

COVID-19 Significantly Impacted Hospital Length of Stay and Discharge Patterns for Adult Spinal Deformity Patients

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Study Design. Retrospective review.

Objective. The primary aim was to compare length of stay (LOS) and discharge disposition of adult spinal deformity (ASD) patients undergoing surgery before and during the pandemic. Secondary aims were to compare the rates of 30-day complications, reoperations, readmissions, and unplanned emergency department (ED) visits.

Summary of Background Data. ASD patients often require extended LOS and non-routine discharge. Given resource limitations during the Coronavirus Disease 2019 (COVID-19) pandemic and caution regarding hospital stays, surgeons modified standard postoperative protocols to minimize patient exposure.

Methods. We identified all patients who underwent elective thoracolumbar ASD surgery with more than or equal to five levels fusion at a tertiary care center during two distinct time intervals: July to December 2019 (Pre-COVID, N=60) and July to December 2020 (During-COVID, N=57). Outcome measures included LOS and discharge disposition (home vs. non-home), as well as 30-day major complications, reoperations, readmissions, and ED visits. Regression analyses controlled for demographic and surgical factors.

Results. Patients who underwent ASD surgery during the pandemic were younger (61 vs. 67 yrs) and had longer fusion constructs (nine vs. eight levels) compared with before the pandemic ($P < 0.05$ for both). On bivariate analysis, patients

undergoing surgery during the pandemic had shorter LOS (6 vs. 9 days) and were more likely to be discharged home (70% vs. 28%) ($P < 0.05$ for both). After controlling for age and levels fused on multivariable regression, patients who had surgery during the pandemic had shorter LOS (IRR=0.83, $P = 0.015$) and greater odds of home discharge (odds ratios [OR]=7.2, $P < 0.001$). Notably, there were no differences in major complications, reoperations, readmissions, or ED visits between the two groups.

Conclusion. During the COVID-19 pandemic, LOS for patients undergoing thoracolumbar ASD surgery decreased, and more patients were discharged home without adversely affecting complication or readmission rates. Lessons learned during the pandemic may help improve resource utilization without negatively influencing short-term outcomes.

Key words: adult spinal deformity, coronavirus, COVID-19, discharge disposition, length of stay, postoperative complications, readmission, reoperation, resource utilization, spine surgery.

Level of Evidence: 3

Spine 2021;46:1551–1556

Starting in mid-March of 2020, the outbreak of Coronavirus Disease 2019 (COVID-19) led to large-scale changes in hospital practices across the United States, including protocols overseeing inpatient hospitalization for a variety of surgeries.^{1–3} A recent national survey found that both patients and physicians have sought to reduce patient exposure to hospitals during the pandemic to limit resource utilization and prevent the spread of COVID-19.⁴ As a result, the pandemic provided a unique opportunity to assess whether the changing practice patterns favoring shorter hospitalization could impact outcomes following major surgeries, such as adult spinal deformity (ASD) correction, which usually require longer hospital stays (LOS).

In the United States, ASD has a prevalence of up to 68% in adults over the age of 60.⁵ Recent reviews have reported a 17% to 68% incidence of postoperative complications following

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Acknowledgment date: May 5, 2021. First revision date: July 3, 2021. Acceptance date: July 21, 2021.

The manuscript submitted does not contain information about medical device(s)/drug(s).

No funds were received in support of this work.

Relevant financial activities outside the submitted work: grants, payment for lecture.

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DOI: 10.1097/BRS.0000000000004204

ASD surgery, with around 42% of ASD patients requiring non-routine discharge.^{6–10} To facilitate recovery and minimize the risk of complications, postoperative monitoring, and stabilization of patients in the inpatient setting is often needed. Prior studies have reported an average LOS of approximately 8 days following ASD surgery,^{8,11,12} but it is currently unknown how the pandemic has impacted duration of hospital stay and complication rates in this patient population.

The primary aim of this study was to compare LOS and discharge disposition of ASD patients undergoing surgery before and during the pandemic. Secondary aims were to compare the rates of 30-day complications, readmissions, and emergency department (ED) visits before and during the pandemic. We hypothesized that the mean LOS after ASD surgery was lower during the pandemic compared with before, though that may have increased the rate of complications, readmissions, and/or ED visits. We also hypothesized that there would be a significant increase in the rate of home discharge following surgeries performed during the pandemic.

MATERIALS AND METHODS

This study was approved by our institutional review board.

