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Research Article

A Retrospective Descriptive Cohort Study of Preoperative, Intraoperative and Postoperative Management of Children in Scoliosis Surgery

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Abstract

Background

What is already known

- Scoliosis surgery in children is a common intervention in pediatric tertiary centers. These patients depending on the type of scoliosis, idiopathic or neuromuscular or congenital have also severe comorbidities which necessitate management in specailized centers. Blood and fluid loss can be important issues in this setting.
- Scoliosis surgery has a high rate of postoperative complications. Data exist concerning the importance of goal directed fluid therapy and hemodynamic monitoring to minimize postoperative morbidity in moderate to high risk adult patients undergoing moderate to high risk surgery.
- Evidence has shown that blood transfusion protocols (based on viscoelastic methods, erythropoietin and iron supplementation) can reduce blood product exposure in this setting. It is known that transfusion is a predictive factor of negative postoperative outcome in children.
- Rapid enhanced protocols have shown to reduce length of hospital stay and complications in adults. In children these protocols are beginning to develop.

What is not known

- The impact of intraoperative fluid and hemodynamic goal directed therapy on postoperative outcome in pediatric surgery in general is not known.

Objective of this Study

- The primary objective of this study was to identify postoperative negative outcome predictors in pediatric scoliosis surgery which could be improved by implementing protocols based on existing evidence.
- Main outcome measures of postoperative negative outcome were complications and transfusion.

Methods: Medical records of children admitted for scoliosis surgery were retrospectively analysed from 1 January 2015 to 8 December 2017 in Queen Fabiola Children's University Hospital, Brussels. Forty-one children with an average age of 13.15 ± 2.79 years were included. Main outcome measures were postoperative complications and transfusion. XLSTAT 2018.3 software was used for statistic analysis.

Results: Length of postoperative hospital stay (LOSHOSP) was predictive of postoperative complications and transfusion with an odds ratio of 1.337 [1.048 - 1.705], p = 0.019. Cobb's angle (p = 0.002), length of surgery (p < 0.0001) and length of postoperative α2 agonists infusion (p < 0.0001) were independent predictive factors of postoperative transfusion.

Conclusion: Implementing improvement protocols aiming to reduce length of hospital stay such as fluid, hemodynamic, transfusion goal-directed therapies and enhanced recovery pathways may upgrade postoperative outcome in pediatric scoliosis surgery.

Keywords: *Children; Scoliosis Surgery*

Abbreviations

LOSICU: Length of Stay in the Intensive Care Unit; LOSHOSP: Length of Hospital Stay after Surgery; LMV: Duration of Mechanical Ventilation; Pa02: Arterial Oxygen Partial Pressure; $PaC0_2$: Arterial Carbone Dioxide Partial Pressure; $HC0_3$: Bicarbonate; VAS: Visual Analgesia Scale; FLACC: Face Legs Activity Cry Consolability; CHEOPS: Children's Hospital of Eastern Ontario Pain Scale; ICU: Intensive Care Unit; SD: Standard Deviation; ASA: American Society of Anesthesiologists; HES: Hydroxyethylstarch; SVV: Stroke Volume Variation; ml: Mililiter; kg: Kilogram; PONV: Postoperative Nausea and Vomiting; RCT: Randomized Controlled Trials; cm: Centimeter

Introduction

The most common spinal pediatric pathology is adolescent idiopathic scoliosis; postoperative pain management and rapid recovery are important goals in scoliosis surgery to reduce length of hospital stay which in some studies varie between 5 to 6 days [1].

Intraoperatively, consequent blood and fluid loss occur during scoliosis surgery. Adequate preoperative management, intraoperative optimal fluid therapy and measures to reduce blood loss and transfusion are necessary to have an optimal postoperative patient outcome [2-5].

Scoliosis surgery has a high rate of complications which can varie from 0 - 80% depending on the etiology [6]. Preoperative and postoperative nutritional deficiency has also an impact on postoperative recovery in these patients and screening nutritional status is mandatory in order to apply necessary measures in the perioperative period [7,8].

Objective of the Study

The primary objective of this study was to identify postoperative negative outcome predictive factors which could be improved by implementing protocols based on existing evidence. Main outcome measures of postoperative negative outcome were complications and transfusion.

