

Pitfalls in Assessing Blood Loss and Decision to Transfer

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INTRODUCTION

It is axiomatic that most postpartum hemorrhage (PPH) occurs unpredictably, and no parturient is immune from its risk. Unlike uterine rupture which can precede death by 24 h and antepartum hemorrhage may lead to death in half that time, PPH most often occurs within 2 h of delivery and can be lethal within that time period¹. Women who voluntarily present for delivery in health care facilities that can promptly and effectively manage PPH have a far lower chance of death from hemorrhage². Most maternal deaths continue to occur in developing countries in women delivering at home or in health care facilities that do not efficiently manage obstetric complications including PPH³.

Our understanding of the definitions of PPH is evolving, as most women experiencing a loss of 500 ml of blood, the common definition of PPH, do not receive clinical intervention or experience serious consequences^{4,5}. These definitions are described in Chapter 16. Traditionally, blood loss after delivery is visually estimated. The birth attendant makes a gross quantitative estimate; however, there is wide variation and inaccuracy in such estimates. The importance of accurately measuring vaginal blood loss at delivery was stressed by Williams as early as 1919⁶. In the past, various mechanisms have been advocated to estimate postpartum blood loss. These include the acid hematin method, by which blood in the sponges and pads was mixed with a solution that converted hemoglobin to acid hematin or cyanmethemoglobin, which in turn was measured by a colorimeter. Other methods were plasma volume determinations before and after delivery using radioactive tracer elements, determination of changes in other blood indices before and after delivery, and use of ⁵¹Cr-labeled erythrocytes⁷. Quantitative methods for estimating vaginal blood loss include direct collection of blood into bedpans or plastic bags and gravimetric methods wherein pads are weighed before and after use, the difference in the weight being used to determine the amount of blood lost⁸.

Numerous studies of carefully quantified postpartum blood loss indicate that clinical visual assessment is unreliable and generally underestimates measured postpartum blood loss, with an average underestimation of 100–150 ml; of equal

importance, using visual estimation is accompanied by greater inaccuracy with higher volume blood loss, which may underestimate the incidence of PPH by 30–50%^{7–13}. For example, the prevalence of PPH and severe PPH (loss of 1000 ml or more) is 6.1% and 1.7%, respectively, when visually estimated, and 10.6% and 3.0%, respectively, when quantitatively measured⁴. The prevalence of PPH is also much lower in observational studies (6.0% in 31) than in clinical trials (13.9% in 24) that place greater priority on accurately evaluating blood loss⁷. As a result, numerous authorities advocate a more objective approach to the diagnosis of PPH.

The accurate measurement of blood loss by an ideal method remains a gray area. While measurement of postpartum vaginal blood loss is critical in research, the methods described above have not been adopted in clinical practice because of their complexity, expense and the time required to obtain results before being able to act upon them. Given these circumstances, visual (clinical) estimation, inaccurate as it may be, remains the norm. To facilitate accurate and timely measurement, the BRASSS-V drapeTM (discussed below), an elongated, V-shaped calibrated plastic pouch, sometimes tied around the woman's waist, with a funnel portion hanging between her legs (Excellent Fixable Drapes, Madurai, Tamil Nadu, India) was developed in 2002 and costs less than 3 US dollars each¹².

NORMAL BLOOD LOSS DURING DELIVERY

The range of average blood loss during vaginal delivery is uncertain, being variously reported at the low end as 343 ml in 1000 consecutive term vaginal deliveries, as 339 ml and 490 ml in two separate albeit small studies of 100 and 123 patients, respectively, using the acid hematin spectrophotometric method and as 450 ml in 123 deliveries using chromium-labeled erythrocytes^{8,14–16}. Despite these variations, it is generally accepted that blood loss during vaginal delivery varies from 400 to 500 ml¹⁷, whereas most cesarean births are associated with 500–800 ml loss^{18,19}. Unfortunately, these values are mostly reflective of hospital based data, primarily obtained among women in the developed world, most of whom receive prophylactic

uterotonics to prevent PPH. A recent meta-analysis of measured loss indicates that median postpartum loss without prophylactic uterotonics ranges from 450 to 500 ml compared with 200 to 300 ml in women receiving prophylactic uterotonics¹⁷.

