Submitted: 05 July, 2023 Accepted: 29 August, 2023 Published: 08 February, 2024 DOI:10.22514/sv.2023.121

Open Access
Signa Vitae

ORIGINAL RESEARCH

Perioperative characteristics and predictors of intensive care needs in patients undergoing surgery for scoliosis: a retrospective study of 165 patients

Shamsiya Mahammadova[1], Sibel Oba[1,*], Ayşe Surhan Çinar[1], Hacer Şebnem Türk[1], Hacı Mustafa Özdemir[2]

[1]Department of Anaesthesiology and Reanimation, Health Sciences University, Sisli Hamidiye Etfal Training and Research Hospital, 34396 Istanbul, Turkey
[2]Department of Orthopaedics and Traumatology, Health Sciences University, Sisli Hamidiye Etfal Training and Research Hospital, 34396 Istanbul, Turkey

***Correspondence**
sibel.oba@sbu.edu.tr
(Sibel Oba)

Abstract

In this study, we retrospectively performed a review of medical records of all patients who underwent scoliosis surgery between January 2018 and January 2021. A total of 165 patients were included; (64.2% were female and the mean age was 21.6 ± 16.7 years). The most frequent aetiologies of scoliosis were idiopathic, congenital, degenerative and neuromuscular. In 48 patients who required Intensive Care Unit (ICU) stay, the rate of comorbidity was 75% (n = 36); lung disease was present in 54% (n = 26) of cases and restrictive lung disease was present in 47.9% of cases (n = 23), which were significantly higher than those who did not require ICU stay ($p < 0.001$). The proportion of patients with neuromuscular problems was 45.8% (n = 22) ($p = 0.004$) while those with epilepsy was 16.7% (n = 8) ($p = 0.027$). The proportion of patients with neuromuscular scoliosis was 25% (n = 12), the median number of fused vertebrae (fusion level) was 15, and the proportion of American Society of Anaesthesiologists (ASA) III patients was 54.2% (n = 26) (all $p < 0.001$). The median surgical duration was 307.5 minutes ($p = 0.006$) and the proportion of patients which received blood transfusion was 91.7% (n = 44) ($p = 0.002$). The pre- and post-operative haemoglobin (Hb) levels, and the post-operative arteriel blood gases (ABG) potential of hydrogen (pH) and lactate levels of patients, who needed ICU were significantly different from those who did not require the ICU ($p = 0.043$, $p = 0.039$, $p < 0.001$ and $p = 0.037$). In conclusion, a presence of restrictive lung disease, epilepsy, neuromuscular scoliosis, a high fusion level, a need for blood transfusion, long surgical duration, low Hb and pH values, and high lactate levels were found as the predictors of ICU admission.

Keywords

Intensive care unit; Perioperative characteristics; Scoliosis; Spine; Surgery

1. Introduction

Scoliosis refers to the lateral curvature of the spine in the frontal plane and is often accompanied by rotation in the axial plane. Scoliosis kyphosis, kyphoscoliosis and revision thoracolumbar fusion surgery are among the complex corrective surgeries performed on the spine. Although there are congenital, neuromuscular and mesenchymal disease-related types of scoliosis, the most common form is idiopathic adolescent scoliosis [1, 2].

Patients with scoliosis often develop lung pathology, especially the restrictive type; this is due to the reduced thoracic volume and chest wall compliance. Moreover, patients with scoliosis may develop cardiovascular, neurological and other diseases. Scoliosis surgery aims to prevent progressive spinal curvature, respiratory dysfunction, and other diseases caused by spinal curvature [3, 4]. However, many factors can result in major blood loss during scoliosis surgery, including surgical technique, operation time, the number of fused vertebrae, mean arterial pressure, the anaesthetics used, dilutional coagulopathy and the development of primary fibrinolysis [5]. In this patient group, which features serious comorbidities, complex scoliosis surgery becomes even more risky [6].

In the present study, we aimed to retrospectively evaluate the perioperative characteristics and predictors of intensive care needs for patients undergoing surgery for scoliosis.

