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ORIGINAL RESEARCH

Visual estimation of blood loss on swabs by surgeons and anaesthetists in KwaZulu-Natal: an online survey study

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Background: Human blood products are a scarce resource in South Africa. Doctors estimate blood loss from assessing swabs during surgical procedures to decide whether to transfuse blood or not. The objective of this study was to evaluate how accurate anaesthetists and surgeons in KwaZulu-Natal are at estimating the volume of blood in soaked swabs. Additionally, the study sought to determine whether choice of medical discipline, experience or medical rank had an influence on accuracy.

Methods: An observational cross-sectional study was conducted whereby medical officers, registrars and specialists within the anaesthetic and surgical disciplines were sent an electronic survey. The survey consisted of closed-ended questions and images of swabs soaked in known volumes of blood. The survey required participants to visually estimate the blood volumes from the images. Data were analysed using Stata v17.1 (StataCorp, USA) with descriptive statistics determining the accuracy. Multilevel mixed effects logistic regression was used to estimate how medical rank, discipline or experience influenced the accuracy of the assessment. An accurate estimate was defined as within 25% either above or below the actual volume.

Results: In total, 104 surveys were completed; 14 incomplete surveys were excluded. A general accuracy of 28.6% (within a deviation of 25%) was obtained for the 104 participants. No significant differences in accuracy were found based on medical discipline, medical rank, or years of experience in discipline, but accuracy improved with increased volumes.

Conclusion: Anaesthetists and surgeons are poor at visually estimating blood loss from swabs, with marginal non-significant improvements in accuracy with rank and experience. Pictorial guides placed in theatre and further teaching are suggested as options to improve the rate of accuracy among staff, along with the use of quantitative measures of blood loss.

Keywords: swab analysis, blood loss, blood-soaked swabs, blood loss estimation, blood conservation

Introduction

South Africa has one of the highest injury-related mortality rates internationally, a homicide-related mortality rate eight times the global rate, and a road traffic mortality rate twice the global rate. In this context, the decision whether to transfuse becomes an important one.[1]

Between 5 000 and 6 000 blood products are ordered monthly from the South African National Blood Service at the Chris Hani Baragwanath Academic Hospital and up to 30% of these orders are either cancelled or wasted.[2] The Western Province Blood Transfusion Service (WPBTS) must collect approximately 700 units of whole blood every day to meet the needs of the Western Cape according to the WPBTS Annual Report 2017/2018.[3] While it seems intuitive to use blood products to replace that which is lost, this decision is not as simple.

Several factors must be considered before administering blood products in theatre, which include assessing the volume of blood soaked in swabs and linen, spilt blood and blood in suction containers.[4] The patient's haemoglobin level and stability in terms of blood pressure, heart rate, blood gas and other point of care assessment analyses must also be considered.[4] These factors need to be assessed simultaneously, making blood loss estimation challenging. Current point of care assessment methods used to assess or quantify the amount of blood loss are either inaccurate, expensive or have limited supply, with an arterial blood gas analyser available on government tender at approximately ZAR 500 000 and cartridges at ZAR 1 164 each.

Indications for transfusion in the non-operative setting have limited transferability to the operative setting. Blood loss and haemoglobin concentration is unpredictable during surgery, making previous haemoglobin concentrations invalid, and thus making specific haemoglobin triggers for transfusion unfeasible. Also, not all intraoperative bleeding is the same, varying from persistent, slow ooze to massive, rapid blood loss from a major vessel. Reliance on haemodynamics is complex; in addition to blood loss, it is a reflection of multiple variables including, but not limited to anaesthetic agents, patient positioning, the presence of pneumoperitoneum and neurological stimulation. In the non-operative setting, acute blood loss of 20% results in a compensatory tachycardia. However, because of other variables, tachycardia is an unreliable marker of blood loss in the anaesthetised patient. Another recommendation is to look for inadequate oxygenation and perfusion of vital organs, but it is not possible to assess for chest or abdominal pain or loss of consciousness in a patient under general anaesthesia. Another concern is transfusion reactions, which are difficult to monitor under anaesthesia. There is also uncertainty of transfusion indications. Even though there is a global shift to a restrictive transfusion strategy, a wide variability exists in clinical practice with current literature offering vague or limited directives on when to transfuse.[5] The TRICC trial excluded patients who were actively bleeding or required surgical intervention from the study, therefore, the restrictive transfusion trigger of haemoglobin of seven cannot strictly apply to theatre patients.[6]