Methods

Approval for this study was obtained from the local Ethical Commitee of Queen Fabiola Children's university hospital on 31 July 2018 under the registration number CEH n° 84/18 (Chairperson J. Groswasser) which waived the necessity for patient consent.

41 Computerized medical records of children admitted for scoliosis surgery from 1 January 2015 to 8 December 2017 were analysed. Preoperative, intraoperative and postoperative variables were registered.

Preoperative variables consisted of: age, gender, weight, height, type of scoliosis (idiopathic/neuromuscular/congenital), Cobb's angle, comorbidities, ASA (American Society of Anestheiologists) score, plasmatic hemoglobin, platelet, ferritin, transferrin, transferrin saturation, C reactive protein, fibrinogen, prealbumin, albumin, protein levels, mean corpuscular volume, prothrombin time, activated thromboplastin time, blood component transfusion, iron and erythropoietin supplementation.

Intraoperative variables analysed were type of induction and maintenance of anesthesia, duration of surgery and anesthesia, hemodynamic parameters used (invasive blood pressure, central venous catheter), neuromuscular monitoring (motor evoked potentials), cell saver, blood loss, fluid therapy with crystalloids and colloids, blood component transfusion, intraoperative complications, prevention of postoperative nausea and emesis, tranexamic acid, hemoglobin levels; arterial pH, lactate, $Pa0_2$, $PaC0_2$, $HC0_3$, base excess levels at induction of anesthesia and at the end of surgery and anesthesia; analgesia, antibiotherapy.

Postoperative variables analysed were plasmatic hemoglobin, platelet, ferritin, transferrin, transferrin saturation, C reactive protein, fibrinogen levels, mean corpuscular volume, prothrombin time, activated thromboplastin time, blood component transfusion, iron and erythropoietin supplementation.

Postoperative nausea and emesis, treatment of postoperative nausea and emesis, postoperative complications; analgesia with patient controlled analgesia with morphine, ketamine, α2 agonistes, analgesia with other drugs than morphine, analgesia score scales with VAS, FLACC, CHEOPS, antibiotherapy, length of postoperative hospital stay, length of postoperative ICU stay, length of mechanical ventilation, time to first postoperative oral intake, time to first postoperative mobilisation, time to first postoperative stool output.

XLSTAT 2018.3 software was used for statistic analysis.

Parametrical variables were expressed in mean values ± standard deviation (SD), categorical variables were expressed in percentage with 95% confidence interval, a p-value of less than 0.05 was considered significant.

For comparison between two groups, Students t test was used for parametrical variables, Wilcoxon test for non parametrical variables and Chi square or Fisher exact test for categorical variables in univariate analysis. Once the univariate analysis was realised, only variables with p-values less than 0.05 were considered significant for further multivariate analysis with logistic and log linear regressions.

Results

General characteristics (Table 1)

42 scoliosis surgery cases were identified between 1 January 2015 and 8 December 2017 among which 1 was excluded because of missing data and 41 retained. All patients had anesthesia consultation several weeks prior to surgery. All patients had preoperative echocardiography, functional pulmonary respiratory tests and motor evoked potentials prior to surgery.

The average age of patients was 13.15 ± 2.79 years. 68.29% [54.05 - 82.54] of the population were female and 31.71% [17.46 - 45.95] were male patients. Among these children 46.34% [31.08 - 61.61] had idiopathic scoliosis and 53.66% [38.39 - 68.92] had neuromuscular or congenital scoliosis. Mean Cobb's angle was 61.77 ± 18.30 degrees.

41.46% [26.38 - 56.54] were ASA I, 24.39 [11.25 - 37.54] ASA II and 34.15 [19.63 - 48.66] ASA III patients.

Inhalational induction of anesthesia with sevoflurane was in used in 39.02% [24.09 - 53.96] of the cases and induction with total intravenous anesthesia with propofol and remifentanil was the method of choice in 60.97% [46.04 - 75.91] of the children.

All patients had total intravenous maintenance anesthesia with propofol and remifentanil.

