Incidence and Predictive Factors of Sepsis Following Adult Spinal Deformity Surgery

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This abstract was presented in poster format at the 2017 meeting of the Congress of Neurological Surgeons, October 7 to 11, Boston, Massachusetts.

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Received, July 22, 2017.
Accepted, November 4, 2017.
Published Online, December 21, 2017.

BACKGROUND: Surgery for adult spinal deformity (ASD) improves quality of life, yet morbidity is high. Sepsis is a challenging postoperative complication that can result in death and drive inpatient resources.

OBJECTIVE: To identify the incidence and risk factors for development of sepsis within 30 days following ASD surgery.

METHODS: Adult patients who underwent thoracolumbar spinal deformity correction between 2008 and 2014 were identified in the National Surgical Quality Improvement Program database. Demographic and operative variables were extracted. The primary outcome was development of postoperative sepsis. Multivariable logistic regression modeling was used to identify independent risk factors for sepsis.

RESULTS: A total of 6158 patients underwent ASD surgery. Of these, 156 (2.5%) developed sepsis postoperatively. Independent risk factors included operative time (odds ratio [OR]: 1.004, 95% confidence interval [CI]: 1.003-1.005, $P < .001$), male sex (OR: 1.47, 95% CI: 1.05-2.05, $P = .023$), diabetes (OR: 1.59, 95% CI: 1.05-2.40, $P = .027$), functional dependency (OR: 1.82, 95% CI: 1.12-2.95, $P = .015$), weight loss (OR: 2.45, 95% CI: 1.04-5.78, $P = .040$), bleeding disorder (OR: 2.58, 95% CI: 1.34-4.93, $P = .004$), and ascites (OR: 56.11, 95% CI: 5.01-628.50, $P = .001$). This model demonstrated strong predictive capacity, with an area under the curve of 0.80. Patients who developed sepsis were significantly more likely to have a prolonged hospital stay ($P < .001$), be readmitted ($P < .001$), and die ($P < .001$). The median (range) time to sepsis was 9 d (0-30).

CONCLUSION: In patients undergoing ASD surgery, male sex, diabetes, ascites, bleeding disorder, functional dependency, excessive weight loss and increased operative time independently predicted sepsis. This perioperative patient profile can be used for preoperative risk assessment, patient counseling, and postoperative management for patients undergoing ASD surgery.

KEY WORDS: Adult spinal deformity, Sepsis, Septicemia, Infection, Risk factors

Neurosurgery 83:965–972, 2018 DOI:10.1093/neuros/nyx578 www.neurosurgery-online.com

Adult spinal deformity (ASD) surgery has been shown to significantly improve quality of life[1] and reduce pain,[2,3] but the risk of both major and minor complications is high.[4,5] Infection represents a common and inherent potential complication, as 1 study of over 100 000 general spine surgery cases reported a 2.1% local infection rate.[6] In a strictly surgical ASD population of 830 patients, an infection occurred in 5.5% of patients, 3.5% of which were deep. Most often, infections are managed with long-term antibiotics and/or surgical debridement; however, in some cases, local infection can rapidly evolve into sepsis.

Sepsis is the body's overwhelming response to an infection that can lead to end organ failure and/or death and also represents a significant driver of inpatient resources and costs, estimated at over $32 400 per patient.[7] Compared to local infection, which has been well studied in the ASD literature,[4,6,8,9] less is known about the rare and severe occurrence of sepsis. Rates of sepsis following ASD have ranged from 0.7%[10] to 3%,[11] typically developing between postoperative days 10 to 12.[11] ASD patients who

ABBREVIATIONS: ASD, adult spinal deformity; **CI,** confidence interval; **CPT,** Current Procedural Terminology; **ICD,** International Classifications of Diseases; **LOS,** length of stay; **NSQIP,** National Surgical Quality Improvement Program; **OR,** odds ratio develop sepsis have been shown to have 6.9 times the odds of requiring reintubation compared to nonseptic patients.[12] In the rare event of mortality following ASD surgery, sepsis has been the inciting event in as high as 30% of patients.[13] Furthering our knowledge of what places ASD patients at increased risk for sepsis can allow for early diagnosis and avoidance of this major complication, a topic of interest to many stakeholders in medicine.[14]

To our knowledge, few studies have addressed the incidence and predictive factors of sepsis following ASD surgery. This life-threatening complication, particularly in an elective surgical population, warrants further investigation. The purpose of this study was to identify the incidence and risk factors for the development of sepsis within 30 d following surgical treatment for ASD.

