains (Figure). The mean preoperative ODI score was significantly higher in patients discharged to a rehabilitation facility (53 ± 15) versus home (43 ± 17). Similarly, patients discharged to a rehabilitation facility had a higher mean preoperative SRS-22r physical function score (2.7 vs. 2.4, $P = .005$) and a higher SRS-22r pain domain score (2.6 vs. 2.3, $P = .01$). The two

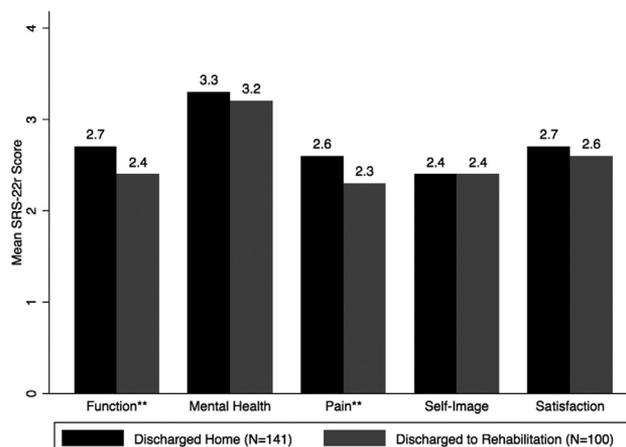


Figure. Comparison of mean Scoliosis Research Society Questionnaire 22r (SRS-22r) domain scores between the two patient groups. The standard deviations of each of the scores for patients in the home group were as follows: function, 0.77; mental health, 0.66; pain, 0.88; self-image, 0.78; satisfaction, 1.01. The standard deviations in the rehabilitation group were as follows: function, 0.69; mental health, 0.88; pain, 0.63; self-image, 0.66; satisfaction, 1.16. **Significant differences ($P < .05$).

groups had similar scores for SRS-22r self-image, mental health, and satisfaction (all $P > .05$).

Multivariate logistic regression

On multivariate analysis, older age, osteoporosis, prolonged LOS, blood transfusion, and 3-CO were significantly associated with nonroutine discharge (Table 2). The odds of nonroutine discharge increased with advancing age. Patients 65 to 74 years of age had 3.4 times greater odds of nonroutine discharge compared with patients < 65 years of age ($P = .0001$). This odds ratio was 6.7 for patients aged 75 years or older ($P = .0001$). Patients with osteoporosis had 2.4 times higher odds of nonroutine discharge compared with those without osteoporosis ($P = .008$). Patients who received blood transfusions had 1.9 times higher odds of nonroutine discharge than those who did not ($P = .034$). Prolonged LOS was associated with 3.2 times higher odds of nonroutine discharge compared with patients with LOS < 8 days ($P = .0001$). Patients who underwent 3-CO had 1.9 times higher odds of nonroutine discharge odds ($P = .04$). Posterior column osteotomy and CCI score greater than two were not significantly associated with increased risk of nonroutine discharge on multivariate analysis.

Discussion

To our knowledge, this is the first study to assess the risk factors for discharge to a rehabilitation facility in ASD patients (Table 3). Truncated inpatient rehabilitation has been shown to diminish functional progress in the six-month postoperative period [14]. We found that 42% of ASD patients were discharged to rehabilitation facilities, which is substantially higher than previously reported (5%) in the overall spine surgery population [4,10]. Our study

Table 2

Odds of nonroutine discharge from multivariate regression analysis in 303 patients after adult spinal deformity surgery, 2009 to 2014

Risk factor	Odds ratio (95% CI)	P
Age ≥75 y	6.7 (2.3–20)	<.0001
Age 65–74 y	3.4 (1.9–6.0)	<.0001
Prolonged hospital stay (>8 d)	3.2 (1.7–5.8)	<.0001
Osteoporosis	2.4 (1.3–4.5)	.008
Blood transfusion	1.9 (1.1–3.6)	.034
3-column osteotomy	1.9 (1.0–3.6)	.04
CCI score ≥2	1.4 (0.8–2.5)	.254
Posterior column osteotomy	0.9 (0.4–1.9)	.786

CCI, Charlson Comorbidity Index; CI, confidence interval.

found that advanced age, osteoporosis, prolonged hospital stay, blood transfusion, and 3-CO osteotomy were risk factors for nonroutine discharge. Univariate analysis demonstrated that ODI score was the greatest preoperative PRO predictive of nonroutine discharge.

In nondeformity spine surgery, higher CCI score, prolonged LOS, and older age have been shown to predict discharge to rehabilitation facilities [3,10–12]. However, these studies relied on surrogate markers of surgical complexity, including diagnosis and billing codes, rather than specific surgical detail such as performance of an osteotomy to control for confounding variables. In contrast, we analyzed the role of specific surgical procedures that are known to increase the risks of perioperative complications [15,16].

Only one prior study has assessed discharge status in elderly scoliosis surgery patients [17]. However, discharge status was not a primary outcome of the study. Additionally, the study used a national database, which has been shown to have substantial coding inaccuracy [18]. Moreover, few studies of risk factors for nonroutine discharge after general spine surgery include preoperative PROs in their analyses. Our study includes preoperative PROs for 80% of our population. Finally, no previous studies have included the performance of osteotomy in their analyses. Our data confirm that the performance of osteotomy is significantly associated with postoperative functional status and dependency and should be included in analysis of risk factors for nonroutine discharge after ASD surgery.

