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How accurate is visual estimation of perioperative blood loss in adolescent idiopathic scoliosis surgery?

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ABSTRACT

Objective: The aim of this study was to assess whether the visual estimation method for perioperative blood loss is accurate in adolescent idiopathic scoliosis surgery.

Methods: Sixty-five consecutive patients, who were operated on from 2012 to 2015 and had a diagnosis of AIS, were included into the study. Gender, age, preoperative weight and height, preoperative major curve magnitude and T5–T12 kyphosis angles, the fusion level, and the time of surgery were recorded. Perioperative blood loss was estimated by the same anesthesiologist for all patients. Then, an experienced surgeon estimated the perioperative blood loss by a gravimetric method, and the results were compared.

Results: Seventeen (26.2%) of the patients were male and 48 (73.8%) were female. The mean age was 15.8 ± 1.9. The mean height of the patients was 162.1 ± 8.9 cm and the mean weight was 52.6 ± 8.9 kg. The mean preoperative major curve magnitude and kyphosis angles were 49.5 ± 9.2 and 47.1 ± 12.7 respectively. The mean estimate of the surgeon was 1009 ± 404.5 ml and the mean estimate of the anesthesiologist was 434 ± 217.6 ml and the difference was statistically significant ($p < 0.05$). Moreover, if blood loss was high during the operation, the difference between the estimates of the surgeon and anesthesiologist was also higher.

Conclusions: Even in operations where most of the blood goes into a suction canister, such as for AIS, a visual estimation method is not accurate. A short training regarding optimizing the amount of blood contained in sponges that are not fully soaked may be sufficient to improve this method.

Introduction

Adolescent idiopathic scoliosis (AIS) is the most common type of spinal deformity. It affects individuals between 10 and 20 years of age, and multilevel posterior instrumentation and fusion is the primary surgical option for correction of the deformity.[1] Although AIS surgery is associated with less blood loss than other types of scoliosis surgery, the mean blood loss can reach 1500 ml; this lost blood should be replaced to an adequate level.[2] Underestimation may lead to inadequate fluid and blood replenishment, which may be associated with shock, organ damage, and impaired tissue oxygenation.[3,4] Meanwhile, overestimation may lead to an unnecessary transfusion and, as a result, increased complications and mortality.[5,6] Thus, for adequate replacement of blood loss, a reliable estimation of perioperative blood loss (PBL) is essential.

Although there are several methods for estimating PBL, all have limitations and estimating PBL remains a challenge. It may be especially difficult for long-duration operations and when much bleeding is expected, as in scoliosis surgery. The most commonly used method, as at our institution, is visual estimation by anesthesiologists, although several studies have shown its inadequacies.[7,8] In this method, the anesthesiologist estimates PBL by visually examining blood collected in suction canisters, surgical sponges, drapes, towels, and on other surfaces; it has been reported that large losses are typically underestimated, while smaller losses tend to be overestimated.[9]

The Manuscript submitted does not contain information about medical device(s)/drug(s).

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Other methods, like gravimetric techniques and photometry, are not used widely. Although they are more objective, they are not always practical and are also time-consuming. As a result, there is no reliable and routinely applicable method for estimating PBL.

One reason for inaccurate estimates using visual estimation method (VEM) is the inability to determine the exact amount of blood not in the suction canister and sponges, or on drapes and other surfaces.[10] Most of the studies in the literature about the inaccuracy of VEM are related to obstetric operations, which typically involve bleeding out of the surgical site on to sponges and drapes.

We hypothesized that VEM would be accurate for AIS surgeries. Because of the characteristics of the operation site in scoliosis surgery, which is deep and has a distinct border, like a pool, only a small amount of blood leaks away, and most of the blood is suctioned into the canister. Thus, this should result in an accurate estimation. In summary, this study was designed to assess whether estimates of PBL were reliable in spinal fusion surgery when compared with the more objective gravimetric method.

Materials and methods

This was a prospective clinical study approved by the Institutional Ethics Committee/Review Board. Sixty-five consecutive patients, who were operated on from 2012 to 2015 and were diagnosed with AIS between the age of 10 and 20 years, were included in the study. The surgical indication was a deformity with a Cobb angle >40°. Patients with abnormal preoperative laboratory findings, a history of spinal surgery, or congenital anomalies on preoperative spinal magnetic resonance imaging (MRI) were excluded. Patients' gender, age, and preoperative weight and height were recorded. Preoperative major curve magnitude and T5–T12 kyphosis angles were measured according to the Cobb method. The fusion level and time of surgery were also recorded. PBL was estimated by the same anesthesiologist for all patients. Then, an experienced surgeon estimated the PBL independently by a gravimetric method and the estimates were compared.