Data Source and Collection

Data were collected through a retrospective review of a spine surgical registry at a tertiary care center. We identified all adult patients who underwent elective adult thoracolumbar deformity surgery (defined by more than or equal to five level fusion) from July 1 to December 31 of 2019 (pre-COVID, N=60) and July 1 to December 31 of 2020 (during-COVID, N=57). These time periods were chosen to reflect the impact of institutional policies governing elective surgeries at our medical center. The World Health Organization officially declared COVID-19 a pandemic on March 11, 2020,¹³ and many institutional policies had been set in place by July 1, 2020. The same time period was chosen for 2019 to reduce the impact of seasonal variation on case volume.^{14,15} All surgeries were performed by fellowship-trained orthopedic spine surgeons. All patients met the 30-day follow-up required for inclusion in this study. We excluded any non-elective surgeries, malignancy, trauma, or infection (pre-COVID: nine patients; during-COVID: seven patients). An additional exclusion criterion was a diagnosis of COVID-19 during the hospital course, but no patients in the during-COVID period cohort had a COVID-19 diagnosis at any point during their surgical care.

We collected data on baseline patient demographics and surgical risk: age, sex, and American Society of Anesthesiologists (ASA) Classification. We also collected data on surgical characteristics: the number of levels fused, estimated blood loss (EBL), whether or not the surgery was a revision procedure, and the presence of a three-column osteotomy.

Outcome Measures

The primary outcome measures were length of stay (days) and discharge disposition (home *vs.* non-home). Secondary outcome measures were the rates of reoperation, unplanned

ED visit, readmission, and major complications within 30 days postoperatively. Major complications were defined as: neurologic complications (new and persistent postoperative motor weakness or sensory deficit), myocardial infarction, pulmonary embolism/deep vein thrombosis (PE/DVT), pneumonia, or cerebrovascular accident (CVA).

Statistical Analysis

Bivariate analyses were used to detect differences in baseline patient demographics, ASA classification, and surgical characteristics between patients in 2019 and 2020. Categorical variables were assessed with Chi-squared tests, parametric continuous variables with Student *t* tests, and non-parametric continuous variables with Mann–Whitney *U* tests. Bivariate analyses were similarly performed on our primary and secondary outcome measures to detect differences between the two groups. To control for differences in baseline demographics and surgical characteristics, multivariable regression models were constructed for length of stay and discharge disposition, the two outcome measures found to be significant on bivariate analysis. A Poisson regression model was utilized for length of stay, due to the variable being count data,¹⁶ and a logistic regression was used for discharge disposition, a binary variable. Both multivariable regression models controlled for age, sex, ASA, levels fused, three-column osteotomy, EBL, and revision surgery. Results from the Poisson regression are reported as incidence rate ratios (IRR), and results from the logistic regression are reported as odds ratios (OR). Statistical significance was set at $P < 0.05$. Analysis was conducted using STATA version 15.0 (College Station, TX).

RESULTS

Total Case Volume

There was no significant difference in the volume of elective adult thoracolumbar deformity surgeries performed during the two time periods (60 *vs.* 57 cases, $P = 0.782$; Table 1).

Patient Demographics and Surgical Characteristics

On bivariate analysis, patients who underwent ASD surgery during the pandemic were younger (mean: 61 *vs.* 67 yrs, $P = 0.015$) compared to before the pandemic, but there were no significant differences in sex or ASA classification (Table 1). Compared with cases performed before the pandemic, those performed during the pandemic involved significantly longer fusion constructs (mean: nine *vs.* eight levels, $P = 0.007$) and more EBL (mean: 1762 *vs.* 1127 cm³, $P = 0.002$) (Table 1). There were no significant differences between the pre-COVID and during-COVID groups in terms of the number of procedures which were revision surgeries or number of those which involved a three-column osteotomy.

Length of Stay

On bivariate analysis, patients in the during-COVID cohort had 26% shorter LOS compared with those in the pre-

TABLE 1. Bivariate Comparison of Baseline Demographics and Surgical Characteristics

	Pre-COVID		During-COVID		P-Value
	N	%	N	%	
Total	60	–	57	–	0.782
Gender	28	46.7%	27	47.4%	0.939
ASA					0.100
1	0	0.0%	0	0.0%	
2	16	26.7%	24	42.1%	
3	42	70.0%	33	57.9%	
4	2	3.3%	0	0.0%	
5	0	0.0%	0	0.0%	
Revision	27	45.0%	26	45.6%	0.877
3CO	6	10.0%	11	19.3%	0.154
	Mean	SD	Mean	SD	P-Value
Age	67.5	11.8	61.4	14.5	0.015
Levels fused	7.5	2.97	9.1	3.45	0.007
EBL	1126.5	729.6	1762.1	1424.6	0.002

3CO indicates three-column osteotomy; ASA, American Society of Anesthesiologists; EBL, estimated blood loss.
 Bolded p-values indicate statistical significance.

COVID cohort (mean: 6 vs. 9 days, $P = 0.039$; Table 2). The difference in LOS remained significantly shorter after controlling for age, sex, ASA, levels fused, three-column osteotomy, EBL, and revision surgery using the multivariable regression model ($P = 0.015$, Table 3).

