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Original Article

Anaesthesia Section

Factors Affecting Intraoperative Blood Loss in Scoliosis Surgery: An Observational Cross-sectional Study

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ABSTRACT

Introduction: Significant intraoperative blood loss may be associated with scoliosis surgery. To know about the quantity of blood loss and risk factors associated is imperative in limiting the blood loss as well as to plan transfusion strategies like blood conservation techniques.

Aim: To evaluate the quantity of intraoperative blood loss in scoliosis surgery and to study the various factors contributing to blood loss.

Materials and Methods: This was a cross-sectional prospective observational study conducted at Government Medical College, Thiruvananthapuram, India, from January 2019 to January 2020. Thirty-five (ASA I and II) consecutive patients were scheduled to undergo surgery for correction of scoliosis, and consecutive sampling was done. Age, gender, weight, height and body mass index were noted. During surgery, intraoperative blood loss was measured by gravimetric method from the suction drain and by numerically assessing the quality of the surgical field by the operating surgeon using fromme's ordinal scale. All these data were entered into structured proforma and analysed by using Statistical Package for Social Sciences (SPSS) version 21.0.

Results: The mean age of subjects was 13.69±1.43 years. The mean intraoperative blood loss was 645.60±143.26 mL {20.11±11.7 % of Estimated blood volume (EBV)}. Mean duration of surgery (r=0.890, p<0.001), Cobb's angle (r=0.829, p<0.001), number of fused vertebra (r=0.694, p<0.001) correlated with intraoperative blood loss, expressed as a percentage of EBV. The quality of the surgical field, using Fromme's ordinal scale by visual assessment, correlated with the mean intraoperative blood loss (p=0.001).

Conclusion: Duration of surgery, number of fused vertebrae, and preoperative Cobb's angle are the most important factors predicting intraoperative blood loss in patients undergoing scoliosis surgery.

Keywords: Adolescent idiopathic scoliosis, Cobb's angle, Fromme's ordinal scale, Gravimetric method, Intraoperative blood loss

INTRODUCTION

Scoliosis is a complex deformity of the spine leading to lateral curvature and rotation of vertebra, and deformity of the rib cage. Its prevalence in the general population varies from 0.3-15.3% [1]. The prevalence is 3% for curves more than 10 degrees and 0.3% for curves more than 30 degrees [2]. Scoliosis is more common in adolescents, with female to male ratio being 3:1 [3]. Involvement of respiratory, neurologic, and cardiovascular systems usually occurs in scoliosis. Causes of scoliosis can be idiopathic, congenital, and neuromuscular. Neuromuscular scoliosis results from cerebral palsy, spinal cord trauma, spinal muscular atrophy, and Duchenne muscular dystrophy. A 75-90% of cases are of idiopathic type [4]. Adolescent Idiopathic Scoliosis (AIS) is a diagnosis of exclusion after ruling out other causes of scoliosis such as vertebral malformation, syndromic disorders, and neuromuscular disorders. Definitive diagnosis is made by measuring the Cobb's angle in a standing coronal radiograph. The exact aetiology of AIS remains unknown. Multiple genes are implicated like Fibrillin 1 and 2, Collagen type 1 and 2, elastin, aggrecan, and heparin sulfotransferases [5].

Non operative treatment modalities include bracing and physiotherapy which aim at preventing progression [5]. When Cobb's angle exceeds 50 degrees in the thoracic spine and 40 degrees in the lumbar spine, surgery is needed. Surgical treatment aims at the correction of deformity and its maintenance to stop the progression of cardiopulmonary disease. Scoliosis leads to restrictive lung disease and ventilation-perfusion misdistribution. Cardiovascular involvement in the form of elevated right heart pressures, mitral valve prolapse, or congenital heart disease. Pulmonary hypertension or respiratory failure will ensue in 4^{th} or 5^{th} decade of life if idiopathic scoliosis is untreated [3]. During surgeries for correction of spinal deformities, several potential factors contribute to morbidity or even mortality including co-morbidities, patient positioning, blood loss, and neurological damage. Cardiovascular deterioration can occur commonly due to hypovolaemia from blood loss [6]. Anaesthesiologists have intraoperative considerations regarding fluid balance, positioning, spinal cord integrity monitoring, assessment of blood loss, and blood transfusion if needed during the corrective surgery for scoliosis. Blood loss during corrective surgery for scoliosis or spinal fusion is high and may exceed the patient's EBV. Factors that influence blood loss during surgery include many anaesthetic and surgical techniques like the extent of dissection, Mean Arterial Pressure (MAP), number of vertebrae fused, and pressure in the inferior vena cava [7]. In elective spinal surgery, about 30-60% of patients need allogeneic blood transfusion which in turn is associated with risks like transfusion-associated lung injury and infections. To minimise allogeneic blood transfusion needs, methods like autologous blood transfusion and cell salvage techniques are employed [8].

