Original Article

Lumbar fusion during the COVID-19 pandemic: greater rates of morbidity and longer procedures

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Background: The coronavirus disease 2019 (COVID-19) pandemic has altered the standard of care for spine surgery in many ways. However, there is a lack of literature evaluating the potential changes in surgical outcomes and perioperative factors for spine procedures performed during the pandemic. In particular, no large database study evaluating the impact of the COVID-19 pandemic on spine surgery outcomes has yet been published. Therefore, the aim of this study was to evaluate the impact of the COVID-19 pandemic on perioperative factors and postoperative outcomes of lumbar fusion procedures.

Methods: This retrospective cohort study utilized the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database, which was queried for all adult patients who underwent primary lumbar fusion in 2019 and 2020. Patients were grouped into cohorts based on 2019 (pre-pandemic) or 2020 (intra-pandemic) operation year. Differences in 30-day readmission, reoperation, and morbidity rates were evaluated using multivariate logistic regression. Differences in total relative value units (RVUs), RVUs per minute, and total operation time were evaluated using quantile (median) regression. Odds ratios (OR) for length of stay were estimated via negative binomial regression.

Results: A total of 27,446 patients were included in the analysis (12,473 cases in 2020). Unadjusted comparisons of outcomes revealed that lumbar fusions performed in 2020 were associated with higher rates of morbidity, pneumonia, bleeding transfusions, deep venous thrombosis (DVT), and sepsis. 2020 operation year was also associated with longer length of hospital stay, less frequent non-home discharge, higher total RVUs, and higher RVUs per minute. After adjusting for baseline differences in regression analyses, the differences in bleeding transfusions, length of stay, and RVUs per minute were no longer statistically significant. However, operation year 2020 independently predicted morbidity, pneumonia, DVT, and sepsis. In terms of perioperative variables, operation year 2020 predicted greater operative time, non-home discharge, and total RVUs.

Conclusions: Lumbar fusion procedures performed amidst the COVID-19 pandemic were associated with poorer outcomes, including higher rates of morbidity, pneumonia, DVT, and sepsis. In addition, surgeries performed in 2020 were associated with longer operative times and less frequent non-home discharge disposition.

Keywords: Lumbar spine; lumbar fusion; coronavirus; coronavirus disease 2019 (COVID-19); pandemic

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Introduction

The scale and severity of the coronavirus disease 2019 (COVID-19) pandemic is unprecedented in the modern era, and it has dramatically altered healthcare systems globally. In an effort to cope with the pandemic, institutions strove to minimize patient and provider risk and the utilization of healthcare resources, leading to significant surgical delays and cancellations (1). This aimed to reduce the volume of elective procedures to reduce the burden of care for postoperative patients, thereby allowing greater resources to be allocated for patients with COVID-19 (2).

As with all other specialties, the field of spine surgery has been greatly impacted by the systemic changes in response to the pandemic. However, due to the time-sensitive nature of certain spinal pathologies, the spine service has remained relatively more active than other orthopaedic specialties, even during the initial peak of the pandemic and its associated restrictions (3). Spine surgeons have a critical role in the pandemic to identify and still treat patients with urgent and emergent spinal conditions while attempting to minimize resource utilization as feasible (4). Despite the widespread surgery cancellations, care was largely continued for patients presenting with progressive neurological deficits, myelopathy with spinal cord at risk, spine trauma with instability, or cauda equina syndrome (5).

Several studies have evaluated the potential impact of the COVID-19 pandemic on postoperative outcomes following various types of surgical procedures (6-8). However, there is a paucity of literature evaluating the potential changes in surgical outcomes and perioperative factors for spine procedures performed during the pandemic. In particular, no large database study evaluating the impact of the COVID-19 pandemic on spine surgery outcomes has yet been published. Therefore, the aim of the current study was to evaluate the impact of the COVID-19 pandemic on perioperative factors and postoperative outcomes for patients undergoing lumbar fusion procedures. We present the following article in accordance with the STROBE reporting checklist (available at https://jss.amegroups.com/article/view/10.21037/jss-22-45/rc).