A significant proportion of South Africans require transfusion, mainly due to the high incidence of trauma and obstetric haemorrhage.[7,8] Weeber et al.[1] found that one in 15 persons with moderate to severe injuries required a transfusion, whereas one in nine persons requiring a transfusion, will require more than what is locally available (more than six to eight units) at Khayelitsha Hospital.[1] Bates et al.,[9] in a sub-Saharan Africa review, found a direct association between maternal deaths and/or near misses and lack of timely transfusions.

South Africa's blood donor population is strained due to the high prevalence of human immunodeficiency virus (HIV) infection.[10] The high prevalence of anaemia, the high prevalence of HIV with the world's highest absolute number of cases, and other frequently occurring diseases have led to a particularly high rate of 20% blood donor deferrals.[11] Additionally, significant resource constraints – both human and financial – exist in the processing of blood products in South Africa.[1,10]

It has been shown that doctors are inaccurate at estimating blood loss in theatre.[12-15] Therefore, this study aimed to investigate the accuracy of blood loss estimation among anaesthetists and surgeons in KwaZulu-Natal when assessing soaked swabs.

Methods

The hypothesis was that anaesthetists and surgeons are inaccurate at estimating blood loss from blood-soaked swabs. The primary objective of this study was to determine the combined rate of accuracy of estimations among surgeons and anaesthetists. The secondary objective was to ascertain whether the experience level of the practitioner, or their chosen medical discipline, had any influence on the accuracy of the swab assessment.

The University of KwaZulu-Natal (UKZN) Biomedical Research Ethics Committee (BREC) approved an observational cross-sectional study which includes surgeons and anaesthetists in KwaZulu-Natal. The study population comprised specialist anaesthesiologists and surgeons, as well as anaesthetic and surgical registrars and medical officers (in-training staff). The surgical group included doctors from the departments of general surgery, trauma, orthopaedics, and obstetrics and gynaecology. A sample size of 98 was estimated based on a precision of approximately 14% with a probability of 95% using a non-informative baseline of 50%. Stata v15.1 (StataCorp., USA) was used to calculate the sample size.

The principal investigator underwent venesection in a regional hospital's operating theatre to obtain 400 ml of blood, using an anticoagulated blood pack purchased from the South African National Blood Service (SANBS).

Using this blood, spine gauze (100 x 350 mm) 'raytex' swabs and six ply (450 x 370 mm) 'abdominal' swabs were immersed in predetermined volumes of blood to create four scenarios comprising two raytex and two abdominal swabs. The blood-soaked swabs were photographed along with a 30-centimetre desk ruler for scale, and saved in 16-megapixel JPEG format.

The first and second swabs (raytex) were soaked in 20 ml and 80 ml of blood, respectively; while the third and fourth swabs (abdominal) were soaked in 80 ml and 200 ml, respectively.

Study participants then analysed these photographs through a REDcap® (Vanderbilt, Nashville TN) online survey hosted by the UKZN (see Appendix - image 1).

The survey included demographic data such as age, discipline, experience in the respective field, and rank as well as a blood content estimate. The study participants were not asked questions which could reveal their identity and source data was de-identified by the REDcap® platform to maintain confidentiality. The survey was designed to be completed on either a smartphone or a personal computer.

Study participants received an online information sheet and a consent request, embedded in the survey, informing them of the need to perform the study and to allow them to opt out.

The online survey link was distributed via the UKZN's Department of Anaesthesia Weekly Newsletter (DAWN) for four weeks from 25 March to 15 April 2022 as well as via the Department of Surgery email group to all surgical staff. In addition, it was distributed through snowball sampling via email and WhatsApp®.