Hypotensive anaesthesia, aminocaproic acid, tranexamic acid, preoperative erythropoietin can help reduce intraoperative blood loss [9]. This prospective observational study is an attempt to measure the intraoperative blood loss in corrective surgery for AIS and to evaluate factors affecting the intraoperative blood loss.

MATERIALS AND METHODS

The prospective observational cross-sectional study was conducted at Government Medical College, Thiruvananthapuram, India, from January 2019 to January 2020. Institutional Ethical Committee clearance was obtained before starting data collection (IEC NO.01/25/2019/MCT).

Inclusion criteria: Consecutive cases of AIS with informed written consent were included in the study.

Exclusion criteria: Those with bleeding diathesis and abnormal Prothrombin Time (PT), Partial Thromboplastin Time (PTT), or platelet counts, pre-existing hepatic disease, intake of acetylsalicylate within two weeks or Non Steroidal Anti-inflammatory Drugs (NSAID) within seven days before surgery were excluded.

Sample size calculation: The sample size was calculated using the following formula:

$$n=4\sigma^2/d^2$$

where:

σ-Standard deviation of blood loss

d-10 % of mean blood loss applying the values,

n=28.47

The sample size was taken as 35 to fulfil statistical assumptions. The study variables included age, gender, body mass index, Cobb's angle, number of fused vertebrae, duration of surgery mean arterial blood pressure, intraoperative blood loss and quality of surgical field. Body weight was measured using a weighing scale and height using a measuring tape in preanaesthetic check-up.

Cobb's method of measurement recommended by the Terminology Committee of the Scoliosis Research Society consists of three steps [10]:

- Locating the superior end vertebra:
- Locating the inferior end vertebra:
- Drawing intersecting perpendicular lines from the superior surface of the superior end vertebra and the inferior surface of the inferior end vertebra.

Study Procedure

From a similar study done by Guay J et al., the mean blood loss was 1383±369 mL [7]. All patients were induced with Inj. Fentanyl (2 mcg/kg), Inj. Propofol (2-2.5 mg/kg), Inj. Atracurium (0.5 mg/kg) i.v. Maintenance with oxygen: air 2:2, i.v. infusions of propofol (50-75 mcg/kg/min), Fentanyl (1-2 mcg/kg/hour), dexmedetomidine (0.2-0.8 mcg/kg/hour). All patients were given tranexamic acid bolus dose 20 mg/kg and infusion dose 1-2 mg/kg/hour i.v.

All the surgeries were performed by the same surgeon using a posterior approach. During surgery, patients were monitored with an Electrocardiogram (ECG), pulse oximeter, capnometer, and automated oscillometric blood pressure device. An arterial catheter was placed in the radial artery, and a transfusion medicine expert collected autologous blood of 300-500 mL according to the patient's status. The anaesthesiologist replaced three pints of crystalloids for each pint of autologous blood withdrawn and beat to beat variation in blood pressure was monitored through the arterial line. Heart rate and non invasive blood pressure were recorded before induction of anaesthesia and every five minutes during surgery. MAP during surgical exposure which was defined as the time from incision up to the point of instrumentation {Surgical Exposure Mean Arterial Pressure (SE-MAP)} and during the entire surgery {Average Mean Arterial Pressure (MAP)} was noted [11]. During surgery, blood loss was estimated hourly from surgical drain excluding the amount of saline used and by gravimetric method by weighing sponges from the operative field. Dry mops and gauze were weighed before surgery and fully soaked mops and gauze were weighed in grams as soon as they were soaked using an electronic weighing scale after checking for accuracy and repeatability. This was converted into millilitres by dividing the weight in grams by specific gravity. All blood-soaked materials were weighed and converted to millilitres [12]. The specific gravity of human whole blood at 37°C is 1.0506 [13]. Surgical field quality was assessed every 15 minutes by the surgeon using Fromme's ordinal scale. The average grade from Fromme's ordinal scale was taken [14]. Grades are as follows:

5- Massive bleeding; cannot carry out dissection.

