STRATEGIES TO MINIMIZE BLOOD LOSS AND TRANSFUSION IN PEDIATRIC SPINE SURGERY

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Abstract

» Definitive correction of pediatric spinal deformities can result in considerable blood loss, operative time, cost, and need for allogenic blood transfusion.

» Numerous intraoperative strategies are utilized by surgeons and anesthesiologists to minimize blood loss through conservation or transfusion.

» With the use of modern perioperative blood-conserving techniques, blood loss and blood transfusion rates have been reduced substantially in pediatric patients treated operatively for spinal deformities.

Introduction

Surgical correction of spinal deformity may be accompanied by considerable blood loss. Estimated blood loss varies depending on the etiology of scoliosis\(^1\). Patients with idiopathic scoliosis tend to lose less blood (16% to 44% of blood volume) in comparison with patients with scoliosis secondary to a neuromuscular disorder (50% to 75% of blood volume)\(^2\). As the length of fusion increases, blood loss also increases. During a posterior spinal fusion for patients with adolescent idiopathic scoliosis, blood loss per minute per level is greatest during osseous resection with facetectomies and deorticication; however, the largest contribution to the total estimated blood loss is during instrumentation\(^2\).

Controlling blood loss reduces transfusion necessity. Allogenic blood transfusion is expensive; potential risks include viral infection, transfusion reaction, and adverse transfusion-related immunomodulation effects\(^3\). Patients receiving allogenic transfusions during spine surgery demonstrate increased complication and readmission rates compared with patients who do not receive transfusion\(^3\). Even if an allogenic transfusion is not warranted, blood loss can amplify a catabolic state and can cause physiologic stress; it can take up to 21 to 98 days to regenerate lost red blood cells after a surgical procedure in healthy patients\(^6\).

The risk of perioperative blood transfusion is multifactorial. Patient age, coexisting medical conditions, type and extent of spinal correction surgical procedure planned, a revision surgical procedure, and/or presence of a neurogenic spinal disorder must be considered during preoperative counseling. Table I demonstrates our recommendations for clinical screening preoperatively to identify high-risk patients.

Modern perioperative blood conservation techniques have reduced blood loss and transfusion requirements in spinal surgical procedures. This review outlines the current perioperative practices to manage and reduce blood loss during posterior spinal fusion for pediatric patients with scoliosis. We present this review in three sections: preoperative, intraoperative, and postoperative management; each subsection is prioritized.

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TABLE 1 Preoperative Risk Assessment by Clinical History for the Pediatric Patient Undergoing Spine Surgery

<table>
<thead>
<tr>
<th>Category</th>
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<tbody>
<tr>
<td>Anesthetic history</td>
</tr>
<tr>
<td>Complex surgical plan (requiring posterior column osteotomy or vertebral column resection)</td>
</tr>
<tr>
<td>Current medications</td>
</tr>
<tr>
<td>History of blood transfusion</td>
</tr>
<tr>
<td>History of hemorrhage or easy bruising</td>
</tr>
<tr>
<td>Neurologic examination</td>
</tr>
<tr>
<td>Prior hospitalizations</td>
</tr>
<tr>
<td>Prior medical illnesses</td>
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<td>Prior surgical procedures</td>
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from most important to least important recommendations.

Preoperative Management

Preoperative Screening

The presence of one or more risk factors for increased blood loss in the perioperative period prompts preoperative blood draws with hemoglobin, hematocrit, and platelet count measurement if clinically necessary. The diagnosis of anemia has been shown to increase blood loss during a surgical procedure and is linked to a 30-day morbidity and mortality increase following a surgical procedure. To our knowledge, there are no established preoperative screening protocols for patients with adolescent idiopathic scoliosis; however, we recommend a thorough history and preoperative physical examination to elucidate which patients require a preoperative work-up for anemia. Patients at high risk of considerable blood loss during a surgical procedure, such as patients undergoing a revision surgical procedure or patients with neuromuscular spine disorders, are tested preoperatively at our institution to establish baseline hemoglobin and hematocrit levels. Thorough preoperative consideration of risk factors impacting blood loss allows for optimization of care during the perioperative period.

Autologous Blood Donation

High blood loss and transfusion rates during spine surgical procedures led to the implementation of preoperative autologous blood donation in many centers in the 1990s. However, since the early 2000s, use of autologous blood transfusion in spine fusions has decreased and allogenic blood transfusion has increased. The challenge of optimally timing autologous transfusion and poor efficacy of the technique support the declining trend in autologous transfusions in the United States, Canada, and some European countries. In the United States specifically, use of autologous blood has decreased to <0.75% of all blood collected in 2011, compared with 8.5% in 1992.