All patients had endotracheal intubation with pressure or volume controlled mechanical ventilation, positionned in ventral decubitus for surgery (for posterior surgical approach). All patients had an invasive arterial blood pressure catheter, one or two central venous catheters (one in the internal jugular vein and in the femoral vein to monitor for eventual venous return obstruction due to ventral position and compression). Cell saver was ready for all patients. Intraoperative motor evoked potentials were the method for monitoring during surgery. In some patients entropy was used to monitor the depth of anesthesia. Prophylactic antibiotherapy with cefazolin was started intraoperatively and continued 48 hours after surgery. All patients except one received intraoperative tranexamic acid. Patients recieved intraoperative intravenous infusion with ketamine or ketamine with clonidine or clonidine alone. Non steroidal antiflammatory drugs (ketorolac or ibuprofen), paracetamol, tramadol, morphine, ketamine and α2 agonistes (clonidine or dexmedetomidine) were the medication used for postoperative analgesia.

Mean total duration time of anesthesia and surgery was 481.88 ± 103.72 minutes and 290.85 ± 92.87 minutes respectively.

All patients received macrogol postoperatively to prevent constipation. All patients recieved postoperatively antiacid medication with ranitidin or omeprazole to prevent postoperative stress ulcer.

All patients received respiratory and mobilisation physiotherapy postoperatively.

Mean Age ± Standard deviation (SD) in years	13.15 ± 2.79
Percentage of female gender with 95%CI	68.29 [54.05 - 82.54]
Percentage male gender with 95%C	31.71 [17.46 - 45.95]
Mean Weight ± SD in kilograms	40.00 ± 14.78
Mean Height ± SD in centimeters	148.81 ± 17.38
Percentage of idiopathic scoliosis with 95%CI	46.34 [31.08 - 61.61]
Percentage of neuromuscular/congenital scoliosis with 95%CI	53.66 [38.39 - 68.92]
Mean Cobb's angle ± SD in degrees	61.77±18.30
Percentage of ASA I patients with 95%CI	41.46 [26.38 - 56.54]
Percentage of ASA II patients with 95%CI	24.39 [11.25 - 37.54]
Percentage of ASA III patients with 95%CI	34.15 [19.63 - 48.66]
Percentage of patients with inhalational induction anesthesia with sevoflurane 95%CI	39.02 [24.09 - 53.96]
Percentage of patients with intravenous induction anesthesia with propofol and remifentanil 95%CI	60.97 [46.04 - 75.91]
Percentage of patients with intravenous maintenance anesthesia with propofol and remifentanil 95% CI	100 [100 - 100]
Mean total duration time of anesthesia ± SD in minutes	481.88 ± 103.72
Mean total duration time of surgery ± SD in minutes	290.85 ± 92.87

Table 1: *General characteristics.*

Principal comorbidities (Table 2)

The most common comorbidities were cerebral palsy and myopathy in 17.07% [5.56 - 28.59] and 9.76% [0.67 - 18.84] of the children respectively. 43.90% [28.71 - 59.09] of this population had no comorbidities. The other comorbidities are illustrated in table 2.

Principal comorbidities	Number of patients	Percentage [95% confidence Interval]
No comorbidities	18	43.90 [28.71 - 59.09]
Myopathy	4	9.76 [0.67 - 18.84]
Cerebral palsy	7	17.07 [5.56 - 28.59]
Asthma	1	2.44 [0.0 - 7.16]
Spinal amyotrophy	2	4.88 [0.0 - 11.47]
Prader-Willi	1	2.44 [0.0 - 7.16]
Chiari's Malformation type I	1	2.44 [0.0 - 7.16]
Metotrophic bone dysplasia	1	2.44 [0.0 - 7.16]
Marphan Syndrom	1	2.44 [0.0 - 7.16]
Smith-Magenis syndrom	1	2.44 [0.0 - 7.16]
Jacobsen Syndrom	1	2.44 [0.0 - 7.16]
Polymalformative syndrom	1	2.44 [0.0 - 7.16]
Rett Syndrom	1	2.44 [0.0 - 7.16]
Charcot-Marie-Tooth	1	2.44 [0.0 - 7.16]
Total number of patients	41	

Table 2: *Principal comorbidities.*

Intraoperative complications (Table 3)

The percentage of patients with intraoperative complications was 4.88% [0.00 - 11.47].

