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Improving the accuracy of estimated blood loss at obstetric haemorrhage using clinical reconstructions

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Objectives Following the results of the Confidential Enquiries into Maternal Deaths report, which claims two maternal deaths annually in the UK from postpartum haemorrhage, our aim was to assess the accuracy of 'visual estimation of blood loss' and produce suitable pictorial and written algorithms to aid in the recognition and management of massive obstetric haemorrhage.

Design Observational study to determine discrepancy between actual blood loss (ABL) and estimated blood loss (EBL).

Setting Teaching hospital.

Population Hundred and three obstetricians, anaesthetists, midwives, nurses and healthcare assistants.

Methods Clinical scenarios were reproduced in the form of 12 Objective Structured Clinical Examination (OSCE) style stations augmented with known volumes of whole blood. Individual staff estimated the blood loss visually and recorded their results. Digital photographs were used to produce a pictorial 'algorithm' suitable for use as a teaching tool in labour ward.

Main outcome measures Areas of greatest discrepancy between EBL and ABL.

Results Significant underestimation of the ABL occurred in 5 of the 12 OSCE stations: 500-ml (50-cm diameter) floor spill, 1000-ml (75-cm diameter) floor spill, 1500-ml (100-cm diameter) floor spill, 350-ml capacity of soaked 45- × 45-cm large swab and the 2-l vaginal postpartum haemorrhage on bed/floor.

Conclusions Accurate visual estimation of blood loss is known to facilitate timely resuscitation, minimising the risk of disseminated intravascular coagulation and reducing the severity of haemorrhagic shock. Participation in clinical reconstructions may encourage early diagnosis and prompt treatment of postpartum haemorrhage. Written and pictorial guidelines may help all staff working in labour wards.

Keywords Guideline, haemorrhage, obstetric.

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Introduction

'Why Mothers Die' 2000–2002 revealed a striking increase in the number of maternal deaths resulting from postpartum haemorrhage (PPH), from one case in 1997–99 to ten cases in the latest triennium.[1] Life-threatening obstetric haemorrhage occurs in approximately 1 per 1000 deliveries.[2] The importance of accurate estimation of blood loss, prompt recognition and treatment of clotting disorders, early involvement of a consultant haematologist, involvement of a consultant anaesthetist in resuscitation, use of adequately sized intravenous cannulae and precise monitoring of central venous pressure have all been repeatedly advocated. Introduction of specialised obstetric anaesthetists, labour ward protocols, participation in regular 'fire drills' and improved obstetric training have gone part way to addressing these important issues; yet, visual estimation of blood loss at vaginal and abdominal delivery remains inaccurate.[3]

Physiological adaptation of the cardiovascular system in pregnancy results in a 48% increase in plasma volume from 2600 ml to 3850 ml, relatively exceeding that of the 17% increase in red cell mass from 1400 ml to 1640 ml.[4] The protective haemodilution initiates a fall in haemoglobin, haematocrit and red cell count but maintains mean corpuscular volume and mean corpuscular haemoglobin concentration.[5] Circulating blood volume rises by 37% from approximately 4000 ml to 5500 ml, providing not only adequate placental perfusion but also a compensatory reserve such that a healthy woman can usually tolerate acute losses at delivery of up to 1000 ml.

Shock is defined as a profound haemodynamic and metabolic disturbance characterised by failure to maintain tissue perfusion.[4] Hypovolaemic shock in the nonpregnant individual presents with a deterioration in vital signs (tachycardia, hypotension and a falling urine output), but as a consequence of physiological adaptation, these vital signs become relatively insensitive during pregnancy. Tachycardia does not develop until blood loss exceeds 1000 ml[6] and blood pressure is usually maintained in the normal range well beyond this level. The relative masking of signs during pregnancy hinders recognition of hypovolaemia and delays treatment, resulting in further blood loss and increased risk of haemorrhagic shock. Consequently, hypovolaemic women who begin to decompensate, as evidenced by hypotension, will deteriorate extremely rapidly.

