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Original Article

Comparing results of posterior spine fusion in patients with AIS: Are two surgeons better than one?

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ARTICLE INFO

Article history:

Received 2 January 2013

Accepted 30 March 2013

Available online 15 June 2013

Keywords:

AIS

Scoliosis

Dual surgeon

Two-surgeon

Morbidity

ABSTRACT

Aims: Spinal deformity surgery is one of the most complicated procedures performed in pediatric orthopedics. These surgeries can account for long operative times and blood losses. Finding ways to limit patient morbidity undergoing these procedures may benefit many. We hypothesized that utilizing two fellowship trained pediatric spinal deformity surgeons would lead to decreased operative time and blood loss when compared with single surgeon. We felt very little difference would be found in terms of curve correction. **Methods:** A retrospective review of spinal deformity surgeries performed at two institutions was performed. At one institution, the standard of care was to have two fellowship deformity trained surgeons perform all deformity surgeries simultaneously, while at the second institution posterior spinal fusions performed by individual surgeons were performed. The single surgeon cohort was further divided based on instrumentation type (pedicle screw vs hybrid constructs). Cases for this review were limited to posterior spinal fusions without osteotomies in patients with idiopathic or idiopathic like curves. Cohorts were compared pre-operatively for age at surgery, sex, BMI, largest Cobb angle. Intra-operative comparisons included total EBL, instrumentation type screws vs hybrid, levels fused, and operative time. Comparisons between largest remaining Cobb, EBL/level, time/level, lowest recorded Hb, allogenic transfusion requirements, length of PICU stay, and total length of hospital stay were then made. Pair-wise student t-tests was performed between cohorts with significance defined as a *p*-value of 0.05 or less.

Conclusions: Twenty-four patients were found in the (BMP) cohort, where as eighty-two were found in the control group. No significant difference in age, sex, starting hemoglobin, BMI*, or maximum pre-operative Cobb between cohorts was found. A significantly lower number of levels were fused in the BMP cohort than the control (9 ± 2 vs 11 ± 2) $p < 0.001$, and likewise a significantly shorter operative time (average > 2 h) was seen in the BMP cohort. Interestingly, no difference in estimated blood loss, blood loss/level fused, operative time/level fused was observed, yet a significantly greater drop in hemoglobin (average 1 g) $p = 0.001$ and allogenic transfusion rate was seen in the control group (4% (1/24) vs 29% (24/82)) $p = 0.01$. A greater improvement in Cobb angle was seen in the BMP group 46 ± 8 vs $35 \pm 10^\circ$ $p < 0.001$. No differences were seen in nights in the PICU and peri-operative complications, however patients in the BMP averaged nearly 1day less in the hospital than in the control group.

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Utilizing a blood management program including two surgeons in spinal deformity surgery appears to decrease operative time, blood loss, and improve curve correction. Confounding factors such as differences in number of fusion levels, curve types, instrumentation type, and institutional practices prevents drawing definitive conclusions. This is the first study to show potential benefits of utilizing a blood management program with dual surgeons in spinal deformity cases.

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1. Introduction

Corrective surgery for Adolescent Idiopathic Scoliosis (AIS) and neuromuscular scoliosis is a major surgical procedure. The most common procedures performed for these conditions include spinal fusion with instrumentation from either an anterior, posterior, or combined approach. These surgical interventions are among some of the most difficult faced in pediatric orthopedics. As time and experience in treating these deformities has progressed, instrumentation to correct and prevent progression has evolved. With the increased use of pedicle screw fixation treating surgeons can obtain enhanced curve correction resulting in decreased number of levels requiring fusion. This has led to an increase in "posterior only" surgery. While improved deformity correction has been demonstrated, treating these curves can be very demanding. Significant operative time (>6–8 h), blood loss (500–2500 ml), neurologic injury, and cardiovascular complications can occur.^{1–11}

In operative procedures, allogenic blood transfusion and increased operative times have been associated with increased post-surgical infection.^{12–14} Surgical site infections (SSI) in spinal deformity surgery carry a very high morbidity to the patient, the family, and high price tag to the medical system. Knowing that operative time and transfusions (and thus blood loss) increase patient morbidity, all clinicians should be seeking ways to minimize these risk factors. After performing spinal deformity surgeries utilizing two surgeons for over three years utilizing this program, it appeared that our program was decreasing patient morbidity via decreased operative times and intra-operative blood losses. No other reports in the spinal deformity literature could be found assessing the use of two fully trained surgeons operating simultaneously. Only one report investigating the effects of surgical assistant training and outcome could be found.¹⁵ In attempt to more objectively review our results, we arranged a retrospective comparison between our patients and those being performed at a second tertiary center utilizing a single surgeon. Thus our null hypotheses were that no differences would exist between the groups in regards to Cobb angle correction, operative time, blood loss, deformity correction, and hospital length of stay would be found between cohorts.