METHODS

Patient Identification

The 2008-2014 American College of Surgeons National Surgical Quality Improvement Program (NSQIP) database was used to collect data for patients who underwent spinal fusion for ASD. Over 600 hospitals participate in the NSQIP registry, and data are collected prospectively by trained and audited data collection specialists in accordance with rigorous definitions.[17] NSQIP collects roughly 135 clinical variables on patients undergoing major surgeries, including preoperative risk factors, operative data, and postoperative occurrences within 30 d of the index operation.[17] The case series for the present study was generated by employing the following Current Procedural Terminology (CPT) codes:

- 22800 (posterior arthrodesis for spinal deformity up to 6 segments)
- 22802 (posterior arthrodesis for spinal deformity 7-12 segments)
- 22804 (posterior arthrodesis for spinal deformity 13 or more segments)
- 22808 (anterior arthrodesis for spinal deformity 2-3 segments)
- 22810 (anterior arthrodesis for spinal deformity 4-7 segments)
- 22812 (anterior arthrodesis for spinal deformity 8 or more segments)
- 22818 (kyphectomy, resection of vertebral segment, single or 2 segments)
- 22819 (kyphectomy, resection of vertebral segment, 3 or more segments)
- 22843 (posterior segmental instrumentation, 7-12 segments)
- 22844 (posterior segmental instrumentation, 13 or more segments)
- 22846 (anterior instrumentation, 4-7 segments)
- 22847 (anterior instrumentation, 8 or more segments).

Arthrodesis codes such as 22610 (posterior arthrodesis, single-level thoracic), 22612 (posterior arthrodesis, single-level lumbar), 22830 (exploration of spinal fusion), and 22633 (posterior arthrodesis, interbody technique, single lumbar interspace) were considered inherent within the use of the instrumentation codes in ASD. Patients with CPT codes 22842 (posterior segmental instrumentation, 3-6 segments) or 22845 (anterior instrumentation, 2-3 segments) were also included if they were diagnosed with spinal deformity according to an International Classifications of Diseases (ICD-9) code of 737.1, 737.2, 737.3, 737.4, 737.8, or 737.9. These coding parameters were based on a previous NSQIP study of this surgical population.[18-22]

Data Collection

All NSQIP data are collected prospectively by independent data collection specialists. Relevant demographic and perioperative information was collected, including age, sex, race, body mass index, year of operation, operative time, postoperative length of stay (LOS), and in-depth comorbidity profiles. Comorbidities, including diabetes (requiring an oral agent or insulin for sugar control), cigarette use (use in last 1 yr), functional dependency (independent vs partially or totally dependent), ventilator use (ventilator-assisted respiration in 48 h before surgery), chronic obstructive pulmonary disease, hypertension, congestive heart failure, myocardial infarction, dyspnea, peripheral vascular disease, transient ischemic attack, cerebrovascular accident, percutaneous coronary intervention, bleeding disorder (chronic condition that places patient at risk for excessive bleeding such as vitamin K deficiency, hemophilia, or continued anticoagulation therapy), rapid weight loss (unintentional >10% weight loss in last 6 mo), prior transfusion, steroid use, dialysis, prior chemotherapy or radiation treatment, disseminated cancer, and American Society of Anesthesiologists score, were also recorded. Of note, nutritional status measured by albumin levels, which has been shown to affect outcomes after spine surgery,[23,24] was not included in our model due to missing data for a large subset of patients.