4- Severe bleeding; significantly compromises dissection.

3- Moderate bleeding slightly compromises dissection.

2- Mild bleeding, a nuisance but does not compromise dissection.

1- Minimal bleeding; not a surgical nuisance.

0- No bleeding; virtually bloodless field

The EBV was calculated as 70 mL/Kg [15].

Maximum Allowable Blood Loss (MABL) was calculated as:

$$MABL=\frac{\text{EBV (Starting haematocrit-target haematocrit)}}{\text{Starting haematocrit}}$$

To calculate MABL, target haemoglobin was taken as 7 g/dL. Surgical blood losses were replaced with crystalloids upto 20-30% of the EBV in a ratio of 3:1, and with autologous blood or allogenic blood for blood losses exceeding 20-30% of the EBV. The number of vertebrae fused was obtained from the operative notes of the surgeon.

STATISTICAL ANALYSIS

After collection, the data was entered into a master chart using Microsoft excel and analysed by using statistical SPSS 21.0. Qualitative variables were expressed in proportion and quantitative variables were expressed as mean and standard deviation. Tests of significance were done using students' t-test, Analysis of Variance (ANOVA), and linear regression. The p-value <0.05 was considered statistically significant. For linear regression, the correlation coefficient (r value) was taken.

RESULTS

Overall, 68.6% of subjects were females and 31.4% were males. The mean age of subjects was 13.69±1.43 years while the weight was 46.18±3.5 Kg. The mean Body Mass Index (BMI) was 20.26±1.7 Kg/m^2. The mean Cobb's angle of the study subjects was 52.8±9.11 degrees. The mean intraoperative blood loss was 645.60±143.26 mL (20.11±11.7 % of EBV). The mean duration of surgery was 4.8±1.39 hours [Table/Fig-1].

Variables	Minimum	Maximum	Mean±SD
Age (years)	11	16	13.69±1.43
Weight (kg)	39	52	46.18±3.50
Height (cm)	140	165	151.11±5.93
BMI (kg/m^2)	15.6	22.9	20.26±1.70
Cobb's angle (degree)	35	74	52.80±9.11
Hb (g/dL)	10.6	13.1	11.63±0.69
Platelet count (lacs)	1.5	3.6	2.061±0.399
INR	0.6	1.4	0.916±0.207
Number of fused vertebrae	3	7	4.69±1.11
Duration of surgery (hours)	3	8	4.80±1.39
SE MAP (mmHg)	60	72	67.40±2.58
Average MAP (mmHg)	63	74	69.00±2.35
EBV (mL)	2730	3640	3232.80±245.30
MABL (mL)	712.5	1400	1007.04±184.00
Intraoperative blood loss (in mL)	400	910	645.60±143.26
Percentage of blood loss according to EBV	11.66	28.70	20.11±4.76

[Table/Fig-1]: General patient data.
SE MAP: Surgical exposure Mean arterial pressure; EBV: Estimated blood volume; MABL: Maximum allowable blood loss; INR: International normalised ratio

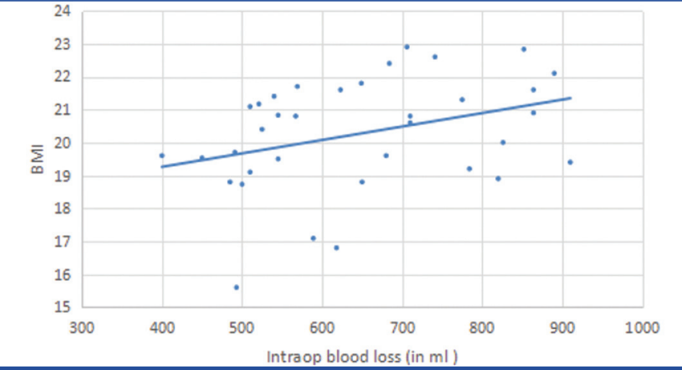
The mean intraoperative blood loss in males and females were 649.7±148.4 mL and 643.7±144.1 mL, respectively [Table/Fig-2]. No significant difference between the two groups was observed. (r=0.114, p=0.910).