2. Methods

This study utilized a retrospective cohort design. All patients ≤18 years of age with a diagnosis of idiopathic or idiopathic-

like scoliosis who have undergone posterior only instrumentation and fusions performed at the Helen DeVos Children's Hospital from 2008 to 2010 utilizing a two surgeon technique. Patients with congenital scoliosis, degenerative scoliosis, or primary kyphosis were excluded. Using the same inclusion criteria, the control cohort was obtained from the University of Wisconsin–Madison and included data from three experienced spinal deformity surgeons operating independently. Patients with idiopathic or idiopathic like curves were included for this analysis. Only those patients undergoing a posterior spinal fusion without anterior releases or posterior osteotomies were included in this review. A power analysis was performed assuming a 25% decrease in blood loss for the two-surgeon group relative to the one-surgeon group, a standard deviation equal to the absolute decrease of blood loss, an $\alpha = 0.05$ and a $\beta = 0.20$, a statistically significant difference will be found with 16 subjects in each group, using a t-test.

Charts and radiographs were independently reviewed at each respective center. Cohorts were compared for age at surgery, gender, BMI, largest pre-operative Cobb angle. Intra-operative comparisons included total EBL, instrumentation type: pedicle screws vs hybrid (hooks, cables and screws) fixation, levels fused, and operative time. Outcome parameters assessed between the groups were largest remaining Cobb, EBL/level, time/level, lowest recorded hemoglobin, allogenic transfusion requirements, length of PICU stay, and total length of hospital stay were. Pair-wise student t-tests was performed between cohorts with significance defined as a p-value of 0.05 or less.

3. Results

Twenty-four patients were found in the two-surgeon cohort, where as eighty-two were found in the control group. No significant difference in age, sex, starting hemoglobin, BMI, or maximum pre-operative Cobb between cohorts was found (Fig. 1). A significantly lower number of levels were fused in the two-surgeon cohort than the control (9 ± 2 levels vs 11 ± 2 levels) $p < 0.001$, and likewise a significantly shorter operative time (328 ± 65 vs 465 ± 107 min) was seen in the two-surgeon cohort. Interestingly, no difference in estimated blood loss, blood loss/level fused, operative time/level fused was observed, yet a significantly greater drop in hemoglobin (average 1 g) $p = 0.001$ and allogenic transfusion rate was seen in the control group (4% (1/24) vs 29% (24/82)) $p = 0.01$. Surprisingly a greater improvement in Cobb angle was seen in the

Variable	Single Surgeon	Dual Surgeon	p value
N	82	24	
Gender (percent female)	79	92	0.2
BMI*	21(+/-5)	23(+/-5)	0.3
Starting hemoglobin	13.3(+/-1)	13.7(+/-1)	0.4
Max Pre-op Cobb Angle	56(+/-8)	56(+/-9)	0.8
Levels fused	11(+/-2)	9(+/-2)	<0.001
Change (decrease) Cobb Angle	35(+/-10)	46(+/-8)	<0.001
Operative Time (min)	465(+/-107)	328(+/-65)	<0.001
Estimated Blood Loss (ml)	783(+/-475)	630(+/-361)	0.2
Change (decrease) in hemoglobin	3.8(+/-1.6)	2.8(+/-1.2)	0.001
Allogenic blood transfusion (% patients)	29% (24/82)	4% (1/24)	0.01
Perioperative complications (% with any complication)	23	29	0.6
Nights in Intensive Care Unit (% 1 night)	85	88	1
Days in Hospital	5.2(+/-1)	4.5(+/-1)	<0.001

* based on N=23 in BMP cohort

Bold=significant difference

Fig. 1 – This chart compares the demographics, operative, and post-operative variables between the single surgeon vs dual surgeon cohorts irrespective of fixation method.