Autologous blood donation includes risks such as contamination, mislabeling of blood, and misadministration of the transfusion. There is a known drop in hemoglobin following autologous donation. A retrospective review on posterior spinal fusion in adults demonstrated a negative correlation between hemoglobin levels and units of blood donated and a positive predictive relationship between blood loss and autologous donation.

Autologous predonation does not improve outcome and contributes overall to a decrease in hemoglobin in patients undergoing posterior spinal fusion. Healthy patients undergoing posterior spinal fusion do not predonate blood at our institution. For patients with more complex spinal deformities or comorbidities, the benefits of autologous donation compared with allogenic transfusions should be discussed preoperatively.

Red Blood-Cell Augmentation

Red blood-cell augmentation with recombinant human erythropoietin has been used in the past for patients who have severe anemia preoperatively. Recombinant red blood-cell augmentation can be used to raise the hemoglobin and hematocrit levels prior to operation if severe anemia is identified. Rosencher et al. conducted a randomized controlled trial (RCT) of 86 adult patients with baseline hematocrit between 30% and 39% to either receive 1 injection per week of erythropoietin (40,000 UI) preoperatively until 40% hematocrit was reached or donate 1 autologous red blood-cell pack before an elective orthopaedic surgical procedure. In the erythropoietin group, the volume of red blood-cell production was significantly higher (p = 0.0001); postoperative hematocrit levels at days 1 and 3 were also significantly higher (p = 0.02). Two erythropoietin injections will sufficiently increase hematocrit to 40%,14. Complications with erythropoietin therapy include hypertensive reactions, thrombosis of the arteriovenous fistula of patients undergoing hemodialysis, and appearance of severe anemia as part of pure red-cell aplasia. Pure red-cell aplasia is a rare complication from extended use of erythropoietin in patients undergoing hemodialysis.
Intraoperative Management
Anesthesiology and surgical teams have a substantial impact on the total intraoperative blood loss, and collaborative efforts between these 2 teams are required to optimize patient outcomes.

Anesthesia Perspective
Patient Positioning
Proper patient positioning can decrease blood loss during spinal surgical procedures. A prospective trial observed inferior vena caval pressure of 20 patients in 3 different positions: supine, prone on a conventional pad, and prone on a scoliosis operating frame. The inferior vena caval pressure was 1.5 times lower on the latter frame, where the patient's abdominal viscera hung freely, compared with the conventional pad. The prone position with abdomen hanging free reduced pressure on the abdomen and resulted in decreased cardiac preload, cardiac output, and mean arterial pressure; these 3 factors decreased the blood loss in the operative field. Park demonstrated significantly less intrabdominal pressure (p < 0.05) and intraoperative blood loss per vertebra (p < 0.05) when using wide support-width pads compared with narrower pads. Figure 1 demonstrates the prone position used at our institution to decrease blood loss.

Blood Pressure Modulation
Blood pressure modulation is a critical strategy requiring a concerted effort between the anesthesia team and the orthopaedic surgery team. Low mean arterial pressure reduces local wound blood flow and reduces extravasation from the wound. A discussion of the blood pressure goals for each stage of the case among the surgeon, anesthesiologist, and neuromonitoring technician is recommended prior to the surgical procedure. During the approach, a hypotensive mean arterial pressure is beneficial for the surgeon, but during corrective maneuvers, a mean arterial pressure at normal or mildly hypertensive levels optimizes spinal cord perfusion. We recommend the mean arterial pressure be <70 mm Hg at incision and during spinal instrumentation and ≥70 mm Hg during corrective maneuvers. Transient hypotension has been observed on an anecdotal basis to contribute to a loss in somatosensory evoked potentials and/or motor evoked potentials after corrective maneuvers have been performed.