Posterior instrumentation and fusion was performed for all patients. All of the surgeries were performed by the same senior spine surgeon from the beginning to the end. Patients were placed in the prone position on a radiolucent table. After a standard midline incision, subperiosteal dissection of the posterior soft tissue was done, to the tips of the transverse processes, by electrocautery. Surgicel, padding, bone wax and electrocautery were used to maintain homeostasis as required. Pedicle screws were placed bilaterally and parallel at each level using a free-hand technique. The posterior release was performed with partial facetectomies at all instrumented levels by using osteotome and hammer. There was no need to perform major osteotomy in any patient. Titanium rods, 6.0 mm in diameter, were contoured to correct deformities. The rods were attached to screws, initially at the top of construct, bilaterally. Deformity were corrected using a direct derotation technique. Then, fluoroscopic control of the coronal and sagittal alignment was performed and compression, distraction and in situ bending maneuvers were added if necessary. The laminae and transverse processes were thoroughly decorticated by rongeur to facilitate the fusion. Allograft bone material was used for fusion. Double hemovac drain was used without activation and they were removed on the second day after surgery. All patients practiced ambulation within the first day after surgery. Stressful activities were avoided for at least 2 months after surgery.

The anesthesiologist was informed about the study and estimated the PBL clinically, i.e., by VEM, and maintained normovolemia by replacing the lost blood with appropriate crystalloids, colloids, or blood products. To estimate the blood loss, they multiplied the number of blood-soaked gauze pieces by 20 cc, and the mopping pads by 100 cc, and then summed them with the blood estimated to be in the suction bottle and around the surgical area. Surgeons estimated the blood loss by weighing all of the soaked gauze pieces and mopping pads postoperatively with a sensitive balance, and summing those data with the amount of blood and irrigation solution mixture in the suction bottle. Then, total dry weight of items and the weight of the irrigation solution in the suction canister (which was calculated by a nurse), were subtracted from the total of stained weight of the items and mixture of suction canister. The difference in weight was noted. This method is called the gravimetric method. As a result, the blood loss estimated by the anesthesiologist and the surgeon could be compared.

Descriptive statistics were used to describe continuous variables. Spearman's rho correlation analysis was used to analyze the relationship between two continuous variables with non-normal distributions, and Pearson correlation analysis was used to analyze the relationship between two continuous variables with normal distributions. Student's *t*-test was used to compare two independent and normally distributed variables, and the Mann–Whitney U test was used to compare two independent variables with non-normal distributions. Statistical significance was set at $p < 0.05$. Analyses were performed using MedCalc software (ver. 12.7.7; MedCalc Software bvba, Ostend, Belgium).

Results

In total, 65 patients with AIS, who were treated with posterior segmental instrumentation and fusion from 2013 to 2015, were included in the analysis. Table 1 lists the demographic information,

Table 1
Preoperative demographics, scoliosis and kyphosis angles and fusion levels.

Variable	Number (65)	Mean	Median	Standard deviation	Minimum	Maximum
Age		15,8	16	1,9	12	20
Height		162,1	162	8,9	144	193
Weight		52,6	51	8,9	35	77
FL		13,1	13	0,7	11	15
PMCA		49,5	47	9,2	40	83
PKA		47,1	47	12,7	17	74

FL: Fusion level, PMCA: Preoperative major Cobb angle, PKA: Preoperative kyphosis angle.

Table 2
Perioperative blood loss estimates.

Variable	Number	Mean	Median	Standard deviation	Minimum	Maximum	P value
Estimated by Surgeon (ml)	65	1009	941	404,5	93	2385	<**0,05**[a]
Estimated by Anesthesiologist (ml)	65	434	350	217,6	150	1100	

[a] Mann-Whitney U p.

Table 3
Parameters Used When Estimating the Perioperative Blood Loss.

