ORIGINAL ARTICLE

Blood loss assessment: Which is the most suitable method for Indonesian midwives?

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ABSTRACT

Background. There are several methods of blood loss estimation, but most of them are complicated and impractical in general clinical practice and some improbable to apply in developing countries, particularly Indonesia.
Aim: To identify the most feasible method of blood loss estimation for Indonesian midwives.
Methods. Twenty-three midwives were interviewed regarding how they assess blood loss during labor, and 167 maternity rooms from 10 provinces in Indonesia were observed after which three methods of estimation were predetermined for comparison. Further, clinical scenario simulation was undertaken to identify the benefits and the shortcomings of each method.
Results. A tendency of overestimated has been found in visual estimation with artificial blood, but when simulation used human blood, it tended to be underestimated. There was also a significant correlation between midwife groups and years of clinical experiences and assessment accuracy, but it was only found at volumes 100 mL and 150 mL. There were differences in the characteristics of contamination results between artificial blood, human blood, and blood in real labor. The diversity of underpad' material and absorption influence the weight of blood contamination so ρ used to calculate blood volume at gravimetric should be adjusted, taking into account the type of underpad used. On using drape, the position of wire and hang drape has affected readable results emerging on the calibrated drape.
Conclusion. Gravimetric and drape are the most suitable blood loss estimation methods to be applied in Indonesia compared to visual estimation. However, those methods must also be used carefully to minimize estimation error.
Keywords: Postpartum hemorrhage, blood loss assessment, visual estimation, gravimetric, delivery drape,

INTRODUCTION

Early postpartum hemorrhage, which is the most common cause of maternal mortality, is traditionally defined as blood loss ≥500 mL within first 24 hours childbirth[1,2] while late postpartum hemorrhage occurs after 24 hours and less than six weeks after childbirth[3]. Hemorrhage has been reported as the leading cause of maternal mortality in the world, particularly in Asia[4,5,6]. In Indonesia, from 2008 to 2012, the maternal mortality ratio was 359 per 100,000 births, 30.1% caused by hemorrhage[7]. One success factor in the handling of obstetric hemorrhage is determined by velocity and accuracy in blood loss assessment in childbirth[8]. Its accuracy not only plays a role in hemorrhage management, but it also allows the health providers in the early detection of clotting disorders[9].

Dildy et al reported that blood loss estimation tended to be overestimated at a lower volume and underestimated at higher volumes[2]. Overestimation can generate unnecessary transfusion, while underestimation may delay hemorrhage management[2]. Delay in the diagnosis of postpartum hemorrhage causes further delay in the management and often leads to an increased risk of poor outcome[8, 10], such as hypovolemic shock, cardiopulmonary arrest, and death[2, 11]. The issue regarding which is the best method of blood loss estimation is still questionable. This question has been asked for Centuries[12]. Blood loss can be assessed by several methods, yet each those methods is complicated and impractical in general clinical practice[2]. In this article, we have summarized some methods of blood loss estimation from previous studies.

First, photometric or colorimetric technique, blood pigment is converted into acid or alkaline hematine by a washing sponge or other contaminated materials with distilled water in a blender. Hydrochloric acid is added, and the solution is compared against a colorimetric[12,13]. One cubic centimeter of blood is diluted in 100 mL in tenth standard hydrochloric acid[12]. This method is the gold standard in blood assessment[12,13]. Second, the dye-dilution method or radioisotope dilution. This method is technically more complicated and needs specialized specific equipment and serial measurements[14,15]. Third, the use of mathematical formulas to compute simple object volume in blood loss assessment. Box volume (a rectangular parallelepiped) is counted as length x width x height[2]. However, because of random distribution, the use of mathematical formulas is not an effective way of computing blood volume and tends to be challenging to do in emergency cases. Fourth, computer-based mathematical modeling where the mathematical equation placed in computer modeling, which allows a quick count of blood loss in individual patients. The numbers emerged from computer modeling is used to facilitate a rapid manual count of blood loss[16]. Fifth, delivery drape, which is a cone-shaped plastic container to collect blood during labor[10]. A blood collection drape is specially designed to assist health providers in estimating blood loss during labor in low-resource settings. The drape consists of a channel and a collection bag adhered to a plastic sheet placed under the mother's buttock immediately after childbirth. There are two waist belts attached to the upper end of the drape and tied to and around the woman's abdomen to optimize blood collection, particularly for the labor executed on the floor or the other flat surfaces. Calibrated levels will show blood volume collected by the drape[17]. Sixth, the gravimetric method which needs a weighing device to weigh the labor equipment such as underpad, sponge, gauze, and tamponade before and after blood contamination[8,18]. Seventh, visual blood loss estimation[2,8,9,10,17,19,20,21], which is the most common method used in the world[8,17]. Not all of those methods can be applied in Indonesia. This study was undertaken to identify the most feasible method of blood loss estimation for Indonesian midwives.