PHYSIOLOGICAL ADAPTATIONS IN PREGNANCY

Antepartum adaptations for physiologic blood loss at delivery include a 51% increase in plasma volume and a 21% increase in red blood cell volume by the third trimester²⁰. Women who develop pre-eclampsia either experience little or no expansion over non-pregnant levels or lose whatever gain had been accrued early in gestation during the third trimester²¹. In severe pre-eclampsia, on the other hand, the blood volume frequently fails to expand and may remain similar to that in a non-pregnant woman²². One of the hallmarks of eclampsia is hemoconcentration with increased sensitivity to even a normal blood loss at delivery²³. Women so afflicted are less prepared to withstand blood loss and may experience life threatening hypovolemia with smaller amounts of hemorrhage²¹. Women with hypertension/HELLP (hemolysis, elevated liver enzymes, low platelets) syndrome are 39% more likely to receive blood transfusions and 157% more likely to receive intensive care than women experiencing PPH²⁴.

Progressively more complicated deliveries are usually accompanied by greater degrees of blood loss: vaginal delivery (500 ml), cesarean section (1000 ml), repeat cesarean section plus hysterectomy (1500 ml) and emergency hysterectomy (3500 ml)^{25,26}. Factors associated with increased blood loss in the third stage of labor include multiple gestation, forceps delivery and episiotomy, particularly when accompanied by laceration^{27–30}. By itself, episiotomy increases postpartum blood loss and the risk of PPH by 70%³¹, whereas forceps delivery does not appear to contribute to blood loss *per se*. Any excess bleeding in this instance is due to the required episiotomy.

DIAGNOSIS OF POSTPARTUM HEMORRHAGE

Over the years, different methods have been used for estimation of blood loss; these can be classified as clinical or quantitative.

Clinical methods

Clinical estimation remains the primary means of diagnosing the extent of bleeding and directing interventional therapy in obstetric practice. Examples include internal hemorrhage due to ruptured tubal pregnancy, ruptured uterus and the concealed variety of abruptio placentae. The classification of hemorrhage can be based on a graded physiological response to the loss of circulating blood volume (Table 1)^{21,32,33}.

This scheme has worked well in the initial management of trauma patients in clinical settings. Knowing that the blood volume of a pregnant woman is 8.5–9%

of her weight, one is able to quickly approximate blood loss based on changes in pulse, systolic blood pressure and mean arterial pressure. Thus, the failure to respond to the initial administration of 3000 ml of crystalloid would suggest a class II hemorrhage with loss greater than 20–30% of the total blood volume or acute ongoing bleeding^{21,32,34}. A systolic blood pressure below 100 mmHg and a pulse rate above 100 beats/min are late signs of depleted blood volume and indicate commencing failure of compensatory mechanisms³⁴, whereas acute blood loss might not be reflected by a decrease in hematocrit or hemoglobin level for 4 h or more^{21,32,33}. Significant cardiovascular changes occur immediately postpartum. The cardiac output remains elevated for 24 h, blood pressure declines initially and then stabilizes on postpartum day 2. Maternal physiological changes of hemodilution lead to reduced hemoglobin and hematocrit values, reflecting the importance of timing of the measurement³⁵. In the majority of patients³⁶, no single timed hemoglobin or hematocrit determination in the first 24 h postpartum will detect the peak. The importance of arriving at a diagnosis when the patient is at the class I stage cannot be too strongly emphasized, as women can progress into class II rapidly. At level III, without prompt, appropriate intervention, women can progress to shock.

Quantitative methods

Visual assessment

The standard observational method for the measurement of blood loss is straightforward and requires no expenditure¹. In medical emergencies, however, the estimation of blood loss in simulated situations (albeit, not PPH) was found to be so poor that use of vital signs, symptoms of shock and co-morbidities was recommended to determine response^{38,39}. Given inaccuracy and interobserver variation, most visual assessments underestimate blood loss, and may be indicative that women require clinical intervention at higher levels (more than 500 ml) of blood loss, to avert serious sequelae^{40–42}.