Highlight box

Key findings

- Lumbar fusion procedures performed amidst the COVID-19 pandemic were associated with poorer outcomes, including higher rates of morbidity, pneumonia, DVT, and sepsis. In addition, surgeries performed in 2020 were associated with longer operative times and less frequent non-home discharge disposition.

What is known and what is new?

- The field of spine surgery has been greatly impacted by the systemic changes in response to the COVID-19 pandemic.
- The current manuscript highlights the impact of the COVID-19 pandemic on outcomes and perioperative factors of lumbar fusions in the United States.

What is the implication, and what should change now?

- These findings suggest that the necessary adaptations of clinical practice in response to the pandemic-related restrictions influenced the outcomes and perioperative variables of lumbar fusion surgery. These effects should be considered in any future systemic changes to healthcare delivery in spine surgery.

Methods

Declaration of Helsinki was not relevant for this study as it did not include any direct patient contact or human subjects. Approval by an institutional ethics board or informed consent were not necessary for this study as it utilized a publicly available, deidentified national surgical database, and no direct patient contact was involved.

Study design and population

This is a retrospective cohort study utilizing data obtained from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database. ACS-NSQIP has been shown to have excellent validity, reliability, and a low rate of reporting error (9,10). The database was queried for all adult patients who underwent primary lumbar fusion in 2019 and 2020 using current procedural terminology (CPT) codes 22612, 22630, 22633, and 22558. Exclusion criteria included cervical or thoracic fusion, arthroplasty, non-elective, emergency cases, deformity procedures, operative levels of 6 levels or greater, osteotomy, revision surgery, malignancy, preoperative sepsis, wound infection, unexpected weight loss, and missing

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perioperative variables. Patients were grouped into cohorts based on 2019 or 2020 operation year.

Outcomes and variables

The primary outcomes included 30-day readmission, reoperation, and morbidity complication rates. Readmission includes any inpatient stay to the same or another hospital related to the surgical procedure. Reoperation includes all major surgical procedures requiring return to the operating room for intervention of any kind. Morbidity includes infectious, pulmonary, cardiac, renal, neurological, hematologic, and thromboembolic complications reported in the ACS-NSQIP datasets (11). Rates of selected individual complications were also analyzed. Incidences of superficial surgical site infections (SSI), deep SSI, organ/space SSI, wound disruption, pneumonia, unplanned intubation, pulmonary embolism, requirement of ventilator >48 hours, progressive renal insufficiency, acute renal failure, urinary tract infection, stroke, cardiac arrest, myocardial infarction, bleeding transfusions, deep venous thrombosis (DVT), and sepsis were compared between the 2019 and 2020 operation year groups. Relative value units (RVUs) assigned for lumbar fusion procedures were also compared between the cohorts. RVU is the basis for the Medicare reimbursement formula and is used to determine physician payments nationally. RVUs consider the physician's work, the expenses of the physician's practice, and professional liability insurance (12,13).

Statistical analysis

The frequency and proportion were recorded for each categorical variable, and descriptive statistics including mean and standard deviation were calculated for continuous variables. Differences in baseline characteristics between operation year 2019 *vs.* 2020 groups were compared with Mann-Whitney U test, Pearson Chi-square test, or Fisher's exact test as appropriate. Baseline variables that approached statistical significance (P<0.10) were included and controlled for in the subsequent multivariate regression models. Differences in 30-day readmission, reoperation, and morbidity rates were evaluated using multivariate logistic regression; backwards stepwise regression model was utilized to account for all baseline differences in demographics, comorbidities, and procedural factors, with entry at P=0.05 and removal at P=0.1. The assumption of normality was assessed for total RVUs, RVUs per minute, operation time, and length of stay using Kolmogorov-Smirnov test and was not met. Therefore, regression coefficients for total RVUs, RVUs per minute, and total operation time were estimated using quantile (median) regression. Odds ratio (OR) for length of stay was estimated via negative binomial regression. Goodness of fit was assessed using Hosmer-Lemeshow test, Akaike Information Criteria, or Bayesian Information Criteria, as appropriate. All statistical analyses were performed using SPSS software (version 28, IBM, Armonk, New York, USA). The criterion for statistical significance was set at P<0.05.