The primary outcome of interest was the development of sepsis or septic shock within the 30-d postoperative period. A diagnosis of sepsis was recorded for patients with at least 2 clinical signs of Systemic Inflammatory Response Syndrome,[25] including abnormal heart rate, respiratory rate, abnormal temperature, or white blood cell count along with positive blood cultures, purulence in the operative site, or bowel ischemia/injury, which is less relevant to an ASD population. Septic shock consists of sepsis that has progressed to documented organ dysfunction. Though the most recent 2016 sepsis guidelines have deemed the Systemic Inflammatory Response Syndrome criteria unhelpful,[26] the definition of sepsis for the prior 25 yr was utilized.[25]

Postoperative complications were classified as major or minor, as per prior neurosurgical NSQIP studies.[19] Major complications included death, ventilator use exceeding 48 h, return to the operating room, unplanned intubation, sepsis, venous thromboembolism, coma, stroke, cardiac arrest, septic shock, myocardial infarction, infection of the surgical site or organ space, and acute renal failure.[14] Minor complications consisted of perioperative blood transfusion, urinary tract infection, pneumonia, renal insufficiency, and wound dehiscence. The third outcome metric of interest was prolonged LOS, which included patients who exceeded the 75th percentile for total hospital stay.[3]

Statistical Analysis

Descriptive statistics were performed to identify the demographics and postoperative characteristics of the patient series. Univariate analyses were then used to test the association between each perioperative variable and subsequent adverse events as well as LOS. Variables that resulted in an association of $P < .10$ were then incorporated into a multivariable logistic regression model in order to identify the independent predictors of sepsis. The c-statistic was computed to assess the predictive capacity of the regression models, and the Hosmer-Lemeshow test was performed to test for lack of goodness-of-fit to the data. The relationship between postoperative sepsis and the risk of other adverse events, including prolonged LOS and death, was evaluated via chi-squared tests. Cases with missing data for any of the variables were excluded by a list-wise deletion method.

TABLE 1. Case Series Characteristics

Demographics	n = 6158
Age (mean ± SD)	59 ± 14 yr
BMI (mean ± SD)	29 ± 7
Sex (M: F)	2670: 3480
Select Comorbidities	
Hypertension	3238 (52.6%)
Smoking	1344 (21.8%)
Diabetes	904 (14.7%)
Dyspnea	402 (6.5%)
Smoking	367 (6.0%)
Perioperative Variables	
Operative time (mean ± SD)	276 ± 150 min
General anesthesia	6131 (99.6%)
ASA score 2-3	5685 (92.5%)
Total hospital stay	6 ± 8 d
Operative Variables	
Posterior arthrodesis for spinal deformity, n (%)	
Up to 6 segments (22800)	428 (7.0%)
7 to 12 segments (22802)	168 (2.7%)
13 or more segments (22804)	42 (0.7%)
Anterior arthrodesis for spinal deformity, n (%)	
2 to 3 segments (22808)	165 (2.7%)
4 to 7 segments (22810)	44 (0.7%)
8 or more segments (22812)	10 (0.2%)
Kyphectomy, resection of vertebral segment, n (%)	
Single or 2 segments (22818)	8 (0.1%)
3 or more segments (22819)	7 (0.1%)
Posterior segmental instrumentation, n (%)	
Up to 6 segments (22842)	652 (10.6%)
7 to 12 segments (22843)	1942 (31.5%)
13 or more segments (22844)	302 (4.9%)
Anterior segmental instrumentation, n (%)	
2 to 3 segments (22845)	262 (4.2%)
4 to 7 segments (22846)	2105 (34.2%)
8 or more segments (22847)	23 (0.4%)
Postoperative Complications	
Sepsis or septic shock	156 (2.5%)
Sepsis	118 (1.9%)
Septic shock	38 (0.6%)
Death	65 (1.1%)
Death following sepsis or septic shock	11 (7.1%)[a]

ASA: American Society of Anesthesiologists; BMI: body mass index
[a]Rate computed for septic patients only (n = 156).

RESULTS

Demographics

A total of 6158 patients surgically treated for ASD from the NSQIP database met inclusion criteria. Of these, 156 (2.5%) developed sepsis postoperatively. Patient demographics are summarized in Table 1. With respect to time, the rate of sepsis was stable: 2008 (2.1%), 2009 (4.6%), 2010 (3.6%), 2011 (3.9%), 2012 (1.9%), 2013 (2.1%), 2014 (2.6%).

