Use of a visual aid to improve estimation of blood loss in obstetrics

N Makhubo,[1] BSc (Physiology), MB BCh; **J D Makin**,[2] MB BCh, BSc Hon (Epidemiol Biostat);
S Adam,[1] MB ChB, FCOG (SA), MMed (UP), Cert Mat Fetal Med (SA), PhD (UP)

[1] *Department of Obstetrics and Gynaecology, Faculty of Health Sciences, University of Pretoria, Pretoria, South Africa*
[2] *Medical Research Unit for Maternal and Infant Health Care Strategies, University of Pretoria*

***Corresponding author**: S Adam (sumaiya.adam@up.ac.za)*

Background. Postpartum haemorrhage (PPH) remains one of the most significant causes of maternal morbidity and mortality. In South Africa (SA) it is the second leading cause of maternal death. Educational programmes, such as visual aids, can improve the estimation of blood loss and subsequently improve clinical judgement and intervention.
Objective. To assess any improvement in blood loss estimation after the introduction of a visual aid.
Methods. We conducted an intervention study at the University of Pretoria Academic Complex and included the Departments of Obstetrics and Gynaecology and Anaesthesiology. The visual aid was created using surgical materials and expired blood from the SA National Blood Services. A pre-intervention objective structured clinical examination (OSCE) was conducted with various blood volumes. Thereafter, the visual aid was made available to all study participants. Nine months later, a second OSCE was conducted.
Results. Eighty-two participants were recruited and 21 were lost to follow-up. Sixty-one participants were included in the analysis. The overall score from the initial OSCE improved from 4.7500 to 5.6393 on the second OSCE (p=0.003). Participants tended to move from underestimation to either overestimation or accurate estimation of blood loss. The consultant group of participants were the most accurate in estimating blood loss (p=0.450).
Conclusion. The use of a visual aid can improve the estimation of blood loss by healthcare professionals, thus potentially improving resuscitation, and impacting positively on maternal morbidity and mortality associated with PPH, while improving the use of resources.

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Postpartum haemorrhage (PPH) remains one of the most significant causes of maternal morbidity in both developing and developed countries, with a global prevalence of 6%. It is also a significant cause of maternal deaths in developing countries, with Africa and Asia accounting for 30% of cases of PPH-related deaths globally.[1-4] In South Africa (SA), the 2013 Saving Mothers Report reported that PPH was the second leading cause of maternal death after sepsis. The main challenge contributing to the high incidence of PPH was the delayed referral from the primary level of care to tertiary institutions; approximately 80% of deaths were thought to have been preventable.[2,3]

Prevention of PPH and early intervention for cases of PPH are the most effective measures to combat this problem. One challenge in attaining the second goal is that, prior to an intervention occurring, a correct estimation of blood loss needs to be made. Visual estimation is the main method used to estimate blood loss in obstetrics leading to interventions such as blood transfusion. Studies have demonstrated that the visual estimation of blood loss is inaccurate. Visual estimation can underestimate blood loss by up to 33 - 50%.[5-7]

In studies comparing the assessment of different specialities, surgeons generally underestimated blood loss while anaesthetists tended to overestimate; also, small blood volumes, e.g. <50 mL, were more likely to be overestimated while large blood volumes, e.g. >1 000 mL were often underestimated.[5-7] Underestimation of blood loss results in a delay in the implementation of the necessary intervention, while overestimation will often lead to wastage of scarce resources, especially in under-resourced settings.

Studies have shown that education programmes, be they web-based or using interventions like a visual aid, can improve the estimation of blood loss and subsequently improve clinical judgement and intervention. These education programmes are institution-based and not easily transferrable, hence the need for the study in each institution.[5]

Objective

The aim of our study was to assess if there would be any improvement in blood loss estimation after the introduction of a visual aid.