Results

A total of 27,446 patients were included in the analysis (12,473 cases in 2020). Fifteen patients were excluded for missing operation time data. The mean age of the total cohort was 61.4±12.6 years, and 14,498 (52.8%) patients were female. For the 2020 cohort, non-White race (24.9% *vs.* 23.4%, P=0.004), functional dependence (1.8% *vs.* 1.4%, P=0.022), congestive heart failure (0.5% *vs.* 0.3%, P=0.015), and ASA class ≥3 (53.5% *vs.* 52.2%, P=0.037) were more common. Outpatient surgery setting was significantly more common in 2020 compared to 2019 (10.7% *vs.* 5.4%, P<0.001). Lumbar fusions performed in 2020 were also associated with longer mean operative time (209.3±99.3 *vs.* 205.9±98.6 minutes, P=0.005) and higher mean fusion levels (1.45±0.69 *vs.* 1.41±0.65, P<0.001) (*Table 1*).

Unadjusted comparisons of outcomes revealed that lumbar fusions performed in 2020 were associated with higher rates of morbidity (12.1% *vs.* 10.9%, P=0.002), pneumonia (0.7% *vs.* 0.5%, P=0.019), bleeding transfusions (7.0% *vs.* 6.1%, P=0.006), DVT (0.7% *vs.* 0.5%, P=0.005), and sepsis (0.6% *vs.* 0.4%, P=0.009). 2020 operation year was also associated with longer length of hospital stay (3.4±2.9 *vs.* 3.3±3.9 days, P=0.002), less frequent non-home discharge (11.6% *vs.* 15.2%, P<0.001), higher total RVUs (56.0±22.5 *vs.* 54.0±21.2, P<0.001), and higher RVUs per minute (0.321±0.190 *vs.* 0.316±0.183, P=0.021) (*Table 2*).

After adjusting for baseline differences in multivariate regression analyses, the differences in bleeding transfusions, length of stay, and RVUs per minute were no longer statistically significant (P>0.05). However, operation year 2020 independently predicted morbidity [OR 1.087, 95% confidence interval (CI): 1.007–1.172, P=0.032], pneumonia (OR 1.407, 95% CI: 1.039–1.906, P=0.027), DVT (OR 1.508, 95% CI: 1.106–2.056, P=0.009), and sepsis (OR 1.537, 95% CI: 1.101–2.146, P=0.012). In terms

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Table 1 Baseline patient characteristics

Characteristics	2019, n (%)	2020, n (%)	P value
N of subjects	14,973	12,473	–
Age (years), mean ± SD	61.4±12.6	61.5±12.6	0.591
Female sex	7,952 (53.1)	6,546 (52.5)	0.300
Non-White race	3,501 (23.4)	3,105 (24.9)	0.004*
Hispanic ethnicity	2,182 (14.6)	1,821 (14.6)	0.950
Comorbidities			
Obesity	7,991 (53.4)	6,524 (52.3)	0.079
Diabetes mellitus	2,992 (20.0)	2,469 (19.8)	0.698
Current smoker	2,500 (16.7)	1,981 (15.9)	0.069
Dyspnea	769 (5.1)	631 (5.1)	0.773
Functional dependence	216 (1.4)	224 (1.8)	0.022*
Ventilator dependent	4 (0.0)	4 (0.0)	0.796
Severe COPD	672 (4.5)	576 (4.6)	0.607
Congestive heart failure	43 (0.3)	58 (0.5)	0.015*
Hypertension requiring medication	8,760 (58.5)	7,214 (57.8)	0.264
Acute renal failure	5 (0.0)	9 (0.0)	0.157
Dialysis	26 (0.2)	18 (0.1)	0.545
Chronic steroid use	674 (4.5)	545 (4.4)	0.597
Bleeding disorder	200 (1.3)	178 (1.4)	0.518
Blood transfusions	11 (0.1)	8 (0.0)	0.770
ASA class ≥3	7,821 (52.2)	6,673 (53.5)	0.037*
Laboratory values			
Elevated creatinine	2,870 (19.2)	2,293 (18.4)	0.098
Elevated white blood cells	1,863 (12.4)	1,554 (12.5)	0.967
Low hematocrit	1,801 (12.0)	1,552 (12.4)	0.296
Low platelet	1,666 (11.1)	1,388 (11.1)	0.997
Procedural factors			
Outpatient setting	812 (5.4)	1,334 (10.7)	<0.001*
Operative time (min), mean ± SD	205.9±98.6	209.3±99.3	0.005*
Wound class ≥2	101 (0.7)	74 (0.6)	0.400
Levels fused, mean ± SD	1.41±0.65	1.45±0.69	<0.001*
1 level	9,960 (66.5)	7,948 (63.7)	<0.001*
2 levels	4,194 (28.0)	3,721 (29.8)	<0.001*
3+ levels	819 (5.5)	804 (6.4)	<0.001*

