

DEFORMITY

Scoliosis Research Society Morbidity and Mortality of Adult Scoliosis Surgery

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Study Design. A retrospective review.

Objective. To obtain an assessment of complication incidence using the largest known database of adult scoliosis and to determine whether the rate of complication depends on various clinical parameters.

Summary of Background Data. The Scoliosis Research Society (SRS) morbidity and mortality database has previously been used to assess complication rates in *adolescents* undergoing scoliosis correction. To better understand complications in *adults*, degenerative and idiopathic adult scoliosis (AS) cases were studied.

Methods. The SRS morbidity and mortality database was queried to identify cases of AS from 2004 to 2007. Complications were identified and analyzed on the basis of patient type of scoliosis (degenerative vs. adult idiopathic), age, use of osteotomy, revision surgery status, and surgical approach. Age was stratified into less than or equal to 60 and greater than 60. Surgical approach was stratified into anterior only, posterior only, and combined anterior/posterior.

Results. A total of 4980 cases of AS were submitted from 2004 to 2007. There were 521 patients with complications (10.5%), and a total of 669 complications (13.4%). The most common complications were dural tear 142 (2.9%), superficial wound infection 46 (0.9%), deep wound infection 73 (1.5%), implant complication 80 (1.6%), acute neurological deficits 49 (1.0%), delayed neurological deficits 41 (0.5%), epidural hematoma 12 (0.2%), wound hematoma 22 (0.4%), pulmonary embolus 12 (0.2%), and deep venous thrombosis 9 (0.2%). There were 17 deaths (0.3%). There were 2555 patients with degenerative and 2425 patients with adult idiopathic scoliosis.

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Acknowledgment date: December 7, 2009. Revision date: March 1, 2010. Acceptance date: March 8, 2010.

This study was performed without any financial support from industry or other organizations.

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DOI: 10.1097/BRS.0b013e3182059bfd

Complication rates in these two groups were not significantly different (11.0% and 9.9%, respectively, $P = 0.20$). Age was not associated with complication rate ($P = 0.32$). Significantly higher complication rates were identified in osteotomies, revision surgery, and/or combined anterior-posterior surgery ($P = 0.0006, 0.006, \text{ and } 0.03$, respectively).

Conclusions. The overall complication rate for AS treatment is 13.4%. Complication rate is significantly higher when osteotomies, revision procedures, and combined anterior/posterior approaches are used. Complication rate is not influenced by scoliosis type or age.

Key words: adult scoliosis, complications, degenerative scoliosis, idiopathic scoliosis, morbidity, mortality. **Spine 2011;36:E593–E597**

The Scoliosis Research Society (SRS) has been collecting data on short-term surgical complications from its members since its inception in 1966. A clear focus of the SRS is scoliosis, and thus far, this database has been utilized to report the morbidity and mortality (M&M) of unspecified scoliosis surgery and of adolescent idiopathic scoliosis.^{1,2} The SRS M&M database has not been queried to formally report the short-term M&M of adult scoliosis. In addition, a comparison of the SRS M&M data on adult degenerative and adult idiopathic scoliosis has not been made. The SRS M&M database was constructed to determine the incidence of major perioperative events that could impact surgical outcomes. To maximize surgeon participation and limit the complexity of the data entry forms, minor complications that would not likely impact hospital stay or clinical outcome were not included as separate categories. Minor complications could be included by writing free-form into an “other” category if they were thought to impact clinical outcome.

In 2006, Coe *et al*¹ reviewed the M&M of adolescent idiopathic scoliosis and demonstrated no significant difference in complication rates between anterior and posterior procedures, but a significantly higher rate of complications in patients undergoing combined anterior and posterior surgery. The overall complication rate reported by Coe *et al* was 5.7%.¹ Given the relatively low figure for this complication rate in adolescents, the authors felt that this would not apply to the adult population and felt the need to conduct this study.

MATERIALS AND METHODS

From 2004 to 2007, a total of 108,480 surgical cases were submitted by SRS members into the M&M database. The data entry system developed by the SRS in the 1990s is a secure Internet-based questionnaire. As of 2003, this database was expanded to include further information about each patient entered, such as specific aspects of the diagnosis, surgical procedure, and complications. This database was queried to identify cases of adult degenerative and adult idiopathic scoliosis from 2004 to 2007. Complications were identified and analyzed on the basis of patient age, type of scoliosis, use of osteotomy, revision surgery status, and surgical approach. Age was stratified into less than 60 years of age and greater than 60 years. Surgical approach was stratified into anterior only, posterior only, and combined anterior-posterior surgery. All reported complications were totaled and displayed in table format. Statistical analysis of these data sets was performed using chi-square analysis using Statview (SAS Institute, Carey, NC). Statistical significance was based on a *P*-value less than 0.05.

