Original Article

Are we all guilty of under-estimating intra-operative blood loss during hip fracture surgery?

Basil Budair^{a,*}, Usman Ahmed^a, James Hodson^b, Michael David^a,
Mujeeb Ashraf^b, Tim McBride^b

^a Birmingham Orthopaedic Training Programme, Health Education West Midlands, 213 Hagley Road, Birmingham B16 9RG, UK

^b University Hospitals Birmingham NHS Foundation Trust, Queen Elizabeth Hospital, Mindelsohn Way, Edgbaston, Birmingham B15 2WB, UK

ARTICLE INFO

Article history:

Received 10 October 2016

Accepted 16 October 2016

Available online 28 October 2016

Keywords:

Blood loss

Hip fractures

Orthopaedic

Perception

ABSTRACT

Aim: To assess how accurately orthopaedic surgeons and anaesthesiologists estimate intraoperative blood loss during hip fracture surgery as part of the Surgical Safety Checklist (SCC).

Methods: A prospective study of 55 operations over 9 months. Pre- and post-operative estimations of blood loss were documented. Actual blood loss was determined by subtracting total amount of lavage fluid used from overall volumes in the suction bag and by weighing used swabs.

Results: Both, surgeons and anaesthesiologists, significantly underestimated intraoperative blood loss ($p < 0.001$).

Conclusion: Rather than numerical estimates, a more useful question within the SCC may therefore be: "Is excessive blood loss expected?"

© 2016 Prof. PK Surendran Memorial Education Foundation. Published by Elsevier, a division of RELX India, Pvt. Ltd. All rights reserved.

1. Introduction

Intraoperative blood loss impacts patient recovery, hampers rehabilitation and outcomes, and can contribute to morbidities such as acute kidney injury and organ failure.^{1,2}

Recognition of intraoperative blood loss as a factor in patient mortality and morbidity³ led to its addition as part of the World Health Organisation (WHO) commissioned Surgical Safety Checklist (SSC).⁴ The SSC is used by a majority of hospitals in the United Kingdom (UK) prior to commencement of surgical procedures. It offers an opportunity for risk evaluation and consolidates the team-approach to patient care. Implementation of the SSC has demonstrably improved morbidity and mortality for patients.^{5–8}

The specific question related to blood loss asks the operative team to consider estimated blood loss (EBL). Such an estimate can allow for preventive measures to be considered (e.g. intravenous tranexamic acid,⁹ local infiltration of surgical site with adrenaline¹⁰, or the use of auto-transfusion drains), and early treatment of acute bleeding (early request and infusion of blood products). Answers are invariably inaccurate and subjective.^{11,12} Such

inaccuracies reported in the literature vary, with EBL often being a fraction of the total amount actually lost.^{13,14} These reports focus on elective surgery as opposed to emergency trauma and hip fractures, a higher risk demographic where the effects of blood loss are more acute.

Our aim is to assess how accurately orthopaedic surgeons and anaesthesiologists estimate intraoperative blood loss during emergency hip fracture surgery.

2. Methods

2.1. Patients and measurements

The study ran prospectively between April and December 2011. No patients were excluded from this study. However, only operations observed directly by one of the authors were included, to ensure accurate and unbiased measurement and recording of data. Hence the cases were not consecutive.

Each theatre session was observed by one of the authors to record estimations of blood loss from the operating surgeon and anaesthesiologists, both prior to surgery (during the SSC) and immediately following the completion of surgery. The grade of the doctors was noted, as was the surgical procedure performed (e.g. hip hemiarthroplasty, dynamic hip screw, or proximal femoral nail).

* Corresponding author at: 4 New Hall Grange Close, Sutton Coldfield B72 1FU, UK.

E-mail address: basil.budair@gmail.com (B. Budair).

The actual volumes of suctioned blood and those from surgical swabs were recorded. Actual blood loss was determined by subtracting total amount of lavage fluid used from the overall volumes in the suction bag and used swabs. Blood in the swabs was determined by weight, with the assumption that one gram of blood is equivalent to one millilitre of blood. Eight orthopaedic surgeons and six consultant anaesthetists took part in this study. In each case, blood loss estimates were compared with actual blood loss, and the discrepancy calculated.

2.2. Statistical methods

Initially, the errors in each blood loss estimate were calculated, by subtracting the observed blood loss from what was predicted. Comparisons were then made between mean errors in the surgeon and anaesthetist groups, as well as between the pre- and post-operative periods using paired t-tests.

Estimated blood loss was plotted against actual blood loss, and a Pearson's correlation coefficient (r) calculated, to assess the degree of accuracy of the estimations. Bland–Altman plots were also produced, to demonstrate how the degree of error varying with the magnitude of measurement. Since actual measurements of blood loss are known, these values were used on the x-axis, instead of the average of the pairs of measurements, as is the convention when true values are unknown. Statistical tests were performed using IBM SPSS 22 (IBM Corp. Armonk, NY), with an alpha level of 0.05 designated as statistically significant.