Avoidance of Hypothermia
Hypothermia during general anesthesia has been demonstrated to reduce platelet function and to impair the coagulation cascade intraoperatively. Avoidance of hypothermia is important to decrease central vasoconstriction and blood loss. Normothermia helps preserve perfusion to the extremities. A meta-analysis revealed that even mild hypothermia, defined as 34°C to 36°C, significantly increased intraoperative blood loss by approximately 16% (p = 0.009) and increased the relative risk for transfusion by approximately 22% (p = 0.027). Continuous temperature modulation by the anesthesia team and the circulating nurse and use of an appropriately sized body-warmer are integral in maintaining normothermia.
Transfusion and Cell Salvage
The need for transfusion increases with greater blood loss relative to blood volume, a greater number of vertebrae fused, and lower body mass index. Lower body weight as a predictor for transfusions may result from increased surgical technical difficulty when operating on small children, chronic nutritional deficiencies that might affect coagulation, or a higher transfusion threshold. General transfusion requirements guide criteria for administering red blood cells at each individual institution. During posterior spinal fusion, lower preoperative hemoglobin levels and a greater number of posterior column osteotomies performed correlate with higher transfusion necessity.

Blood salvage is a technique whereby blood is collected from the surgical field and is returned into circulation via transfusion. Before reinfusion, the suctioned blood is washed to remove contaminants such as soluble hemoglobin, cellular debris, and immunological components. The processed blood is returned as only whole red blood cells. An RCT on cell salvage during 110 consecutive posterior spinal fusions observed a significant reduction in the rate of intraoperative allogenic transfusions (p = 0.032) and perioperative allogenic transfusions (p = 0.025) for patients using cell salvage (n = 55) compared with controls (n = 55). Similar results were reported in a retrospective study on posterior spinal fusion in a patient population with adolescent idiopathic scoliosis.

The literature is conflicting regarding the cost-effectiveness of cell salvage. A retrospective study on cell salvage in posterior spinal fusion to treat adolescent idiopathic scoliosis observed a significant decrease in the intraoperative transfusion rate (p = 0.012) but not the perioperative transfusion rate (p = 0.101) when cell salvage was employed, and the authors concluded that the system was not cost-effective. However, a recent systematic review compared 349 patients with adolescent idiopathic scoliosis undergoing a corrective surgical procedure with cell salvage with a control group of 244 patients with adolescent idiopathic scoliosis. The results showed that a mean blood volume of 453.6 mL was reinfused in the patients undergoing cell salvage and these patients received a mean amount of 1 unit less of allogenic blood, determining that cell salvage is economically viable if it costs less than transfusing 1 unit of allogenic blood. We strongly recommend using intraoperative cell salvage for its demonstrated efficacy in decreasing postoperative transfusion rates.

Antifibrinolytic Agents
Antifibrinolytic agents have been one of the most effective interventions over the past decade to prevent blood loss in spinal surgical procedures. Antifibrinolytic agents work by molecular inhibition of blood clot degradation.

Tranexamic acid is an antifibrinolytic agent effective in reducing blood loss during surgical procedures to treat adolescent idiopathic scoliosis. A retrospective study on tranexamic acid safety in posterior spinal fusion demonstrated significantly less intraoperative blood loss (p < 0.001) and postoperative blood loss (p < 0.001) as well as lower intraoperative transfusion rates (p < 0.001) in the group that received tranexamic acid compared with the control group. No major complications arose in either group.

Xie et al. demonstrated that use of high-dose tranexamic acid was associated with a significant reduction in intraoperative blood loss (p < 0.05) and postoperative transfusion requirements (p < 0.05) in patients undergoing a spine surgical procedure for pediatric deformity; a loading dose of 100 mg/kg followed by 10 mg/kg/hr for 24 hours was used. A retrospective study examined 2 different tranexamic acid dosing regimens for their effect on intraoperative blood loss in patients with adolescent idiopathic scoliosis undergoing posterior spinal fusion. A low dose (10-mg/kg loading, 1-mg/kg/hr infusion) and high dose (20-mg/kg loading, 10-mg/kg/hr infusion) of tranexamic acid were compared. High-dose tranexamic acid (n = 11) showed a trend toward a reduction in transfusion requirements compared with low-dose tranexamic acid (n = 15), although the study was underpowered to demonstrate a significant difference. Use of the higher loading dose of tranexamic acid in this patient population resulted in a 50% reduction in transfusion requirements for patients with adolescent idiopathic scoliosis. Tranexamic acid is considered efficacious, minor postoperative complications have been reported, such as diarrhea, nausea, and postural hypotension. Following the recommendations of Goobie et al., we use a loading dose of 10 mg/kg followed by an infusion rate of 5 mg/kg/hr.