Two patients had intraoperative complications. One patient had a thoracic bedsore due to prolonged intraoperative ventral decubitus position. The second patient had Lower limb paresia with favorable postoperative outcome.

Percentage of patients with intraoperative complications with 95%CI	4.88 [0.00 - 11.47]
Number of patients with intraoperative complications	2
Number of patients without intraoperative complications	39
Total number of patients	41
Type of intraoperative complications	
Thoracic Bedsore due to prolonged intraoperative position	1
Lower limb paresia with favorable postoperative outcome	1

Table 3: *Intraoperative complications.*

Postoperative complications (Table 4)

31.71% [17.46 - 45.95] of the patients had postoperative complications which represents 13 patients of the 41 cases. Two patients had respiratory distress with vocal cords paralysis and pulmonary atelectasis. One patient had acute renal failure with pulmonary atelectasis. One had acute renal failure with favorable outcome. One had pneumonia. One had pulmonary atelectasis. There was one repeat surgery for re-instrumentation. Two patients had bedsores. Two patients had lower limb neuropathic pain with favorable outcome. There was one case of hepatic cytolysis.

One patient had septicemia, with local wound sepsis and urinary infection.

Nutritional status using plasma preoperative prealbumin and albumin levels

Was not assessed since data was missing.

Preoperative coagulation tests

Preoperative platelet levels, coagulation tests were in the normal range in all patients except one patient who had Von Willebrandt disease diagnosed preoperatively and who recieved preoperatively and postoperatively desmopressin.

Comparison between patients who presented postoperative complications and or postoperative transfusion and patients without postoperative complications and transfusion

Two groups were identified and compared with each other: the group of patients who presented postoperative complications and or postoperative transfusion. A postoperative complication was defined as an adverse side effect in the postoperative period which may have a negative impact on outcome. Complications are presented in table 4. Seventeen patients had postoperative complications and or postoperative blood transfusion and twenty-four patients had neither postoperative complications nor postoperative blood transfusion.

Percentage of patients with postoperative complications with 95%CI	31.71 [17.46 - 45.95]
Number of patients with postoperative complications	13
Number of patients without postoperative complications	28
Total number of patients	41
Type of postoperative complications	
Respiratory distress with vocal cords paralysis and pulmonary atelectasis	2
Acute renal failure with pulmonary atelectasis	1
Acute renal failure with favorable outcome	1
Pneumonia	1
Pulmonary atelectasis	1
Repeat surgery for re- instrumentation	1
Bedsore	2
Neuropathic pain with favorable outcome	2
Hepatic cytolysis	1
Septicemia, local wound sepsis, urinary infection	1

Table 4: *Postoperative complications.*

Univariate analysis was realised to compare these two groups and is illustrated in tables 5a to 5d. This analysis showed that the number of patients with postoperative complications, Cobbs'angle, length of surgery and anesthesia, volume of postoperative blood transfusion, LOSICU, LOSHOSP and length of postoperative α2 agonists infusion were significantly different between the two groups. After logistic regression, length of postoperative hospital stay (LOSHOSP) was predictive of postoperative complications and transfusion see table 5e.

	Patients with postoperative complications and or transfusion	**Patients without postoperative complications or transfusion**	**p-value**
Number of patients	17	24	1.00
Number of patients with intraoperative complications	2	0	0.16
Number of patients with postoperative complications	13	0	< 0.001
Age in years ± Standard deviation (SD)	13.3 ± 2.7	13.0 ± 2.9	0.78
Number of female gender	10	18	0.45
Number of male gender	7	9	0.45
Weight in kilograms ± SD	43.5 ± 19.0	41.4 ± 11.4	0.66
Height in centimeters ± SD	147.2 ± 20.1	149.9 ±15.9	0.65
Number of idiopathic scoliosis	7	12	0.81
Number of neuromuscular/congenital scoliosis	10	12	0.81
Number of thoracic instrumentation	1	2	0.66
Number of thoracolumbar instrumentation	14	21	0.66
Number of Thoracosacral instrumentation	1	1	0.66
Number of Cervico-thoraco-lumbo-sacral instrumentation	1	0	0.66
Cobbs' angle in degrees ± SD	68.9 ± 20.5	56.7 ± 15.1	0.03
Number of repeat surgery	0	4	0.22
Number of patients without comorbidities	7	11	0.58
Number of patients with one comorbidities	5	10	0.58
Number of patients with two comorbidities	3	2	0.58

