Spine Deformity

www.spine-deformity.org

Spine Deformity 5 (2017) 387–391

When Does Intraoperative Blood Loss Occur During Pediatric Scoliosis Correction?

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Received 10 October 2016; accepted 15 April 2017

Abstract

Background: The purpose of our study was to assess the relationship between amount of blood loss and surgical stage in pediatric patients undergoing posterior spinal fusion for deformity correction to determine: (1) when the highest rate of blood loss occurred; (2) what percentage of total blood loss occurred during deformity correction and closure; and (3) how to predict remaining blood loss during a procedure. Blood loss following exposure and placement of the final pedicle screw is often underestimated, which may result in lack of sufficient blood product availability. Knowledge of the rate of blood loss plays an important role in intraoperative decision making, facilitating communication with the anesthesia team, and improving patient safety.

Methods: Clinical records were reviewed for all patients 9 to 18 years of age who underwent index spinal fusion surgery with pedicle screw constructs for deformity correction of greater than 4 levels by a single surgeon from April 2013 to July 2015. All patients received tranexamic acid prophylactically. Exclusion criteria included vertebral column resections, cell saver use, cases complicated by signal loss on monitoring, and incomplete records. Sixty-two of 99 patients met criteria and were included in data analysis. The surgery was divided into four stages: exposure, screw/anchor placement, corrective procedures (reduction, osteotomies), and closure. Normalized blood loss (NBL) was calculated by adjusting actual blood loss for patient weight and number of levels fused. Demographic factors of age, sex, weight/BMI, diagnosis, preoperative Cobb angle, and number of levels fused were accounted for and autoregressive moving average was used to assess whether NBL varied significantly at different stages of the procedure.

Results: NBL during reduction and closure (1.69) was significantly greater than NBL during exposure and screw placement (1.49) ($p < .040$). The rate of blood loss was also highest during reduction/deformity correction procedures than exposure ($p < .001$), anchor placement ($p = .010$), and closure ($p < .010$). At the time of placement of the final pedicle screw, 47% of the total blood loss for the case had occurred.

Conclusions: Rate of blood loss varies during pediatric posterior spinal deformity correction surgery, with the highest rates occurring during the reduction portion of the operation. Just over half of the total EBL occurs during the reduction and closure stages of surgery requiring the surgical team to plan accordingly. Additional studies investigating modifiable factors affecting blood loss during the later stages of scoliosis surgery are warranted.

Level of Evidence: Level IV; case series

Keywords: Blood loss; Idiopathic; Neuromuscular; Posterior fusion; Scoliosis

Introduction

Blood loss during posterior spinal fusion surgery in the pediatric spinal deformity patient remains a top concern of the operative team. Higher blood loss increases the likelihood of receiving blood product transfusions, which can result in transfusion reactions, disease transmission, pulmonary complications, an impaired immune response, and increased post-operative bacterial infection risk [1-3]. Excessive and/or rapid blood loss can cause hemodynamic instability, coagulopathy, hypoxemia, and neurologic deficits. Because of its importance, many recent studies have examined different variables that can affect the magnitude of intraoperative EBL, including underlying diagnosis,

Author disclosures: none.

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http://dx.doi.org/10.1016/j.jspd.2017.04.004

number of levels fused, patient size, Cobb angle, and degree of kyphosis [4-6].

Despite recent advances in understanding various factors that affect EBL, to our knowledge, no study enables the surgeon to accurately predict remaining blood loss during a procedure. Knowing the stage of the procedure where the total blood loss will be the greatest as well as knowing the approximate proportion of blood lost at any given stage of the procedure can aid in communication between the surgeon and anesthesiologist and allow for proper planning. This ultimately results in improved patient safety and predicts when and if blood transfusion products will be necessary to avoid potential delays in administration.

In this report, we summarize the estimated blood loss (EBL) and normalized blood loss (NBL) for a single pediatric orthopedic surgeon performing primary posterior spinal fusion with instrumentation for the treatment of scoliosis. Based on our clinical observations, significantly more blood loss appears to occur during the deformity correction phase of the procedure. This may be due to increased mean arterial pressures during deformity correction, as well as the bleeding occurring about osteotomy sites and screws. We hypothesized that at least 50% of the EBL will occur following the completion of pedicle screw placement, and that the rate of blood loss during curve corrective procedures will notably exceed that of the other stages.

Methods

Patient source

This study used a retrospective case series design and was approved by our institutional review board. Clinical records were reviewed for all patients who underwent spinal fusion surgery of greater than four levels by the senior author from April 2013 to July 2015. Blood loss is recorded by totaling Neptune suction, weighing sponges, and subtracting irrigation both hourly and by surgical stage, which is a standard practice for spinal deformity surgery at our institution.

Inclusion/exclusion criteria

All patients between 8 and 19 years of age who underwent index instrumented spinal fusion for deformity correction with pedicle screw constructs were included (n = 99). Exclusion criteria were set to limit the effect of any confounding variables. Patients were excluded for the following: (1) vertebral column resections (n = 2); (2) cell saver utilization (n = 3); (3) ‘‘growing’’ instrumentation placement (n = 8); (4) cervical spine involvement (n = 1); (5) documented signal loss on monitoring with adjustment of correction to regain signals (n = 4); (6) procedure involving anterior approach/instrumentation (n = 2); and (7) inadequate documentation (n = 17). Of the 99 cases reviewed, 62 were included after applying the exclusion criteria.

Table 1
Study demographics.

Variable	Mean	Standard deviation
Age	13.2	2.2
Cobb angle	67.9	22.8
No. of levels fused	13.4	3.8
No. of anchors placed	21.7	4.2
No. of Ponte osteotomies	2.43	2.34
Estimated blood loss	1525.4	971.8

Study variables

The following information was collected: demographic data (including age, height, weight, and sex), diagnosis, preoperative Cobb angle, levels fused, numbers of anchors placed, time spent during each stage of the surgery, and intraoperative EBL.

Patient characteristics

Of the 62 patients who qualified for the study, the average age was 13.2 years and average weight was 45.9 kg. In terms of diagnosis, 34 patients had adolescent idiopathic scoliosis (AIS), 23 had neuromuscular scoliosis (NMS), and 5 had Scheuermann kyphosis. The average number of vertebral levels fused was 13.4 using an average of 21.7 pedicle screws. Preoperative Cobb angle averaged 67.9 degrees. EBL averaged 1,525 mL (Table 1).

Surgical procedure

All operations were performed using a single-stage, posterior-only approach with pedicle screw fixation. All patients were given a preincision tranexamic acid loading dose (20 mg/kg with max of 1 g) and maintenance drip (10 mg/kg/h) throughout the case as per our hospital protocol. Dissection was performed with electrocautery. A high-density pedicle screw placement pattern was used in all cases using bilateral screws at nearly all levels for idiopathic scoliosis. A slightly more variable pattern was used for neuromuscular cases, which included fusion to the pelvis using S2 alar iliac fixation for the majority of cases. Ponte osteotomies were performed following screw placement in 38 of the 62 patients (average 3.8 levels/case when performed) as needed to facilitate reduction of the curve. Reduction maneuvers included various combinations of differential rod contouring, cantilever, apical vertebral derotation, compression/distraction, and in situ bending. The patient’s mean arterial pressure is maintained around 60 mmHg during the initial stages of the procedure, and this is increased to 80 mmHg during reduction to prevent ischemia. Decortication was performed immediately prior to bone graft placement and closure. Local autograft bone was used in most idiopathic