

Complications in Spinal Fusion for Adolescent Idiopathic Scoliosis in the New Millennium. A Report of the Scoliosis Research Society Morbidity and Mortality Committee

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Study Design. The Morbidity and Mortality database of the Scoliosis Research Society (SRS) was queried as to the incidence and type of complications as reported by its members for the treatment of adolescent idiopathic scoliosis (AIS) with spinal fusion and instrumentation procedures regarding surgical approach (anterior, posterior, or combined anterior-posterior) during a recent 3-year period.

Objective. To evaluate the incidence of surgeon-reported complications in a large series of spinal fusions with instrumentation for a single spinal deformity diagnosis and age group regarding surgical approach.

Summary of Background Data. The SRS has been collecting morbidity and mortality data from its members since its formation in 1965 with the intent of using these data to assess the complications and adverse outcomes (death and/or spinal cord injury) of surgical treatment for spinal deformity. Surgical approaches to the management of treatment of AIS have a measurable impact on efficacy of correction, levels fused, and operative morbidity. However, there is a lack of consensus on the choice of surgical approach for the treatment of spinal deformity.

Methods. Of the 58,197 surgical cases submitted by members of the SRS in the years 2001, 2002, and 2003, 10.9% were identified as having had anterior, posterior, or combined spinal fusion with instrumentation for the diagnosis of AIS, and comprised the study cohort. All reported complications were tabulated and totaled for each of the 3 types of procedures, and statistical analysis was conducted.

Results. Complications were reported in 5.7% of the 6334 patients in this series. Of the 1164 patients who underwent anterior fusion and instrumentation, 5.2% had complications, of the 4369 who underwent posterior in-

strumentation and fusion, 5.1% had complications, and of the 801 who underwent combined instrumentation and fusion, 10.2% had complications. There were 2 patients (0.03%) who died of their complications. There was no statistical difference in overall complication rates between anterior and posterior procedures. However, the difference in complication rates between anterior or posterior procedures compared to combined procedures was highly significant ($P < 0.0001$). The differences in neurologic complication rates between combined and anterior procedures, as well as combined and posterior procedures were also highly statistically significant ($P < 0.0001$), but not between anterior and posterior procedures.

Conclusions. This study shows that complication rates are similar for anterior *versus* posterior approaches to AIS deformity correction. Combined anterior and posterior instrumentation and fusion has double the complication rate of either anterior or posterior instrumentation and fusion alone. Combined anterior and posterior instrumentation and fusion also has a significantly higher rate of neurologic complications than anterior or posterior instrumentation and fusion alone.

Key words: scoliosis, adolescent, idiopathic, surgery, complications, morbidity, mortality. **Spine 2006;31:345-349**

The Scoliosis Research Society (SRS) has been collecting Morbidity and Mortality data from its members since its formation in 1965. MacEwen *et al*¹ published the first significant analysis of SRS Morbidity and Mortality data in 1975 that analyzed 7885 scoliosis cases performed by members between 1965 and 1971. These investigators noted a 0.72% neurologic complication rate in this large cohort of patients, most of whom had undergone posterior spinal fusion with Harrington rod instrumentation. However, since then, the results of this data collection effort have been limited to periodic (annual) presentation to the members of the SRS, and, thus, there have been no published reports of SRS Morbidity and Mortality complication data, except as quoted by members in other publications.² This report addresses the lack of published SRS Morbidity and Mortality data, and specifically focuses on the complications of the surgical treatment of adolescent idiopathic scoliosis (AIS).

Surgical approaches to the treatment of AIS have a measurable impact on efficacy of correction, levels fused, and operative morbidity. There is a lack of consensus on the choice of surgical approach for the treatment of spinal deformity, and the observed variability may be per-

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petuated by the absence of an evidence-based approach to the surgical treatment of specific deformities.³⁻⁸ Recorded complications are an important consideration in choosing a surgical approach to AIS, and an analysis of complications recorded by SRS members may help to guide future decision making for deformity correction.¹⁻³ Therefore, the purpose of this study is to analyze the recorded complications of anterior, posterior, and combined surgical approaches for the treatment of AIS, as reported by the SRS membership over a recent 3-year period. The null hypothesis for this study is that the surgical approach used for instrumentation and fusion of AIS (anterior, posterior, and combined) has no effect on the overall rates, types, or frequencies of recorded complications.