Statistical analysis

Descriptive statistics were used to summarise the data. Frequencies and percentages were used for categorical data, such as medical discipline. Frequency distribution of numeric data, such as age and volume of blood was examined for normality, with means and medians used as appropriate.

The data consisted of the participants' estimates of the volume of blood for four specimens and the known volume for each specimen. An accurate estimate was defined as one that is within 25% either above or below the known volume. A participant's score was given as 0, 1, 2, 3 or 4 out of four estimates. Multilevel mixed effect logistic regression analysis was undertaken to describe participant accuracy, based on their experience, chosen medical discipline or rank. The accuracy of each estimate was also examined to establish if the volume of blood influenced it.

The design of the study required a multilevel analysis approach, with 416 observations nested within 104 doctors. There were thus 104 groups with the participant being the grouping variable. This analysis is termed a multilevel mixed effects logistic regression. There are two levels. Level 1 is the individual responses, the 416 estimates based on the selected criteria. Level 2 refers to the 104 clusters of estimates at participant level. A design factor of 1.71 was calculated.

Binary logistic regression was used to predict the outcome of whether the estimates are correct. More specifically, binary logistic regression was used to predict the probability of correctly predicting the blood volume within a specified deviation.

Stata v17.1 (StataCorp., USA) was used for the statistical analysis, while REDcap® was used for data collection and Microsoft® Excel (Microsoft Corporation, Redmond, USA) was used for saving the database.

Results

Data collection yielded 104 completed surveys, after being circulated to at least 550 doctors, resulting in a response rate of approximately 18.9%. Additionally, 14 surveys were excluded as nine were never started and five were partially completed. Regarding medical discipline, 40 surveys were completed by surgeons and 64 surveys were completed by anaesthetists. Concerning rank, 52 surveys were completed by medical officers or registrars and 52 surveys were completed by specialists. In total, 62% of the participants had 10 years or less experience in their respective disciplines (Table I).

Table I: Participant demographics

Description		***n***	**%**
Medical discipline	Surgeon	40	**38%**
	Anaesthetist	64	**62%**
Age	< 30	9	**9%**
	30–39	58	**56%**
	40–49	28	**27%**
	≥ 50	9	**9%**
Years' experience in discipline	< 2 years	8	**8%**
	2–5 years	20	**19%**
	6–10 years	37	**36%**
	> 10 years	39	**38%**
Medical rank	Medical officer/registrar	52	**50%**
	Specialist	52	**50%**
Total		**104**	**100%**

Using the 25% higher or lower variance as the criterion for accuracy, a general combined rate of accuracy of 28.5% was obtained for the 104 participants, thus confirming the hypothesis that clinicians are grossly inaccurate at estimating blood loss from soaked swabs.

Furthermore, 38% of the participants were unable to estimate any swabs accurately, 49% estimated one or two swabs accurately, 12% estimated three out of four swabs accurately, and only one participant estimated all four swabs accurately.

On analysis of the individual swab estimates, the first raytex swab (20 ml) had a median estimate of 50 ml (IQR 20–55 ml; SD 49.96), the second raytex swab (80 ml) had a median of 100 ml (IQR 60–200 ml; SD 106.49), the third swab (abdominal) (80 ml) had a median of 150 ml (IQR 100–250 ml; SD 118.62), and the final abdominal swab (200 ml) had a median of 250 ml (IQR 150–400 ml; SD 195.79) (Figure 1).

This study had a Wald statistic of 26.68 ($p < 0.001$) with surgeons obtaining a rate of accuracy of 23.8% and the anaesthetists obtaining a rate of accuracy of 31.6% ($\chi2(1) = 3.00$, $p = 0.083$). Medical officers and registrars obtained a 26.4% rate of accuracy in comparison to specialists with 30.8% ($\chi2(1) = 0.95$, $p = 0.329$). Participants with more than ten years' experience achieved a 33% rate of accuracy versus those with less than ten years' experience who had 25.8% ($\chi2(1) = 2.73$, $p = 0.098$).