Provided that intravascular volume remains adequate for perfusion, a haemoglobin concentration of 7 g/dl (equivalent to a haematocrit of 0.21) has been shown to provide sufficient oxygen carrying capacity to maintain cardiopulmonary function.[7] Treatment of haemorrhagic shock requires initial restoration of intravascular volume and judicious transfusion of blood products. Concerns regarding infection, transfusion reactions and cost, however, have resulted in a recent fall in transfusion rates.[8] Furthermore, recent governmental measures to minimise the risk of transmission of variant Creutzfeldt-Jakob Disease (vCJD) through blood transfusion has reduced the number of suitable blood donors and the Department of Health have therefore advocated a reduction in use of blood products.[9]

Accurate visual estimation of cumulative blood loss forewarns of impending haemorrhagic shock. Estimates of blood loss by paramedics[10] and surgeons[11] are inaccurate, and studies following vaginal[12] and abdominal delivery[13] show visual estimation to be of limited clinical use. Menstrual pictograms to facilitate the assessment of menorrhagia in the field of gynaecology[14] have now been produced; however, little pictorial data yet exist to facilitate similar estimations of blood loss in obstetrics.

The aims of this study were to identify areas of greatest discrepancy between estimated blood loss (EBL) and actual blood loss (ABL) and thus identify those clinical scenarios where inaccurate estimation of blood loss is most likely to occur. From these observations, we planned to produce simple written and pictorial guidelines that would facilitate accurate visual estimation of blood loss at obstetric haemorrhage.

Methods and materials

Blood products

Fifteen units of whole blood were generously donated from clinically unusable stocks from the National Blood Service Centre in Colindale. Blood was stored at 4°C, transported from the laboratory to the study area on the morning of the experiment and allowed to reach room temperature. Disposal of contaminated materials was performed according to hospital policy.

Clinical stations

Twelve everyday clinical scenarios during which routine estimation of blood loss is required were devised and reconstructed in the form of OSCE stations (Table 1). Standard labour ward equipment was utilised to replicate a clinical scenario and each station was augmented with predetermined volumes of whole blood. Stations were photographed for future teaching purposes using a Nikon Coolpix 995 digital camera (Nikon, Tokyo, Japan) (Figure 1A–I). Throughout the experiment, appropriate precautions were taken to avoid spillage and prevent contamination according to local health and safety regulations.

Stained maternity pad and saturated maternity pad

A standard absorbency maternity pad (Robinson Healthcare Ltd, Worksop, UK) was partially stained (30 ml) and saturated to capacity (100 ml) using whole blood. The pads were placed on a flat, nonabsorbent, numbered surface.

Floor spills of 50-cm, 75-cm and 100-cm diameter

Large areas of floor were covered in protective polythene sheeting and 500 ml, 1000 ml and 1500 ml of blood were poured into discrete puddles (these produced floor spills measuring 50 cm, 75 cm and 100 cm in diameter, respectively). Blood was poured centrally from measuring jugs and allowed to spread evenly in a circular pattern across the floor. A standard metre-long paper tape measure was then sellotaped to the floor to provide scale.

Kidney dish

A sterile kidney dish was removed from a standard delivery pack and placed on a flat surface. Five-hundred millilitres of whole blood was poured into the dish and allowed to clot.

Stained incontinence pad

A single-absorbent incontinence pad (75 × 57 cm, Warden Dressings Co., Hexam, UK), used routinely in labour ward to keep the bed, bed sheets and patient dry, was placed on the floor and soiled with 250 ml of blood.

Bedpan

Standard plastic bedpan containing 100 ml of clotted blood.

Surgical swabs

Small (10 × 10 cm 32 ply) and large (45 × 45 cm 12 ply) swabs used routinely at caesarean section (Detex by Vernon-Carus

Table 1. Median EBL (1st, 3rd quartiles)