TABLE 2. Variables Associated With Postoperative Sepsis via Univariate Analysis

All Patients	OR (95% CI)
Male sex	1.50 (1.09-2.06)
Diabetes	2.05 (1.42-2.96)
Smoking	0.49 (0.30-0.79)
Dyspnea	2.04 (1.25-3.32)
Dependent functional status	3.16 (2.03-4.92)
Ascites	117.67 (12.17-1137.64)
CHF	3.34 (1.02-10.99)
Hypertension	1.42 (1.02-1.96)
Steroid use	1.66 (0.93-2.96)
Weight loss	5.48 (2.45-12.28)
Bleeding Disorder	4.71 (2.65-8.39)
Transfusion	2.69 (1.16-6.24)
Age	1.02 (1.00-1.03)
BMI	1.02 (1.00-1.05)
Operation time	1.004 (1.003-1.005)
ASA Score[a]	–

ASA: American Society of Anesthesiologists; BMI: body mass index; CHF: congestive heart failure.
[a]ASA Score was assessed as part of a 4 × 2 table and the OR could thus not be computed.

Logistic Regression Analyses

Perioperative variables that resulted in $P < .10$ in association with postoperative sepsis are listed in Table 2. When assessed as covariates in a multivariable model, independent risk factors included male sex (odds ratio [OR]: 1.47, 95% confidence interval [CI]: 1.05-2.05, $P = .023$), diabetes (OR: 1.59, 95% CI: 1.05-2.40, $P = .027$), smoking (OR: 0.50, 95% CI: 0.30-0.84, $P = .009$), functional dependency (OR: 1.82, 95% CI: 1.12-2.95, $P = .015$), ascites, (OR: 56.11, 95% CI: 5.01-628.50, $P = .001$), preoperative weight loss (OR: 2.45, 95% CI: 1.04-5.78, $P = .04$), bleeding disorder (OR: 2.58, 95% CI: 1.34-4.93, $P = .004$), and operative time (OR: 1.004, 95% CI: 1.003-1.005, $P < .001$). All independent predictors are summarized graphically (Figure 1). Interestingly, patients who smoked a cigarette in the year prior to surgery had a protective effect against the development of sepsis. A receiver operating characteristic curve was developed (Figure 2). This model demonstrated strong predictive capacity, with an area under the curve of 0.80. These findings are summarized in Table 3.

Sepsis and Other Postoperative Adverse Events

Unadjusted analysis via chi-squared testing was done. Postoperative sepsis was associated with a significantly greater risk of mortality (OR: 8.36, 95% CI: 4.28-16.31, $P < .001$) and prolonged LOS (OR: 10.38, 95% CI: 6.91-15.60, $P < .001$). The median (range) time to sepsis or septic shock was 9 d (0-30; Figure 3).