The coefficients of the five predictors have positive regression slopes indicating that higher predictor scores are associated with higher probabilities of correct estimates. However, only the coefficients for the medium and high blood level predictors are significant ($Z = 2.84$, $p < 0.01$; $Z = 4.84$, $p < 0.001$, respectively). Their coefficient values of 1.00 and 1.91 indicate the predicted change in logits per unit increase in these significant predictor variables. Of all the predictors, the 200 ml abdominal swab indicates the greatest change in the logits, the greatest change in the probability of a correct estimate of blood level relative to an incorrect estimate.

The odds ratios show a synonymous interpretation with the high blood concentration level predictor having the highest odds

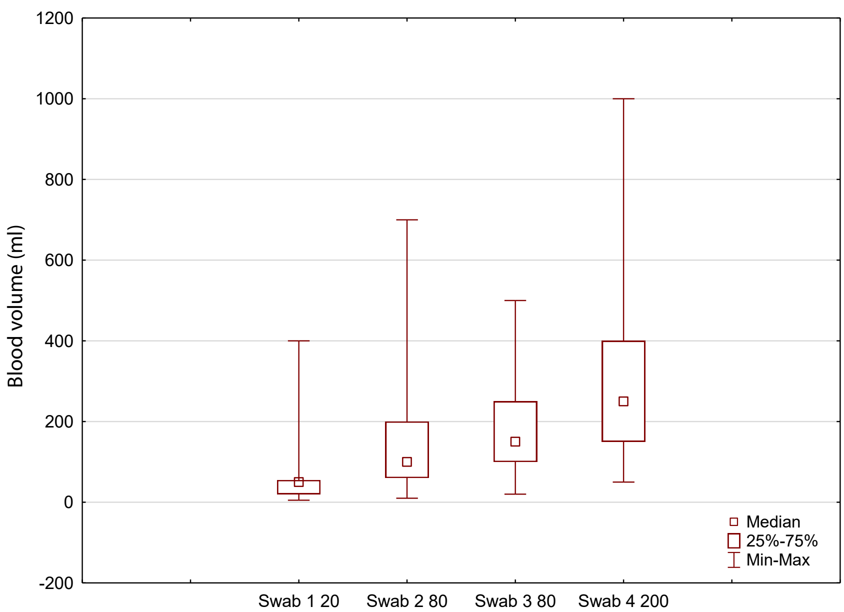
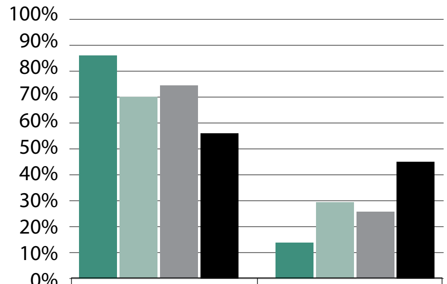


Figure 1: The box and whisker plots display the distributions of the observed estimates



	Incorrect	Correct
	Within 25%	
Swab 1 20	86%	14%
Swab 2 80	70%	30%
Swab 3 80	74%	26%
Swab 4 200	56%	44%

Figure 2: The distribution of correct and incorrect estimates per swab for a 25% scoring criterion

ratio (6.77). Thus, for every one unit increase of 200 ml blood, the predicted odds of a correct estimate are 6.77 greater than the odds of an incorrect estimate.

Discussion

Results of this study showed a 28.5% rate of accuracy using a 25% variance. This is in keeping with prior research that indicate that doctors are inaccurate when visually estimating blood loss.[6-9]

Anaesthetists were found to be slightly more accurate than surgeons (31.6% vs 23.8%). Accuracy also improved with experience as demonstrated by groups with specialist rank as well as those with ten or more years' experience. The fact that experience was shown to have a positive influence on accuracy is contrary to the most current research studies.[6-8]

One of the most significant findings of this study was that the odds of correct estimation increased with soaked blood volume by a factor of 6.77 by every one unit increase of 200 ml. This indicates that doctors are more accurate at high blood loss estimates which is an important finding as this suggests that doctors are making appropriate decisions during major surgery.