The major advantage of direct measurement is that it provides a real-time assessment and enables the birth attendant to correlate findings, on an individualized

Table 1 Classes of hemorrhage³⁷

Class	Blood loss		Blood pressure (mmHg)	Signs and symptoms
	ml	%		
I	500–1000	10–15	Normal	Palpitations, dizziness, tachycardia
II	1000–1500	15–25	Slightly low	Weakness, sweating, tachycardia
III	1500–2000	25–35	70–80	Restlessness, pallor, oliguria
IV	2000–3000	35–45*	50–70	Collapse, air hunger, anuria

* > 2500 ml blood loss – 50% mortality if not managed urgently and appropriately

basis, with the clinical presentation. However, the significant differences between clinical estimates and actual measurements are demonstrated in several studies and commented upon in other chapters of this book^{17,35}. The most common error is underestimation of blood lost, with an average error of 35–50% when estimates at the time of delivery are compared with those of more precise methodology. As might be expected, observers tend to give median or average estimate of blood loss (called ‘heaping’ whereby amounts are aggregated at round or common values, i.e. 100 ml, 250 ml and 500 ml). When losses are large, they are far more likely to be underestimated; on the other hand, when losses are less than average, they are often overestimated^{7,15,43}.

The accuracy of visual estimation can be improved by training and standardization^{7,42}. One simple approach is to train the observer to determine the blood loss using a single collecting container and fixed-sized gauze pads of size 10 × 10 cm, using simulated scenarios with known measured blood volumes (Figure 1)^{36,44}. This methodology is useful and can be routinely practiced in low or high resource settings, albeit differing somewhat based on training the providers and standardization of the pads (size and quality) used during delivery^{7,39}. Still, visual estimation is more accurate when blood is collected in containers rather than pads or cloth⁴². The accuracy of estimated blood loss has not been shown to be dependent upon the age or the clinical experience of the observer^{17,38,45,46}. Of particular clinical importance is a reduction in underestimation of blood loss in the face of greater degrees of measured blood loss; correction of this practice has the strongest potential to reduce hemorrhage-related morbidity and mortality⁴⁷.

Direct collection of blood into fixed containers or cloth

Another method of calculation is to allow blood to drain into a fixed collecting container (Figure 2) for estimation at the end of 1 h. Blood losses on the delivery table, garments and floor should also be assessed³⁹. At the end of 1 h, the total amount of blood lost is estimated by totaling up the blood in the container, in the sponges and secondary blood spillage on the delivery table, garments and floor. How often such calculation is utilized is unknown, but failure to do so contributes to underestimation⁴².

In Tanzania, traditional birth attendants (TBA) have used a method to identify excess postpartum blood loss in home births by placing standard size kangas (100 cm × 155 cm cotton cloth, similar to a sarong in Asia or cotton skirt wrap elsewhere), under women during, and after delivery⁴⁸. A small validation trial found two soaked kangas predicted an average blood loss of 500 ml. Interestingly, the TBAs had typically qualified postpartum blood loss as excessive when three to four kangas were soaked, indicating that, as in the case of trained clinicians, experienced TBAs are prompted to intervene at levels of blood loss higher

than 500 ml. A consistent size and weight of cloth is critical to widespread use of this method.

Direct collection of blood into bedpan or plastic bags

This approach was used in the World Health Organization (WHO) multicenter, randomized trial of misoprostol in the management of the third stage of labor². In this trial, blood loss was measured from the time of delivery until the mother was transferred to postnatal care. Immediately after the cord was clamped and cut, the blood collection was started by passing a flat bedpan under the buttocks of a woman delivering in a bed or placing an unsoiled sheet for a woman delivering on a delivery table.