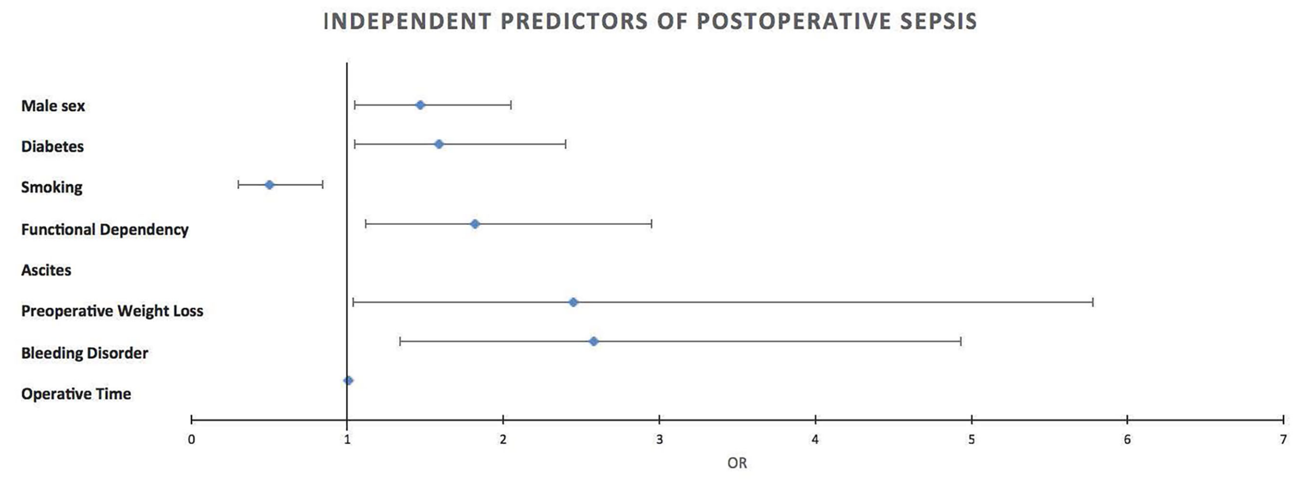

FIGURE 1. *Forest plot of independent predictors of sepsis with corresponding odds ratio.*

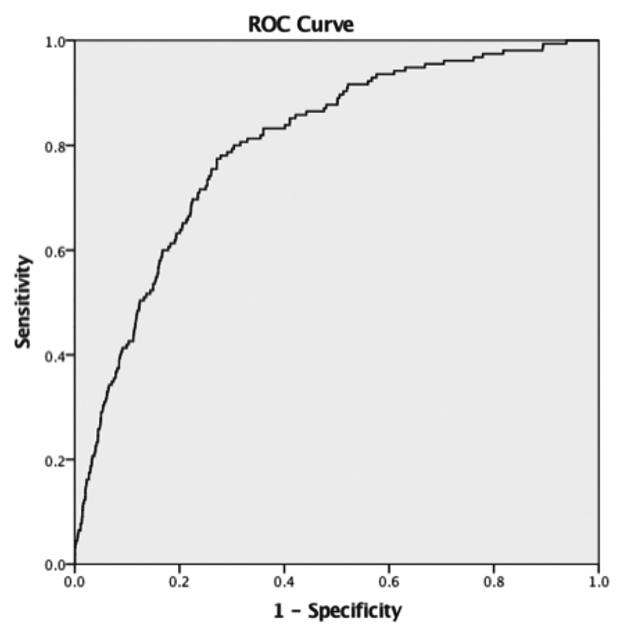

FIGURE 2. *Receiver operating characteristic curve showing the ability to predict postoperative sepsis or septic shock based on the proposed multivariable model.*

TABLE 3. Independent Risk Factors for Postoperative Sepsis (AUC = 0.800)

Perioperative Risk Factor	Odds Ratio	95% CI	*P*
Male sex	1.47	1.05-2.05	.023
Diabetes	1.59	1.05-2.40	.027
Smoking	0.50	0.30-0.84	.009
Dependent functional status	1.82	1.12-2.95	.015
Ascites	56.12	5.01-628.50	.001
Weight loss	2.45	1.04-5.78	.040
Bleeding disorder	2.58	1.34-4.93	.004
Operation time	1.004	1.003-1.005	<.001

AUC: area under the curve.

DISCUSSION

We sought to quantify the incidence and risk factors for sepsis within 30 d following ASD surgery. Among 6158 patients, 2.5% developed sepsis. With strong predictive value, the following factors conferred an independent risk of the development of sepsis: male sex, diabetes, functional dependency, ascites, bleeding disorder, unintentional weight loss, and operative time. Furthermore, those who became septic had a significantly higher chance of prolonged hospital stay and death. These results have implications for the preoperative, intra operative, and postoperative management of ASD patients, and more importantly, the early diagnosis of sepsis can be made to reduce associated morbidity and mortality.

Though we are not aware of any studies that have studied sepsis exclusively among ASD patients, the literature is replete with comorbidities associated with risk of infection. In a study of 448 patients undergoing ASD surgery, smoking was an independent risk factor for medical and infectious complications.[9] Of note, and counterintuitively, smoking offered a protective effect against the development of sepsis in the present study, for which we do not have an obvious explanation. One possibility is that NSQIP only asks if a cigarette was smoked in the year before surgery, which is a relatively low threshold for labeling smokers and may

