Estimation of Simulated Blood Loss by Orthopaedic Residents Before and After Brief Training

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Abstract

Background: Accurate estimation of blood loss (EBL) may be helpful for patient safety during certain operative procedures; however, medical students and residents are rarely instructed in EBL. In a series of two tests, we attempted to reveal any significant improvement in accuracy of EBL after a brief training session.

Methods: Fourteen orthopaedic residents were recruited. Participants estimated the amounts of simulated blood before and after a training session that involved a visual of 110 cm^3 of the spilled fluid. Three volumes of 50, 237, and 531 cm^3 of simulated blood were spilled on a lap sponge, blanket, and trash bag, creating nine stations total for estimating blood loss.

Results: The EBL for each surface was inaccurate, particularly on the absorbent material (ie, sponge and blanket). Of the 126 initial estimates, a total of 13 (10%) were within 20% of the true value. After a brief training session, a total of 43 estimates (34%) were within 20% of the true value spilled. Individual estimates maintained a wide range in both tests.

Conclusions: Although EBL is a difficult skill to learn, training may result in significant improvement of accuracy. Healthcare professionals should be aware of the complications in estimating blood loss and possible benefits of formal instruction.

Introduction

Intraoperative estimation of blood loss (EBL) may be important for patient safety. Hematocrit values can be poor indicators of short-term blood loss, whereas accurate EBL helps guide fluid resuscitation and transfusion. EBL can be especially useful in treating pediatric patients with low blood levels and possible blood-level shifts after operative procedures involving higher potential blood loss and risk of cardiovascular disease. Additionally, accurate EBL may help in comparing surgical and pharmacological techniques for reducing short-term intraoperative blood loss.[1]

However, medical schools and residency programs do not normally include formal training in EBL. Irrigation fluid, absorbent materials, and drying of blood can complicate intraoperative EBL. Furthermore, confusion exists on fluid amounts (eg, ounces, milliliters, and cubic centimeters). Even if surgeons are familiar with such measurements and corresponding container sizes, it is difficult to distinguish that amount of fluid when spilled on various surfaces.

We tested the ability of orthopaedic residents to estimate blood loss using methods encountered in the operating room. Because blood and fluid spread on lap sponges, blankets, and floors are different than those in containers, we hypothesized that initial EBL would be inaccurate.

Methods

Liquid with color and viscosity similar to blood was created using corn syrup, water, and red food coloring. Three volumes (50, 237, and 531 cm^3) of simulated blood were each poured onto three surfaces (lap sponge, blanket, and flat white trash bag), creating nine stations total.

Fourteen orthopaedic surgery residents in post-graduate years 1 to 5 were recruited and informed consent was given. The participants proceeded through each station and gave amount estimates (126 total) of simulated blood. This process was repeated after residents were briefly shown the appearance of 110 cm^3 of simulated blood on a lap sponge.

Results

For each station, initial mean EBL was lower than the true value spilled (Table 1). Of the 126 initial estimates, five (4%) were greater than the true value. Seven of the 13 estimates (10%) within 20% of the correct amount involved the lesser volume. For higher amounts of fluid used (237 and 531 cm^3), initial mean EBL was most and least accurate on the nonabsorbent trash bag and lap sponge, respectively.

After visual training, accuracy of EBL and number of estimates within 20% of the true value improved (Table 2). Forty-three of the 126 (34%) post-training estimates

were within 20% of the true fluid volume. Forvhigher fluid amounts, half of the average estimates were within 10% of the true value. Range of estimates was great, and 21% of individual estimates was within 20% of the true fluid value. Post-graduate year of resident did not correspond to the accuracy of estimate before or after training.

Table 1. Before a brief training session, estimations (126 total) by 14 orthopaedic residents of three amounts of spilled simulated blood on three different surfaces

Surface	True value[a] (cm^3)	Mean (cm^3)	Median (cm^3)	Range (cm^3)	Within 20% of true value (%)	Underestimate (%)	Overestimate (%)
Lap sponge							
	50	25	20	5-50	29	79	0
	237	47	41	20-100	0	100	0
	531	107	82.5	30-300	0	100	0
Blanket							
	50	20	20	5-50	7	93	0
	237	116	73	20-400	0	86	14
	531	118	77.5	20-400	0	100	0
Trash bag							
	50	22	17.5	10-50	14	86	0
	237	135	77.5	30-500	29	86	14
	531	284	180	60-1000	14	93	7

[a]Actual amount of simulated blood poured on the material.