2. Materials and methods

This study was carried out retrospectively. All patients who had undergone scoliosis surgery between the 1st of January 2018 and the 1st of January 2021 in the Orthopedics and Traumatology Clinic of Sisli Hamidiye Etfal Training and Research Hospital was included. Patients for which data could not be accessed, those who underwent emergency surgery or received repeat surgeries, were excluded. We collected a

range of patient information by reviewing medical records, including gender, age, American Society of Anaesthesiologists (ASA) score, scoliosis aetiology, Cobb angle, comorbid diseases (lung, neuromuscular, cardiac, epileptic, renal and haematological disease), pre-operative and post-operative haemoglobin (Hb) and arterial blood gas (ABG). During scoliosis surgery, anaesthesia was maintained by total intravenous anaesthesia (TIVA) in all patients following the induction of standard general anaesthesia. In addition to standard monitoring, all patients were monitored by motor evoked potentials (MEP) and somatosensory evoked potentials (SSEP) throughout the operation. We also recorded the duration of the operation, the level of fusion, the amount of bleeding, the amount of replacement (packed red blood cells (PRBC), fresh frozen plasma (FFP) and fluid) and whether tranexamic acid was administered.

Postoperatively, we evaluated respiratory failure, neurological complications and bleeding, hemodynamic instability (those who need vasopressors and inotropes), the need for intensive care, the duration of hospital stay and mortality.

SPSS version 15.0 (SPSS Inc., Chicago, IL, USA) for Windows was used for statistical analysis. Descriptive statistics are expressed as numbers and percentages for categorical variables, and by median and interquartile ranges for numerical variables. The Mann-Whitney U test was used to compare numerical variables between the two independent groups as data were not normally distributed. Rates were compared between the two groups with Chi-Square test. Relationship analyses were performed by Spearman Correlation analysis when the conditions for parametric testing were not met. We identified key predictors by logistic regression analysis. The level of statistical significance was set to $p < 0.05$.

3. Results

Of the 246 patients who underwent surgery for scoliosis in the Orthopaedics and Traumatology Clinic of our hospital between the 01 January 2018 and the 01 January 2021, 165 patients met our inclusion criteria and were featured in the final analysis.

With regards to demographics, 64.2% (n = 106) of the patients were female and 35.8% (n = 59) were male, with a mean age of 21.6 $\pm$ 16.7 years (age range: 1–77 years). Demographic data, the aetiology of scoliosis, Cobb angle, fusion level, ASA score, operative duration and ICU requirements are shown in Table 1.

Forty-eight patients required the intensive care unit (ICU) stay. The number patients with idiopathic scoliosis who needed ICU treatment (n = 16) was significantly lower than those who did not require ICU treatment ($p = 0.001$). The proportion of patients with neuromuscular scoliosis was statistically significantly higher (25%) in those who needed ICU stay than those who did not require such stay ($p < 0.001$). A Cobb angle >60 degrees was significantly more frequent in those who needed ICU care ($p = 0.01$). The median fusion level of the patients who required ICU stay was 15 and was statistically significantly higher ($p < 0.001$) than those who did not need ICU stay. The number of patients with an ASA score of III was significantly higher (54.2%) ($p < 0.001$). The median operative duration of the patients who required ICU stay was 307.5 minutes; this was significantly longer than those who did not require ICU stay ($p = 0.006$) (Table 1).

The median bleeding volume was 800 mL. Blood transfusion was given to 75.8% of patients. The median volume of PRBC administered was 2 U, and the mean volume of FFP administered was 1 U. The median volume of fluid (crystalloid) was 3500 mL. Tranexamic acid was given to 72.1% of the patients; the median amount of tranexamic acid was 1 g (Table 2).

The median duration of hospital stay was 7 days (IQR: 5–8 days). The perioperative complication rate, the types of complications, postoperative care and mortality rates of the patients are given in Table 3.

The proportion of patients with comorbidity who required ICU stay was 75% ($p < 0.001$). The proportions of patients who required ICU stay and had lung disease (54.2%) or restrictive lung disease (47.9%) were higher than in patients who did not need ICU stay ($p < 0.001$). The proportion of patients with neuromuscular problems who required ICU stay was 45.8% ($p = 0.004$). The proportion of patients with epilepsy who required ICU stay was 16.7% ($p = 0.027$). In addition, the proportion of patients who required blood transfusion was 91.7%; this was significantly higher than those who did not require ICU stay ($p = 0.002$) (Table 4).

Pre- and post-operative Hb levels, ABG pH and lactate levels of patients who required ICU stay were significantly different than for patients who did not require ICU stay ($p = 0.043$, $p = 0.039$, $p < 0.001$, $p = 0.037$) (Fig. 1).