This project was submitted to the Hospital for Special Surgery (New York, NY) institutional review board (IRB) and

was determined to be exempt from the IRB approval based on the use of de-identified data (IRB #29045).

RESULTS

Of the 108,480 cases submitted between 2004 and 2007, 4980 cases of adult scoliosis (AS) were submitted. There were a total of 521 patients with complications (10.5%) and an overall total of 669 complications (13.4%; Table 1). The most common complications included 142 dural tears (2.9%), 80 implant complications (1.6%), 73 deep wound infections (1.5%), 49 acute neurological deficits (1.0%), 46 superficial wound infections (0.9%), and 41 delayed neurological deficits (0.5%). There were 2920 patients who were aged 60 years or younger (mean: 43.1, range: 18–60) and 2060 patients who were older than 60 years (mean: 69.6, range: 61–90). Two hundred ninety-five patients in the younger group had complications (10.1%), while 226 patients in the older group had complications (11.0%). This difference was not statistically significant (*P* = 0.32).

Patients were classified as having either degenerative (2555 patients) or adult idiopathic scoliosis (2425 patients) (Table 2). Complication rates in these two groups were not significantly

TABLE 1. Complications in 4980 Cases of Adult Scoliosis Patients from the Years 2004–2007 Stratified by Patient Age

Complication, N (%)	Patient Age* (yrs)		
	All (n = 4980)	≤60 (n = 2920)	>60 (n = 2060)
Dural tear	142 (2.9%)	77	65
Wound infection			
Superficial	46 (0.9%)	28	37
Deep	73 (1.5%)	43	46
Implant complication	80 (1.6%)	50	30
Acute neurological	49 (1.0%)	31	18
Delayed neurological	41 (0.5%)	22	19
Epidural hematoma	12 (0.2%)	8	4
Wound hematoma	22 (0.4%)	12	10
Cardiac	7 (0.1%)	1	6
Pulmonary embolus	12 (0.2%)	7	5
Pulmonary (not PE)	31 (0.5%)	21	10
DVT	9 (0.2%)	4	5
Death	17 (0.3%)	9	8
Sepsis	6 (0.1%)	3	3
Visual acuity change	3 (0.06%)	2	1
Other complication	119 (2.4%)	65	54
Total number patients with complications	521 (10.5%)	295 (10.1%)	226 (11.0%)
Total complications†	669 (13.4%)	384 (13.2%)	321 (15.6%)

*Age not available for 33 patients.

†Percent complications = $100 \times (\text{total number of complications}) / (\text{total number of patients})$. Overall complication rate was not significantly higher for procedures performed on patients older than 60 years compared with procedures performed on patients 60 years or younger (*P* = 0.32).

TABLE 2. Complications Stratified by Clinical Parameters

Clinical Category	No. of Cases	No. Complications (%)	P
Degenerative scoliosis	2555	281 (11.0)	0.20
Idiopathic	2425	240 (9.9)	
No osteotomy	3887	376 (9.7)	0.0006
Osteotomy	1093	145 (13.3)	
No revision	3973	392 (9.9)	0.006
Revision	1007	129 (12.8)	
Anterior only	611	53 (8.7)	0.03*
Posterior only	3154	325 (10.3)	
Anterior and posterior	804	102 (12.7)	
Unspecified	409	40 (9.85)	

*Complication rate was significantly higher in anterior and posterior group when compared to the combination of anterior only and posterior only groups.

different (11.0% vs. 9.9%, respectively, $P = 0.20$). Patients were also classified into those who received osteotomies (1,093 patients) as part of their scoliosis correction versus those who did not (3887 patients). Patients who underwent osteotomies had a significantly higher complication rate of 13.3% versus 9.7% ($P = 0.0006$). In particular, infection was significantly more common in the osteotomy group with an infection rate of 3.3% versus 2.1% in the nonosteotomy group ($P = 0.02$). Of the 1093 osteotomies, 692 were performed in patients who were aged 60 years or younger, versus 401 in patients who were older than 60 years. There was a significantly higher tendency to perform osteotomies in the younger patient group ($P = 0.0004$). On multivariate analysis, adjusting for the effect of age, osteotomy remained significantly associated with increased complication rate ($P = 0.001$) while age remained insignificantly associated with complication rate ($P = 0.25$). For the purpose of the multivariate analysis, age was treated as a continuous variable.