two-surgeon group 46 ± 8 vs $35 \pm 10^\circ$ $p < 0.001$. No differences were seen in nights in the PICU and peri-operative complications, however patients in the two-surgeon cohort averaged nearly 1 day less in the hospital than in the control group Fig. 1. A large portion of the control patients was found to have a hybrid construct ($N = 73$) whereas all the two surgeon group were primarily pedicle screw constructs, we attempted to see if the differences observed were due only to an increased number of levels fused due to utilizing hybrid fixation or if the observed difference were due to the management program. Thus we compared each type of instrumentation within the control cohort with the two-surgeon cohort.

Comparing single surgeon pedicle screw cases ($N = 9$) to dual surgeon pedicle screw cases ($N = 24$), a significantly higher ($p = 0.03$) percentage of males (44% vs 8%) to females (56 vs 92%), Lenke type curve distribution $p = 0.023$, with a trend toward older age (16 ± 3 vs 14 ± 2 , $p = 0.06$), were observed. No differences were seen in starting hemoglobin (13.8 vs 13.7), BMI (22.5 vs 22.6), maximum pre-operative Cobb angle (54 vs 56), or number of levels fused 10 ± 3 vs 9 ± 2 . Operative time on average was nearly 100 min less (328 vs 428) in the two-surgeon cohort than the single surgeon cohort ($p = 0.01$). Separating out the screw only constructs, average blood loss was nearly 2x's as much in the single surgeon cohort (1200 ± 610 ml) as that observed in two-surgeon cohort (630 ± 362 ml) ($p = 0.01$), resulting in a greater drop in hemoglobin (4.3 vs 2.8) and a significantly higher exposure to allogenic blood (66% vs 4%) in the single surgeon group ($p < 0.001$). Curve correction was significantly greater in the two-surgeon cohort ($46 \pm 8^\circ$ vs $33 \pm 9.5^\circ$). No differences in complications, days in the PICU, or hospital nights were seen in either group (Fig. 2).

Comparing the single surgeon hybrid cases ($N = 73$) to the dual surgeon pedicle screw cases ($N = 24$), no differences were seen in terms of age (14 years), gender, starting hemoglobin (13.2 vs 13.7), BMI (21 vs 23), preoperative Cobb measurements (57 vs 56), or distribution of Lenke curve types. A significantly higher numbers of levels were fused in the single surgeon

cohort (12 ± 2 vs 9 ± 2) $p < 0.001$ and this correlated with a longer operative time (469 ± 103 vs 328 ± 65 min) $p < 0.001$. Average overall estimated blood loss was similar in both cohorts (731 ± 433 ml vs 630 ± 362) $p = 0.3$, but resulted in a greater drop in hemoglobin (3.8 vs 2.8) $p = 0.002$, and caused a greater exposure to allogenic blood 25% vs 4% ($p = 0.04$) in the single surgeon cohort. A significantly greater curve correction was obtained in the two-surgeon screw cohort than the hybrid cohort (46 ± 8 vs 35 ± 10) $p < 0.001$. Approximately, one less day was spent in the hospital 4.5 vs 5.2 ($p < 0.001$) for the two-surgeon cohort. No significant differences were seen in the number of complications or days in the PICU (Fig. 2).

4. Discussion

From this study we were able to show significantly lower operative times, exposure to allogenic blood transfusion, and improved curve correction between our two-surgeon cohort than our control group despite similar starting demographics. Larger drops in hemoglobin and longer hospital stays were noted in the control group. No difference was seen in terms of peri-operative complications. While this cohort would be too small to detect a difference in surgical site infections, one could reason from the literature,^{12–14} that the relative risk for this complication would be lower given the decreased operative time and exposure to allogenic blood. Three significant differences found between cohorts that may be confounding factors include: overall blood management program, levels fused, and fixation method.