Materials and Methods

A total of 58,197 surgical cases were submitted by members of the SRS in the years 2001, 2002, and 2003, using the secure internet-based questionnaire that was developed by the SRS Morbidity and Mortality committee in the early 1990s, with minor modifications (primarily by the addition of questions regarding nonscoliosis cases and more detailed questions about the performed surgical procedure) for 2003. Of the submitted cases, 14,554 (25.0%) were performed for the treatment of scoliosis, of which 6716 (11.5% of the total submitted cases) were performed for the treatment of AIS, with this group defined as patients between the ages of 10 and 17 years, inclusive, at surgery with idiopathic scoliosis. The 6334 patients (10.9% of the total submitted cases) identified as having had anterior, posterior or combined spinal fusion with instrumentation for the diagnosis of AIS, comprised the cohort under study (Figure 1). Specifically excluded from analysis were anterior fusions without instrumentation because it was assumed that the majority of this small subset of cases were the first stage of 2-stage procedures. All reported complications were tabulated and totaled for each of the 3 types of procedures, and statistical analysis was performed using the Fisher exact test (SAS software; SAS Institute Inc., Cary, NC).

Results

The distribution of the 6334 procedures performed was: 1164 patients (18.4%) underwent anterior fusion and instrumentation, 4369 (69.0%) underwent posterior fusion and instrumentation, and 801 (12.6%) underwent combined instrumented fusion (Figure 2). Complications were reported in 363 (5.7%) of the 6334 patients in this series. Of the 1164 patients who underwent anterior fusion and instrumentation, 60 (5.2%) had complications, of the 4369 who underwent posterior instrumentation

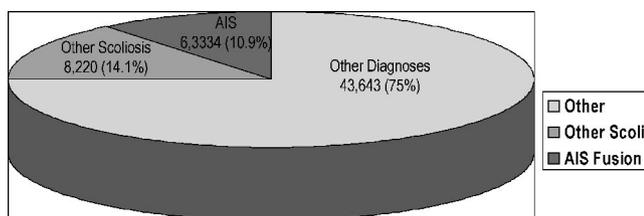


Figure 1. Distribution of surgical cases.

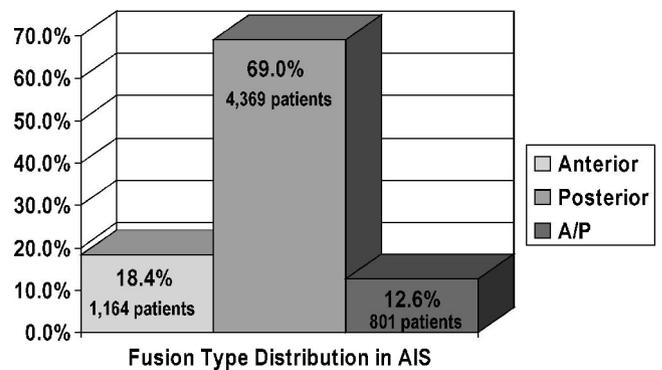


Figure 2. Fusion type distribution. A/P indicates anterior-posterior.

and fusion, 221 (5.1%) had complications, and of the 801 who underwent combined instrumentation and fusion, 82 (10.2%) had complications (Figure 3). There were 2 patients (0.03%), both in the posterior group, who died of their complications, including 1 patient of air embolus and the other of intraoperative blood loss.

There was no statistical difference in overall complication rates between anterior and posterior procedures ($P = 0.59$). However, the difference in complication rates between anterior or posterior procedures compared to combined procedures was highly significant ($P < 0.0001$). The complications in anterior procedures are listed in Table 1. The most common complications for anterior procedures were pulmonary (1.6%), excluding pulmonary embolus, and implant-related (1.4%). Wound infections were reported in only 0.2% of anterior-only procedures. The complications in posterior procedures are listed in Table 2. The most common complications for posterior procedures were wound infections (1.4%), with pulmonary complications reported in 1.0% of posterior cases. The complications in combined procedures are listed in Table 3. The most common complications for combined procedures were pulmonary, excluding pulmonary embolus, at 3.5%, with wound infections reported in 1.4% of combined cases.