Table 2. After a brief training session, estimations (126 total) by 14 orthopaedic residents of three amounts of spilled simulated blood on three different surfaces

Surface	True value[a] (cm^3)	Mean (cm^3)	Median (cm^3)	Range (cm^3)	Within 20% of true value (%)	Underestimate (%)	Overestimate (%)
Lap sponge							
	50	68	60	40-110	57	7	57
	237	144	145.5	50-240	36	93	7
	531	319	315	50-600	14	86	14
Blanket							
	50	67	60	25-150	36	21	57
	237	364	275	100-1000	36	36	64
	531	484	300	200-2000	14	86	14
Trash bag							
	50	55	50	20-100	50	29	29
	237	259	250	100-500	36	43	57
	531	509	490.5	150-1000	29	64	36

[a]Actual amount of simulated blood poured on the material.

Discussion

Results of other studies have shown similar difficulties in estimating blood loss. Ashburn et al[2] used stage blood to study the EBL of emergency department attending physicians and residents, with only 8% of estimates within 20% of the true value present. No significant differences were noted between residents' and physicians' estimates. Additionally, Duthie et al[3] found that visual estimation of blood was inaccurate during childbirth.

In our study, improved mean accuracy but wide range of individual estimates after training concur with findings of other studies. Dildy et al[4] noted both occurring after instructing medical personnel to estimate blood loss. Moscati et al[5] educated emergency medical technicians to estimate blood loss, and the mean percent error decreased from 65% to 52% at 1 month post-training.

Limitations of this study include unmatched characteristics of the simulated blood to its true form. However, significant improvement in accuracy using real blood is unlikely because the main difficulty involved guessing the amount of spilled fluid on various surfaces. Because this is a preliminary investigation with limited participants, clinical relevance and possible improvement in accurate EBL has yet to be determined. Our findings reaffirm the importance of educating healthcare professionals in estimating blood loss.

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Conflict of Interest

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References

1. Zan PF, Yang Y, Fu D, Yu X, Li GD. Releasing of tourniquet before wound closure or not in total knee arthroplasty: a meta-analysis of randomized controlled trials. J Arthroplasty 2015;30(1):31-7.
2. Ashburn JC, Harrison T, Ham JJ, Strote J. Emergency physician estimation of blood loss. West J Emerg Med 2012;13(4):376-9.
3. Duthie SJ, Ven D, Yung GL, Guang DZ, Chan SY, Ma HK. Discrepancy between laboratory determination and visual estimation of blood loss during normal delivery. Eur J Obstet Gynecol Reprod Biol 1991;38(2):119-24.
4. Dildy GA 3rd, Paine AR, George NC, Velasco C. Estimating blood loss: can teaching significantly improve visual estimation? Obstet Gynecol 2004;104(3):601-6.
5. Moscati R, Billittier AJ, Marshall B, Fincher M, Jehle D, Braen GR. Blood loss estimation by out-of-hospital emergency care providers. Prehosp Emerg Care 1999;3(3):239-42.

Comparison of Blood Loss Between Short-Stem and Conventional Femoral Implants in Total Hip Arthroplasty

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Abstract

Background: Although the postoperative results of total hip arthroplasty (THA) are generally successful, the standard technique and implant design have many proposed modifications. The purpose of the current study was to determine if using short-stem femoral implants minimized the intraoperative blood loss during THA when compared with conventional THA.

Methods: The medical records of patients who underwent THA using short-stem and conventional femoral implants between 2009 and 2013 were reviewed. Patients with previous surgical procedures for treating the acetabulum or proximal femur and patients without reported hematocrit levels were excluded; subsequently, a total of 53 patients for each group (short-stem or conventional implants) were included. Demographic and outcome variables were collected and analyzed for statistical significance using the Fisher exact test.

Results: No significant difference was noted in the patient mass index, preoperative hematocrit level, postoperative decrease in hematocrit level, and mean operating time between the groups. On unadjusted analysis, age, sex, transfusion rates, and blood loss were significant between the groups ($P < 0.001$, $P = < 0.001$, $P = 0.04$, and $P = 0.01$, respectively). On adjusted analysis for age and sex, no significant difference in transfusion rate was noted ($P = 0.12$ and $P = 0.01$, respectively).