Regression analysis was made. Parameters with a p value < 0.250 in the univariate analyses were then used in a regression model. The requirement for ICU stay was significantly associated with the presence of restrictive lung disease (odds ratio (OR): 8.363; $p = 0.016$), blood transfusion (OR: 0.068; $p = 0.039$) and neuromuscular problems (OR: 0.088; $p = 0.018$) (Table 5).

4. Discussion

In this study, we identified several predictors for an increased rate of admission to the ICU after surgery for scoliosis, including restrictive lung disease, epilepsy, neuromuscular scoliosis, a high fusion level, the need for transfusion, a long operative duration, low Hb and pH values, and high lactate values.

The demographic features and perioperative characteristics of scoliosis patients have been investigated in many previous studies because of the increased risk and complications of this form of surgery [7–10]. With regards to gender, previous studies have reported that scoliosis is more common in females. Furthermore, female gender was associated with an increase in the duration of hospital stay [7]. In our study, female patients were more common (64.2%), although there was no significant effect of gender on a patient's requirement for ICU treatment. With regards to perioperative characteristics, a Cobb angle above 100 degrees was shown to increase the risk of respiratory failure and pulmonary hypertension [3]. In a previous study, Yu *et al.* [11] reported that the volume of bleeding may increase in patients with a Cobb angle >50 degrees. In our study, the median Cobb angle was 55 degrees; however, we found that patients with a Cobb angle >60 degrees were more

TABLE 1. Gender, age, aetiology, Cobb angle, fusion levels, ASA score and operative duration of the included patients according to ICU needs.

	ICU		*p*
	Yes n (%)	No n (%)	
Gender			
Male	15.0 (31.3)	44.0 (37.6)	0.439
Female	33.0 (68.8)	73.0 (62.4)	
Age median (IQR)	16.5 (12.0–22.0)	15.0 (11.5–21.5)	0.184
Aetiology			
Idiopathic scoliosis	16.0 (33.3)	71.0 (60.7)	0.001
Congenital scoliosis	10.0 (20.8)	26.0 (22.2)	0.844
Neuromuscular scoliosis	12.0 (25.0)	4.0 (3.4)	<0.001
Degenerative scoliosis	8.0 (16.7)	12.0 (10.3)	0.252
Degenerative kyphoscoliosis	1.0 (2.1)	1.0 (0.9)	0.498
Developmental scoliosis	1.0 (2.1)	1.0 (0.9)	0.498
Tumour-associated scoliosis	0.0 (0.0)	2.0 (1.7)	1.000
Cobb angle			
<40	4.0 (9.3)	16.0 (14.8)	0.010
40–50	6.0 (14.0)	40.0 (37.0)	
50–60	11.0 (25.6)	22.0 (20.4)	
>60	22.0 (51.2)	30.0 (27.8)	
Fusion levels, median (IQR)	15.0 (13.0–16.0)	13.0 (11.0–14.0)	<0.001
ASA score			
ASA I	8.0 (16.7)	67.0 (57.3)	<0.001
ASA II	13.0 (27.1)	46.0 (39.3)	
ASA III	26.0 (54.2)	4.0 (3.4)	
ASA IV	1.0 (2.1)	0.0 (0.0)	
Operative duration (min)	307.5 (260.0–352.5)	270 (240.0–302.5)	0.006

Data expressed as, n (%) and median (IQR) and "Yes/No". ICU: intensive care unit; ASA: American Society of Anaesthesiologists; IQR: interquartile range.

TABLE 2. Bleeding volume, PRBC, FFP and tranexamic acid use in patients who underwent scoliosis surgery.

Bleeding parameters	Mean	Median (IQR)
Amount of bleeding (mL)	800	500–1300
Amount of PRBC	2.0	1.0–2.0
Amount of FFP	1.0	1.0–2.0
Amount of crystalloid (mL)	3500	2500–4500
Tranexamic acid (g)	1.0	(1.0–1.5)
	n	%
Blood transfusion		
Yes	125.0	75.8
No	40.0	24.2
Tranexamic acid		
Yes	119.0	72.1
No	46.0	27.9

Data expressed as, n (%) and median (IQR) and "Yes/No". PRBC: packed red blood cells; FFP: fresh frozen plasma; IQR: interquartile range.

TABLE 3. Perioperative complications, postoperative care and mortality of patients undergoing scoliosis surgery.

	n (%)
Complications	
No	99 (60.0)
Yes	66 (40.0)
Bleeding	58 (35.2)
Respiratory failure	14 (8.5)
Hemodynamics	7 (4.2)
Neurological	0 (0.0)
Postoperative care	
Ward	117 (70.9)
ICU, Extubated	41 (24.8)
ICU, Intubated	7 (4.2)
Mortality	
Yes	1 (0.6)
No	164 (99.4)

Data expressed as, n (%) and "Yes/No". ICU: intensive care unit.

