

# Preoperative Variables Predicting Massive Blood Loss During Surgical Management of Adolescent Idiopathic Scoliosis

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**Background:** Massive blood loss is one of the most important concerns in scoliosis surgery. There are some factors suggested to predict the massive blood loss in patients with adolescent idiopathic scoliosis (AIS), however, their predictive value remained unclear.

**Objectives:** The current study aimed to investigate whether preoperative variables can predict perioperative massive blood loss in patients with AIS.

**Patients and Methods:** There were 60 patients with AIS who underwent surgical treatment in the current retrospective study. Posterior spinal fusion (PSF) was performed on 36 patients and PSF and anterior spinal fusion (ASF) for the other 24. Estimated blood loss (EBL) was calculated intraoperative. The correlation between preoperative radiographic and demographic variables with EBL was investigated.

**Results:** Among the variables, only AVB-R ratio positively correlated with the amount of intraoperative blood transfusion ( $r = 0.28$ ;  $P = 0.03$ ). Also, preoperative lateral rib hump positively correlated with blood loss in the PSF group ( $r = 0.39$ ;  $P < 0.05$ ). Also, the classification of the scoliosis did not affect the amount of blood loss and the number of transfused units.

**Conclusions:** The preoperative lateral rib hump is an important factor positively correlated with the EBL.

**Keywords:** Scoliosis; Hemorrhage; Blood Transfusion; Spinal

## 1. Background

Massive intraoperative blood loss is one of the most important concerns in the surgical treatment of the adolescent idiopathic scoliosis (AIS). Surprisingly, it is reported that bleeding volume can reach up to 4.5 L (1, 2). Long incision, wide exposure with stripping of muscle off bone, long surgical time, wide decortications of osteoporotic bone with wide vascular channels are important factors affecting the blood loss volume in the patients with AIS (1, 2). The considerable blood loss necessitates substantial allogenic blood transfusion which may associate with several complications such as transmission of infectious diseases, higher risk of postoperative infection and immune system-related problems (3-7). Also, blood transfusion exerts great financial burden on the patient and health care system.

Although some blood conservative technique modalities such as autologous blood donation, controlled hypotensive anesthesia, preoperative administration of erythropoietin, intraoperative blood salvage, acute normovolemic hem dilution method, intrathecal morphine and administration of specific agents like tranexamic acid during the operation lead to reduced blood loss and blood transfusion, they are costly and risky (8-14).

Due to financial burden and concerns about poten-

tial side effects, authors and surgeons prefer not to use these blood conservative modalities for all the patients since they can lead to unnecessary usage in many of the cases. Some authors tried to find methods to predict the likelihood of massive blood loss preoperatively (11-15). Although there are several risk factors introduced for massive blood loss in spinal surgeries including magnitude of spinal deformity, type of spinal deformity, patients anthropometric characteristics, preoperative hemoglobin and hematocrit, operation time, type of procedure, intraoperative mean arterial pressure, the surgical procedure and number of fused levels (16-23), however, the predictive value of these factors remains unclear (11, 15).

## 2. Objectives

The current study aimed to overcome the lack of knowledge and to reliably anticipate the massive blood loss; however, more widespread studies are needed. The current study aimed to retrospectively investigate the factors affecting the intraoperative blood loss during surgical correction of AIS which would enable researchers to predict the volume of blood loss and required amount of blood transfusion.

### 3. Patients and Methods

The study was approved by the ethic committee of the bone and joint reconstruction research center. From 2010 to 2011, there were sixty patients diagnosed with AIS who underwent corrective operation by the senior surgeon who investigated the current retrospective study. There were 14 males (23.3%) and 46 females (76.7%). The mean age of the patients was  $16.3 \pm 3.6$  years and their mean weight was  $46.9 \pm 8.8$  Kg. Of these, thirty six patients had posterior spinal fusion (PSF) and posterior segmental spinal instrumentation (PSSI) only, and 24 patients had anterior spinal fusion (ASF) at the first stage, and PSF and PSSI one week later, at the second stage. Patients with previous history of spinal surgery and coagulopathy (abnormal PT, PTT and International Normalized Ratio) were excluded. Also, patients with neuromuscular, congenital or syndrome scoliosis were excluded.