Patient	Gauze Pieces(n)	Gauze Pieces(gr)	Mopping Pads(n)	Mopping Pads(gr)	Suction Canister(ml)	Estimation of Surgeons (ml)	Estimation of Anesthesiologist (ml)
1	51	863	0	0	1600	907	500
2	77	1315	5	397	1600	1100	400
3	54	1026	3	508	1750	1560	700
4	49	864	2	106	1000	576	250
5	55	1027	1	60	2200	1057	650
6	67	1369	0	0	1700	1667	1050
7	46	786	2	159	1400	968	680
8	55	1391	4	545	1600	1689	800
9	57	1450	1	67	1500	1625	800
10	48	1152	1	72	1300	1336	650
11	57	902	0	0	1300	860	500
12	65	1542	2	123	1800	1475	350
13	51	1013	2	124	1500	931	700
14	65	1314	2	123	1000	947	400
15	59	1114	2	124	1100	783	400
16	90	1934	0	0	1400	1594	800
17	42	813	2	124	1000	585	700
18	75	1100	0	0	1200	550	320
19	63	965	4	145	1500	822	700
20	52	1023	2	124	1600	735	600
21	52	1024	2	121	1300	1013	700
22	51	855	3	105	1200	704	350
23	49	713	2	124	950	93	200
24	56	1234	4	267	1800	1265	300
25	62	1054	2	123	1800	905	350
26	80	1413	2	124	2300	1657	500
27	58	1145	2	123	1500	1120	400
28	55	943	2	124	1400	1217	400
29	45	934	2	123	1300	787	200
30	48	843	2	124	600	479	150
31	48	835	2	124	1700	1071	300
32	49	824	2	124	1800	1054	300
33	51	942	2	123	1600	1059	250
34	40	845	2	123	1600	828	250
35	56	945	2	120	1500	832	350
36	55	1053	2	124	1900	1247	300
37	31	562	0	0	600	226	300
38	54	942	2	123	1500	941	200
39	56	983	2	124	1600	1021	250
40	65	1073	2	124	1400	907	300
41	51	813	2	124	1200	731	650
42	56	1033	2	124	1000	1021	700
43	45	1013	2	124	1300	867	250
44	53	1213	2	124	1600	719	200
45	52	815	2	123	1400	926	300
46	100	1950	2	124	1400	1574	400
47	79	1312	2	124	1900	1762	750
48	59	652	2	124	1500	922	300
49	79	1215	2	124	1200	765	450
50	75	1612	2	125	2700	2385	1100
51	42	723	2	124	1000	645	500
52	53	932	3	126	1100	840	300
53	46	714	2	124	900	462	450
54	51	864	2	123	1400	481	200
55	51	932	2	124	1900	1350	320
56	61	1135	2	124	2500	1543	400
57	63	1213	2	124	1300	1159	250
58	55	935	2	124	1500	929	250
59	53	1046	2	124	1600	1052	250
60	49	814	2	123	700	243	250
61	54	1143	2	123	1500	1042	250
62	72	1134	2	123	1650	925	300
63	47	841	2	123	1800	1082	300
64	104	1145	2	124	2100	1145	650
65	54	924	2	123	1200	823	200

n: number gr: gram ml: milileter

preoperative major Cobb angles, preoperative thoracic kyphosis angles, and fusion levels of the patients. The mean estimate of the surgeon was 1009 ± 404.5 ml and the mean estimate of the anesthesiologist was 434 ± 217.6 ml and the difference was statistically significant ($p < 0.05$) (Table 2). Weight and the number of the blood-soaked gauze pieces and mopping pads and the amount of the blood in the suction canister, which are the components of the estimation of PBL, and the estimations by surgeons and anesthesiologist were presented for each patient in Table 3. Regarding the surgeon's estimates, preoperative major curve magnitude was the only variable that correlated with blood loss. Preoperative kyphosis magnitude, patient height and weight, total operative time, and fusion levels showed no correlation with blood loss. Regarding the anesthesiologist's estimates, in contrast to those of the surgeon, the fusion level was the only variable that correlated with blood loss, while total operative time, magnitude of Cobb angle, preoperative magnitude of kyphosis, and patient height and weight showed no association with blood loss. Age and gender also showed no association with the amount of blood loss in either the surgeon or anesthesiologist's data. There were only three operations in which the anesthesiologist estimated greater blood loss than did the surgeons. Moreover, if blood loss was high during the operation, the difference between the estimates of the surgeon and the anesthesiologist was greater.