TABLE 4. Comorbidity, the need for blood transfusion, and the amount of crystalloid and tranexamic acid use in scoliosis surgery patients according to ICU needs.

	ICU		*p*
	Yes	No	
	n (%)	n (%)	
Comorbidity			
No	12 (25.0)	68 (58.1)	<0.001
Yes	36 (75.0)	49 (41.9)	
Lung disease	26 (54.2)	19 (16.2)	<0.001
Obstructive	3 (6.3)	6 (5.1)	<0.001
Restrictive	23 (47.9)	13 (11.1)	
No lung disease	22(54.8)	98 (83.8)	
Neuromuscular problems	22 (45.8)	27 (23.1)	0.004
Cardiac problems	9 (18.8)	11 (9.4)	0.095
Epilepsy	8 (16.7)	6 (5.1)	0.027
Blood Transfusion	44 (91.7)	81 (69.2)	0.002
Amount of crystalloid (mL) Median (IQR)	3750 (2500–5000)	3500 (3000–4500)	0.897
Tranexamic acid	33 (68.8)	86 (73.5)	0.531

ICU: intensive care unit; IQR: interquartile range.

TABLE 5. Determining factors for ICU stay in regression analysis.

	p	OR	95% CI	
Age	0.083	1.032	0.996	1.070
Cobb angle (Ref: <40)	0.245			
40–50	0.950	1.061	0.167	6.718
50–60	0.188	3.693	0.529	25.774
>60	0.218	3.182	0.505	20.066
Fusion level	0.071	1.165	0.987	1.376
Comorbidity	0.808	1.249	0.208	7.517
Lung disease (Ref: None)	0.036			
Obstructive	0.726	1.558	0.130	18.669
Restrictive	0.016	8.363	1.484	47.126
Cardiac problems	0.841	1.230	0.163	9.259
Operative duration (min)	0.549	0.996	0.984	1.008
Blood transfusion	0.039	0.068	0.005	0.872
Pre-op Hb g/L	0.091	0.726	0.501	1.052
Pre-op ABG pH	0.951	0.694	0.000	
Pre-op ABG lactate	0.120	0.416	0.138	1.255
Epilepsy	0.705	0.650	0.070	6.040
Neuromuscular problems	0.018	0.088	0.012	0.657

Hosmer and Lemeshow test, p = 0.256; Cox & Snell R Squared: 0.373. OR: odds ratio; Hb: haemoglobin; ABG: arterial blood gas; pH: potential of hydrogen; CI: confidence interval.