Neurologic complication rates for anterior, posterior, and combined procedures were 0.26%, 0.32%, and 1.75%, respectively (Figure 4). The differences in neuro-

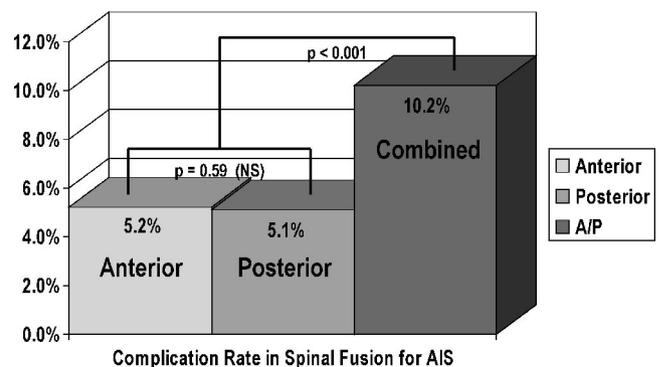


Figure 3. Complications rates. A/P indicates anterior-posterior; NS, not significant.

Table 1. Complications in 1164 Anterior Instrumentations and Fusions for AIS

Complication Type	No.	Incidence
Pulmonary (not pulmonary embolus)	18	1.55%
Implant related	16	1.37%
Other	15	1.29%
Dural tear	3	0.26%
Nonfatal hematologic	3	0.26%
Neurologic	3	0.26%
Wound infection	2	0.17%

logic complication rates between combined and anterior procedures, as well as combined and posterior procedures were statistically significant ($P < 0.0001$), but not between anterior and posterior procedures ($P = 0.51$). Spinal cord complications occurred in 18 patients in this series, all of which were incomplete spinal cord injuries (Figure 5). Nine each occurred in the posterior (0.21%) and combined (1.12%) group. No spinal cord complications were noted in the anterior group. The differences in spinal cord complication rates between combined and anterior procedures, as well as combined and posterior procedures were statistically significant ($P < 0.0001$), but not between anterior and posterior procedures ($P = 0.12$). Complete recovery was noted in 7, and incomplete recovery was noted in 2 of the 9 patients in the posterior group, whereas complete recovery was noted in 4, incomplete recovery noted in 4, and no recovery noted in 1 of the 9 patients with spinal cord complications in the combined group.

Discussion

MacEwen *et al*¹ published the first, and so far the only, formal publication of SRS Morbidity and Mortality data in 1975. This was a report of 7885 cases collected from the membership of the SRS from its formation in 1965 through 1971. The data were manually entered on forms by members and subsequently submitted to the SRS. All subtypes of scoliosis were included in this report, with nearly all patients having undergone posterior fusions with or without Harrington instrumentation. They calculated the overall incidence of neurologic complications at 0.72%. These investigators reported neurologic com-

Table 2. Complications in 4369 Posterior Instrumentations and Fusions for AIS

Complication Type	No.	Incidence
Wound infection	59	1.35%
Other	59	1.35%
Pulmonary (not pulmonary embolus)	42	0.96%
Implant related	28	0.64%
Neurologic	14	0.32%
Dural tear	8	0.18%
Nonfatal hematologic	6	0.14%
Deep venous thrombosis	2	0.05%
Pulmonary embolus	1	0.02%
Blood loss (fatal)	1	0.02%
Air embolus (fatal)	1	0.02%

Table 3. Complications in 801 Combined Instrumentations and Fusions for AIS

Complication Type	No.	Incidence
Pulmonary (not pulmonary embolus)	28	3.50%
Other	18	2.25%
Neurologic	14	1.75%
Wound infection	11	1.37%
Implant related	8	1.00%
Nonfatal hematologic	2	0.25%
Dural tear	1	0.12%

plications in 87 patients, 74 of whom had spinal cord complications. About half of these spinal cord complications were complete deficits, and half were incomplete. Of these 74 patients, 42 underwent posterior spinal fusion with Harrington instrumentation, 20 underwent posterior spinal fusion without instrumentation, and 6 became paraplegic after skeletal traction. Approximately one third of these patients with spinal cord injury had no recovery, approximately one third had partial recovery, and one third had a full recovery.