Adult spinal deformity surgery in elderly patients has been associated with major postoperative complications, including hemorrhagic shock, surgical-site infection, and unplanned readmission [17,19]. Our data further emphasize the risk of spine surgery in the elderly. We found that patients aged 65 years or older had 3-fold higher odds of nonroutine discharge. Moreover, patients aged 75 years or older had greater than 6-fold higher odds of nonroutine discharge. These findings parallel those of several studies in non-ASD spine surgery [6,10–12,20]. Few hypotheses have been offered for the cause of the higher rate of nonroutine discharge in elderly patients. We attribute the higher rate to the diminished physiologic reserve common in

Table 3
Studies investigating discharge status after spine surgery

First Author, Year	Patients	National database study	Discharge status as primary outcome	Variables analyzed										
				Age	PRO	Osteotomy	No. of levels fused	OT	ICU	LOS	LOS	Complications	BT	
Current study	ASD	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Drazin, 2016	Scoliosis in elderly (>65 y)	Yes	No	Yes	No	No	No	No	No	No	Yes	Yes	No	No
Aoude, 2016	Lumbar or thoracic arthrodesis	Yes	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Murphy, 2016	Lumbar arthrodesis (DSS)	Yes	Yes	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes
Best, 2015	Spinal arthrodesis (IDD)	Yes	Yes	Yes	No	No	No	No	No	No	No	Yes	Yes	Yes
Sharmat, 2014	Spinal cord tumors	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	No	No
Kanaan, 2014	Lumbar laminectomy	No	Yes	Yes	Yes	No	No	No	No	No	Yes	Yes	No	No
Gruskay, 2013	One- to three-level arthrodesis	No	No	Yes	No	No	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes

ASD, adult spinal deformity; BT, blood transfusion; DSS, degenerative spine disease; ICU, intensive care unit; IDD, intervertebral disc disease; LOS, length of stay; OT, operative time; PRO, patient-reported outcomes.

patients of this age group [19]. This finding could also indicate an iatrogenic cause, as caretakers may assume a patient requires discharge to a rehabilitation facility on the basis of the patient's age rather than the patient's true health status [19].

Our data show that blood transfusion is associated with greater than twice the odds of nonroutine discharge. This finding agrees with those of large national database studies, which show that high blood loss and blood transfusion are risk factors for prolonged LOS [21,22]. However, our study further illustrates this association by controlling for surgical factors known to increase blood loss, including osteotomy and number of spinal levels fused. These data are of interest given the research showing increased all-cause morbidity, including wound infections, with administration of blood products in spine surgery [21].

With respect to type of surgical procedure, posterior column osteotomy did not predict nonroutine discharge. However, 3-CO was associated with 2-fold higher odds of nonroutine discharge. Recent data suggest a 66% rate of major or minor postoperative complications after 3-CO, including excessive bleeding, neurologic deficits, and overall/wound infections [13,23]. We advocate that the substantially increased risk of nonroutine discharge after 3-CO should be discussed with the patient preoperatively when this procedure is planned.

Length of stay is important given the economic burden of inpatient hospitalization. The average daily cost of inpatient hospitalization is 10 times higher than that of inpatient rehabilitation [21]. With respect to ASD, prolonged LOS has been associated with intraoperative complications, as well as greater number of comorbidities [1,3,12]. When controlling for these factors, our ASD data agree with several non-ASD studies indicating that prolonged LOS is an independent risk factor for discharge to rehabilitation facilities [6,21,22]. Prolonged LOS may be a product of system inefficiencies or may reflect delayed postoperative mobility and patient reluctance to participate in therapy given the relatively high morbidity after ASD surgery.

Bone quality has been evaluated extensively in ASD patients. Osteoporosis has been associated with risk of revision surgery, proximal junction kyphosis, pseudarthrosis, and instrumentation failure after spine surgery [24–26]. Recent research has evaluated the association of osteoporosis with postoperative outcomes, including increased risk of major blood loss. Our data show that osteoporosis was associated with 2.4 times higher odds of nonroutine discharge. Despite controlling for comorbidities on multivariate analysis, the influence of osteoporosis on the likelihood of nonroutine discharge may still be attributable to overall poor physiologic health.

We did not find thrombotic, cardiovascular, or pulmonary complications to be predictive of nonroutine discharge. Nor did we find CCI to be predictive of discharge status on multivariate analysis. This may be partially explained by the relatively small number of patients in our study compared with studies of nondeformity spine patients

that have found significant associations with the aforementioned variables using large national databases [2–4,12]. Soroceanu et al. [27] demonstrated that medical complications after surgery for ASD are not associated with less improvement in quality of life. Therefore, it is possible that medical complications similarly do not increase the risk of nonroutine discharge in this patient population.

Our study has several limitations. Compared with national database studies, our study includes fewer patients. However, as mentioned above, we were able to include specific operative detail in our analysis, limiting confounding bias in our conclusions. Our data were reviewed retrospectively and are thus subject to the inherent biases of this research method. Furthermore, certain risk factors that may influence discharge status, such as the cause of disease, the type of symptoms, and the duration of disease, were unavailable for analysis. Additionally, our study consists of a single-surgeon, single-center population. Thus, the operative indications, technique, and postoperative care patterns may not be generalizable to the entire ASD population.

Conclusion

To our knowledge, this is the first study to evaluate the factors associated with nonroutine discharge disposition after ASD surgery. We found that older age, 3-CO, and blood transfusion are associated with significantly higher odds of nonroutine discharge. We advocate for preoperative discussion of nonroutine discharge risk, particularly for elderly patients who are expected to require blood transfusion.

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