Blood collection and measurement continued until cessation of the third stage of the labor when the woman was transferred to the postnatal ward. This period was generally 1 h postpartum. At that time, the collected blood was poured into a standard measuring jar provided by WHO and its volume measured. To simplify the procedure for measurement of total blood loss, any small gauze swabs soaked with blood were put into the measuring jar and included in the measurement together with the blood and clots. A validity study was performed before the trial to assess the effect of adding the gauze swabs; this process increased the blood loss measurements by approximately 10%.

The errors associated with collection of blood by any of the methods described thus far are numerous; moreover, they are compounded by ignoring maternal

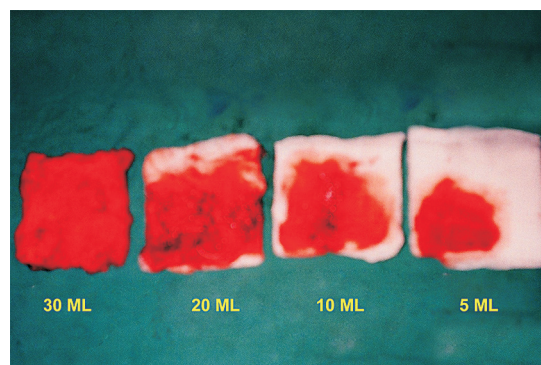


Figure 1 Soakage characteristics of 10 × 10 cm pads



Figure 2 Blood drained into a fixed collecting container

blood within the placenta (approximately 150 ml) and spillage, confusion related to the mixing of blood contaminated with amniotic fluid and urine, and technical inaccuracies associated with transfer of the collection to a measuring device³⁹. In non-clinical settings in tropical climates, care must be taken to minimize evaporation before retrieval and measurement of blood directly collected or transferred into containers or plastic bags⁴⁹.

Gravimetric method

The gravimetric method requires the weighing of materials such as soaked sponges on a scale and subtracting the known dry weights of these materials to determine the blood loss⁵⁰. The difference in weight provides a rough estimate of blood loss. This method has been used most to assess blood loss associated with surgery, and is sometimes used in combination with other methods to calculate blood loss^{51–53}. Inaccuracies can arise at several steps in this procedure, including lack of international standardization of size and weight of gauze, sponges and pads⁵³.

Determination of changes in hematocrit and hemoglobin

Changes in the hematocrit and hemoglobin values before and after delivery provide quantitative measurements of blood loss, as depicted in Figure 3^{54–56}. The American College of Obstetricians and Gynecologists cites a 10% post-delivery decline in hematocrit compared with pre-delivery as a secondary definition of PPH, but notes that postpartum hemoglobin and hematocrit concentrations do not always directly reflect hematologic status⁵³. Routine hematocrit determination is possible where equipment is available. However, routine postpartum hematocrits are unnecessary in clinically stable patients with an estimated blood loss of less than 500 ml. After delivery associated with an average blood loss, the hematocrit drops moderately for 3–4 days, followed by an increase. The peak drop may be appreciated on day 2 or day 3 postpartum⁵⁷. By days 5–7, the postpartum

hematocrit will be similar to the pre-labor hematocrit²⁰. Should the postpartum hematocrit be lower than the pre-labor hematocrit, it is an indication that blood loss may have been larger than appreciated²⁵.

Acid hematin method

This method is based on collected blood being mixed with a standardized solution which converts hemoglobin to acid hematin or cyanmethemoglobin. This in turn can be measured by a spectrophotometer or colorimeter. Spectrophotometric analyses are described by Chua *et al.*⁵⁸, Brant *et al.*³⁴, and Wallace⁵⁹. Photometric analyses are described in Duthie *et al.*⁸, Duthie *et al.*¹⁸, Larsson *et al.*⁶⁰ and Wilcox *et al.*⁶¹. Razvi *et al.*¹¹ describe the colorimetric approach. The first study reporting measurement of blood loss during surgical procedures employed the colorimetric technique, which required that hemoglobin be washed from surgical materials in a blender and measured in a colorimeter⁶². Clearly, use of the acid hematin method of calculating blood loss is impractical in obstetric care.