Number of patients with three or more comorbidities	2	1	0.58
Number of ASA I patients	6	11	0.71
Number of ASA II patients	4	6	0.71
Number of ASA III patients	7	7	0.71
Length of surgery in minutes ± SD	327.6 ± 91.4	264.9 ± 86.6	0.03
Length of anesthesia in minutes ± SD	522.2 ± 120.0	453.3 ± 81.5	0.03
Number of inhalational induction of anesthesia	6	10	0.93
Number of intravenous induction of anesthesia	11	14	0.93
Number of patients with intraoperative ketamine infusion	17	21	0.32
Number of patients with intraoperative clonidine infusion	0	2	0.32
Number of patients with intraoperative ketamine and clonidine infusion	0	1	0.32
Number of patients without intraoperative vasopressors	12	14	0.27
Number of patients with intraoperative ephedrine	0	3	0.27
Number of patients with intraoperative phenylephrine	4	7	0.27
Number of patients with intraoperative ephedrine and phenylephrine	1	0	0.27
Number of patients with PONV	12	18	0.97
Number of patients without PONV	5	6	0.97

Table 5a: *General characteristics.*

	Patients with postoperative complications and or transfusion	**Patients without postoperative complications or transfusion**	**p-value**
Preoperative hemoglobin levels in g/dL ± SD	13.9 ± 1.2	13.2 ± 1.5	0.13
Postoperative hemoglobin levels in g/dL ± SD	8.8 ± 1.8	9.9 ± 1.9	0.07
Preoperative Mean Corpuscular Volume (MCV) in fL ± SD	82.4 ± 4.1	83.2 ± 5.2	0.62
Preoperative platelet levels per μL ± SD	277000 ± 78898.7	275291.7± 64363.4	0.93
End surgery pH levels ± SD	7.4 ± 0.1	7.3 ± 0.1	0.69
End surgery lactate levels in mg/dL ± SD	16.9 ± 12.2	17±11.3	0.97
End surgery base excess levels in mEq/L ± SD	−5.3 ± 2.6	−4.2 ± 2.4	0.19
End surgery PaCO2 levels in mmHg ± SD	38.7±7.2	39.7± 4.9	0.58
End surgery bicarbonate levels in mmol/L ± SD	20.1 ± 2.6	21.1 ±2.0	0.19

Table 5b: *Hemoglobin levels and arterial gas analysis.*

	Patients with postoperative complications and or transfusion	**Patients without postoperative complications or transfusion**	**p-value**
Number of patients with preoperative oral iron supplementation	4	1	0.21
Number of patients with preoperative intravenous iron supplementation	0	1	0.21
Number of patients with preoperative oral and intravenous iron supplementation	0	1	0.21
Number of patients with postoperative oral iron supplementation	5	5	0.63
Number of patients with postoperative intravenous iron supplementation	0	1	0.63
Number of patients with postoperative oral and intravenous iron supplementation	0	1	0.63
Intraoperative blood transfusion in mk/kg ± SD	0.51 ± 2.1	0.53 ± 1.78	1.00
Postoperative blood transfusion in ml/kg ± SD	2.7 ± 4.31	0.00 ± 0.00	0.03
Intraoperative tranexamic acid in mg/kg/h ± SD	15.2 ± 7.9	13.7 ± 4.8	0.44
Intraoperative crystalloids in ml/kg ± SD	47.9 ± 27.6	36.6 ± 14.2	1.00
Intraoperative colloids in ml/kg ± SD	12.3 ± 10.4	11.5 ± 14.3	0.2