Epsilon-aminocaproic acid (EACA) is another efficacious antifibrinolytic agent. An RCT on patients with adolescent idiopathic scoliosis showed a significant decrease in perioperative blood loss (p = 0.036) and postoperative transfusion rates in the EACA group (p = 0.002). Another RCT studying the effect of EACA use on posterior spinal fusion for the neuromuscular population, mainly patients with cerebral palsy, found similar results. One case study showed an adverse event of "excessive thrombus formation on pulmonary artery catheters" for an adult patient undergoing a cardiac surgical procedure who received EACA. Overall, the risks to EACA are minimal, with no significant difference in complications among groups receiving EACA and those not receiving EACA.

The use of tranexamic acid or EACA is recommended to reduce blood loss and transfusion necessity during pediatric spine surgical procedures. To our knowledge, the risk of thrombosis has not been described with use of antifibrinolytics in pediatric spine surgical procedures.

Intrathecal Narcotic Agents
Intrathecal morphine has been shown to improve postoperative pain control.
and to decrease blood loss. A retrospective study of 256 patients demonstrated a >60% decrease in intraoperative blood loss during a surgical procedure with the use of intrathecal morphine to treat adolescent idiopathic scoliosis, as well as improved hemodynamic stability. Patients who received intrathecal morphine received significantly fewer transfusions (30 transfusions in 128 patients) compared with those who did not receive intrathecal morphine (122 transfusions in 128 patients) (p < 0.0001). To our knowledge, no prospective studies have identified the ideal dose of intrathecal morphine to provide pain control and to decrease blood loss without causing complications. Complications secondary to the use of intrathecal morphine include postoperative nausea and vomiting, respiratory depression, and postoperative hypotension. To our knowledge, no neurologic adverse events have been associated with use of intrathecal morphine as a single dose perioperatively. At our institution, intrathecal morphine is given routinely for all cases at 7.5 μg/kg, maximum 500 μg (for patients diagnosed with obstructive sleep apnea, 5 μg/kg, maximum 350 μg), administered by the anesthesia team prior to the surgical incision.

**Hemodilution**

Normovolemic hemodilution can also mitigate blood loss in pediatric spine surgical procedures. Normovolemic hemodilution is achieved by removing 1 to 2 units of blood and replacing with crystalloid (2 to 4 ml per each milliliter of blood harvested). A retrospective study on hemodilution in patients with adolescent idiopathic scoliosis treated with posterior spinal fusion presented a 37% transfusion rate in the hemodilution group and a 73% transfusion rate in the non-hemodilution group. Hemodilution has been demonstrated to safely reduce the perioperative transfusion need of adolescents undergoing posterior spinal fusion. This strategy is not currently used at our institution.

**Surgical Perspective**

**Hemostasis During Operative Exposure**

During the surgical approach, soft-tissue handling strategies to minimize blood loss are important. Several thermal coagulation devices have been introduced, including bipolar electrocautery and a bipolar tissue sealant device. The radiofrequency bipolar hemostatic sealant device uses saline solution-cooled delivery of energy that seals blood vessels rather than burning them. Hill et al. found in adult patients that a radiofrequency bipolar hemostatic sealant along with unipolar cautery significantly decreased hemoglobin loss during posterior spinal fusion compared with unipolar cautery alone (p = 0.008). Several studies showed safe use of a radiofrequency bipolar hemostatic sealant to reduce blood loss, transfusion requirements, and cost for patients undergoing posterior spinal fusion.

**Bone Resection**

Blood loss occurs when cancellous bone is exposed and bleeds throughout the operation. The majority of bleeding from bone occurs during spinous process resection and facetectomies. An ultrasonic bone scalpel, designed to decrease blood loss during bone dissection, can be used for facetectomies, posterior column resection, and 3-column resections. One study demonstrated a significant reduction in blood loss (p < 0.05) during surgical correction of adolescent idiopathic scoliosis with use of the ultrasonic bone scalpel for facetectomies compared with controls in whom the ultrasonic bone scalpel was not used. We routinely use the ultrasonic bone scalpel for facetectomies in spinal deformity cases and for posterior column osteotomies and 3-column spinal osteotomies when indicated.

Local hemostatic agents are also useful intraoperatively. Cancellous osseous bleeding can be abated with the use of bone wax as well as thrombotic agents (microfibrillar collagen, oxidized regenerated cellulose hemostatic, or fibrin glue). These absorbable materials are often left in place to decrease postoperative hematoma formation. Bone wax, a mixture of beeswax (70%) and petroleum jelly (30%), is a nonabsorbable material that becomes malleable in the hand. Removal of wax from potential sites of spinal fusion is recommended. Wax should never be used in the spinal canal because of the risk of spinal cord compression secondary to a mass effect.