Methods

We conducted an intervention study at the hospitals in the University of Pretoria Academic Complex, which includes the Kalafong Tertiary Academic and Steve Biko Academic Hospitals, in the Departments of Obstetrics and Gynaecology and Anaesthesiology. The intervention was a visual aid that was created using materials commonly used in a labour ward and expired blood from the SA National Blood Services (SANBS). Images were then taken to create the visual aid (Fig. 1).

Participants included in the study were consultants, registrars, interns and midwives who worked in these departments and were involved in the management of obstetric patients. Second-year interns and final-year registrars who would not be available for the duration of the study were excluded.

The study was conducted using two objective structured clinical examinations (OSCEs). The first OSCE was conducted prior

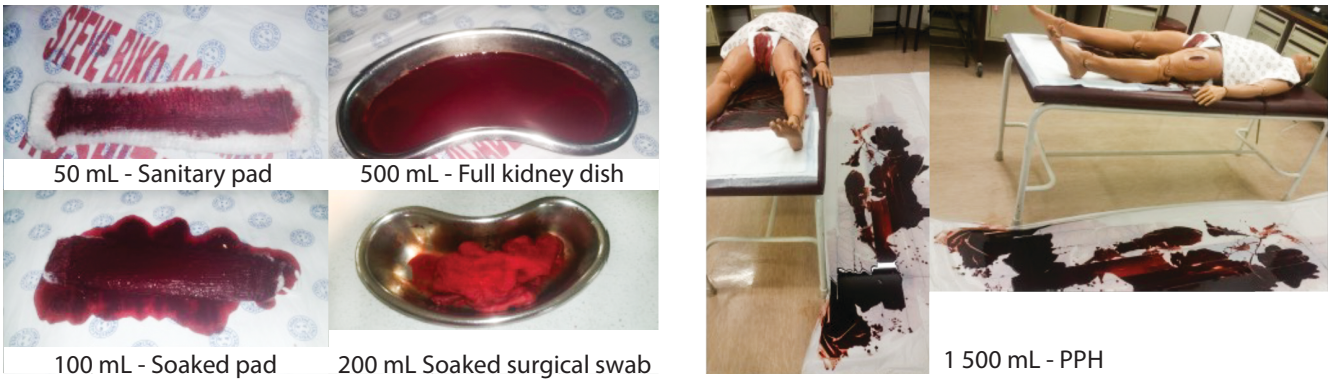

Fig.1. Visual aid with known blood volumes. (PPH = postpartum haemorrhage.)

to introduction of the intervention in November 2015. This OSCE had 5 stations with the following volumes of blood:

- Station 1: Pad with 30 mL of blood
- Station 2: Soaked pad with 80 mL of blood
- Station 3: Half-soaked swab with 100 mL of blood
- Station 4: Kidney dish with 350 mL of blood
- Station 5: Picture with 1 500 mL of blood on the bed and the floor.

Participants completed a questionnaire with demographic information and their estimation of blood loss at each station. Participants were not informed about the outcome of the OSCE. Thereafter, posters of the visual aid were put up in all labour rooms and obstetric theatres at both hospitals. In addition, all participants were provided with a pocket-sized version of the visual aid (Fig. 1). The second OSCE was conducted in August 2016, 9 months after introduction of the visual aid.

Nine months later, the same individuals were asked to participate in a second OSCE with the following blood volumes. Of note is that these volumes were not identical to the volumes used in OSCE 1:

- Station 1: Pad soaked with 20 mL blood
- Station 2: Pad soaked with 40 mL of blood
- Station 3: Swab soaked with 100 mL of blood
- Station 4: Kidney dish with 100 mL of blood
- Station 5: PPH image depicting 1 200 mL blood loss

A study number was allocated to each candidate and the same number was used to identify participants in both OSCEs. No new candidates were included in the second OSCE. Participants who did not complete the second OSCE were excluded from the study as paired data were not available for comparison.