Table 5c: *Iron supplementation, blood transfusion, fluid therapy.*

	Patients with postoperative complications and or transfusion	Patients without postoperative complications or transfusion	p-value
LOSICU in days ± SD	2.1 ± 3.1	0.5 ± 0.7	0.04
LMV in days ± SD	1.2 ± 3.5	0.1 ± 0.3	0.5
LOSHOSP in days ± SD	14.3 ± 8.8	8.8 ± 2.4	0.01
Length of postoperative morphine infusion in days ± SD	3.1 ± 2.2	2.9 ± 1.3	0.9
Length of postoperative morphine bolus in days ± SD	5.7 ± 1.8	4.7 ± 1.7	0.2
Length of postoperative ketamine infusion in days ±SD	1.4 ± 0.7	1.0 ± 0.8	0.2
Length of postoperative α2 agonistes in days ± SD	3.1 ± 1.9	1.7 ±1.3	0.01
Postoperative oral in take in days ± SD	1.8 ± 0.8	1.5 ± 1.0	0.2

Table 5d: *LOSICU,LMV LOSHOSP, post-operative morphine, ketamine, α2 agonistes.*

Independent variable	Odds ratio [95%CI]	p-value
Cobb's angle	1.054 [0.968 - 1.148]	0.224
Length of surgery	1.014 [0.996 - 1.033]	0.118
Length of anesthesia	0.980 [0.959 - 1.001]	0.067
LOSICU	1.543 [0.636 - 3.745]	0.338
LOSHOSP	1.337 [1.048 - 1.705]	0.019
Postoperative α2 agonist infusion	2.191 [0.786 - 6.107]	0.134
Postoperative transfusion	0.849 [0.574 - 1,256]	0.413

Table 5e: *Logistic regression for patients with complications and or transfusion.*

After log linear regression for transfusion, Cobbs angle, length of surgery and length of postoperative *α*2 agonists infusion were independent predictive factors of postoperative transfusion table 5f.

Independent variable	Wald value [95%CI]	p-value
Cobb's angle	0.054 [0.02 - 0.089]	0.002
Length of surgery	0.027 [0.015 - 0.039]	< 0.0001
Length of anesthesia	0.007 [-0.003 - 0.18]	0.185
LOSICU	-1.065 [-1.659- (-0.472)]	0.0004
LOSHOSP	-0.062 [-1.83 - 0.06]	0.322
Postoperative α2 agonist infusion	1.152 [0.682 - 1.627]	< 0.0001
Postoperative complications	-0.490 [-1.371 - 0.390]	0.275

Table 5f: *Log linear regression for patients with transfusion.*

Discussion

Several predictive outcome factors were identified in this retrospective descriptive study.

Independent predictive factors for postoperative transfusion were Cobb's angle, length of surgery, and length of postoperative *α*2 agonists infusion. Cobbs angle has been related in early studies as a predictive factor of transfusion [3]. The length of surgery was predictive of transfusion this could be explained by blood loss [3], in this study blood loss was not compared between the two groups because some data was missing for some patients. Average intraoperative blood loss in the entire cohort was 14.11 ± 11.42 ml/kg (when missing data was not taken into account).

Preoperative hemoglobin levels, preoperative and postoperative iron supplementation were not different between the two groups in this study.

Several studies in scoliosis surgery have evidenced the importance of implementing multimodal measures to minimize blood loss and transfusion (intraoperative tranexamic acid, cell salvage, preoperative iron and erythropoietin supplementation and viscoelastic methods to guide transfusion) [2-5].

Iron supplementation which costs less than erythropoietin can be an efficient and simple mean to anticipate postoperative anemia and should be administered preoperatively and postoperatively in patients with iron deficiency with or without anemia but there are no randomized controlled trials in scoliosis surgery concerning this issue. Viscoelastic methods when used to guide transfusion intraoperatively in hemorrhagic surgeries in adults reduce postopperative morbidity and mortality in adults [9]. In children large randomized controlled trials concerning these methods and postoperative outcome are lacking.

The raison why postoperative $\alpha 2$ agonist infusion was related to postoperative transfusion in this study was not clear. One hypothesis is that $\alpha 2$ agonist infusion can be associated with low blood pressure. Maybe patients who were anemic with low blood pressure were more easily transfused than those with anemia without low blood pressure. This hypothesis cannot be verified since complete data concerning postoperative blood pressure measurements in all patients was not always available.

Nevetherless, the sedative effects of $\alpha 2$ agonists normally reduce oxygen consumption which may increase with the severity of anemia [10].

The independent predicitive factor was LOSHOSP for postoperative complications and transfusion.