#### 3.1. The Operative Technique

For ASF operation, the patient was placed in lateral decubitus position with the convex side of the curve up. The incision was made along the appropriate rib and the vertebrae involved in the curve were exposed using intrapleural and extra peritoneal approaches according to level of the curve. Segmental arteries were ligated if necessary. The disk material was excised and the spaces were filled with morselized autologous bone graft from the patient's rib. For PSF and PSSI operation, the patient was placed in prone position with two posts under chest wall and iliac crest while the arm was abducted at  $90^\circ$  position and protected with pads. Hip and knee joints were extended. A straight incision was made from the upper to the lower vertebrae through the dermal layer. The intra dermal and subcutaneous areas were then infiltrated with 1'500'000 epinephrine solution. The bone of the spinal column was exposed from spinous processes to transverse processes subperiosteally. Facetectomy was performed using Hall's technique. ZIA spinal system (Stryker co, USA) was used for instrumentation based on the preoperative map and corrected the curves using derotation technique. Wake up test was performed at this stage. The bone was decorticated and autogenous bone graft was placed in fusion site. The surgical wound was sutured in three layers with a heamovacume on the fascia.

Intraoperative, estimated blood loss (EBL) was determined by calculating the blood volume in the suction container after subtracting irrigation in addition to the difference in the weights of dry and blood soaked sponges. Demographic data such as age at the time of surgery, sex and body mass index (BMI) were collected. Cobb's angle, thoracic kyphosis, type of the curve based on the King's classification, hemoglobin level were measured pre- and post-operatively. Also, the operating time, amount of perioperative blood transfusion, the percentage of curve rigidity and curve correction, preoperative apical vertebral body-rib (AVB-R) ratio, and lateral rib

hump as indices of vertebral rotation were measured. The flexibility of the curve and the curve correction were calculated using the following formulas:

- Flexibility:  $(\text{primary curve} - \text{bending curve} / \text{primary curve}) \times 100$
- Correction:  $(\text{preoperative curve} - \text{postoperative curve} / \text{preoperative curve}) \times 100$

#### 3.2. Statistical Analysis

Data were presented for all of the patients and for the separated surgical groups. The mean of blood loss and number of transfused blood units were compared using a one-way ANOVA. Also, the mean of pre- and post-operative scoliotic curve were compared using paired t-test. The correlation between the measured variables and EBL was determined using Pearson's correlation coefficient ( $r$ ) and Spearman's rank correlation coefficient ( $\rho$ ). Finally, logistic regression analysis was performed to investigate the potential effect of each variable on the EBL. The analyses were performed utilizing SPSS statistical software (version 15, SPSS, Chicago, IL).  $P < 0.05$  was considered as the level of significance.

### 4. Results

The post-operative FVC increased significantly ( $70.7 \pm 16\%$  versus  $74.9 \pm 16\%$ ;  $P = 0.001$ ). The mean operation time was  $9.9 \pm 1.7$  hours in PSF and ASF group,  $6.9 \pm 2.1$  hours in PSF group and  $8.2 \pm 2.7$  hours in total. The pre- and post-operative radiographic findings, in total and in separated surgical groups, are presented in table 1. As shown in table 1, the magnitude of the main scoliotic curve, AVB-R ratio, and lateral rib hump decreased significantly after the operation ( $P < 0.001$ ). The main scoliotic curve decreased significantly in PSF and ASF group ( $81.6 \pm 15.6^\circ$  Vs.  $31.2 \pm 16^\circ$ ;  $P < 0.05$ ) and PSF groups ( $58.6 \pm 16.6^\circ$  Vs.  $25 \pm 12.6^\circ$ ;  $P < 0.05$ ). The mean ASF level of the patients was  $5.4 \pm 1.1$ . Table 2 shows the volume of blood loss, number of units transfused, and pre- and post-operative Hb levels. The postoperative Hb level was significantly lower than that of the preoperative one ( $P < 0.001$ ). There was no significant difference in terms of intraoperative blood loss and the required transfused units between the patients with different types of scoliosis based on King's classification ( $P > 0.05$ ) (Table 3).