Data were entered into an Excel spreadsheet, corrected for inaccuracies and exported to SPSS version 23.0 (IBM Corp., USA) for analysis. The answers to all the OSCEs were classified as follows: accurate if the estimation was between -20% and +20% of the actual blood volume; overestimation if it was >20% of the blood volume; and underestimation if it was <20% of the correct blood volume. This classification follows that used by Zuckerwise *et al.*[8]

Frequencies and proportions were used to describe the levels of inaccuracy of blood loss estimation by clinicians and at what levels of blood loss difficulties exist. We compared the OSCE results to ascertain whether there was any difference in estimations, pre- and post-intervention in terms of estimation, by means of cross tabulation. A score was created by assigning points to the categories of estimation, i.e. 0 - underestimation, 1 - overestimation, and 2 - accurate. The reasoning behind this was that overestimation was deemed 'safer' than underestimation. The pre- and post-test OSCE scores were compared by means of a paired *t*-test.

The effect of years of experience, category of the healthcare worker and department (obstetrics and gynaecology v. anaesthesiology) were assessed by means of Pearson correlations, one-way analysis of variance (ANOVA), and independent sample *t*-tests as appropriate. These variables were then entered into a repeated measures mixed linear analysis to assess whether they had a significant independent effect on the score as a whole. A *p*-value <0.05 was considered significant.

Ethical approval for the study was obtained from the University of Pretoria, Faculty of Health Sciences Ethics Committee (ref. no. 292/2015) and from the SANBS Ethics Committee. Informed consent was obtained from the participants prior to inclusion into the study.

Results

There were 82 participants in the first OSCE. Twenty-one (25.6%) participants were lost to follow-up. Sixty-one (74.4%) participants were included in the analysis. Fifty-three (86.9%) participants were from the Department of Obstetrics and Gynaecology and 8 (13.1%) participants were from the Department of Anaesthesiology. There were 13 (21.35%) consultants, 18 registrars (29.5%), 11 interns (18%) and 19 midwives (31.1%). Thirty-nine (63.9%) participants had between 1 - 5 years of experience, with a range of between 1 and 40 years of experience (median 4 years) (Fig. 3).

Table 1 illustrates the comparison of the pre- and post-intervention OSCE. Initially with a small blood volume (Station 1), most participants (n=40; 65%) overestimated the blood loss, while 14 (22.9%) underestimated blood volume. Only 6 (9.8%) participants were accurate. Post-intervention we found that 52 (85.2%) participants now overestimated blood loss, 6 (9.8%) remained accurate, and only 3 (4.9%) participants underestimated blood loss.

In Station 2 initially, 35 (57.4%) participants overestimated blood volume, 20 (32.8%) underestimated blood loss and 6 (9.8%) were accurate in their estimation. Post-exposure, 57 (93.4%) of the participants overestimated, 3 (4.9%) were accurate and only 1 (1.6%) underestimated blood volume.

For the estimation of moderate blood loss (Station 3), pre-intervention, 47

(77%) participants overestimated, 12 (19.7%) were accurate and 2 (3.3%) underestimated. Post-intervention, 42 (68.9%) participants overestimated, 18 (29.5%) were accurate, and 1 (1.6%) underestimated blood volume.

In Station 4, most participants (n=35; 57.4%) underestimated blood loss initially, 15 (24.6%) overestimated, while 11 (18%) were accurate. Post-intervention, 48 (78.7%) participants overestimated, while 11 (18%) were accurate and only 1 (1.6%) underestimated blood volume at this station.

In the case of massive blood loss (Station 5), 31 (50.8%) participants underestimated, 18 (29.5%) overestimated, and 11 (18%) were accurate. Post-intervention, 42 (68.9%) overestimated, 13 (21.3%) were now accurate and only 6 (9.8%) underestimated blood loss.

On analysis, the overall score from the initial OSCE (4.7500) improved to 5.6393 on the second OSCE (p=0.003). Participants tended to move from underesimation to either overestimation or accurate estimation of blood loss (Table 2).

It was found that blood loss estimation was inversely related to the number of years of experience; that is, the more experience a participant had, the less accurate was the blood estimation (p=0.006). However, of note is that the years of experience includes all the categories, from midwives to consultants.