Discussion

Estimating PBL is an important issue for both anesthesiologists and surgeons, so as to be able to replace lost blood adequately, and there is often disagreement between surgeons and anesthesiologists about the degree of blood loss. Especially in long operations and operations with significant bleeding, estimating blood loss may be a challenge. The most widely used method is visual estimation by anesthesiologists, but its reliability is controversial.[7,8] However, there are several other methods that, although being more objective and better able to measure the exact amount of blood loss, are not always practical; they are also time-consuming and thus are not used routinely. While it is not particularly accurate, VEM remains the most widely used method for PBL estimation.

Because of the frequency of potentially fatal complications related to PBL, most studies on the relevance of VEM concern obstetric operations. Moreover, hemorrhage continues to be a leading cause of maternal mortality in the United States, and perioperative blood replacement is important.[11] To achieve that, accurate estimation of blood loss is needed. According to Prasertcharoensuk et al postpartum hemorrhage was underestimated by visual estimation versus direct measurements.[12] In contrast, Razvi et al reported that estimated blood loss was 20% greater than measured blood loss after vaginal births.[13] Moreover, Brant et al suggested that when the actual amount of blood loss increased, the incidence of underestimation also increased.[14]

The differences in these studies are understandable, because most of the blood goes into sponges, and the most important component of VEM is estimation of the amount of blood in sponges and towels. Guidelines for these estimations state that each fully soaked 10.16 cm (4 in) × 10.16 cm surgical sponges holds ~10 ml of blood, and each fully soaked 30.48 cm (12 in) × 30.48 cm gauze holds ~100–150 ml of blood.[15] If these items are only partially saturated, the anesthesiologist must estimate how much blood they contain. Furthermore, the surgeon typically uses irrigation solutions that dilute the blood and increase the volume of liquid in the items. For that reason, if most of the blood is outside the suction canister, the measurement will be more subjective, whereas if most of the blood goes into the suction canister, rather than the sponges, more appropriate estimations may result.

Estimation of PBL in spinal surgery is an important issue, as in other surgeries. There are studies in the literature on preoperative estimations and minimization of blood loss during spinal surgery, but if the perioperative measurement is not accurate, adequate replacement of lost blood will be impossible. Thus, an accurate method is needed to evaluate blood loss. Mooney et al conducted a study on the validity of estimated PBL during pediatric spinal surgery.[8] They compared the blood loss estimates of surgeons and anesthesia providers. Anesthesia providers made estimates by VEM, while the surgeon's estimate were based on the volume of blood in products processed by a Cell-Saver device. Their results also suggested the inaccuracy of the VEM. However, congenital and neuromuscular scoliosis patients were included in their study. These patients mostly required osteotomies for correction of abnormalities, where PBL would be expected to be higher than for AIS patients. There was also a patient who needed both anterior and posterior approaches. All of these factors increase PBL and lead to inaccuracy in VEM. In AIS surgery, the posterior approach alone is typically sufficient, and osteotomies are rarely needed. Thus, nearly all of the blood is lost from the paravertebral muscle during the surgical approach, and then from the corpus while opening the screw hole. As a result, most of the blood goes into the suction canister as soon as it leaves the body. Moreover, if it accumulates at the surgical site, because of the pool-like characteristics of the paravertebral region, it mostly goes into the suction canister thereafter. Thus, in contrast to other reports about the inconsistencies of the visual estimation method, it may be accurate for AIS surgeries.

However, the results of our study suggest that VEM is not accurate even for AIS surgery. The anesthesiologist's blood loss estimates were approximately half as large as those of the surgeon. We believe that the underestimation resulted from a high number of sponges that were not-fully soaked. The senior surgeon in this study used a given sponge only once, after which, if needed, another was used; thus, there were many non-fully soaked sponges after the operation. As mentioned above, non-fully soaked sponges are an important factor in the subjectivity of this method. Estimation of the amount of blood in a non-fully soaked sponge depends on the anesthesiologist; although the anesthesiologist in this study was experienced, estimates may differ between anesthesiologists. The anesthesiologist in this study was also an experienced physician, but it has been demonstrated that the accuracy of PBL estimation is unrelated to seniority or experience.[16–20]

Zuckerwise et al reported that it was possible to improve the PBL estimates using visual cards.[21] Dildy III et al also suggested the possibility of improving PBL measurements with a 20-min presentation that focused on estimating the amount of blood in non-fully soaked items.[22]

In conclusion, we suggest that, even in operations where most of the blood goes into the suction canister, like AIS surgeries, VEM is not accurate. A training session regarding optimizing the amount of blood contained in sponges that are not fully soaked may be sufficient to improve this method.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.aott.2018.03.003.

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