At the two-surgeon institution, a comprehensive a pediatric Blood Avoidance Service was consulted in these spinal deformity patients. This included a preoperative evaluation and ordering appropriate screening laboratory tests, use of pre-operative hematinics, intra-operative anti-fibrinolytics (these were also routinely used in the control group). This protocol may have led to a more conservative use of blood products; yet, no difference would be expected in curve

Variable	Single Surgeon (Hybrid)	Dual Surgeon	Single Surgeon (Screws)	p value hybrid	p value screws
N	73	24	9		
Age	13.8(+/-3.2)	13.8(+/-2)	16.1(+/-3.1)	0.9	0.06
Gender (percent female)	82	92	56	0.3	0.03
BMI*	21(+/-5)	23(+/-5)	23(+/-5)	0.2	0.9
Starting hemoglobin	13.2(+/-1.3)	13.7(+/-1)	13.8(+/-1)	0.3	0.9
Max Pre-op Cobb Angle	57(+/-8)	56(+/-9)	54(+/-11)	0.7	0.5
Levels fused	12(+/-2)	9(+/-2)	10(+/-3)	<0.001	0.2
Change (decrease) Cobb Angle	35(+/-35)	46(+/-8)	33(+/-10)	<0.001	0.003
Operative Time (min)	469(+/-103)	328(+/-65)	428(+/-137)	<0.001	0.01
Estimated Blood Loss (ml)	731(+/-433)	630(+/-361)	1200(+/-610)	0.2	0.01
Change (decrease) in hemoglobin	3.8(+/-1.6)	2.8(+/-1.2)	4.3(+/-1.3)	0.002	0.006
Allogenic blood transfusion (% patients)	25%(19/76)	4%(1/24)	67%(6/9)	0.04	<0.001
Perioperative complications (% with any complication)	23	29	22	0.6	1
Nights in Intensive Care Unit (% 1 night)	86	88	78	1	0.8
Days in Hospital	5.2(+/-1.1)	4.5(+/-1.1)	5.1(+/-1.3)	<0.001	0.1

* based on N=23 in BMP cohort

Bold=significant difference

Fig. 2 – This chart compares the demographics, operative, and post-operative variables between the single surgeon vs dual surgeon cohorts separated by fixation type.

correction or operative time with use of this service. These variables might be explained due to the increased number of levels fused in the control group. This has been shown in the literature to correlate with increased blood loss. We felt that the increased levels of fusion may be related to the significant differences in fixation methods. While all of the blood management groups were fixed with primarily pedicle screw fixation, the majority of controls had undergone hybrid fixation. Multiple studies in the literature have demonstrated similar blood loss between techniques with screws requiring shorter fusion lengths. Dividing our control cohort by fixation method and comparing them with the two-surgeon cohort, we saw no differences in levels fused when screw cohorts were compared. Interestingly significant differences remained in terms of time, blood loss, and transfusion rates between screw cohorts, however some demographic differences were also seen when this group was separated.

Improved curve correction was another interesting finding in this study. While not included in this study, metal type, rod diameter, curve flexibility, and implant density may lead to more insight into this finding. These confounding factors combined with potentially less blood loss and increased expertise (have two deformity surgeons) during instrumentation and curve correction may also play a role in leading to improved curve correction.

While this study has several potentially confounding factors, we feel it is the first to begin to show a potential advantage to utilizing two surgeons in scoliosis surgery. Decreasing blood loss, operative time, and allogenic transfusion may be important in decreasing over patient morbidity as well as surgical site infections. Decreasing fusion levels, without compromising curve correction, may be important for long term spine function. Differences in complication rates between the two groups were not found, this may be due to low numbers of patients who are undergoing fusion for idiopathic type scoliosis. It is possible that a more significant advantage of two surgeons over one would be found when comparing patients with larger curves as a result of neuromuscular causes. It is well known that complication rates in non-

idiopathic curves are much higher and thus a more rapid procedure may be associated with improved outcome. Whether or not two surgeons and their combined surgical fees using all pedicle screw fixation leads to lower costs than one surgeon using hybrid fixation remains to be seen as this report did not perform a cost analysis.

Utilizing two surgeons in spinal deformity surgery appear to decrease operative time and improve curve correction. Using dual surgeons as part of a blood management program led to decreased exposure to allogenic blood transfusions. Confounding factors such as differences in number of fusion levels, curve types, instrumentation type, and institutional practices prevents drawing definitive conclusions. This is the first study to show potential benefits of dual surgeons in spinal deformity surgery. Further study is needed to determine if a greater effect on patient results and cost to the health care system can be found in patients with more challenging curve patterns and with significant medical co-morbidities.

Conflicts of interest

All authors have none to declare.

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