*, indicates statistical significance (P<0.05). SD, standard deviation; COPD, chronic obstructive pulmonary disease; ASA, American Society of Anesthesiologists.

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Table 2 Unadjusted 30-day outcomes of lumbar fusions performed in 2019 *vs.* 2020

Variable	2019, n (%)	2020, n (%)	P value
N of subjects	14,973	12,473	–
30-day outcomes			
Readmission	777 (5.2)	664 (5.3)	0.620
Reoperation	416 (2.8)	365 (2.9)	0.463
Morbidity	1,633 (10.9)	1,512 (12.1)	0.002*
Complications			
Superficial SSI	193 (1.3)	161 (1.3)	0.989
Deep SSI	53 (0.4)	57 (0.5)	0.179
Organ/space SSI	63 (0.4)	65 (0.5)	0.224
Wound disruption	50 (0.3)	50 (0.4)	0.359
Pneumonia	78 (0.5)	93 (0.7)	0.019*
Unplanned intubation	25 (0.2)	31 (0.2)	0.136
Pulmonary embolism	79 (0.5)	70 (0.6)	0.706
Ventilator >48 hours	20 (0.1)	16 (0.1)	0.904
Renal insufficiency	27 (0.2)	23 (0.2)	0.937
Acute renal failure	9 (0.1)	8 (0.1)	0.894
Urinary tract infection	228 (1.5)	189 (1.5)	0.960
Stroke	24 (0.2)	20 (0.2)	0.999
Cardiac arrest requiring CPR	6 (0.0)	7 (0.1)	0.543
Myocardial infarction	49 (0.3)	53 (0.4)	0.186
Bleeding transfusions	918 (6.1)	868 (7.0)	0.006*
Deep venous thrombosis	72 (0.5)	93 (0.7)	0.005*
Sepsis	63 (0.4)	81 (0.6)	0.009*
Perioperative variables			
Length of stay (days), mean ± SD	3.3±3.9	3.4±2.9	0.002*
Non-home discharge	2,274 (15.2)	1,449 (11.6)	<0.001*
Total RVUs, mean ± SD	54.0±21.2	56.0±22.5	<0.001*
RVUs per minute, mean ± SD	0.316±0.183	0.321±0.190	0.021*

*, indicate statistical significance (P<0.05). SSI, surgical site infection; CPR, cardiopulmonary resuscitation; RVUs, relative value units.

of perioperative variables, operation year 2020 predicted greater operative time (OR 5.000 minutes, 95% CI: 2.576–7.424 minutes, P<0.001), non-home discharge (OR 0.690, 95% CI: 0.642–0.743, P<0.001), and total RVUs (OR 1.044, 95% CI: 1.004–1.083, P=0.006) (*Table 3*).

Discussion

This study aimed to evaluate the impact of the COVID-19 pandemic on perioperative factors and postoperative outcomes of lumbar fusion procedures. Lumbar fusion

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Table 3 Multivariate regression analysis of impact of operation year 2020 on postoperative outcomes following lumbar fusion

Variable	Odds ratio/coefficient	95% confidence interval	P value
30-day outcomes			
Readmission	1.009	0.906–1.123	0.877
Reoperation	1.028	0.891–1.186	0.710
Morbidity	1.087	1.007–1.172	0.032*
Complications			
Deep SSI	1.301	0.891–1.901	0.173
Pneumonia	1.407	1.039–1.906	0.027*
Bleeding transfusions	1.099	0.995–1.212	0.061
Deep venous thrombosis	1.508	1.106–2.056	0.009*
Sepsis	1.537	1.101–2.146	0.012*
Perioperative variables			
Length of stay[†]	1.019	0.991–1.045	0.178
Operative time[#]	5.000	2.576–7.424	<0.001*
Non-home discharge	0.690	0.642–0.743	<0.001*
Total RVUs[#]	1.044	1.004–1.083	0.006*
RVUs per minute[#]	1.004	1.000–1.009	0.060