These investigators noted that patients with the conditions of kyphosis, congenital scoliosis, high magnitude curves, and preexisting neurologic deficits were at increased risk for neurologic complications.¹ They also noted that patients undergoing the procedures of skeletal traction, spinal osteotomy, Harrington instrumentation in congenital scoliosis, and Harrington instrumentation for additional correction after skeletal traction also were at increased risk for neurologic injury. According to these investigators, prognosis for recovery was better for incomplete deficits than complete spinal cord deficits. These investigators also noted an improved prognosis in both complete as well as incomplete deficits in patients in whom the Harrington instrumentation was removed within 3 hours of diagnosis of the deficit.

The results of the study by MacEwen *et al*¹ led to the development of the wake-up test and intraoperative neurophysiologic monitoring, as well as an improved understanding of the effects of spinal instrumentation on neurologic function, particularly the dangers of distraction instrumentation in congenital scoliosis and kypho-

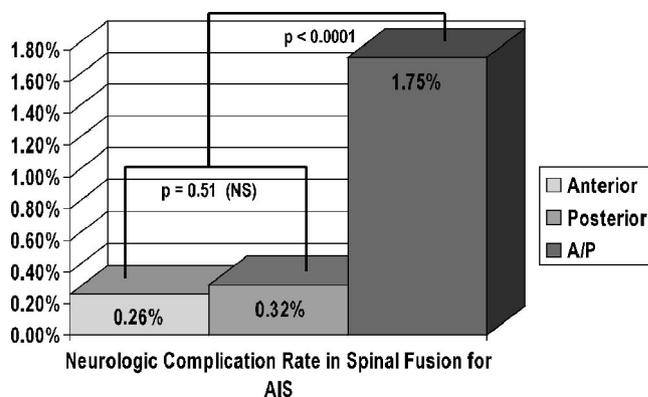


Figure 4. Neurologic complications. A/P indicates anterior-posterior; NS, not significant.

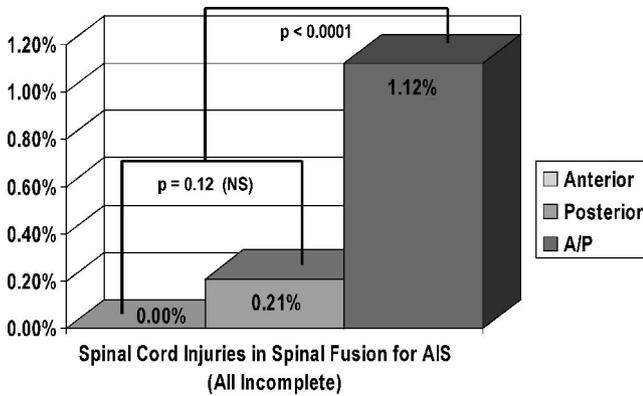


Figure 5. Spinal cord injury. A/P indicates anterior-posterior; NS, not significant.

sis.^{2,9-15} Most importantly, it validated the efforts of the SRS in collecting and analyzing morbidity and mortality data, a feature that distinguishes this society from nearly every other major spine society.^{1,2} Over time, further investigations have refined our understanding of neurologic complications in spinal deformity surgery. A variety of additional factors have been noted regarding neurologic complication in spinal deformity surgery, including hook placement, hyperkyphosis, as well as combined anterior-posterior surgery.^{14,15}

The current study shows that complication rates are similar (at a nearly identical rate of just more than 5% in this study) for anterior *versus* posterior approaches to AIS deformity correction, however, with different distributions of complication types. Combined anterior and posterior instrumentation and fusion has a significantly higher rate of complications (10.2%) than anterior or posterior instrumentation and fusion alone. Combined anterior and posterior instrumentation and fusion also has a significantly higher rate of neurologic complications (1.75%) than anterior or posterior instrumentation and fusion alone. The most common complications for anterior and combined procedures were pulmonary, whereas the most common complications for posterior procedures were wound infections. Although both fatal complications were in the posterior group, no meaningful conclusions regarding significance can be drawn because of the rarity of fatalities in the cohort under study.