Conclusions: The use of short-stem implants may not be significantly related to a reduced blood loss compared with conventional implants. However, further studies are needed to analyze the clinical significance between blood loss and implant use.

Introduction

More than 330,000 total hip arthroplasty (THA) procedures are performed in the United States annually.[1] Despite generally successful postoperative results, the standard technique and implant design have many proposed modifications, especially when used on younger patients. Use of neck-preserving, short-stem femoral implants in particular may be a potential alternative to conventional femoral stems. Results of biomechanical studies have shown that these implants can reproduce anatomical hip kinetics and may decrease risk of periprosthetic fractures.[2,3]

Short-stem implants rely primarily on metaphyseal fixation. Reports of their use in laboratory studies indicate a physiological load transfer and reduction of stress shielding through this mechanism.[4-6] Additionally, results of medium-term follow-up in younger patients with short-stem femoral components are encouraging.[7-9] Decreased thigh pain, ease of revision, and reduced rate of dislocation have been reported using short-stem implants in THA.[10,11]

However, no study to date has analyzed intraoperative blood loss for comparing the effectiveness between use of short-stem and conventional femoral implants. We reviewed the medical records of patients to determine if using short-stem devices diminished the blood loss during THA. We hypothesized that short-stem femoral implants would result in lower intraoperative blood loss and transfusion rates compared with conventional femoral implants.

Methods

Approval from our Human Research Review Committee was obtained for this study (HRRC #13-548). The medical records of patients were reviewed electronically at our university hospital for patients who underwent THA using Metha Short Hip Stem (Aesculap Implant Systems, Center Valley, PA) between 2009 and 2013. A total of 53

patients matched the search criteria and were compared with a control group of 53 patients who underwent THA using conventional femoral stems between the same years. Exclusion criteria were patients with previous surgical procedures for treating the acetabulum or proximal femur. Additionally, patients without noted preoperative and postoperative hematocrit levels were not included.

All surgical procedures were performed by the senior author, using a standard posterior approach to the hip in the lateral position. Tranexamic acid was not used in treating any of the patients.

Patient demographics in the short-stem and conventional implant groups were recorded. Outcome variables of transfusions performed, pre- and postoperative hematocrit levels, operating time, and blood loss were also noted. Measurement of postoperative hematocrit level was reported at 24 hours postoperatively. Operating time was obtained from the record of the surgical nurse at the time of operative procedure. The surgeon recorded blood loss immediately after the procedure.

The Fisher exact test was used for statistical analysis. A P value of < 0.05 was considered to represent a statistically significant difference between the groups treated with short-stem and conventional femoral implants.

Table 1. Demographics of 106 patients who underwent total hip arthroplasty using conventional or short-stem implants

Variable	Patients with conventional implants (n = 53)	Patients with short-stem implants (n = 53)	*P* value
Sex			< 0.001
Male	17	36	—
Female	36	17	—
Mean (range) age, y	59.2 (31-80)	49.9 (18-60)	< 0.001
Mean (range) BMI	33.9 (19-52)	31.8 (19-45)	< 0.19
Mean (range) PHL	42.6 (34-50)	42.9 (28-51)	0.82

BMI, body mass index; PHL, preoperative hematocrit level.

Results

Concerning patient demographics (Table 1), no significant difference was noted in body mass index and preoperative hematocrit level between short-stem and conventional femoral implant groups.

However, sex and age were significant, with the patients' mean age at 9.3 years younger in the short-stem implant group compared with conventional implants. In the short-stem implant group, women had a significantly increased transfusion rate ($P = 0.02$).

Postoperative variables corresponding to blood loss are shown in Table 2. Decrease in postoperative hematocrit level and mean operating time were not significant between the groups. Transfusion rates were significant, with patients in the short-stem implant group receiving fewer transfusions ($P = 0.04$). Additionally, blood loss was significantly less for patients in the short-stem implant group ($P < 0.01$).

Adjusted statistics for age and sex were analyzed after significant differences were noted between group demographics. No significant difference in transfusion rate was identified between groups when data were adjusted for sex ($P = 0.12$) and age ($P = 0.01$).