One thousand seven patients were identified as revision cases and 3973 were classified as initial corrections of scoliosis. Patients undergoing revision surgery were significantly more likely to have complications than patients undergoing initial corrections (12.8% vs. 9.9%, $P = 0.006$). Finally, patients were also classified by surgical approach with 611 patients undergoing anterior only surgery, 3154 undergoing posterior only surgery, and 804 patients undergoing combined anterior and posterior surgery. The combined anterior/posterior patients had significantly higher rates of complication than patients having either anterior or posterior only surgery (12.7% vs. 10.0%, $P = 0.03$).

Overall, there were 17 deaths, making the mortality rate 0.3%. Of these 17 deaths, 7 patients had either cardiac and or respiratory causes, 6 had sepsis, 2 had excessive blood loss and died intraoperatively, and 2 had unknown causes of death. Eight deaths were in patients aged 60 years or younger, and nine deaths were in patients older than 60 years. Eight deaths were in patients with degenerative scoliosis, and nine

deaths were in patients with idiopathic scoliosis. There were no significant differences in mortality rate when assessed by age and scoliosis type ($P = 0.63$ and $P = 0.73$, respectively).

There were 90 neurological deficits reported in the 4980 patients resulting in an overall neurological deficit complication rate of 1.8%. Of these 90 neurological deficits, 12 (13.3%) were determined intraoperatively, 37 (41.1%) were found within 24 hours of surgery, and 42 (46.7%) were found after 24 hours of surgery. Of the 90 patients with neurological deficits, 71 (78.9%) patients had nerve root injuries, 11 (12.2%) patients had incomplete spinal cord injuries, 1 (1.1%) patient had a complete injury, and 5 (5.6%) patients had cauda equina syndrome. Of the 90 patients with neurological deficits, 75 had information available on the degree of recovery from the injury. For the nerve root injuries, 23 had complete recovery, 33 had partial recovery, and 2 had no recovery. For the incomplete spinal cord injuries, six had complete recovery and five had partial recovery. For the cauda equina injuries, one had a complete recovery, three had partial recovery, and one had no recovery. The rate of neurological deficits did not significantly change with respect to age, type of scoliosis, revision surgery status, use of osteotomy, or surgical approach ($P = 0.96, 0.42, 0.31, 0.06,$ and 0.61 , respectively; Table 3).

Of the 90 patients with new neurological deficits, 63 (70%) had some form of neurological monitoring consisting of 59 (65.6%) cases with somatosensory-evoked potentials, 41 (45.6%) with electromyography, and 31 (34.4%) with motor-evoked potentials. Fifteen cases (16.7%) had implants removed as a result of intraoperative monitoring. Four (5.6%) of the 71 nerve root injuries had abnormalities detected intraoperatively through neurological monitoring. Of the 12 spinal cord injuries, 11 had somatosensory-evoked potentials monitoring and 6 had motor-evoked potential monitoring. Six of these patients with spinal cord injury had neuromonitoring abnormalities detected intraoperatively and implants were removed in four of these patients. Six wake-up tests were performed, with five of six demonstrating a deficit. All five

TABLE 3. Neurological Deficits Stratified by Clinical Parameters

Clinical Category	No. of Cases	No. Complications (%)	P
Age ≤ 60	2920	53 (1.8)	0.96
Age > 60	2060	37 (1.8)	
Degenerative scoliosis	2555	50 (2.0)	0.42
Idiopathic	2425	40 (1.6)	
No revision	3973	68 (1.7)	0.31
Revision	1007	22 (2.2)	
No osteotomy	3887	63 (1.6)	0.06
Osteotomy	1093	27 (2.5)	
Anterior or posterior	3765	71 (1.9)	0.61
Anterior and posterior	804	13 (1.6)	

patients with new cauda equina syndrome had neurological monitoring, but none had positive findings intraoperatively.