Gender	N	Mean intraop blood loss (mL)
Male	11	649.7±148.4
Female	24	643.7±144.1

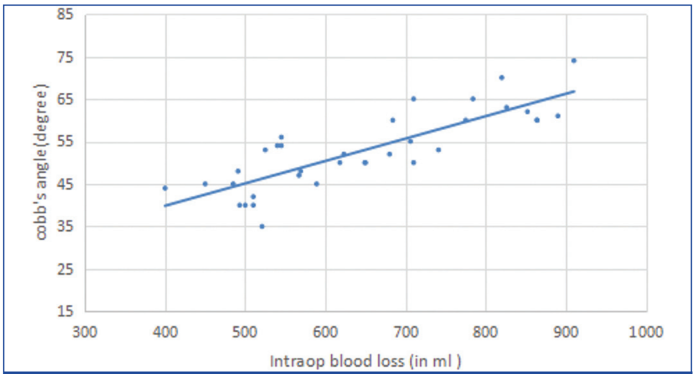
[Table/Fig-2]: Intraoperative blood loss in males and females.

There was a positive correlation between BMI and mean intraoperative blood loss (r=0.345) [Table/Fig-3]. Cobb's angle showed a positive correlation with the mean intraoperative blood loss (r=0.829, p<0.05) [Table/Fig-4]. The number of fused vertebrae showed a positive correlation with the mean intraoperative blood loss (r=0.694, p<0.05) [Table/Fig-5].

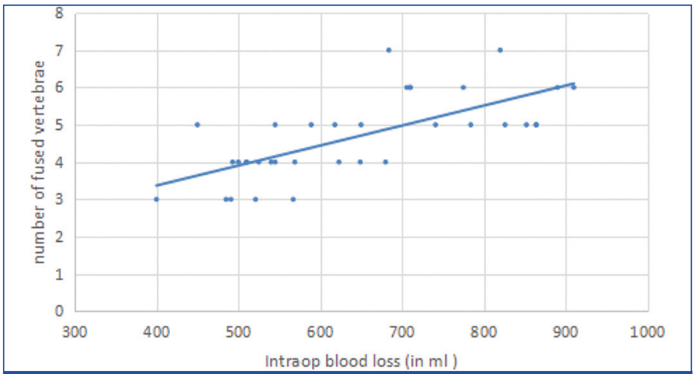
The duration of surgery was found to be positively correlated with the mean intraoperative blood loss (r=0.890, p<0.05) [Table/Fig-6].



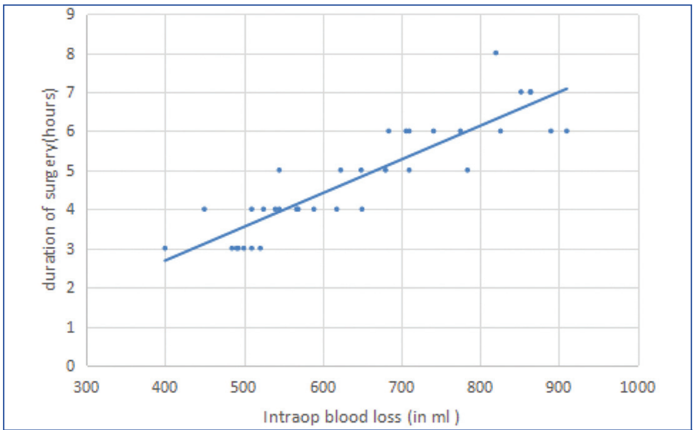
[Table/Fig-3]: Correlation between BMI and blood loss (r=0.345, p=0.043).



[Table/Fig-4]: Correlation between Cobb's angle and blood loss (r=0.829, p<0.05).



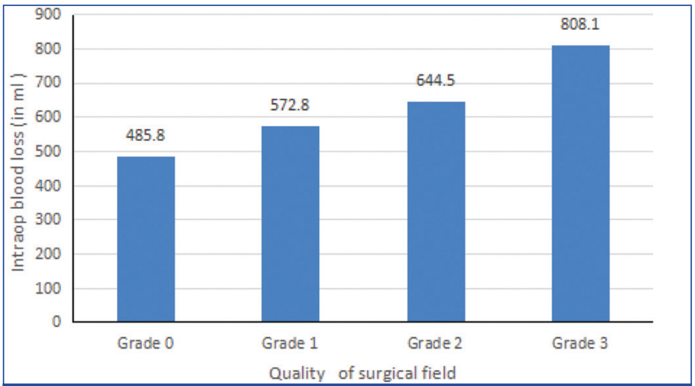
[Table/Fig-5]: Correlation between the number of fused vertebrae and blood loss (r=0.694, p<0.05).



[Table/Fig-6]: Correlation between duration of surgery and blood loss (r=0.890, p<0.05).