Table 2. Unadjusted outcome variables of 106 patients who underwent total hip arthroplasty using conventional or short-stem implants

Variable	Patients with conventional implants (n = 53)	Patients with short-stem implants (n = 53)	*P* value
Transfusions performed (%)	17 (32.1)	7 (13.2)	0.04
Mean decrease in PHL[a]	26%	25.7%	0.86
Mean operating time, min	127.9	131.4	0.5
Mean blood loss, mL[b]	552.8	397.7	0.01

PHL, postoperative hematocrit level.

[a]Hematocrit levels were reported at 24 hours postoperatively.

[b]Blood loss was recorded immediately after the procedure.

Discussion

Many potential benefits have been proposed with the use of short-stem femoral implants in THA. Reports of long-term outcomes are still lacking, but early results are promising regarding level of function, wear rates, and patient outcomes.[5-7] Despite the theoretical decrease in blood loss caused by abbreviated canal preparation, we found no statistically significant difference in blood loss between the short-stem and conventional implant groups. Although we noted a difference in transfusion rates, the significance was eliminated when adjusted for age and sex. No significant difference was observed in mean operating time between the groups.

The current study has several limitations. As commonly reported, accurate measurements of intraoperative blood loss are inherently difficult. Additionally, transfusion criteria may differ depending on other patient and physician factors. Finally, because we obtained data through electronic records, any statistical significance in the demographic differences between groups was likely the result of surgeon preference. Short-stem implants were preferentially used in younger patients and mostly male patients, presumably because of a perceived increase in demand of these devices.

Despite the theoretical benefits of short-stem implants used in THA, it remains unclear whether these devices contribute to diminished intraoperative blood loss compared with conventional implants. Subsequently, prospective randomized controlled trials would be useful in addressing the limitations of bias in our retrospective review. Larger sample sizes may show a significant difference.

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Conflict of Interest

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References

1. Centers for Disease Control and Prevention. National hospital discharge survey: 2010 table. Hyattsville, MD: Centers for Disease Control and Prevention, US Department of Health and Human Services; 2012. http://www.cdc.gov/nchs/data/nhds/4procedures/2010pro4_numberprocedureage.pdf.

2. Amenabar T, Marimuthu K, Hawdon G, Gildone A, McMahon S. Total hip arthroplasty using a short-stem prosthesis: restoration of hip anatomy. J Orthop Surg (Hong Kong) 2015;23(1):90-4.

3. Jones C, Aqil A, Clarke S, Cobb JP. Short uncemented stems allow greater femoral flexibility and may reduce periprosthetic fracture risk: a dry bone and cadaveric study. J Orthop Traumatol 2015;16(3):229-35.

4. Gronewold J, Berner S, Olender G, et al. Changes in strain patterns after implantation of a short stem with metaphyseal anchorage compared to a standard stem: an experimental study in synthetic bone. Orthop Rev (Pavia) 2014;6(1):5211.

5. Jahnke A, Engl S, Altmeyer C, et al. Changes of periprosthetic bone density after a cementless short hip stem: a clinical and radiological analysis. Int Orthop 2014;38(10):2045-50.

6. Bieger R, Ignatius A, Reichel H, Dürselen L. Biomechanics of a short stem: In vitro primary stability and stress shielding of a conservative cementless hip stem. J Orthop Res 2013;31(8):1180-6.

7. Thorey F, Hoefer C, Abdi-Tabari N, Lerch M, Budde S, Windhagen H. Clinical results of the metha short hip stem: a perspective for younger patients? Orthop Rev (Pavia) 2013;5(4):e34.

8. Kim YH, Park JW, Kim JS, Kang JS. Long-term results and bone remodeling after THA with a short, metaphyseal-fitting anatomic cementless stem. Clin Orthop Relat Res 2014;472(3):943-50.

9. Morrey BF, Adams RA, Kessler M. A conservative femoral replacement for total hip arthroplasty: a prospective study. J Bone Joint Surg Br 2000;82(7):952-8.

10. Banerjee S, Pivec R, Issa K, Harwin SF, Mont MA, Khanuja HS. Outcomes of short stems in total hip arthroplasty. Orthopedics 2013;36(9):700-7.

11. Stulberg SD, Patel RM. The short stem: promises and pitfalls. Bone Joint J 2013;95-B(11 suppl A):57-62.