No statistically significant correlation was found between the volume of blood loss and preoperative radiographic parameters evaluated in the current study, sex, age, body weight, and operation time. However, AVB-R ratio was positively correlated with the amount of intraoperative blood transfusion ( $r = 0.28$ ;  $P = 0.03$ ). Also, the surgical technique was not significantly correlated with the amount of blood loss in the thoracic and lumbar areas ( $P > 0.05$ ).

Considering the differences in the duration of surgery,

body weight, vertebral levels in fusion, and severity of preoperative rotation (preoperative AVB-R ratio and lateral rib hump), which can affect directly or indirectly the amount of bleeding, the current study corrected the intraoperative EBL for one or more parameters. Notably, lateral rib hump and preoperative rotation index were positively correlated with blood loss during the PSF surgery ( $r = 0.39$ ;  $P < 0.05$ ).

**Table 1.** The Preoperative Radiographic Findings in Total Number of the Patients and Separated Surgical Groups <sup>a,b</sup>

Group	Total (n = 60)	PSF and ASF (n = 24)	PSF (n = 36)
Cobb's angle, degree	67 ± 19.5	81.6 ± 15.6	58.6 ± 16.6
Curve flexibility, %	36.8 ± 18.9	29.4 ± 16.3	43.5 ± 19.1
Lumbar lordosis, degree	43.4 ± 12.3	46.9 ± 7.8	43 ± 14.8
Kyphosis, degree	44.5 ± 8.9	45.3 ± 8.7	41.7 ± 8.3
AVB-R ratio, cm	3 ± 2.8	3.2 ± 1.3	2.7 ± 3.6
Lateral rib hump, cm	8.2 ± 11.3	7.5 ± 11.6	8 ± 10.4

<sup>a</sup> Abbreviations: ASF, anterior spinal fusion; AVB-R, apical vertebral body-rib; PSF, posterior spinal fusion.

<sup>b</sup> Data are presented as mean ± SD.

**Table 2.** The Volume of Blood Loss, the Number of Units Transfused and Pre-and Post-Operative Hb Levels <sup>a,b</sup>

Variables	Values		
	PSF (n=36)	PSF and ASF (n=24)	Total (n=60)
Blood loss volume, mL	812.8 ± 405.9	994.2 ± 462	732.8 ± 255.1
Blood loss per PSF level, mL	-	-	67.1 ± 27.3
Blood loss per ASF and PSF level, mL	-	101.6 ± 39.3	-
Transfused packed cells	2.4 ± 1.4	2.9 ± 1.6	1.9 ± 1.1
Preop Hb, mg/dL	13.4 ± 1.5	13.2 ± 1.5	13.6 ± 1.4
Postop Hb, mg/dL	10.6 ± 1.2	10.9 ± 1.3	10.4 ± 1.1

<sup>a</sup> Abbreviations: ASF, anterior spinal fusion; Hb, hemoglobin; Postop, postoperative; Preop, preoperative; PSF, posterior spinal fusion.

<sup>b</sup> Data are presented as mean ± SD.

**Table 3.** Intraoperative Blood Loss and the Number of Transfused Blood Units in Different Types of King's Classification <sup>a,b</sup>

King's classification	Bleeding, mL		Bleeding Per Vertebrae, mL		Transfused Packed Cells
	PSF and ASF (n = 24)	PSF (n = 36)	PSF and ASF (n = 24)	PSF (n = 36)	
1	150	839	31.94	58.32	2
2	150	793	29.17	63.90	2
3	150	715	24.76	69.32	2
5	-	250	-	25.00	1

<sup>a</sup> Abbreviations: ASF, anterior spinal fusion; PSF, posterior spinal fusion.

<sup>b</sup> Data are presented as No.

## 5. Discussion

Multilevel spinal fusion in patients with AIS is associated with considerable intra- and post-operative bleeding because of the long incision and extensive invasion to the soft tissue and bony structures. It has been reported that AIS patients underwent multilevel spinal fusion often require one to eight transfused blood units (24-26). The potential complications of allogenic blood transfusion and its high cost made the authors and surgeons to find blood conservative techniques to reduce the need for blood transfusion. Also, it is favorable to recognize the preoperative factors which enable surgeons to predict massive intraoperative blood loss.