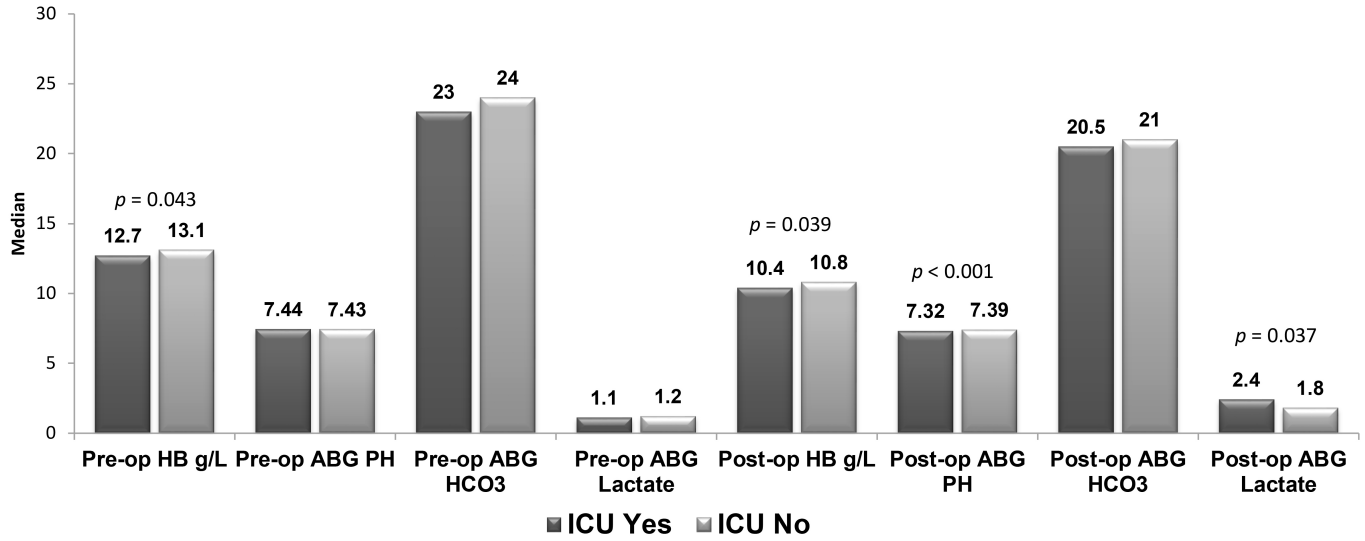

FIGURE 1. Laboratory parameters of the patients according to ICU needs. ICU: intensive care unit; ABG: arterial blood gas; Hb: haemoglobin; pH: potential of hydrogen; HCO_3: bicarbonate.

likely to be admitted to the ICU. In addition, the use of ASA classification was previously confirmed, in a study involving 5805 patients, as a criterion for health prior to spinal surgeries in adults; furthermore, ASA classification was associated with morbidity and mortality [12]. In our study, a higher ASA classification was significantly associated with an increased rate of admission to the ICU, thus concurring with previous studies.

Recent studies have investigated the comorbidities of patients with scoliosis [13–15]. In a previous study, Sciubba *et al.* [14] established a comorbidity score for adult patients who undergo surgery for spinal deformities; there was a high probability of major complications in patients with a high comorbidity score. In our study, comorbid disease was detected in approximately 52% of patients; neuromuscular (29%) diseases were the most common, followed by pulmonary comorbidities (27%).

Intraoperative major bleeding is one of the most significant complications of scoliosis surgery. In a previous study, Guay *et al.* [16] reported that the mean volume of intraoperative bleeding was 1971 mL in patients undergoing surgery for idiopathic scoliosis; furthermore, bleeding was correlated with the number of vertebrae and the duration of the procedure. In another study, Cristante *et al.* [10] found no significant relationship between transfusion and scoliosis angle, gender or the duration of surgery; however, allocating a greater spinal level to the arthrodesis was associated with a greater extent of transfusion. On average, approximately 800 mL of bleeding occurred in our patient and 76% of patients received an average of 2 U of blood transfusion. Transfusion was indicated when blood loss exceeded 15% of the estimated total blood volume in patients without anemia. In addition, the continuance of bleeding or the risk of bleeding during surgery, and the comorbidity of the patients were considered when making decisions related to blood transfusion. The proportion of patients who required blood transfusion and ICU treatment was 91.7%; this was statistically significant. During major bleeding, the volume of IV fluid replacement is very important. A limited number of studies have been conducted on IV fluid replacement in orthopaedic patients; however, the results of these studies were contradictory. In a previous study, Lu Che *et al.* [17] observed an association between individualized fluid management and a significant reduction in postoperative complications in patients undergoing major spinal surgery. Zirka *et al.* [18] reported that total blood and crystalloid volumes were associated with delayed extubation times, and the rate of postoperative pneumonia was three-fold higher in patients with delayed extubation. In our cohort, crystalloid fluids were preferred as IV infusions, and an average of 3500 mL of crystalloid was replaced. Previous studies have reported that the administration of antifibrinolytics can reduce bleeding and the need for transfusion [19, 20]. During our study period, an average of 1 g of tranexamic acid was used in 72% of our patients, and the use of tranexamic acid did not have significant effect on ICU admission.

In a previous study, Kishk *et al.* [21] reported that major complications were more common in neuromuscular scoliosis, in the presence of comorbidities, and when combined surgical approaches were used. In another study, reported that the most common postoperative complications were hypoxemia and hypercapnia; this was attributed to poor cardiopulmonary function [22]. Obstructive lung disease has been shown to be the leading factor that increases the risk of complications; other factors that can increase the risk of complications are an ASA classification of 2 and above, insulin-dependent diabetes, and chronic steroid use [22]. In a previous study, Zhang *et al.* [23] reported an overall incidence of complications of 25.2%; furthermore, heart disease and diabetes comorbidities were identified as independent risk factors for major complications. In our study, 40% (n = 66) of patients experienced complications; 35.2% experienced bleeding, 8.5% experienced respiratory complications (pre-operatively, none of the patients received oxygen either by mask or ventilator), and 4.2% experienced post-operative hemodynamic instability. Another point to add is the duration of hospital stay. Previous studies found that patients with a greater degree of blood loss, a large curvature

requiring a longer surgery duration, pelvic obliqueness and severe cerebral sequelae, required a longer period to hospital discharge [8, 24]. The mean duration of hospital stay following surgery was approximately 7 days in our study.