Plasma volume changes

The plasma volume can be determined before and after delivery using radioactive tracer elements. Stafford *et al.*¹⁹ found visual assessment underestimates calculated measurements of postpartum blood loss based on maternal blood volume by a third in vaginal and by over half in cesarean births. Blood volume estimation using dye- or radioisotope dilution techniques is more difficult and requires special equipment and serial measurements^{63,64}. Measurement of erythrocytes appears to be more consistent than estimates of plasma volume in pregnancy^{12,65}. As is the case with acid hematin, this method is impractical for use in a bleeding patient.

BRASSS-V DRAPE: BLOOD LOSS COLLECTION TOOL

A randomized, placebo-controlled trial to test the effectiveness of oral misoprostol to reduce the incidence of acute PPH and hence maternal morbidity and mortality was conducted in women delivering in rural villages (away from major hospitals) in Belgaum District, Karnataka, India. The intervention was delivered by local health care workers. A critical component of this trial was the development of a specially designed low-cost ‘calibrated plastic blood collection drape’ that would objectively measure the amount of blood collected in the immediate postpartum period. The BRASSS-V drape was developed by the NICHD-funded Global Network UMKC/JNMC/UIC collaborative team specifically to estimate postpartum blood loss^{66,67}. (The name ‘BRASSS-V’ was coined by adding the first letter of the names of the seven collaborators who developed the drape.) The drape has a calibrated and funneled collecting pouch, incorporated within a plastic sheet that is placed under

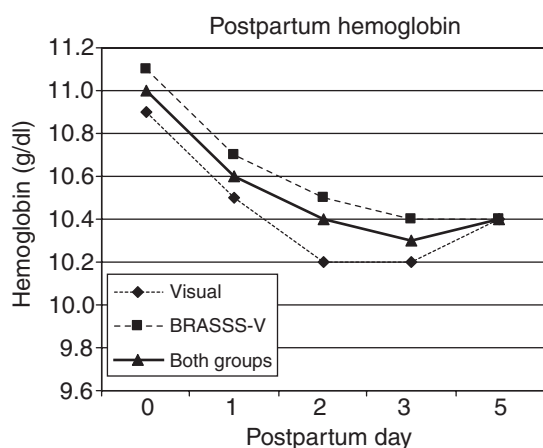


Figure 3 Postpartum hemoglobin changes

the buttocks of the patient immediately after the delivery of the baby. The upper end of the sheet has a belt, which is loosely tied around the woman's abdomen to optimize blood collection, particularly for deliveries performed on the floor or on a flat surface at homes or in rural primitive health posts. This simple tool not only has the potential for more accurate detection of postpartum blood loss, but also may improve timely response with the ultimate goal of decreasing maternal morbidity and mortality associated with PPH. Since most developing countries use some form of under-buttock sheet, either at home, in the health center or in hospitals, drape substitution is acceptable and relatively simple. The BRASSS-V calibrated drape used for objective estimation of blood loss is shown in Figure 4.

Results of three studies conducted at JNMC, Belgaum, Karnataka, India^{12,68,69} strongly suggest that the BRASSS-V drape is an accurate and practical tool to measure blood loss in the third stage of labor. Although the ranges of blood loss were similar in both visual and drape assessment among women with little blood loss, the actual visual assessment amount was considerably lower compared with the calibrated drape values (Table 2 and Figure 5). This observation further attests to the inaccuracy of the visual estimation method as described in the literature; in contrast, differences between the drape and spectrophotometry values were found to be 37.15 ml, with the drape having the higher value (an average error of 16.1%). The drape measured blood loss equally efficiently as gold-standard spectrophotometry (Pearson's correlation coefficient of 0.928; $p = 0.01$, Table 3).

Use of the drape diagnosed postpartum blood loss of 500 ml or more four times as often as the visual estimate (Figure 6). The drape has been used in a number of international settings including India^{12,70}, Tibet, Vietnam, Egypt, Ecuador, Brazil and Argentina, and has been most recently employed in randomized controlled trials of treatment for PPH in Burkina Faso, Ecuador, Egypt, Turkey and Vietnam^{71,72}.