Discharge Disposition

On bivariate analysis, patients were significantly more likely to be discharged home in the during-COVID cohort compared with pre-COVID cohort (70% vs. 28%, $P < 0.001$; Table 3). After controlling for age, sex, ASA, levels fused, three-column osteotomy, EBL, and revision surgery in the multivariable regression model, patients in the during-

COVID cohort were found to have 7.2-times greater odds of home discharge compared with the pre-COVID cohort ($P < 0.001$; Table 3).

Readmissions, ED Visits, Major Complications

There were no statistically significant differences in the rates of 30-day major complications, readmissions, or unplanned ED visits between the pre-COVID and during-COVID cohorts (Table 2).

DISCUSSION

The length of hospital stay and discharge disposition after ASD surgery carry substantial implications for patient care

TABLE 2. Bivariate Comparison of Outcome Measures

	Pre-COVID		During-COVID		P-Value
	N	%	N	%	
Home discharge	17	28.3%	40	70.2%	<0.001
Reoperation	6	10.0%	4	7.0%	0.308
ED visit	4	6.7%	4	7.0%	0.940
Readmission	7	11.7%	7	12.3%	0.945
Major complication	5	8.3%	6	10.5%	0.685
Neurologic	1	1.7%	2	3.5%	0.529
Myocardial infarction	0	0.0%	2	3.5%	0.143
PE/DVT	2	3.3%	2	3.5%	0.958
Pneumonia	2	3.3%	1	1.8%	0.589
Cerebrovascular accident	0	0.0%	0	0.0%	–
	Mean	SD	Mean	SD	P-Value
Length of stay	8.5	7.1	6.3	3.8	0.039

ED indicates Emergency department; PE/DVT, pulmonary embolism/deep vein thrombosis.
 Bolded p-values indicate statistical significance.

TABLE 3. Multivariable Regression Analysis of Length of Stay and Discharge Disposition

	IRR/OR	95% CI	P-Value
Length of stay	0.83*	0.72–0.96	0.015
Home Discharge	7.23 [†]	2.79–18.77	<0.001

Both IRR and OR are reported for the During-COVID cohort relative to the Pre-COVID cohort.
 *IRR, incidence risk ratio.
[†]OR, odds ratio.
 CI indicates confidence interval.
 Bolded p-values indicate statistical significance.

and healthcare costs. The resource limitations and increased demand for hospital beds due to COVID-19 presented a unique opportunity to assess how shorter LOS could influence postoperative outcomes. In this study, we examined the impact of the pandemic on LOS, discharge disposition, and 30-day postoperative complications after elective, adult thoracolumbar deformity surgery. Our data demonstrate that ASD patients who underwent surgery during the pandemic had significantly shorter LOS and were more likely to be discharged home compared with those treated before the pandemic. Importantly, there were no significant differences in rates of major complications, reoperation, readmission, or ED visits resulting from the shorter LOS and increased rate of home discharge.

In the current era of value-based care, postoperative LOS and discharge disposition are important considerations both clinically and economically. While ASD surgery is primarily elective, patients usually require a longer LOS with more extensive inpatient monitoring compared with other spine and orthopedic procedures.¹⁷ The ASD patient population is thus uniquely suitable for our study's objective of detecting changes in LOS resulting from the pandemic. Although close inpatient monitoring is required after ASD surgery, prolonged LOS can also slow the recovery process by preventing faster mobilization and delaying patient independence. Further, extended inpatient hospitalization has been shown to increase the risk of complications such as pneumonia and other hospital-acquired infections.¹⁸

ASD surgery is also quite costly, and one major component of this cost is the longer hospital stay often required after ASD surgery relative to other spine surgeries.^{19–21} A 2019 report from the Kaiser Family Foundation estimated that the average hospital expense for each inpatient day ranged from \$1274 to \$3329.²² Although costs were not directly assessed in the present study, one important implication of our findings is that shortening LOS for ASD surgery for appropriate patients may potentially lead to healthcare savings without increasing short-term complication or readmission rates.

There are several factors that may have contributed to the shortened LOS seen in our analysis. At the hospital and provider levels, the pandemic increased the demand for hospital beds, and many surgical floors across the nation were transitioned to care for medicine patients due to the

need for increased hospital capacity. Due to these circumstances, providers may have felt a need to discharge patients more rapidly compared with before the pandemic. From the patient perspective, several national surveys have demonstrated that patients with non-COVID illnesses sought to avoid hospitals to reduce risk of exposure to the virus.^{4,23} As a result, recent data has shown declines in non-COVID emergency department admissions as well as declines in a variety of medical admissions and surgical cases due to the pandemic.^{24–28} It is thus possible that patients undergoing surgery during the pandemic may have tried to meet discharge requirements faster with the goal of leaving the hospital sooner.