This study is not without significant limitations. The SRS database is dependent on the accurate submission of data by members. Because the compliance with data submission is not 100%, the data presented are not a consecutive series and may represent only a subset of the cases performed by those SRS members who have submitted their cases during the 3 years in question. Although the data are de-identified regarding surgeon as well as patient identifiers before analysis to protect privacy and prevent medical-legal repercussions, accurate reporting of complication data cannot be guaranteed.

Also, the curve characteristics (magnitude and rigidity) were not controlled, and it is likely that the patients with combined anterior and posterior surgery had more

severe deformity. Furthermore, complications regarding curve type as well as the “invasiveness” of anterior approaches (thoracoscopic *vs.* open) could not be reasonably analyzed in this study because this type of information has only been collected by the SRS since 2003. Complications in combined procedures, including neurologic complications and infections, could not be attributed to which part of the procedure (*i.e.*, anterior *vs.* posterior) that the complication was associated because this information was not requested in the data collection process. In addition, long-term results and late complication rates (nonunions, late instrumentation failure, late infections, curve progression caused by crankshaft phenomenon, *etc.*), which are often significant, cannot be assessed by evaluation of the SRS Morbidity and Mortality database as it is currently structured.^{7,8,16-18}

Nevertheless, despite these limitations, this study represents a valuable examination of one of the largest series of patients with AIS ever reported regarding complications of surgical treatment. Furthermore, the data in this study are consistent with other reports in the literature. Bridwell *et al*¹⁴ showed a series of 1090 patients who underwent spinal surgery for spinal deformity of various etiologies. They reported 4 spinal cord injuries, all of which occurred in combined anterior-posterior cases. Grossfeld *et al*¹⁸ showed a series of 599 patients who underwent anterior procedures, the majority of whom underwent either same-day or staged anterior-posterior procedures, with a major complication rate of 7.5%. However, both of these studies included patients with a variety of diagnoses and are not necessarily directly comparable to the current study. This study represents an analysis of a pure series of patients with AIS with an inclusive listing of major complications. We believe that data from this study can be used to counsel patients and their parents regarding the nature and rates of complications associated with the surgical approaches used in spinal fusion and instrumentation for AIS in the hands of experienced scoliosis surgeons, and may help to guide future decision making for deformity correction in AIS.

Improvement in the Morbidity and Mortality data collection effort is currently being implemented to increase compliance of membership submission, and increase the accuracy and specificity of surgical case and complication data. As noted previously, included is the collection of data regarding the “invasiveness” of the surgical approach, much more relevant as these types of procedures become more common.¹⁹ Also, the latest revised Morbidity and Mortality questionnaire and algorithm now collect complication data regarding visual acuity loss and neurologic deficit in either the upper and/or lower extremities that are caused by positioning or other nonspinal factors because these types of complications have become more recognized in the recent spinal deformity literature.²⁰⁻²² As further analysis of this important database takes place, the Morbidity and Mortality data collection questionnaire and algorithm will be periodically updated to maximize the value of the collected data

and provide valuable insight into the complications associated with spinal deformity surgery.

■ Conclusions

This study evaluated a large cohort of patients with AIS (6334), who underwent surgery since the end of the year 2000 performed by experienced deformity surgeons. Most (about two thirds) of these patients underwent posterior spinal fusion with instrumentation. The overall complication rate was just less than 6%, with complication rates being about equal in posterior spinal fusion and anterior spinal fusion at about 5%. However, the complication rates were twice as high (about 10%) in combined anterior-posterior fusion with instrumentation as compared to posterior spinal fusion and anterior spinal fusion alone.

■ Key Points

- This study evaluated a large cohort of patients with AIS (6334), who underwent instrumented spinal fusion since the end of the year 2000 performed by experienced spinal deformity surgeons.
- Most (about two thirds) of these patients underwent posterior spinal fusion with instrumentation.
- The overall complication rate was just less than 6%, with complication rates being nearly equal in posterior spinal fusion and anterior spinal fusion at about 5%.
- The complication rates were twice as high (about 10%) in combined anterior-posterior fusion with instrumentation as compared to posterior spinal fusion and anterior spinal fusion alone.

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