When assessing categories separately in both departments, it was noted that the consultant group (including Department of Obstetrics and Gynaecology and Anaesthesiology) was the most accurate group in visually estimating blood loss. These values were, however, not statistically significant (p=0.450). Comparison between the two departments showed that the Department of Anaesthesia (95% CI 0.341 - 1.940) was more accurate in visual estimation of blood loss than the Department of Obstetrics and Gynaecology (mean (SD) difference 1.141 (0.399); 95% CI 0.341 - 1.940; p=0.006).

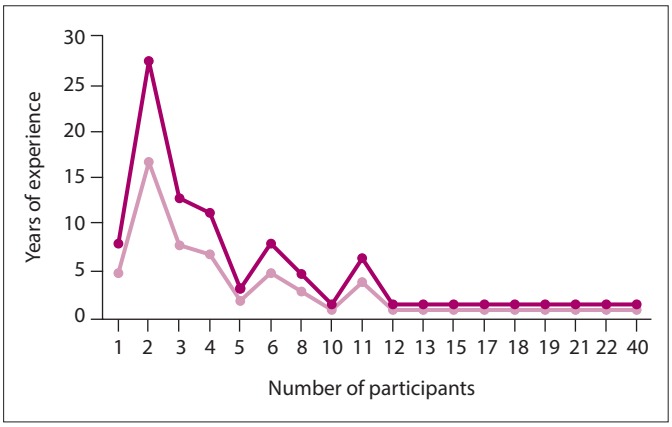

Fig. 2. Years of experience of participants.

Table 2. Score improvement (N=61)

	Frequency, n (%)
Worse	19 (31.1)
Stayed the same	13 (21.3)
Improved	29 (47.5)

Discussion

Visual blood loss estimation has been reported to be very inaccurate in numerous studies. Most studies demonstrated that there is a tendency to underestimate large blood volumes, i.e. more than a 1 000 mL, and a tendency to overestimate volumes that are less than 50 mL.[4,5] This is similar to the findings in our study. Since small blood volumes were used in both OSCEs it was noted that there was a tendency to overestimate blood loss as noted in most of our stations. The tendency to overestimate was more evident in the second OSCE, in which most participants who had initially underestimated, were now overestimating blood loss.

For practical purposes, underestimating blood loss is worse than overestimating blood loss, since the former results in less reaction, or delayed reaction to postpartum haemorrhage, and thus under-resuscitation of the bleeding patient. Whilst overestimating is not as desirable as accuracy, it is safer, since it leads to over-resuscitation, which can decrease mortality as well as morbidity. Therefore, this means the intervention has sensitised most of our participants to err on the side of caution and react quicker to acute blood loss. This, however, does have undesirable consequences such as unnecessary expenditure, especially when scarce commodities such as blood products are consumed.

Studies have demonstrated that the visual aid or other educational programmes results in an improvement in blood loss estimation.[5-8] This was also seen in our study group. The overall scoring in all stations demonstrated an improvement in estimation of blood loss, when comparing the two OSCEs. In our study, the constant exposure to the visual aid in labour ward and theatre may have contributed to the improved blood loss estimation. This gave our midwives, registrars and interns an opportunity to educate themselves each time they were working in the labour ward or the obstetric theatre. The long duration of exposure, i.e. nine months, is a lengthy period for education and remediation. The provision of a pocket visual aid to our participants probably contributed to the improvement as well, since they had it available as an easy reference throughout the 9-month period.