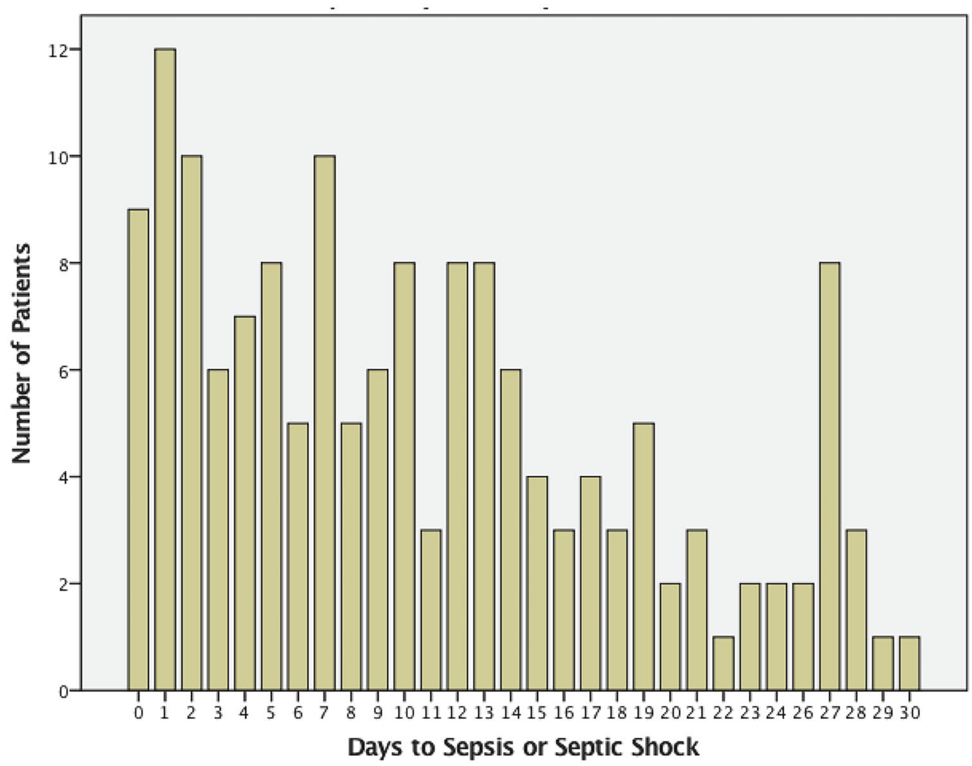

FIGURE 3. *Days to sepsis or septic shock.*

not accurately reflect patients that are active or regular smokers. Further information is needed to clarify this unexpected finding. Diabetes is a well-known risk factor for infection after spinal fusion[27] and diabetics requiring an oral-agent or insulin also predicted sepsis in the current study. Interestingly, obesity was not found to correlate with sepsis in the current study, though it has been correlated with infection in other studies.[8,28,29] Nutritional status (albumin levels) has received much attention in avoiding infection after spine surgery,[23,24] and though not studied in the current model due to missing data, should be addressed preoperatively in all ASD patients. Furthermore, while weight loss is often encouraged to optimize patient health status before surgery, unintentional weight loss of >10% current body weight was an independent risk factor for sepsis in the current study. Caution should be exercised in the preoperative counseling stage of any unintentional weight loss most likely due to associated nutritional loss and catabolic state, especially when pain and disability prevent normal levels of exercise and weight-bearing movement, leading to muscle loss.

The 1 intraoperative risk factor for sepsis in our final model was operative time, which is potentially modifiable and under direct surgeon control. Increased operative time is a well-documented risk factor for infection in general spinal surgery,[23,27,30,31] and the same trend for sepsis after ASD surgery makes intuitive sense. Options to decrease surgical time may include the involvement of 2 attending surgeons, though this has not been shown to consistently decrease operative time, but has been linked to decreased complication rates.[32] Spinal navigation is another tool that may expedite instrumentation placement but is somewhat controversial, as several studies have reported lengthened operative time, especially during the early stages of use.[33] Staging surgeries, especially when anterior or lateral interbody work is performed, has also drawn significant attention. However, a recent report of staged vs same-day ASD surgeries found increased complications in the staged group, including deep infection (sepsis was not studied).[34] Regardless of the strategy employed, a meticulously planned and well-executed surgery is perhaps the best tool to help shorten operative time.