In our study, we did not observe any neurological complications. As with existing literature, the use of preoperative SSEP and MEP neuromonitoring during spinal surgery was an effective method for detecting neurological damage [6]. We believe that we did not see any neurological complications because we excluded patients who underwent emergency surgery and repeat surgeries in our study.

A common topic for research is whether there is a need for follow-up in the ICU after scoliosis surgery [7, 21, 25]. In a previous study, Malik *et al.* [25] reported that 39.5% of their total cohort of patients were admitted to the ICU after surgery; these authors identified a number of factors that were associated with ICU admission, including anterior fusion, combined fusion, non-idiopathic scoliosis, preoperative ventilator dependence, asthma, structural pulmonary abnormality, growth retardation, patients requiring nutritional support and a total operative duration >270 minutes. In another study, Kay *et al.* [7] found that the ICU admission of patients who had degenerative spinal surgery was associated with age, female gender, ASA grade, cardiac comorbidities, intraoperative blood loss and surgery. It has also been reported that patients with neuromuscular scoliosis and comorbidities, patients who underwent anterior or combined spinal fusion, and patients who used long-acting opioids for anaesthesia, required admission to the ICU [21]. In a previous study, White *et al.* [26] showed that patients with a diagnosis of neuromuscular scoliosis have a greater need for postoperative intensive care treatment. In our study, 29% (n = 48) of patients were admitted to the ICU; seven of these patients were intubated. Retrospective analysis showed that these seven patients were ASA class III and IV, with a long operation duration and a high intraoperative blood loss. Extubation attempts for these patients resulted in immediate desaturation with hypoxemia and hypercapnia. Patients with neuromuscular scoliosis, and/or epilepsy, and/or other comorbidities, and patients with a longer operation duration, were more likely to be admitted to ICU.

However, a lower number of patients with idiopathic scoliosis required ICU admission. In particular, the rate of admission to the ICU of patients with restrictive lung disease was found to be higher than those with obstructive pulmonary disease. An increase in spinal curvature is known to exert adverse effects on the respiratory system and other systems. These patients are known to have an increased risk of developing respiratory failure and pulmonary hypertension [7, 27]. In our study, we found that patients with a Cobb angle >60 degrees were more likely to be admitted to the ICU. Furthermore, a high fusion level was found to be associated with an increased rate of ICU admission. Moreover, the rate of admission to the ICU was found to be higher in patients with low pre- and post-operative Hb values. In our study, we also compared arterial blood gas values; patients with a low pH and high lactate levels were more likely to be admitted to the ICU.

Smith *et al.* [27] reviewed the Scoliosis Research Society Morbidity and Mortality Database and reported a total of 197 (0.18%) deaths among 108,419 patients; furthermore, the most common causes of death were respiratory/pulmonary causes, cardiac causes, sepsis, stroke and intraoperative blood loss. Shaffrey *et al.* [28] reported a mortality rate of 1.50 per 1000 cases, and identified respiratory, cardiac problems, sepsis, organ failure and blood loss as common causes of mortality. In our study, the mortality rate was 0.6% (n = 1); this patient was an 8-year-old ASA IV patient with neuromuscular scoliosis and restrictive lung disease, who died in the ICU as a result of cardiopulmonary failure.

Our study has some limitations that need to be considered. First, this was a retrospective study carried out in a single centre. Second, the clinical procedures were all performed by the same team of orthopaedic surgeons and anaesthesiologists; this may not be broadly relevant to all patients with scoliosis. Perioperative decisions, such as the need of tranexamic acid, whether a patient is a candidate for extubation in the operating room, or whether transfer to the ICU with an endotracheal tube, were made by the same team according to their collective experience. However, we believe that our findings enhance our understanding in this field because our study featured a large study cohort and considered the specific aetiology of scoliosis. Therefore, additional prospective studies are now needed to fully determine risk factors for the need to attend the ICU postoperatively in scoliosis patients.