It is important to note that patient selection may have played a role in these findings. In our data, although there was no difference in overall surgical risk between the groups in terms of the ASA classification, the pre-COVID patients were on average 6 years older than the during-COVID patients. This may be due to surgeons selecting younger patients for elective surgery during the pandemic since they were less likely to contract as severe form of COVID-19. As such, one possible explanation for the differences in LOS may be that the older patients in the pre-COVID period inherently required more postoperative medical optimization than the younger patients in the during-COVID period. Interestingly, our data suggests that the during-COVID patients may have received more invasive surgeries, due to significantly greater number of levels fused per patient as well as greater EBL. This could be explained by the fact that ASD patients with the most severe deformity or clinical presentation could have been prioritized during the pandemic. Although our study rigorously controlled for various factors that have been shown to influence LOS and discharge disposition such as age, ASA class, the number of levels fused, revision surgery, and three-column osteotomy,^{10,29} our analysis did not control for spinal alignment or preoperative health-related quality of life (HRQoL) scores.

Several factors may explain the 42% higher rate of home discharge observed during the pandemic compared with before. Recent literature has shown that the pandemic placed increased capacity demands on rehabilitation centers across the country.^{30,31} A recent review by Khan and Amata³² estimated that approximately 20% of patients who

were hospitalized for COVID-19 during the initial months of the COVID-19 outbreak required facility-based rehabilitation following discharge. This increased demand of rehabilitation centers to care for an unexpected population of COVID-19 patients may have factored into the decision-making of surgeons and physical therapists to discharge a greater percentage of patients home. Further, as the pandemic progressed and nursing facilities became epicenters of virus spread, approximately 1800 nursing facilities across the country closed or merged.³³ The public reputation of nursing homes during this time may have further encouraged patients and their families to avoid nursing facilities in favor of home discharge.

Importantly, our data suggests that even with the hospital and patient factors that led to reduced LOS and the increased rate of home discharge, ASD patients did not have increased 30-day complications, ED visits, or readmissions during the pandemic. While surgeons should not alter their practice solely on the basis of resource availability in patients who clearly require more extensive inpatient recovery or facility services, lessons learned from the pandemic indicate that efforts toward reducing LOS may not necessarily have negative consequences on ASD patients in the immediate postoperative interval. Prior literature has examined several potential methods for optimizing perioperative care pathways to shorten hospital stay, including preoperative nutritional repletion, multimodal anesthesia, intraoperative maintenance of patient temperature, postoperative resumption of diet, and early mobilization.^{34–36} Similar to our findings, these prior studies also found no difference in postoperative complications and readmission rates after reductions in LOS. Such techniques may have already helped to reduce LOS in the ASD population, as the average total length of stay for ASD surgery has declined over the past decade on a national scale.¹⁷ Similar efforts aimed at reducing modifiable risk factors for non-routine discharge may likewise result in greater home discharge rates without an increase in complications or readmissions.

The results of our study should be interpreted in the context of its limitations. First, although we rigorously controlled for a multitude of factors that have been shown to be associated with adverse outcomes in ASD surgery, we were unable to control for spinal alignment or HRQoL indices. The patients in the pre-COVID and during-COVID cohorts may thus have slight differences in terms of disease severity which may have affected our outcome measures, but every effort was made to control for these potential confounders through our study design. Second, our study only investigated major complications, but not minor complications that could potentially prolong LOS such as postoperative urinary tract infection or ileus. Finally, our study was limited in follow-up duration due to the recency of the COVID-19 pandemic. Ultimately, adult spinal deformity constitutes a unique patient population, and further insight is needed on whether these findings are consistent across more common spine and orthopedic surgical procedures.

Larger sample sizes using data from multiple institutions will be needed to further support our findings.

CONCLUSIONS

During the COVID-19 pandemic, the LOS for patients undergoing thoracolumbar ASD surgery decreased, and more patients were discharged home without adversely affecting complication or readmission rates. Lessons learned during the pandemic may help improve resource utilization without negatively influencing outcomes.

➤ Key Points

- ❑ Hospital length of stay after ASD surgery was significantly shorter during the COVID-19 pandemic compared with before (6 vs. 9 days, $P = 0.039$).
- ❑ ASD patients were more likely to be discharged home during the pandemic compared with before (70% vs. 28%; $P < 0.001$).
- ❑ Despite shorter length of stay and higher home discharge rates, there were no significant differences in major complications, reoperations, readmissions, or ED visits between patients who underwent ASD surgery before the pandemic and those who underwent surgery during the pandemic ($P > 0.05$ for all).
- ❑ Lessons learned during the pandemic may help improve resource utilization without negatively influencing short-term outcomes.

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