Some studies noted there was no difference in the accuracy of blood loss estimation when comparing years of experience.[7-10] In our study there was a statistically significant difference noted in estimating blood loss, with an inverse relationship when comparing

Table 1. Overall comparisons of the estimations of the first and second OSCE results (N=61)

	OSCE 1			OSCE 2		
Station number	**Overestimation, n (%)**	**Underestimation, n (%)**	**Accurate, n (%)**	**Overestimation, n (%)**	**Underestimation, n (%)**	**Accurate, n (%)**
1	40 (65.6)	14 (23)	7 (11.5)	52 (85.2)	3 (4.9)	6 (9.8)
2	35 (57.4)	20 (32.8)	6 (9.8)	57 (93.4)	1 (1.6)	3 (4.9)
3	47 (77.0)	2 (3.3)	12 (19.7)	42 (68.9)	1 (1.6)	18 (29.5)
4*	15 (24.6)	35 (57.4)	11 (18.0)	48 (78.7)	1 (1.6)	11 (18.0)
5*	31 (50.8)	18 (29.5)	11 (18.0)	42 (68.9)	6 (9.8)	13 (21.3)

OSCE = objective structured clinical examination.
*Only 60 participants completed Station 4 in the post-exposure OSCE (i.e. OSCE 2) and Station 5 in the pre-exposure OSCE (i.e. OSCE 1).

years of experience with accurate estimation of blood loss. However, the group with more years of experience, that is, more than five years' experience, were mainly midwives. When comparing categories exclusively, it was noted that the consultant category had the highest score; however, the result was not statistically significant. We would theoretically expect this group to estimate more accurately, since practically speaking, they have more experience. It needs to be noted however, that that the consultant group also included consultants from both departments (Obstetrics and Gynaecology and Anaesthesiology).

The literature reports that surgeons tend to underestimate blood loss as opposed to anaesthetists who usually overestimate blood loss.[7,8] In our setting, the anaesthetists had a significantly higher overall score compared with the Department of Obstetrics and Gynaecology. This may be attributed to the anaesthetists working with a variety of surgeons and estimating various volumes of blood loss on a daily basis, or the surgeons preferring a lower documented blood loss, to the detriment of the patient. The smaller number of anaesthetists in our study and the inclusion of midwives in the obstetric group may have influenced this outcome.

In our study, we are uncertain regarding whether the visual aid pocket card or the charts had a greater impact. The charts were posted in labour ward and in theatre. This was advantageous as these are the sites where blood loss is estimated. The advantage of the pocket-sized chart was that it was always with the individual.

It is of interest, yet not surprising, that most of our participants shifted from under- to overestimation, since we used small volumes in both our OSCEs due to practical considerations. There is a shortage of blood products and we could only secure a limited amount of expired blood per OSCE.

Health professionals tend to overestimate small blood volumes (<50 mL) and underestimate large volumes (>1 000 mL).[5-8] Hence, it was not surprising that most of the volumes were overestimated, and that there was a shift from underestimation to overestimation post-intervention. This shift is particularly important because overestimation as opposed to underestimation is preferable, since morbidity and mortality can be prevented int the event of an overestimation of blood loss.

Overall, our study is in keeping with findings in previous studies that teaching programmes, be it a visual aid, as in our case, or computer programmes, can lead to improvement in the estimation of blood loss. However, what needs to be remembered is that education is institution-dependent and ongoing.

The strength of our study is that we included a range of healthcare workers, including midwives, with varying levels of experience. We also used human blood rather than artificial blood or its equivalent in our OSCEs and visual aids.

Study limitations

Limited matched data were available for analysis, owing to the significant loss to follow-up. This could be due to the long period between the two OSCEs. The other limitation was the type of blood used. As whole blood is expensive and a scarce resource, we used expired red cell concentrate which is concentrated compared with whole blood which also includes plasma.

We also noted that 31% of participants did not improve in this study, though 47% did. This suggests that the visual aid intervention still needs improvement; this might be either by using a greater range of blood loss images (we have already acknowledged that there were a number of images with limited blood loss due to the limited amount of expired blood available), or perhaps by some other adjustment of the intervention.

Conclusion

The use of a visual aid can improve the estimation of blood loss by healthcare professionals. We have demonstrated that a visual aid can be developed for each institution. This holds the potential to improve resuscitation and thus decrease maternal morbidity and mortality associated with PPH underestimation, and to decrease unnecessary intervention and the use of scarce resources by overestimation.

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