5. Conclusions

In this study, we identified a range of predictors for an increased risk of admission to the ICU in patients undergoing scoliosis surgery, including restrictive lung disease, epilepsy, neuromuscular scoliosis, a high fusion level, the need for transfusion, a long operative duration, low Hb and pH values, and high lactate values.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

SM and SO—Study conception and design; SM, HŞT and HMÖ—Data collection; SM, SO and ASÇ—Analysis and interpretation of results; SM, SO and HŞT—Draft manuscript preparation; SM, SO and HMÖ—Critical revision of the article; ASÇ and HŞT—Other (study supervision, materials, *etc.*); All authors (SM, SO, ASÇ, HŞT, HMÖ) reviewed the results and approved the final version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was carried out retrospectively after the approval of Sisli Hamidiye Etfal Training and Research Hospital Local Ethics Committee (02 February 2021; approval reference: 3130). The committee waived the need for informed consent because of the retrospective nature of this study.

ACKNOWLEDGMENT

Not applicable.

FUNDING

This research received no external funding.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Hengartner AC, Havlik J, David WB, Reeves BC, Freedman IG, Sarkozy M, *et al*. Association between intravenous to oral opioid transition time and length of hospital stay after posterior spinal fusion for adolescent idiopathic scoliosis. International Journal of Spine Surgery. 2023; 17: 468–476.

[2] Pico J, Sola C, Saour AC, Chapron K, Coruble L, Bringuier S, *et al*. Enhanced recovery after surgery (ERAS) for adolescent idiopathic scoliosis: Standardisation of care improves patient outcomes. Anaesthesia Critical Care & Pain Medicine. 2022; 41: 101116.

[3] Hudec J, Prokopová T, Kosinová M, Gál R. Anesthesia and perioperative management for surgical correction of neuromuscular scoliosis in children: a narrative review. Journal of Clinical Medicine. 2023; 12: 3651.

[4] Antolovich GC, Cooper MS, Johnson MB, Lundine K, Yang Y, Frayman K, *et al*. Perioperative care of children with severe neurological impairment and neuromuscular scoliosis—a practical pathway to optimize perioperative health and guide decision making. Journal of Clinical Medicine. 2022; 11: 6769.

[5] Julien-Marsollier F, Penisson L, Happiette A, Ilharreborde B. Can hydroxyapatite charged collagen sponge help reduce perioperative blood loss in adolescent idiopathic scoliosis surgery? Preliminary results in 68 patients. European Spine Journal. 2023; 32: 883–888.

[6] Buhl LK, Bastos AB, Pollard RJ, Arle JE, Thomas GP, Song Y, *et al*. Neurophysiologic intraoperative monitoring for spine surgery: a practical guide from past to present. Journal of Intensive Care Medicine. 2021; 36: 1237–1249.

[7] Kay HF, Chotai S, Wick JB, Stonko DP, McGirt MJ, Devin CJ. Preoperative and surgical factors associated with postoperative intensive care unit admission following operative treatment for degenerative lumbar spine disease. European Spine Journal. 2016; 25: 843–849.

[8] Helenius L, Gerdhem P, Ahonen M, Syvänen J, Jalkanen J, Charalampidis A, *et al*. Postoperative outcomes of pedicle screw instrumentation for adolescent idiopathic scoliosis with and without a subfascial wound drain: a multicentre randomized controlled trial. The Bone & Joint Journal. 2022; 104-B: 1067–1072.

[9] Tang CYK, Kamath VHD, Cheung PWH, Cheung JPY. Predictive factors for intraoperative blood loss in surgery for adolescent idiopathic scoliosis. BMC Musculoskeletal Disorders. 2021; 22: 225.

[10] Cristante AF, Borges PA, Barbosa AR, Letaif OB, Marcon RM, Barros-Filho TE. Predictive factors for perioperative blood transfusion in surgeries for correction of idiopathic, neuromuscular or congenital scoliosis. Clinics. 2014; 69: 672–676.

[11] Yu X, Xiao H, Wang R, Huang Y. Prediction of massive blood loss in scoliosis surgery from preoperative variables. Spine. 2013; 38: 350–355.

[12] Somani S, Capua JD, Kim JS, Phan K, Lee NJ, Kothari P, *et al*. ASA classification as a risk stratification tool in adult spinal deformity surgery: a study of 5805 patients. Global Spine Journal. 2017; 7: 719–726.

[13] Shaw KA, Harris H, Sachwani N, Ruska T, Murphy JS, Fletcher ND. Avoiding PICU admission following PSF for neuromuscular scoliosis in non-ambulatory cerebral palsy managed with ERAS protocol. Spine Deformity. 2023; 11: 671–676.