3. Results

Eight orthopaedic registrars and six consultant anaesthesiologists participated. Our sample size was 55 procedures: 11 proximal femoral nails antirotation (PFNA), 28 cemented hemiarthroplasties and 16 dynamic hip screws (DHS). The quantity of blood lost was not found to differ significantly by surgery type ($p = 0.322$, Kruskal–Wallis test), with medians of 420, 444 and 300 ml respectively (Fig. 1).

Fig. 1. The quantity of blood loss by surgery type

Table 1 compares the mean discrepancies between estimated and actual blood loss for both surgeons and anaesthesiologists. All four groups significantly underestimated the volume of blood lost ($p < 0.001$). The largest mean discrepancy of 249 ml (SEM: 45) was observed in the pre-operative estimations of surgeons. Anaesthetists were significantly more accurate at estimating blood loss than surgeons, with mean underestimates of 183 vs. 249 ml pre-surgery and 175 vs. 221 ml post-surgery (both $p < 0.001$). Blood estimations failed to improve significantly in accuracy when made prior to surgery in contrast to when made at the end of surgery amongst both surgeons ($p = 0.130$) and anaesthesiologists ($p = 0.631$).

Fig. 2 plots the relationships between actual and estimated blood loss within each group. There was no significant correlation detected between the actual and estimated values from surgeons ($p = 0.760$), with a correlation coefficient of -0.042 . In other words, surgeons consistently underestimated blood loss (mean -226 ml, SEM: 10), regardless of actual intra-operative blood loss. Anaesthesiologists performed marginally better in the pre-operative period, with a positive correlation between estimated and actual blood loss ($r = 0.294$, $p = 0.03$). However, they still had a tendency to considerably underestimate blood loss, with the discrepancy increasing with the magnitude of actual blood loss.

The reason behind these poor correlations was that both surgeons and anaesthesiologists tended to consistently give the

Fig. 2. Plots of actual vs. estimated blood loss by specialist and time. Broken lines are plotted at actual = estimated, and so are the target for accurate estimation. Red lines are from linear regression models.

Table 1

Mean discrepancies in estimated blood loss.

	Mean (SEM)	p-Value vs.			
		Surgeon pre-op	Surgeon post-op	Anaesthetist pre-op	Anaesthetist post-op
Surgeon pre-op	–249 (45)	–	0.130	<0.001	<0.001
Surgeon post-op	–221 (38)	0.130	–	0.037	0.002
Anaesthetist pre-op	–183 (41)	<0.001	0.037	–	0.631
Anaesthetist post-op	–175 (38)	<0.001	0.002	0.631	–

p-Values from paired *t*-tests.Bold *p*-values are significant at $p < 0.05$. **Fig. 3.** Bland–Altman plots of blood loss by specialist and time.

same estimates, regardless of what blood loss actually occurred. Pre-operatively, 75% of surgeons and 67% of anaesthesiologists gave an estimate of 200–300 ml, whereas only 13% of operations actually had blood loss in this range, with most (65%) having greater blood loss.

In post-operative estimates, the performance of surgeons and anaesthesiologists improved marginally, with both sets of estimates now being significantly correlated with the actual measurements (both $r = 0.50$, $p < 0.001$). However, the tendency to underestimate blood loss remained.

Bland–Altman plots are shown in Fig. 3 and re-enforce our findings. In all cases, the regression analysis (Table 2) detected a

significant intercept (all $p < 0.001$), with coefficients ranging from 169 to 249. An interpretation being that even for an operation with minimal blood loss, estimates of around 200 ml would be expected. As the magnitude of the actual blood loss increased, estimates of blood loss are increasingly undervalued (all $p < 0.001$).

4. Discussion

The estimation of intra-operative blood loss is vital and can have a direct impact on patient care in the perioperative period. It is routine practice to perform a blood test within 48 h of hip fracture surgery to check for anaemia and renal impairment. The timing of these tests may be based on surgeon and anaesthesiologist estimates of blood loss. This study demonstrates gross underestimation of blood loss in hip fracture surgery.

Surgeon estimates are consistently more conservative than anaesthetists. Regardless of the procedure performed or individual patient factors, there is a tendency to simply quote 200–300 ml for estimated blood loss. This may be due in part to inexperience, but may also just be a part of the habit of the SSC.

It is difficult to define excessive blood loss in the operative setting, but the application of the ATLS™ definition of and criteria for shock may be of use with respect to physiological disturbance

Table 2

Regression models of the Bland–Altman plots.

	Intercept	Gradient
Surgeon pre-op	231 (194, 268)	–1.01 (–1.07, –0.95)
Surgeon post-op	169 (119, 218)	–0.82 (–0.91, –0.73)
Anaesthetist pre-op	249 (202, 296)	–0.91 (–0.99, –0.83)
Anaesthetist post-op	212 (162, 262)	–0.81 (–0.90, –0.73)

Results from regression models, with the error in the estimate as the dependent variable, and the actual blood loss as a covariate. Reported values are the coefficients from the model, with 95% confidence intervals, all of which were significant at $p < 0.001$.

excessive blood loss leads to. Although the clinical relevance of blood loss is clear as part of a clinical evaluation and treatment of anaemia, our results suggest that peri-operative estimation may not be useful at all, especially if used in isolation without any formal attempt to evaluate the blood loss from suction systems and used swabs.