Absorbable gelatin sponge sponges are commonly used to fill the cavity of a laminectomy in a bloody field. Absorbable gelatin powder should be removed from sites of potential fusion as it has been shown to interfere with osseous healing in animal studies. Absorbable gelatin powder is contraindicated in spinal infection cases as it may enhance the infectious process. It can also double in volume by swelling, causing compressive complications if left in the spinal canal. If soaked in thrombin, absorbable gelatin powder has an augmented hemostatic function. A multicenter RCT showed that 2 to 4 units of absorbable gelatin powder with human thrombin significantly decreased total estimated blood loss (p = 0.027) compared with no thrombotic agent use in posterior spinal fusion for adolescent idiopathic scoliosis.

Microfibrillar collagen, an alternative to absorbable gelatin powder, directly stimulates platelet release without increasing in volume. Complications reported with microfibrillar collagen include interference with bone healing, allergic reactions, and infection.

We recommend using bone wax to cover exposed cancellous bone after sharp resection of spinous processes and for any pedicle screw tracks that are prepared but not filled with screws. We do not routinely use local thrombotic agents.
Bone-Grafting and Bone-Graft Substitutes
In most pediatric spine surgical procedures for scoliosis, autologous bone graft from the spinous processes and inferior facetectomies of the vertebral levels exposed are morcelized and are used for local bone graft. At our institution, this is the sole source of bone graft. Literature in the adult spine arena describes the use of bone-graft substitutes as well as additional harvest from the ilipect crest for autologous bone graft. The addition of iliac crest bone graft has the potential for additional donor-site morbidity as well as an increase in blood loss potential. As high fusion rates have been the standard for the majority of pediatric spine surgical procedures, regardless of approach, the use of bone-graft substitute is not routine. To our knowledge, the effect of bone-graft substitute on local hemostasis has not been investigated in this population.

Implant Considerations
Implant type also impacts intraoperative blood loss. Pedicle screws usually stop bleeding from screw tracks once placed. Sublaminar wires or hooks require entrance through the spinal canal, increasing the potential for epidural bleeding at each level placed. Implant density influences intraoperative blood loss; each level instrumented is an opportunity for increased blood loss.

Efficiency in screw placement is essential for decreasing intraoperative blood loss. Blood loss from a screw track occurs as a function of time while the screw hole is open; therefore, many spine surgeons are decreasing time during screw placement by forgoing tapping pedicle tracks and simply placing screws after the awl has created a track. Many surgeons fill the screw tracks with local hemostatic agents (hemostatic gelatin matrix, bone wax) during the few seconds prior to final screw placement. Warnings regarding the use of hemostatic gelatin matrix have been issued against forceful application. Buchowski et al. reported 2 patients who, as a result of inadvertent extravasation of the matrix into the spinal canal during pedicle screw placement, developed epidural spinal cord compression requiring emergency decompression because of neurologic deficit. Hemostatic gelatin matrix was noted at the time of decompression and was evacuated. A porcine animal model evaluated the embolization of injectable gelatin into the pedicle track using transesophageal echocardiography. This model saw embolic showering of the right ventricular outflow tract when the gelatin was injected and again with screw insertion, thus recommending caution during use of gelatin agents. We prepare the pedicle track using either an awl or powered drill. Tapping is not routinely done. Any screw tracks that are abandoned are plugged with bone wax.

Postoperative Management

Postoperative Transfusion Guidelines
The use of intraoperative and postoperative allogenic blood transfusion is on a downward trend. Authors from a hospital in Ireland have reported that blood transfusions have not been necessary from 2012 to 2015 in patients with adolescent idiopathic scoliosis. Despite the decreased requirement for transfusion, most institutions do prepare for postoperative allogenic transfusions. The literature has shown strong correlation between low hemoglobin levels and need for a transfusion. Each institution sets a transfusion trigger threshold, usually between 7 and 10 g/dL.

A recent systematic review of Level-I studies argues that, in the adult population, there is no exact transfusion threshold; rather, the clinical presentation of the patient, recognizing anemia and other comorbidities, needs to be considered to make a comprehensive transfusion decision. At a major pediatric academic hospital with a transfusion trigger of 7 g/dL, Klaus et al. discovered in a retrospective study that, on most services, including orthopaedics, blood was transfused with hemoglobin levels higher than the service’s threshold.