Transfusion has been shown in other studies to be a predictive factor of LOSHOSP and Complication [11,12].

Since LOSHOSP was a predictive factor of postoperative complications, improvement measures should focus on implementing rapid pathway rehabilitation programs to reduce LOSHOSP. Enhanced recovery after surgery protocols have demonstrated reduction in LOSHOSP and postoperative complications by 30-50% in adults and children [13,14].

In children compared to adult enhanced rapid recovery pathways after surgery are just beginning to develop [14]. In adult surgery these protocols are well established and more inadvance in comparison to children. Randomized studies in children concerning rapid enhanced recovery pathways should be developed to determine the impact on postoperative outcome.

Intraoperative fluid therapy with crystalloids and colloids, was not found to be a predictive factor of postoperative complications and transfusion in this study because of the small number of patients. Fluid therapy monitored by hemodynamics has been proven to reduce postoperative morbidity in adult surgery [15,16].

During scoliosis surgery, fluid and blood loss can be important and therefore adequate fluid management is mandatory. In this study, mean intraoperative blood loss was 14.11 ± 11.42 ml/kg. Unoptimal intraoperative fluid management can have negative impact on postoperative outcome (too much fluid or not enough fluid).

In this study all patients had invasive arterial pressure and central venous catheters but there was no protocol using validated pediatric devices to monitor fluid therapy and hemodynamics in this setting.

In adults, studies have shown postoperative outcome improvement when using goal directed fluid therapy with non invasive hemodynamic devices such as oesophageal doppler probe [15].

A recent prospective study in 160 adults in major abdominal surgery comparing colloids to cystalloids directed therapy using a closed loop system evidenced decreased postoperative complications in the colloid group [16].

Pulse pression variation using invasive arterial catheter to manage fluid therapy is not a valid method in children [17,18].

Central venous pressure is not an optimal method to monitor fluid therapy responsiveness intraoperatively [17,18]. In children the method validated to monitor fluid therapy responsiveness is stroke volume variation (SVV).

Stroke volume variation which gives an indication of cardiac output can be used to monitor fluid therapy responsiveness using echocardiography or oesophageal doppler probe and these systems are validated in children [17,18].

A recent meta-analysis in adult cardiac surgey and non cardiac surgery patients showed that goal directed fluid and hemodynamic therapy reduced mortality, morbidity and length of hospital stay [19]. Studies in pediatric settings are lacking and efforts should be done

to develop intraoperative goal directed fluid and hemodynamic protocols in order to demonstrate whether postoperative outcome is improved.

Conclusions

Several predictive outcome factors were identified in this study and improvement measures can be proposed for managing patients admitted for scoliosis surgery. These improvement measures should be integrated in randomized controlled trials (RCT) in order to establish the impact on postoperative outcome in children since randomized controlled trials concerning these issues are lacking in children. Pediatric studies mentioned in this survey are essentially retrospective and observational. Efforts in developping randomized trials to implement improvement measures are necessary in children.

1. Integrating an intraoperative protocol with a goal directed therapy to monitor and manage intraoperative fluid therapy with a device such as oesophageal doppler probe or echocardiography
2. Systematic detection of preoperative iron deficiency and preoperative and postoperative iron supplementation in patients with iron deficiency with or without anemia (in the limits of contreindications), quid of using intravenous iron supplementa tion preoperatively. Quid for preoperative erythropoietin. Integrating viscoelastic methods to guide transfusion intraoperatively.
3. Implementation of a rapid recovery pathway: early mobilisation, reducing the length of alpha 2 agonists infusion, early oral intake, non opioid analgesia, use of gabapentinoids, optimizing preoperative nutritional state, quid of minimal invasive surgical technics.

Limits to this Study

Retrospective study and small number of patients

Declarations

Ethics approval was obtained on 31 July from the local Ethics Committee which waived the necessity for informed consent to participate.

Consent to Publish

The local Ethics Committee waived the necessity for consent to publish since the study was retrospective and was part of an implementation improvement program.

Availability of Data and Materials

Data and material concerning this study is available in the attached files.

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There was no funding.

Conflicts of Interest

There were no competing interests

Authors' Contribution

The author contributed in collecting, analysing data, in writing or reviewing this article.

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