The topic of mortality in the context of sepsis deserves further mention. The rate of morality following ASD surgery is 1.5 per 1000 cases.[35] In a study of 87 162 scoliosis cases, 131 deaths occurred, 12 of which (9.2%) were due to sepsis. A second study of 407 patients reported 10 deaths, 3 of which (30%) were due to sepsis. In our study, sepsis conferred an 8-fold increase in the odds of death and a 10-fold increase in the odds of prolonged hospital stay. Quantifying the risk of mortality following sepsis can help educate patients and providers about the importance of addressing predictive risk factors in their shared decision making.

An important trend relevant to a discussion of postoperative sepsis is the use of vancomycin powder. A recent meta-analysis of 5888 patients across 10 studies by Chiang and colleagues[36] reported a protective effect of vancomycin powder on the occurrence of surgical site infection, deep infections, and *staph aureus* infections in all spine surgeries. Specific to deformity, a large series of 215 ASD patients with a minimum of 3-month follow-up compared 64 controls to 151 patients receiving vancomycin powder. Significantly fewer hospital readmissions for surgical site infection were seen in the vancomycin group (2.6%) compared to the control group (10.9%), and a corresponding cost analysis reported cost savings of $244 402 per 100 ASD operations.[37] While the NSQIP database does not include the use of vancomycin powder, given its increased use in recent decades, time may be a surrogate variable to evaluate its effectiveness. However, in our study, the rate of sepsis remained stable from 2008 to 2014. While vancomycin may protect against local infection, further study is required to determine if its antimicroboial effects extend to the prevention of sepsis. However, it seems intuitive that in patients preoperatively identified as high risk for postoperative sepsis, the use of vancomycin powder should be strongly considered.

These results introduce several important considerations for the surgical management of ASD. Our findings emphasize the importance of controlling comorbidities, such as diabetes, prior to surgery. Additionally, preoperative assessment can include special attention to liver disease, increased bleeding risk, and unintentional weight loss for this patient population. Several institutions have reported their experiences with a multidisciplinary deformity spine conferences comprised of anesthesia, internal medicine, behavioral health, and nursing to decide each patient's suitability for surgery.[38,39] The use of such multidisciplinary boards has shown significant reduction in the rates of many complications, including wound infections.[38] Given the importance of pre-existing bleeding disorders or anticoagulation medication that cannot be discontinued, the intraoperative anesthesia team can also help combat excessive blood loss. The use of tranexamic acid and aminocaproic acid can be used to prevent excess hemorrhage, with potential to decrease transfusion of packed red blood cells and fresh frozen plasma, and reduce the risk of volume overload and facial swelling.[40] Lastly, intensivists involved in postoperative care can be made aware of patients at particularly high risk of sepsis. Concern over early and subtle warning signs of sepsis—tachycardia, tachypnea, hypoxia, hypothermia, hyperthermia—can be heightened. Understanding the potential risk factors for sepsis following ASD surgery may help in determining the appropriate levels of postoperative surveillance and aid in the avoidance, early diagnosis, and treatment of this complication.

Lastly, as healthcare costs continue to become unsustainable, sepsis after ASD surgery must be framed from a cost-effective and value-based perspective. Further scrutiny of expensive interventions such as ASD surgery is needed. A recent multicenter study found that the average cost per quality-adjusted life year for patients undergoing ASD surgery was $243 761, yet 10% of patients had costs per quality-adjusted life year less than $100 000, making the procedure cost-effective.[15] Drivers of cost-effectiveness were older age, prior surgery, and worsening spinal alignment, which may also place patients at increased risk of complication. A recent systematic review concluded that hospital costs for patients with complication were 2.3 to 3.1 times greater than those without complications.[16] In an already expensive, debilitated, and medically complex population, understanding the cost implications of treating severe complications, such as sepsis, can have important downstream financial effects. In patients with many of the previously stated risk factors, the risk of sepsis and/or severe complication may be too great to pursue surgery. However, it is the authors' recommendation that these results are used to optimize patients for ASD surgery who are suffering, with significantly decreased quality of life. Rather than not offering a life-changing surgery to a patient in need, we can use these results to mitigate preoperative risk factors, subsequently reducing the risk of major complication and decreasing cost. Furthermore, given the cost of ASD surgery amongst all surgical interventions, it may behoove the NSQIP database to include additional spine-specific variables that can allow for more definitive conclusions.