	Anaesthetist	Obstetricians	Gynae nurse	Midwife	Theatre nurse	HCA
60-ml small swab	50 (25,75)	50 (20,85)	50 (30,60)	50 (30,80)	45 (29,125)	80 (25,200)
*350-ml large swab	200 (163,300)	150 (100,250)	200 (115,275)	200 (135,250)	300 (200,350)	175 (119,269)
500-ml kidney dish	850 (712,975)	800 (500,1000)	575 (500,1000)	550 (400,800)	625 (500,1500)	475 (225,575)
30-ml sanitary pad	45 (33,50)	27 (20,50)	50 (40,50)	50 (30,88)	20 (20,40)	30 (23,30)
*500-ml floor spill	250 (200,300)	220 (150,400)	220 (175,750)	200 (175,750)	275 (188,463)	100 (100,300)
*1000-ml floor spill	450 (363,600)	400 (200,750)	300 (200,550)	350 (250,500)	450 (400,750)	350 (200,875)
*1500-ml floor spill	875 (525,1500)	600 (400,1000)	1000 (488,1500)	600 (400,900)	1000 (600,1500)	750 (250,1175)
100-ml sanitary pad	100 (93,150)	70 (50,114)	100 (79,113)	100 (80,200)	70 (50,300)	75 (50,100)
250-ml incopad	325 (250,463)	250 (100,300)	225 (95,363)	200 (150,300)	275 (175,500)	170 (140,238)
1000-ml PPH on bed	1100 (925,1500)	1000 (1000,1200)	1000 (650,1575)	1000 (725,1500)	850 (550,1500)	925 (438,563)
*2000-ml PPH bed/floor	2000 (2000,2500)	2000 (1300,2500)	1875 (1350,2000)	1500 (1100,2000)	1200 (950,2000)	900 (800,1000)
100-ml bedpan	200 (150,340)	200 (138,363)	100 (85,200)	150 (100,250)	200 (138,275)	50 (50,300)

HCA, healthcare assistant.
*Significant underestimation, $P < 0.05$.

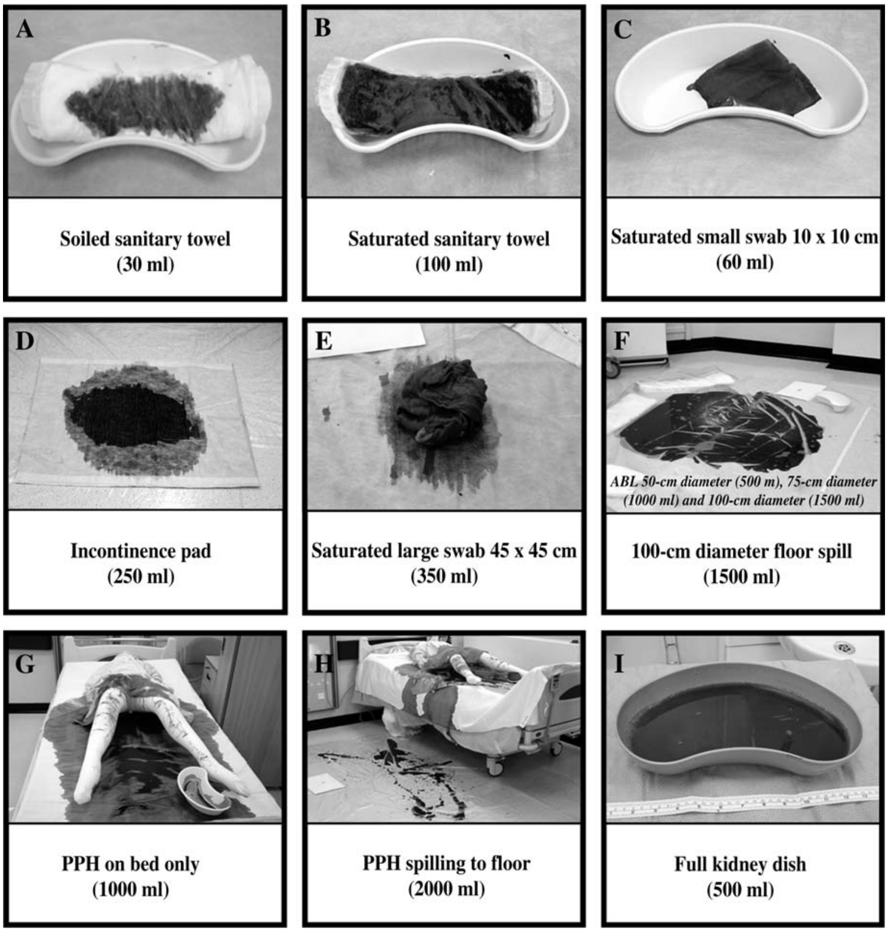

Figure 1. Pictorial Guidelines to facilitate visual estimation of blood loss at obstetric haemorrhage.