Postoperative transfusions are less common in practice, but having guidelines in place should a transfusion be warranted is still important. At our institution, a perioperative orthopaedic blood transfusion guideline suggests a transfusion criterion of hematocrit of <24% or hemoglobin of <8 g/dL combined with one or more symptoms of anemia including tachycardia, hypotension, lightheadedness, dizziness, and fatigue with activity.

Closed-Suction Drainage Systems
An RCT comparing posterior spinal fusion with and without closed-suction wound drainage showed no difference in operative or clinical outcomes; however, those patients without drains began walking 1 day prior than the group with drains (p < 0.001). The use of drains does not influence wound-healing. A retrospective study on lumbar spine fusions and drain usage showed a 39% transfusion rate increase in patients with post-hemorrhagic anemia and drains compared with only a 5% transfusion rate increase in patients without drains or anemia. A meta-analysis performed by Liu et al. analyzing 4 RCTs and 4 non-RCTs reported no significant difference in estimated blood loss or complications between groups with or without closed-suction drains; the evidence did not support the use of closed-suction drains for posterior spinal fusion.

Reinfusion Drainage Systems
The use of reinfusion drainage systems with closed-suction wound drains has been debated. Behrman and Keim prospectively studied patients undergoing a spine surgical procedure with regard to patients who received no blood salvage, patients who received blood salvage intraoperatively, and patients who received blood salvage postoperatively. The patients receiving cell salvage both during and after the surgical procedure...
had a 68% reduction in transfusion rates compared with a 35% reduction from normal in the intraoperative-only group.

Recent literature does not support the postoperative use of blood salvage units in orthopaedic surgery. A fully automated autotransfusion system has been introduced that collects, washes, and returns a highly concentrated volume of red blood cells to patients intraoperatively and postoperatively; it can reinfuse autologous blood saved up to 12 hours after a surgical procedure. A recent RCT by Springer et al. demonstrated no significant difference in the transfusion rate (p = 0.22) among adult patients undergoing total joint arthroplasty with a reinfusion drain (n = 60), a standard drain (n = 61), or a single dose of tranexamic acid (p = 0.65). The unit cost of the reinfusion system ($581.89) was substantially higher than a standard drain ($75.56) and tranexamic acid ($35.91/g). To our knowledge, reinfusion drain systems have not yet been studied in the pediatric population.

Dashboard Reporting

The use of the Hawthorne effect, in which surgeons monitor their performance relative to others, impacts patient outcomes. A pediatric spine study group created a multilevel dashboard for surgeons to report surgical parameters and outcomes. The visibility of the surgeons' performances and patients' outcomes over 3 years on the dashboard was associated with a considerable decrease in the reported blood loss.

Our Preferred Treatment

We recommend a combination of the following strategies to ensure an optimal perioperative course for the patient. Preoperatively, we recommend a thorough history and physical examination according to the screening protocol outlined in Table 1 to identify those at risk for higher perioperative blood loss. Two blood samples are drawn for typing and crossmatching, to ensure screening accuracy, at our institution. Red cell augmentation therapy is not used. We routinely use proper patient positioning as shown in Figure 1, blood pressure modulation in cooperation with the anesthesia team, avoidance of hypothermia, intraoperative cell salvage, tranexamic acid at a loading dose of 10 mg/kg followed by 5 mg/kg/hr, intrathecal narcotics at a dose of 7.5 µg/kg, the radiofrequency bipolar hemostatic sealer, the ultrasonic bone scalpel, and local hemostatic agents. We are continually working to improve efficiency in the operating room for decreasing operative time and increasing efficiency in screw placement. Requirements for postoperative transfusion are hematocrit of <24% and hemoglobin of <8 g/dL in combination with symptoms secondary to anemia. We do not use closed-suction drains at our institution postoperatively. We use a dashboard reporting system and meet monthly with a multidisciplinary team as well as the anesthesia team and the operating room staff to report surgical outcomes and continually improve our process for optimal patient care. We believe that the transparency of dashboard reporting is essential and should be the standard of care.

Overview

There have been numerous recent advances in the management of blood loss during pediatric spine surgical procedures. Utilizing the described strategies can decrease blood loss perioperatively. In turn, this decreases complications such as blood transfusion, infection, length of hospital stay, and readmission. More recently, the development of standardized protocols for a surgical procedure to treat adolescent idiopathic scoliosis and reporting of individual performance to surgeons have been implemented at several academic institutions to improve outcomes. Further research is necessary to examine the specific effects of each described strategy to gain control of overall blood loss in the perioperative period.

Note:

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