Based on the initial Indian experience, the drape appears to have great potential for training delivery attendants to determine postpartum blood loss in an accurate and timely manner. Apart from being an objective tool for measurement of postpartum blood loss, it also provided a hygienic delivery surface while permitting early management and referral. Residents and nurses in hospital settings and the nurse midwives who used the BRASSS-V drape during home delivery all found it to be a very useful tool that often led to earlier transfer from rural areas to a higher level facility⁷⁰. At the same time, women who delivered at home and their family members appreciated the ease with which body fluids could be disposed of after birth⁶⁸.

In home deliveries or facilities in resource poor areas that do not have the capability to manage acute PPH, accurate measurement of blood loss at delivery as a means of early detection of PPH may improve care and outcome for several reasons. Uterotonics,

while an important component for addressing the third stage of labor, do not address all factors related to PPH. Trauma of the birth canal during delivery and retained placental fragments are also important causes



Figure 4 BRASSS-V blood collection drape with calibrated receptacle

Table 2 Distribution of blood loss

	Blood loss (ml)		
	Visual (n = 61)	Drape (n = 62)	All cases (n = 123)
Mean ± SD (range)	203.1 ± 147.5 (50–950)	302.8 ± 173.3 (50–975)	253.4 ± 168.9 (50–975)

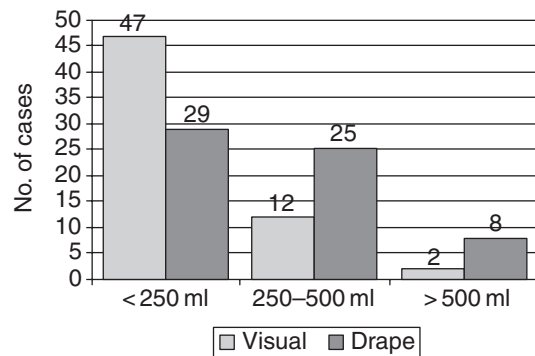
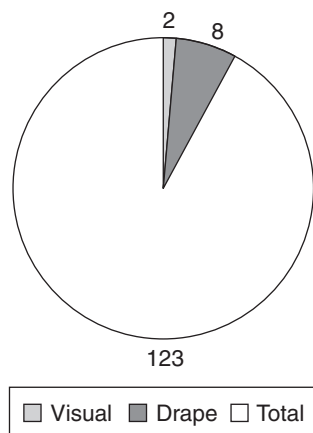


Figure 5 Number of cases detected for specific blood loss ($p < 0.01$). The calibrated drape more accurately determined true blood loss when ≥ 250 ml and more accurately estimated overall levels

Table 3 Comparison between drape-measured and spectrometrically analysed blood loss

	Blood loss (ml)	
	Drape-measured	Spectrometry
Mean \pm SD (range)	225.0 \pm 96.1 (100–350)	187.8 \pm 61.8 (93.2–286.0)

**Figure 6** Number of cases of postpartum hemorrhage (PPH) detected for specific blood loss ($p < 0.01$). The calibrated drape diagnosed PPH at a rate four times that of the visual estimate method

of PPH and may occur more often than previously reported. Visual assessment of blood loss in the presence of a contracted uterus may diagnose traumatic PPH late and therefore result in delayed referrals.

In India and many other developing nations, a large percentage of all births take place in rural areas. Most of these deliveries are conducted by indigenous health care providers such as dais (traditional birth attendants) or auxiliary nurse midwives who have varying levels of training. Blood loss appears to be commonly underestimated, as visual assessment is the only means available to the birth attendant to diagnose PPH. The clinical symptoms of blood loss (low blood pressure, fast pulse, pallor and sweating, signs of hypovolemia and impending shock) are often the primary indicators for intervention. However, relying on the onset of such symptoms may lead to delayed intervention, resulting in increased rates of morbidity and mortality. As other quantitative methods employed have practical as well as technical limitations, the employment of simple tools, such as the BRASSS-V drape with a calibrated receptacle can be effectively employed for objectively assessing the blood loss.

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