Table 2. Median percentage error (1st, 3rd quartile) by professional group

n = 103	Anaesthetist, *n* = 9	Obstetrician, *n* = 24	Gynae nurse, *n* = 11	Midwife, *n* = 42	Theatre nurse, *n* = 12	HCA, *n* = 5	Median EBL (%)
*1-l floor spill	−55% (−64, −40)	−60% (−80, −25)	−70% (−80, −45)	−65% (−75, −50)	−55% (−60, −25)	−65% (−80, −13)	−62
*500-ml floor spill	−50% (−60, −40)	−56% (−70, −20)	−56% (−65, 50)	−60% (−66, −40)	−45% (−63, −8)	−80% (−80, −20)	−58
*1.5-l floor spill	−42% (−65, 0)	−60% (−73, −33)	−33% (−68, 0)	−60% (−73, −40)	−33% (−60, 0)	−50% (−83, −22)	−46
*350-ml large swab	−43% (−54, −14)	−57% (−71, −29)	−43% (−67, −21)	−43% (−61, −29)	−14% (−43, 0)	−50% (−66, −23)	−42
*2-litre PPH	−0% (0, 25)	−0% (−35, 25)	−6% (−33, 0)	−25% (−45, 0)	−40% (−53, 0)	−55% (−60, −50)	−21
100-ml sanitary pad	0% (−8, 50)	−30% (−50, 50)	0% (−21, 13)	0% (−20, 100)	−30% (−50, 200)	−25% (−50, 0)	−14
60-ml small swab	−17% (−58, 25)	−17% (−67, 42)	−17% (−50, 0)	−17% (−50, 33)	−25% (−52, 108)	33% (−58, 233)	−10
250-ml incopad	30% (0, 85)	0% (−60, 20)	−10% (−62, 45)	−20% (−40, 20)	10% (−30, 100)	−32% (−44, −5)	−4
1-litre PPH	10% (−8, 50)	0% (0, 20)	0% (−35, 58)	0% (−28, 50)	−15% (−45, 50)	−8% (−56, 0)	−2
30-ml sanitary	50% (8, 67)	−10% (−33, 67)	67% (33, 67)	67% (0, 192)	−33% (−33, 33)	0% (−25, 0)	23
500-ml kidney dish	70% (43, 95)	60% (0, 100)	15% (0, 100)	10% (−20, 60)	25% (0, 200)	−5% (−55, 15)	29
100-ml bedpan	100% (50, 240)	100% (38, 263)	0% (−15, 100)	50% (0, 150)	100% (38, 175)	−50% (−50, 200)	50
Mean median error by profession (%)	4	−11	−13	−14	−13	−32	

HCA, healthcare assistant.
*Significant underestimation, $P = 0.03125$.

Ltd, Preston, Lancs, UK) were soaked to capacity in whole blood for several minutes, removed to drain off excess blood and then placed on a flat surface adjacent to a similar, dry, unfolded swab for comparison.

Mannequins simulating vaginal PPH on standard delivery bed

Disposable mannequins were clothed in delivery suite gowns and TED stockings and placed on a delivery bed with standard cotton bed sheets to simulate a normal vaginal delivery. Blood was poured over the pelvic area and bed sheet (1000 ml). When a larger volume (2000 ml) of blood was added, blood volume exceeded the capacity of the bed sheets and spilled on to the floor.