There was no correlation between SE MAP and the mean intraoperative blood loss [Table/Fig-7]. The quality of surgical field showed a significant association with the mean intraoperative blood loss (p=0.001) [Table/Fig-8]. Duration of surgery, Cobb's angle, and number of fused vertebra correlated with intraoperative blood loss expressed as a percentage of EBV.

[Table/Fig-7]: Correlation between SE MAP and blood loss (r=-0.497, p=0.002).



[Table/Fig-8]: Comparison of quality of the surgical field and blood loss (p=0.001).

DISCUSSION

In the present study, mean intraoperative blood loss was 645.60±143.26 mL; while the mean intraoperative blood loss in a study done by Guay J et al., was 1383±369 mL [7]. In this study, duration of surgery, Cobb's angle, and number of the fused vertebra were found to be important factors in predicting the mean intraoperative blood loss both as a percentage of EBV and absolute blood loss. There was no significant difference in mean intraoperative blood loss between the male and female groups.

A positive correlation between BMI and mean intraoperative blood loss (r=0.345) was observed in this study. However, Meert KL et al., observed in their study that low body weight was associated with increased blood loss [16]. This could be due to differences in bone mineral density among patients with the same body weight, so more studies are necessary to prove the relationship between these two factors. Rather than visual assessment, objective measurement of intraoperative blood loss allows more judicial decisions regarding whether cross-matched blood should be arranged or which blood conservation techniques should be utilised for a specific patient [17].

The present study found that, the duration of surgery and number of fused vertebrae positively correlated with mean intraoperative blood loss. In a similar study, Guay J et al., also found that intraoperative bleeding correlated with the number of fused vertebrae and the duration of surgery [7]. Similarly, Morcos MW et al., also noted that multilevel fusion was significantly correlated with the amount of blood loss [18]. Carabini LM et al., also found that the number of levels instrumented, predicted duration of surgery, and complexity of surgical instrumentation were independent predictors of intraoperative blood loss [19]. In this study, it was observed that Cobb's angle and the number of fused vertebrae were positively correlated with mean intraoperative blood loss. Similarly, Yu X et al., studied the predictors of massive blood loss during scoliosis surgery. Preoperative Cobb's angle >50 degrees, number of fused levels >6, and more osteotomies were associated with massive (>30% of EBV) blood loss [20]. Hassan N et al., found that a higher Cobb's angle was associated with a higher amount of intraoperative blood loss. They also noted that an increased number of segments fused and lower patient weight was associated with increased odds for transfusion [21]. Koerner JD et al., found that patients with lower preoperative haemoglobin received more allogeneic blood transfusion than those with higher preoperative haemoglobin [22]. In this study, there was no correlation between preoperative haemoglobin and mean intraoperative blood loss in this study.

In the present study, there was no correlation between the decrease in MAP and blood loss. Similar observations were noted by Guay J et al., [7]. This could be due to relatively constant inferior vena cava pressures at a wide range of MAP.

In a study by Paul JE et al., authors found some support for using deliberate hypotension in decreasing blood loss, but they also opine that their results are affected by small sample sizes and differences in the quality of methodology [23]. Butler JS et al., studied the risk factors associated with significant transfusion requirements in spinal surgery and found that multilevel surgery is a predictor of >2 units Packed Red Blood Cell (PRBC) transfusion requirement. Authors suggested that increased awareness of risk factors associated with transfusion is necessary to optimise patient blood management [24].

There is strong evidence to support the use of antifibrinolytic agents during spine surgery to decrease blood loss and transfusion requirements. The use of cell salvage, recombinant factor VIIa, activated growth factor platelet gel to prevent haemorrhage during spine surgery are currently unacceptable due to lack of evidence [25]. In the present study center, antifibrinolytic agent tranexamic acid is routinely used to reduce blood loss. Depending on the preoperative Cobb's angle, number of fused vertebrae and duration of surgery, we have to plan blood maangement strategies for patients undergoing surgery for scoliosis correction.

Limitation(s)

ASA I or II patients were included. So, results cannot be generalised for ASA III/IV patients. More sophisticated methods of estimating intraoperative blood loss could have yielded more accurate values.

CONCLUSION(S)

Duration of surgery, number of fused vertebrae, and preoperative Cobb's angle are the most important factors predicting intraoperative blood loss in patients undergoing scoliosis surgery. ASA PS class II and an increase in BMI are also associated with increased intraoperative blood loss.

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