We have not assessed the impact of the estimated blood loss here. Neither have we assessed transfusion requirements or post-operative anaemia, as perioperative blood loss and its impact is already well established in medical literature. We did not consider the experience of the surgeons or anaesthetists in this study. Our sample size is small in part an effect of the number of staff free to act as third-party observers. Case complexity (including length of surgery) has not been used for sub-group analysis, as in principle surgeons and anaesthesiologists should anticipate such factors during the SSC. Instead we have chosen a commonly occurring pathology in the form of hip fracture surgery on the assumption that procedures carried out were likely to be fairly uniform in terms of patient group, surgical technique and operation length.

5. Conclusion

Our study demonstrates that our current estimates, in particular the surgical and anaesthetic pre-operative estimates, are grossly inaccurate. We believe it is crucial to recognise values of blood loss quoted during the SSC are simply estimates, and efforts are needed during surgery to monitor blood loss. We acknowledge that there are many variables in each procedure for there to be a standardised estimate of blood loss. However, we would prefer to over-estimate blood loss with closer intraoperative monitoring to better treat the physiology of this high-risk demographic, rather than underestimate losses and be reassured falsely. With regard to the WHO checklist, perhaps rather than guessing a numerical figure, a more pertinent question to ask might be “whether there is an expectation of excessive blood loss?”

Authors' contribution

Basil Budair – Study design, data collection & analysis and manuscript writing and revision.

Usman Ahmed, Michael David – Data analysis, manuscript writing and revision.

James Hodson – Statistical analysis, manuscript writing and revision.

Mujeeb Ashraf – Study set up and Data collection.

Tim McBride – study design, data collection, manuscript write up and revision.

Ethical approval

Formal ethical approval was not required, as the study was designated a service evaluation by our Trust's Clinical Governance team.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest

The authors have none to declare.

References

- Halm EA, Wang JJ, Boockvar K, et al. The effect of perioperative anemia on clinical and functional outcomes in patients with hip fracture. *J Orthop Trauma*. 2004;18(July (6)):369–374.
- Lawrence VA, Silverstein JH, Cornell JE, Pederson T, Noveck H, Carson JL. Higher Hb level is associated with better early functional recovery after hip fracture repair. *Transfusion*. 2003;43(December (12)):1717–1722.
- Keating EM, Meding JB. Perioperative blood management practices in elective orthopaedic surgery. *J Am Acad Orthop Surg*. 2002;10(November (6)):393–400.
- Mahajan RP. The WHO surgical checklist. *Best Pract Res Clin Anaesthesiol*. 2011;25(June (2)):161–168.
- Van Klei WA, Hoff RG, van Aarnhem EEHL, et al. Effects of the introduction of the WHO “surgical safety checklist” on in-hospital mortality: a cohort study. *Ann Surg*. 2012;255(January (1)):44–49.
- Haynes AB, Weiser TG, Berry WR, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. *N Engl J Med*. 2009;360(January (5)):491–499.
- Fudickar A, Hörle K, Wiltfang J, Bein B. The effect of the WHO surgical safety checklist on complication rate and communication. *Dtsch Arztebl Int*. 2012;109(October (42)):695–701.
- Bliss LA, Ross-Richardson CB, Sanzari LJ, et al. Thirty-day outcomes support implementation of a surgical safety checklist. *J Am Coll Surg*. 2012;215(December (6)):766–776.
- Yang Z-G, Chen W-P, Wu L-D. Effectiveness and safety of tranexamic acid in reducing blood loss in total knee arthroplasty: a meta-analysis. *J Bone Jt Surg Am*. 2012;94(July (13)):1153–1159.
- Malone KJ, Matuszak S, Mayo D, Greene P. The effect of intra-articular epinephrine lavage on blood loss following total knee arthroplasty. *Orthopedics [Internet]*. 2009;32(February (2)). Available from: <http://www.healio.com/orthopedics/knee/journals/ortho/2009-2-32-2/%7Bf43bbe8-1445-4535-adc3-2c6c828ac8bb%7D/the-effect-of-intra-articular-epinephrine-lavage-on-blood-loss-following-total-knee-arthroplasty> [cited 28.09.15]
- Brecher ME, Monk T, Goodnough LT. A standardized method for calculating blood loss. *Transfusion (Paris)*. 1997;37(October (10)):1070–1074.
- Schorn MN. Measurement of blood loss: review of the literature. *J Midwifery Women's Health*. 2010;55(January (1)):20–27.
- Sehat KR, Evans R, Newman JH. How much blood is really lost in total knee arthroplasty? *Knee*. 2000;7(July (3)):151–155.
- Rosencher N, Kerckamp HEM, Macheras G, et al. Orthopedic Surgery Transfusion Hemoglobin European Overview (OSTHEO) study: blood management in elective knee and hip arthroplasty in Europe. *Transfusion (Paris)*. 2003;43(April (4)):459–469.