Volunteer groups

Participants from six professional groups volunteered to take part in this study. The study lasted a whole weekday morning,

Table 3. Guidelines for visual estimation of blood loss

Small, 10- ×10-cm 32 ply swab (maximum saturated capacity)	60 ml
Medium, 30- × 30-cm 12 ply swab (maximum saturated capacity)	140 ml
Large, 45- × 45-cm 12 ply swab (maximum saturated capacity)	350 ml
1-kg soaked swabs	1000 ml
50-cm diameter floor spill	500 ml
75-cm diameter floor spill	1000 ml
100-cm diameter floor spill	1500 ml
Vaginal PPH limited to bed only	Unlikely to exceed 1000 ml
Vaginal PPH spilling over from bed to floor	Likely to exceed 1000 ml

thus enabling medical, midwifery and nursing staff from both day and night shifts to participate. Staff were invited to visit the study area individually and asked to write their estimates on a preprinted questionnaire. Questionnaires were collected for data analysis. Areas of widest variation between EBL and ABL were targeted as areas of potential risk. Data were entered onto a Microsoft excel spreadsheet (Microsoft Corp., Redmond, WA, USA). Median and interquartile ranges were calculated.

Immediately after participation in the exercise, individuals were taken into a separate room and the ABL at each station was revealed. Inter-observer variations were discussed openly. Individuals were then encouraged to revisit the clinical scenarios with both their own estimates (EBL) and the correct answers (ABL). Informal discussion within groups was encouraged in order to facilitate learning and memory imprinting.

Statistical analysis

In an effort to minimise type II errors, interquartile ranges and error of the median were used for statistical calculation rather than mean and SD. The Wilcoxon signed rank (non-parametric) test was used to compare observed versus expected values. Differences were deemed clinically significant if $P < 0.05$.

Results

One hundred and three questionnaires were collected during the course of the study from six groups of healthcare professionals (Table 1). There was an extremely wide range of observations and the data did not follow a normal distribution. Five of the 12 stations showed statistically significant ($P = 0.03125$) underestimation of actual blood volume (labelled as * in Tables 1 and 2). None of the stations was significantly overestimated.

Discussion

Visual estimation of blood loss following both vaginal and abdominal delivery is notoriously inaccurate[15] and has been shown to be of limited clinical use. The considerable range in EBL recorded by individuals within each professional group (Table 2) highlights the failings of untrained subjective assessment. Overestimates as well as underestimates can have significant clinical implications and both should be considered.

Significant underestimation in the volumes of large floor spillage, large surgical swab capacity and massive PPH was demonstrated by this study. Previous studies confirm that blood loss at vaginal delivery are underestimated by –35% (EBL = 260 ml versus ABL = 401 ml)[3] and that mean ABL at a first caesarean section is in fact 1290 ± 240 ml,[13] significantly more than the EBL recorded by most obstetricians. Losses in excess of 1500 ml predispose to increased risk of severe hypovolaemic shock. If prolonged by delayed or inadequate resuscitation, hypovolaemic shock will trigger disseminated intravascular coagulation and myocardial ischaemia.[16] Consequently, accurate cumulative estimation of blood loss should constitute a vital element of postpartum care.

The maximum capacity of a saturated large 12 ply 45- × 45-cm surgical swab is 350 ml. All professional groups underestimated the capacity of a large swab, most noticeably the obstetricians who were the least accurate (median percentage error = –57%). As swab count is a universal method for estimating blood loss at caesarean section, accurate knowledge of swab capacities is essential. Capacities of various swab sizes are included for reference in Table 3.

Percentage errors ranked by profession (Table 1, bottom row) substantiate the perception that, when specifically compared with other professional groups, such as orthopaedic surgeons,[17] anaesthetists tend to overestimate blood volume ($P = 0.0039$). In this study, the anaesthetists were the most accurate estimators of blood loss, recording a median overestimate of just 4% and the smallest interquartile range. The EBL documented in surgical notes is often inconsistent with the clinical condition of the patient. The anaesthetic tendency to 'overestimate' blood volumes is almost certainly a compensatory response to surgical underestimation. Furthermore, planning of routine postoperative fluid management and fluid management of emergency resuscitations is often the responsibility of the anaesthetist and this may contribute to their 'estimating' skills.