Limitations

This study must be examined in the context of its limitations, several of which are inherent to utilizing a large database. First, this study is a retrospective analysis of prospectively collected data, and is thus inherently at risk for selection bias. We attempted to mitigate this by including all cases performed over a 6-yr period. Second, NSQIP only reports adverse events that occur within 30 d following a procedure. As such, we could not assess the incidence and predictive risk factors of long-term outcomes. Third, the NSQIP database does not contain spine surgery specific variables, such as pelvic parameters, curve type, durotomies, or patient-reported outcome measures. Using administrative databases to answer spine-specific intervention, questions that do not include the aforementioned variables can lead to spurious conclusions. It is important to interpret these results in the context of an administrative database, understanding that a physician-managed database may offer more specificity. One example is seen with smoking offering a protective effect against sepsis, which is likely an artifact of data collection rather than a valid trend. Fourth, some variables (ascites) were less commonly seen and resulted in unusually wide CIs with statistical significance. Lastly, the study of ASD in national administrative databases compared to physician-managed databases has been shown to capture a different population than physician-managed database, with significantly decreased levels fused, surgical invasiveness, and 3-column osteotomies.[41] As such, though specifically selected to represent a true ASD population, the current population may be less strict than physician-managed databases.

CONCLUSION

In a study of 6158 patients undergoing ASD surgery, several independent predictors of sepsis were identified, including male sex, smoking, diabetes, ascites, bleeding disorder, deconditioned status, and increased operative time. Furthermore, those who became septic had a significantly higher chance of prolonged hospital stay, readmission, and death. Spine surgeons along with other members of the perioperative team may consider these data in preoperative risk stratification and postoperative management of ASD patients, with the goal of reducing the incidence of this life-threatening complication.

Disclosure

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article.

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COMMENT

The authors present an analysis of NSQIP data on 6158 patients who underwent deformity correction examining one aspect in particular: the risk of sepsis. Among the 6158, 154 (2.5%) developed sepsis. The authors identified a positive correlation with operative time, male gender, and diabetes all leading to an increased risk of sepsis. Functional dependency, bleeding disorders, and ascites were also found to be positively correlated. The authors found that when sepsis occurs, the fate of these patients is highly predictable with a greater likelihood of longer hospital stays and re-admission and even a higher likelihood of death. The only surprise finding is the fact that smoking is protective of sepsis, clearly an artifact of data collection within NSQIP. The remaining findings are unsurprising and confirm a surgeon's intuition. However, unlike a surgeon's intuition, these findings are bolstered by firm data from a registry. Big data does not always support our clinical intuition. The analysis on ASD surgery is 1 circumstance where it does.

The shortcomings of NSQIP for analysis of spinal procedures are one of the more important observations that the authors have made in their paper. NSQIP is as vulnerable, if not more vulnerable than the Quality Outcomes Database, which tends to be monitored closer by the surgeons. The fact that the data in this study suggest that smoking appears to be protective of sepsis is clearly an artifact of data collection. The authors have thoughtfully identified some significant data points that are missing. Pelvic parameters, curve type, patient-reported outcomes, and the incidence of durotomies would have all added immeasurably to the study, but remain outside the granularity offered by NSQIP. The question remains: what database is best for an analysis of a large dataset such as this? NSQIP, the preferred database of hospital administrators and trauma surgeons, has provided some valuable data. But a more granular database could provide even more.

The authors are to be congratulated on their timely analysis of such a large database. Distilling down meaningful conclusions from so many variables in a data set this size is no small feat. The message delivered by the authors is in perfect pitch with the current tenor of the socioeconomic milieu. It is through the careful analysis of large datasets such as what the authors have presented that will provide the insight and guidance to continue efforts to optimize quality while decreasing cost. It goes without saying that understanding the risk to the patient with regards to sepsis, is equally valuable to epidemiologists studying population health as it does to the surgeon who is sitting before a deformity patient and obtaining an informed consent.

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