*, indicate statistical significance (P<0.05); [†], negative binomial regression; [#], quantile (median) regression. SSI, surgical site infection; RVUs, relative value units.

procedures performed during the COVID-19 pandemic were associated with poorer outcomes, including higher rates of morbidity, pneumonia, DVT, and sepsis. Surgeries performed in 2020 were also associated with longer operative times and less frequent non-home discharge disposition.

During the initial peak of the COVID-19 pandemic, federal and state governments have mandated postponement or suspension of non-urgent surgical interventions (14,15). Orthopaedic surgical case volume was reported to have been reduced by 44% in 2020, with an increase in emergency-to-elective procedures ratio from 1.3:1 to 3.8:1 (16). However, the surgical volume in the current study remained similar between 2019 and 2020, which may reinforce the previous point that spine procedures were largely able to proceed during the pandemic due to the prevalence of urgent and emergent procedures. Since the initial peak of the pandemic, national restrictions on surgical procedures have loosened, and elective cases have largely been resumed, in conjunction with several studies supporting the safety of this trend. In a prospective observational study, Mohammed *et al.* demonstrated that with diligent adherence to national guidelines and COVID-19-secure pathways, elective spine surgery can safely be restored while avoiding viral transmission and without increasing the risk of complications (17). Manuia *et al.* showed that common operating room procedures do not increase the risk of symptomatic COVID-19 infection (18).

Regarding 30-day outcomes, the current study found that lumbar fusions performed during the COVID-19 pandemic were associated with significantly higher 30-day morbidity and higher rates of pneumonia, DVT, and sepsis. This increase in morbidity rate may be related to treatment of more complex pathology requiring greater level of case complexity on average. This is supported by the greater mean total RVUs assigned to the 2020 group compared to the 2019 group. It is possible that less complex procedures for less severe pathology were more frequently postponed or cancelled during the pandemic whereas more complex procedures may have been still performed due to the greater urgency, thereby leading to higher average complexity of cases. The difference in morbidity

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and complications may also be related to COVID-19-related policy changes, which may have hindered operating room efficiency and caused significant delays in cases. Furthermore, there were likely differences in peri- and postoperative factors which would ultimately influence surgical outcomes, such as the availability and effectiveness of physical therapy. In 2020, the World Confederation for Physical Therapy recommended physical therapists to postpone treatments considered not urgent, which led to a widespread suspension of physical therapy services (19). Patients unable to receive physical therapy were likely less active following spine surgery, which may have contributed to the increase in DVT rates during the pandemic. In addition, among patients undergoing major elective surgery, a history of COVID-19 infection within 8 weeks prior to surgery is associated with an increased risk of postoperative pneumonia (20). During the initial peak of the pandemic, it is possible that this may have been a significant contributor to the increase in pneumonia rates within our study cohort.

Prior studies have also evaluated the impact of the pandemic on short-term outcomes following spine surgery. Louie *et al.* performed a matched comparison of the perioperative outcomes of patients undergoing spine surgery during the pandemic to those who underwent surgery before the pandemic and found no significant differences in 1-month postoperative complication rates (16.5% pandemic *vs.* 12.6% control) (3). Riley *et al.* found that spine surgeries performed during the COVID-19 pandemic were associated with a 30-day mortality rate compared to surgeries performed during the same period in 2019 (4.2% *vs.* 2.3%), but this was not statistically significant (5). The lack of statistical significance in these studies, however, may be attributed to type II error given the limited cohort sizes of 127 and 72 patients, respectively.