DISCUSSION

Since there have been no studies thus far that have used the SRS database to specifically focus on adult scoliosis, this study serves as a useful reference to benchmark complication rates in the literature. Furthermore, this study provides spine surgeons with a practical comparison of major complications stratified by various traditional clinical parameters used to assess outcome in spine surgery. While the SRS database has the benefit of being the largest known repository of such information on patients undergoing scoliosis surgery, one must also acknowledge its limitations. These include the lack of functional outcome data, no reporting of long-term follow-up, and no reporting of number of levels fused. The SRS M&M database was initiated to determine the incidence of major perioperative complications such as new neurological deficit. Although the amount of data collected by the database has been substantially expanded through serial revisions, the emphasis has continued to be on assessment of major perioperative events. It is certain that minor complications are underreported in the database and this report. Despite these significant limitations, the SRS database provides spine surgeons with the statistical power to examine various topics in spine surgery due to its large sample size. One must also acknowledge that in studies where the sample size is very large, the clinical importance of statistically significant differences is subject to interpretation.

Daubs *et al*³ report their rate of adult deformity complications in adults older than 60 years. They evaluated 38 patients with a mean age of 67 years and a mean follow-up of 4.2 years. Their overall reported complication rate was 37%, with a major complication rate of 20%. In the study by Ali *et al*⁴ from 2003, 28 patients with adult idiopathic scoliosis were studied, with an average age of 48.5 years. Four of the 28 patients had complications, making the complication rate 14.3%.⁴ These four complications were patients who required further surgery and hence may be regarded as major complications. Swank *et al* reported their complication rate in the

treatment of 222 adult scoliosis patients with a mean age of 30.7 years. Their complication rate was as high as 53%, but their thorough review of complications included complications such as urinary tract infections and should be interpreted as representing both minor and major complications.⁵ Furthermore, this study dates to 1981 and the more dated surgical technologies from this time period may not apply to current surgical techniques. In a more recent study by Glassman *et al*⁶ from 2007, major complications were reported to occur in 10% of 138 cases. This rate is more consistent with numbers reported in this study.⁶ While no effort has been made in this article (or the SRS database) to classify the complications as major or minor, by evaluating the complication types listed in Table 1, the vast majority of complications reported in the SRS database would be classified as major complications when comparing these complications with those from other studies.

Age has been shown to have an increased correlation with major complications in patients undergoing major deformity surgery.^{3,5,7,8} In this series, age greater than 60 years did not correlate with a higher rate of complications. One must note, however, that there was a significantly greater tendency to perform osteotomy procedures in the younger patient group. It was initially thought that the lack of association between age and increased complication rate was confounded by the fewer osteotomy procedures performed in older patients. Nevertheless, on multivariate analysis, age remained insignificant in its association with complications while the use of osteotomy remained robustly associated with increased complication risk.

While this report demonstrated an overall complication rate of 13.4% in SRS adult scoliosis patients, one must remember that the SRS study by Coe *et al*¹ on adolescent scoliosis patients revealed an overall complication rate of 5.7%. Given that the SRS data show this differential in complications between adult and adolescent scoliosis patients, one can argue that the SRS database does indeed support the notion that advanced age leads to increased risk for the development of complications. The SRS database also supports the notion that combined anterior posterior surgery leads to significantly higher complication rates as this was found to be true in this study and the report from

Coe *et al.*¹ This recognition of increased risk of complications in patients undergoing combined anterior posterior surgery has led to an increased rate of posterior only constructs.⁹⁻¹¹

The data presented in this study demonstrate a significantly higher rate of complications in patients who underwent a revision procedure (12.8% *vs.* 9.9%). Patients with a previous history of spinal surgery typically present a greater surgical challenge to the surgeon. Careful technique should be used when performing revision surgery to help reduce the already-established increased risk of spinal fluid leaks and other complications in revision cases.¹²⁻¹⁴

CONCLUSION

As spine technologies develop and surgical techniques advance, the spine surgeon is presented with a greater number of options for the treatment of adult scoliosis. At times, it may be difficult to determine the most appropriate strategy to maximize the benefit to the patient while minimizing the risks. While some of the older reported complication rates for scoliosis have been quite high, our report is on the lower end of the spectrum and is similar to recent published rates. As expected, complications were encountered more frequently in patients undergoing osteotomies, revision procedures, and combined anterior posterior spine surgery. These data provide general benchmarks for patient counseling and for ongoing efforts to improve quality of care.

➤ Key Points

- ❑ The major complication rate in adult patients undergoing surgical correction of scoliosis is 13.4%.
- ❑ Complication rate in the surgical correction of adult scoliosis is significantly higher in patients undergoing osteotomies, revision procedures, and combined anterior/posterior approaches. These patients should be counseled during the preoperative period about the increased morbidity risk.
- ❑ Complication rate is not influenced by type of scoliosis or age.

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