To the researchers' knowledge there are limited studies regarding the prediction of massive bleeding and need to allogenic blood transfusion during and after the multilevel spinal fusion in the patients with AIS. Many of these studies reveal that preoperative Cobb's angle and the number of fused vertebrae are important predictive factors of massive perioperative bleeding. Doi et al. intro-

duced the number of fused vertebrae as a factor affecting the amount of bleeding in AIS surgeries (18). Similarly, Guay et al. reported similar results regarding the role of the number of fused vertebrae in volume of intraoperative and total bleeding in patients with AIS (19). Hassan et al. also, found that blood loss was associated with Cobb's angles in surgical treatment of pediatric idiopathic scoliosis. Furthermore, they demonstrated that blood loss, the number of fused vertebrae and low weight of the patients are associated with increased need for allogenic blood transfusion (17). Yu et al. found similar results and suggested that Cobb's angle  $> 50^\circ$  and multilevel spinal fusion or osteotomy (more than six levels) are associated with massive blood loss (11). Shah et al. found some other predictive factors in addition to Major Cobb's angle including sex, operation time, use of pedicle screw and age (27). Similar to the findings of Shah et al., recently, Ialenti et al. found that sex, operation time and preoperative kyphosis angle are predicting factors of increased blood loss in posterior spinal fusion in patients with AIS and proposed a formula to calculate the EBL as follows:

EBL: 233 (for males) or 270 (for females) + (6.4 × operative time) - preoperative thoracic kyphosis - 8.7.

They also observed that the mean arterial pressure and operative time are predictors of bleeding in the anterior fusion (15).

Some other researchers demonstrated different preoperative variables as predictive factors of massive bleeding in patients with AIS. Carling et al. stated that preoperative fibrinogen plasma concentration can lead to limited hemostasis and perioperative bleeding in AIS surgery and should be measured before the operation (28). In another study, Modi et al. investigated blood loss during different levels of scoliosis surgery and found that poor bone marrow density increases the risk of blood loss up to nine times (29). According to the above mentioned studies, there is no comprehensive consensus regarding the predictive factors of massive blood loss during and after the surgical treatment of AIS patients, however, some parameters such as the number of fused vertebrae and operative time are recognized in several studies. The current study was conducted based on the lack of knowledge and the need for more studies to investigate the factors affecting the amount of perioperative bleeding. Unfortunately, the current study observed no significant correlation between the bleeding volume and different types of scoliosis based on King's classification, type of operation (one stage or two stages), sex, age, weight, curve rigidity, magnitude of deformity, lumbar lordships, thoracic kyphosis and ABV-R ratio. Interestingly, it was observed that greater preoperative lateral rib hump was an index of vertebral rotation is significantly correlated with higher EBL which to the authors' knowledge was not pointed out in the previous studies. However, due to the different results obtained by different authors, it looks necessary to perform more extended prospective studies to clarify the factors affecting bleeding in patients with AIS who must undergo surgical fusion. Like any other studies, there were some limitations to the current study. The current study was limited its retrospective nature. Also, it is favorable to perform studies with greater sample sizes which can help finding more precise results.

Prediction of blood loss is an important factor to manage AIS surgery. In the current study, the preoperative amount of vertebral rotation as measured by the lateral rib hump significantly affected the amount of intraoperative bleeding. Based on the findings, much more blood loss is expected in patients with greater lateral rib hump regardless of age, weight, curve magnitude, rigidity, and curve type based on king's classification. The operative team should be ready to manage this condition with safe and innovative techniques in such patients.

### Authors' Contributions

Study concept and design: Vahid Tari, Ebrahim Ameri , Ghandhari, Farshad Nikouei; Data acquisition of: Ebrahim Ameri , Hasan Ghandhari, Farshad Nikouei; Data analysis and interpretation: Vahid Tari, Ebrahim Ameri;

Drafting of the manuscript: Vahid Tari, Ebrahim Ameri , Hasan Ghandhari, Farshad Nikouei , Hamid Hesarikia; Critical revision of the manuscript for important intellectual content: Vahid Tari, Ebrahim Ameri , Hasan Ghandhari, Farshad Nikouei , Hamid Hesarikia; Statistical analysis: Hasan Ghandhari, Farshad Nikouei , Hamid Hesarikia; Study supervision: Ebrahim Ameri.

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