Compared to lumbar fusions performed in 2019, those performed in 2020 were associated with significantly longer operative times. A potential explanation for this finding is an increased average case complexity for surgeries performed during the pandemic. This is further supported by the fact that lumbar fusions performed in 2020 were also associated with higher mean total RVUs despite no significant difference in mean RVUs per minute of operative time. RVUs vary based on the physician's work and procedure complexity and difficulty (21,22). Therefore, the increase in operation times during the COVID-19 pandemic noted within this cohort can likely be attributed to an increase in average case complexity and increase in procedures being performed per case, as opposed to decreased efficiency from pandemic-related changes in the hospitals at a national level. Weiner *et al.* performed a cross-sectional observational study via surveys distributed to AO spine members and found that COVID-19 significantly decreased clinical productivity, revenue, and income (23). A possible reason why these findings may not be as prominent in our study cohort is that the ACS-NSQIP database is comprised mostly of academic institutions (11). The study by Weiner *et al.* included a more even distribution of practice types, and the authors noted that private practice and privademic surgeons experienced greater losses in revenue and income compared with academic or public surgeons (23).

There were significant differences in perioperative variables between cohorts. Non-home discharge disposition, including discharge to rehabilitation and non-home skilled care (24,25), was significantly less frequent after lumbar fusions performed in 2020. Similar findings have been reported in literature; Wang *et al.* evaluated the hospital length of stay and discharge patterns for patients undergoing adult spinal deformity surgery during the COVID-19 pandemic. Compared to the 2019 control group, patients who underwent surgery during the pandemic were found to have decreased length of stay and higher home discharge rates, with no significant difference in major complications, reoperations, or readmissions (26). This finding may be explained by several factors. The pandemic placed significant capacity demands on rehabilitation centers throughout the United States (27,28). During the initial months of the pandemic, about 20% of the patients hospitalized for COVID-19 required post-discharge facility-based rehabilitation (29). With the progression of the pandemic, many nursing care facilities became epicenters of COVID-19 spread, forcing approximately 1,800 nursing facilities to close or merge (30). These factors may have led to the reduced availability of post-discharge rehabilitation centers for spine patients and encouraged surgeons and patients to favor home discharge following surgery when possible. Outpatient surgery was also more frequently performed during the pandemic. This shifting trend was likely secondary to the limited inpatient operating room availability during the peak pandemic period. Another motivation to increase outpatient volume may have been to reduce infection risk associated with inpatient stays within hospitals. Although the current evidence reports favorable outcomes and safety profile of outpatient lumbar fusions (31,32), a future investigation on

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the influence of increased outpatient surgery specifically in the setting of the pandemic on postoperative outcomes may be warranted.

There are several important limitations that must be considered when interpreting the current study. The retrospective study design limits the level of evidence and the conclusions that can be drawn. The ACS-NSQIP database is comprised mainly of academic medical centers, which may limit the generalizability of the current study findings. As previously noted, the impact of the pandemic has been shown to significantly differ between private practice and academic surgeons (23); thus, this may limit the generalizability of the current study's findings. Further, the study cohorts were divided based on operation years 2019 and 2020. Given that the global pandemic was declared by the World Health Organization in March 2020, patients who underwent surgery in January or February 2020 were likely unaffected by the pandemic and its associated restrictions. However, analyses performed while controlling for admission quarters revealed no significant association between admission quarter and 30-day outcomes. Another limitation is the inability to account for participation of postoperative rehabilitation after lumbar fusion, which may have been significantly different between the cohorts due to rehabilitation center closures during the peak pandemic period. Despite these limitations, the current study provides valuable evidence for evaluating the impact of the COVID-19 pandemic on short-term outcomes following lumbar fusion surgery on a national scale.

Conclusions

Lumbar fusion procedures performed amidst the COVID-19 pandemic were associated with poorer 30-day outcomes, including higher rates of morbidity, pneumonia, DVT, and sepsis. In addition, lumbar fusions performed in 2020 were associated with longer operative times and less frequent non-home discharge disposition.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://jss.amegroups.com/article/view/10.21037/jss-22-45/rc

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Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://jss.amegroups.com/article/view/10.21037/jss-22-45/coif). The authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The Declaration of Helsinki was not relevant for this study as it did not include any direct patient contact or human subjects. Approval by an institutional ethics board or informed consent were not necessary for this study as it utilized a publicly available, deidentified national surgical database, and no direct patient contact was involved.

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