[14] Sciubba D, Jain A, Kebaish KM, Neuman BJ, Daniels AH, Passias PG, *et al*. Development of a preoperative adult spinal deformity comorbidity score that correlates with common quality and value metrics: length of stay, major complications, and patient-reported outcomes. Global Spine Journal. 2021; 11: 146–153.

[15] Kanda Y, Kakutani K, Egi M, Zhang Z, Yurube T, Takeoka Y, *et al*. Preoperative base excess as a predictor of perioperative complications in patients with nonidiopathic scoliosis who have high risk associated with general anesthesia. Spine Surgery and Related Research. 2022; 7: 268–275.

[16] Guay J, Haig M, Lortie L, Guertin MC, Poitras B. Predicting blood loss in surgery for idiopathic scoliosis. Canadian Journal of Anaesthesia. 1994; 41: 775–781.

[17] Che L, Zhang XH, Li X, Zhang YL, Xu L, Huang YG. Outcome impact of individualized fluid management during spine surgery: a before-after prospective comparison study. BMC Anesthesiology. 2020; 20: 181.

[18] Anastasian ZH, Gaudet JG, Levitt LC, Mergeche JL, Heyer EJ, Berman MF. Factors that correlate with the decision to delay extubation after multilevel prone spine surgery. Journal of Neurosurgical Anesthesiology. 2014; 26: 167–171.

[19] Shapiro F, Zurakowski D, Sethna NF. Tranexamic acid diminishes intraoperative blood loss and transfusion in spinal fusions for duchenne muscular dystrophy scoliosis. Spine. 2007; 32: 2278–2283.

[20] Kolz JM, Neal KM. Hidden blood loss in adolescent idiopathic scoliosis surgery. Orthopaedics & Traumatology, Surgery & Research. 2022; 108: 103216.

[21] Abu-Kishk I, Kozer E, Hod-Feins R, Anekstein Y, Mirovsky Y, Klin B, *et al*. Pediatric scoliosis surgery—is postoperative intensive care unit admission really necessary? Pediatric Anesthesia. 2013; 23: 271–277.

[22] Özçelik M, Özalp Ş, Kalem M, Bermede O, Yazar T, Ökten F, *et al*. Postoperative complications in patients undergoing scoliosis surgery. Turkiye Klinikleri Journal of Anesthesiology Reanimation. 2017; 15: 24–30.

[23] Zhang XN, Sun XY, Meng XL, Hai Y. Risk factors for medical complications after long-level internal fixation in the treatment of adult degenerative scoliosis. International Orthopaedics. 2018; 42: 2603–2612.

[24] Soini V, Raitio A, Helenius I, Helenius L, Syvänen J. A retrospective cohort study of bleeding characteristics and hidden blood loss after segmental pedicle screw instrumentation in neuromuscular scoliosis as compared with adolescent idiopathic scoliosis. North American Spine Society Journal. 2022; 12: 100190.

[25] Malik AT, Yu E, Kim J, Khan SN. Intensive care unit admission following surgery for pediatric spinal deformity: an analysis of the ACS-NSQIP pediatric spinal fusion procedure targeted dataset. Global Spine Journal. 2020; 10: 177–182.

[26] White KK, Bompadre V, Krengel WF, Redding GJ. Low preoperative lung functions in children with early onset scoliosis predict postoperative length of stay. Journal of Pediatric Orthopaedics. 2021; 41: e316–e320.

[27] Smith JS, Saulle D, Chen CJ, Lenke LG, Polly DW Jr, Kasliwal MK, *et al*. Rates and causes of mortality associated with spine surgery based on 108,419 procedures. Spine. 2012; 37: 1975–1982.

[28] Shaffrey E, Smith JS, Lenke LG, Polly DW Jr, Chen CJ, Coe JD, *et al*. Defining rates and causes of mortality associated with spine surgery: comparison of 2 data collection approaches through the scoliosis research society. Spine. 2014; 39: 579–586.

How to cite this article: Shamsiya Mahammadova, Sibel Oba, Ayşe Surhan Çinar, Hacer Şebnem Türk, Hacı Mustafa Özdemir. Perioperative characteristics and predictors of intensive care needs in patients undergoing surgery for scoliosis: a retrospective study of 165 patients. Signa Vitae. 2024; 20(2): 46-52. doi: 10.22514/sv.2023.121.