Overestimation of blood volumes can also have significant implications. Unnecessary cross matching of blood wastes valuable time and resources. Blood is becoming an increasingly precious resource and over transfusion of patients, if marked, can result in morbidity as well as unnecessary exposure to the known risks of blood products.[18]

Participation in this simple study provided a valuable learning tool for a variety of healthcare professionals who routinely estimate peripartum blood loss. The equipment required to stage these scenarios was minimal and easily obtained in labour ward. The acquisition of blood products required the cooperation of our consultant haematologist and the local blood service centre based at Colindale. Regulations pertaining to the use of blood products may differ according to region, although replication of these scenarios as a teaching aid should not be problematic. The study took just a few hours to prepare and approximately 30 minutes for participants to complete the questionnaire, obtain appropriate feedback and review their own results. By virtue of the subject matter and realism/novelty of the scenarios, the experiment stimulated much interest among health professionals of all grades. Most claimed to have benefited from the experience and have welcomed a repeat of such an exercise.

Conclusion

Significant discrepancy between EBL and ABL in 5 of the 12 clinical stations reaffirms clinical difficulty in accurately estimating blood loss, particularly in obstetric scenarios. Significant underestimation in three key areas (floor spillages, surgical swab capacity and massive PPH) was identified in all professional groups and a pictorial guideline was produced. A basic algorithm (Table 3) to facilitate future visual estimation is presented here and will be available online via www.bmfms.org.uk. Clinical reconstructions provide a popular and useful learning tool to facilitate the visual estimation of blood loss. Participation in similar reconstructions may also prove beneficial to healthcare professionals in allied surgical specialties.

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References

1 Royal College of Obstetricians & Gynaecologists. *Lemach Why Mothers Die 2000–2002*. London: RCOG, 2004.
2 Drife J. Management of primary postpartum haemorrhage. *Br J Obstet Gynaecol* 1997;104:275–7.
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;38:119–24.
4 Hofmeyr GJ, Mohlala BKF. Hypovolaemic shock. *Best Pract Res Clin Obstet Gynaecol* 2001;154:645–62.
5 Nelson-Piercy C. *Handbook of Obstetric Medicine*, 1st edn. Northampton, UK: Oxford University Press, 1997.
6 Aitkenhead AR, Rowbotham DJ, Smith G. *Textbook of Anaesthesia*, 4th edn. New York, USA: Churchill Livingstone, 2001.
7 Murphy MF, Wallington TB, Kelsey P, Boulton F, Bruce M, Cohen H, *et al*. Guidelines for the clinical use of red cell transfusions. *Br J Haematol* 2001;113:24–31.
8 Ekeroma AJ, Ansari A, Stirrat GM. Reviews—Blood transfusion in obstetrics and gynaecology. *Br J Obstet Gynaecol* 1997;104:278–84.
9 Department of Health. Update on precautions to protect blood supply. 0270. London, UK: Department of Health Publications, 2004.
10 Tall G, Wise D, Grove P, Wilkinson C. The accuracy of external blood loss estimation by ambulance and hospital personnel. *Emerg Med (Fremantle)* 2003;15:318–21.
11 Beer HL, Duvvi S, Webb CJ, Tandon S. Blood loss estimation in epistaxis scenarios. *J Laryngol Otol* 2005;119:16–18.
12 Glover P. Blood loss at delivery: how accurate is your estimation? *Aust J Midwifery* 2003;16:21–4.
13 Read MD, Anderton JM. Radioisotope dilution technique for measurement of blood loss associated with lower segment caesarean section. *Br J Obstet Gynaecol* 1997;84:859–61.
14 Wyatt KM, Dimmock PW, Walker TJ, O'Brien S. Determination of total menstrual blood loss. *Fertil Steril* 2001;76:125–31.
15 Dildy GA III, Paine AR, George NC, Velasco C. Estimating blood loss: can teaching significantly improve visual estimation? *Obstet Gynecol* 2004;104:601–6.
16 Karpati PC, Rossignol M, Pirot M, Cholley B, Vicaut E, Henry P, *et al*. High incidence of myocardial ischemia during postpartum hemorrhage. *Anesthesiology* 2004;1:30–6.
17 Meiser A, Casagranda O, Skipka G, Laubenthal H. Quantification of blood loss. How precise is visual estimation and what does its accuracy depend on? *Anaesthesist* 2001;50:13–20.
18 Stainsby D. ABO incompatible tansfusions—experience from the UK. Serious hazards of transfusion (SHOT) scheme transfusions ABO incompatible. *Transfus Clin Biol* 2005;12:385–8.