Rothermel and Lipman[4] conducted a cross-sectional study with 60 participants. The participants evaluated operative simulations soaked with known volumes of porcine blood. Survey forms were completed to include participant experience, speciality and estimates. Similar studies were done by Dildy et al.[12] with 53 participants and Homcha et al.[13] with 46 participants. Each of these studies found that visual estimation of blood loss is unreliable and inaccurate, irrespective of discipline or experience. However, these studies had relatively small study populations comprising nurses, students, anaesthetic assistants and scrub technicians in addition to doctors making their populations highly varied in terms of training and experience. This current study included 104 doctors with 50% being specialists, making the population very homogeneous in terms of experience and training.

Taking these findings into account, the magnitude of inaccuracy of blood loss estimation could be detrimental to healthcare in South Africa. In a country that is financially and resource strained, a cost-effective solution needs to be explored.

Several studies show improvement in blood loss estimation among participants when they are exposed to visual analogue scales or teaching.[12,13] Dildy et al.[12] subjected their study population to a 20-minute didactic session whereby a Microsoft® PowerPoint (Microsoft Corporation, Redmond WA) slide presentation was used as a tool to teach blood loss estimation, comparing the participants' performance before and after teaching. The presentation included mathematical formulae to calculate the volume of simple objects, the volumes of familiar objects were displayed as well as techniques to estimate the soaked blood volume contained within common theatre materials. Dildy et al.[12] achieved a significant improvement in per cent error in five of the seven blood loss estimation scenarios after the didactic teaching session. Homcha et al.[13] exposed their study population to a caesarean delivery blood loss scene, before and after showing them an educative pictorial on blood loss estimation. After this intervention, the number of participants estimating within 5% of the actual volume, increased from 7% to 24%. Algadiem et al.[14] determined the absorptive capacity of different sizes of surgical gauze and Bose et al.[15] developed a pictorial guide with common theatre blood loss scenarios, thus creating a knowledge base which can be adapted at local institutional level. Placing pictorial guides in theatres could serve as a cheap and accessible way to improve blood loss estimation and misuse of blood products by all theatre users.

Study limitations

Owing to the COVID-19 pandemic, this study was performed electronically and remotely as opposed to in a clinical setting to avoid placing the participants and researchers at risk of COVID-19 infection. As a result, swab size and estimates may have been influenced by scale and the limitations of the participants' computer or mobile device quality as well as the quality of the photographic equipment used. Our achieved rate of accuracy could have been influenced by technical factors such as the study being conducted online and not in person, thus not simulating a real-life clinical scenario. A question of validity could also have been introduced into the study, as participants used different electronic devices to complete the survey, with differing display qualities that could have influenced their competency. However, we attempted to reduce validity issues through open swab layout with photographs captured with ruler for scale in a standard manner for all swabs. The use of a different brand of swabs from that which the participants are accustomed to, as well as educational or exposure factors, including the variability of teaching among the different medical disciplines partaking in the study and their various experience levels could have influenced the outcome.

The surgical group comprised multiple surgical disciplines from various institutions, thus the performance of bigger disciplines could possibly skew the results of the study population. It was challenging to compensate for this as the surgical departments vary in size.

Conclusion

Anaesthetists and surgeons are mostly inaccurate at visually estimating blood loss. This is minimally influenced by their medical discipline, rank or experience, but their accuracy increased with higher estimates. Knowing when to transfuse is important, as blood products are a scarce commodity with inherent risks. Blood products, when misused can pose significant danger. Thus, ways to improve accuracy need to be sought.

Research shows the value of visual scales and teaching as a cost-effective, practical tool to improve accuracy. This is easy to implement, both in theatres and within academic departmental meetings, and could possibly be a source for follow up research on this topic.

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Conflict of interest
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Ethical approval
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