METHOD OF STUDY

This research was started by conducting interviews with midwife practitioners and observations in maternity rooms. Interviews were carried out face-to-face and by phone for around 40-60 minutes to midwife practitioners. Twenty-three midwives were involved in these in-depth interviews. They were ten midwives who work at hospitals, eight midwives of public health centers (PHCs), a village midwife, and 4 of them were independent midwifery practices (IMPs).

The interviews data analysis found that all midwives did not routinely undertake blood loss assessment in each labor. Blood loss assessment was only executed if the patient's condition shows emergency signs or distress. The assessment commonly used physiological parameters (general condition, blood pressure, and heart rate), a visual method with an underpad, or direct method. In the visual method, an underpad full with blood is assumed to equal with 500mL. While the direct method commonly used a kidney dish placed near a woman's buttock or a box container placed in the middle of the lower part of the gynecological bed. A medium-sized kidney dish filled with blood is equivalent to 250 mL. Furthermore, the midwives also expressed that determination of PPH intervention (fluid amount for hydration and blood transfusion needs) was not based on blood loss assessment but commonly based on general condition, pulse rate, and blood pressure of the patient.

To verify the qualitative data, midwife students who were in a final semester (midwife candidate) and are doing internship were then asked to observe maternity rooms. 167 maternity rooms have been observed in 10 provinces in Indonesia (Jambi, South Sumatera, Lampung, West Java, Central Java, Yogyakarta, West Nusa Tenggara, West Kalimantan, East Kalimantan, and Southeastern Sulawesi) include 16 hospitals, 8 midwifery clinics, 30 PHCs, 1 auxiliary health centers, 2 village maternity posts, and 110 IMPs. The observed objects were types of delivery bed, pad used during labor, and maternity room condition. The observation results can be seen in table 1 and figure 1.

Table 1: Observation findings towards maternity rooms

Aspects	f (%)
Type of delivery bed*	
Gynecological beds	32 (17.9)
Gynecological beds that function as an ordinary bed	51 (28.5)
Ordinary beds	96 (53.6)
Delivery pad*	
Underpad 60 cm x 90 cm	158 (92.4)
Patient's fabric	13 (7.6)
Brand of underpad used in labor	
Do not know	71 (42.5)
Non-branded underpad	12 (7.2)
Sensipad	42 (25.1)
Top underpads	11 (6.6)
Oto underpads	9 (5.4)
Diapro underpads	2 (1.2)
ProCare underpads	14 (8.4)
Patient's fabric	6 (3.6)

*Note: * Some health facilities use more than one option*

According to the findings above, we determined three methods of blood loss assessment being used. They were visual estimation (indirect method) for labor using underpad and ordinary bed or gynecological bed that functions like an ordinary bed, the gravimetric (indirect method) for labor that use either underpad or patient's fabric and ordinary bed or gynecological bed that functions like an ordinary bed, and finally delivery drape (direct method) for labor using a gynecological bed.

Furthermore, we conducted clinical scenario simulations using artificial blood, which consists of glycerin, food coloring, and emulsifier. This blood is commonly available at medical supply stores in Indonesia (its brand is 'pabrik darah, Kumalasari Tanara'). These simulations were executed at a PHC in Bandung, West Java Province. Then, to clarify the findings, we did further simulations using human blood. These further simulations were not only done to obtain the density of human blood but also to confirm the simulation results of artificial blood. The simulation was done using whole blood (WB) and packed red blood cells (PRC).

Figure 1. Three types of delivery beds used by Indonesian midwives

Gynecological beds — Gynecological beds that function as an ordinary bed — Ordinary beds

WB is blood that contains the plasma, red blood cells, white blood cells, and platelets while PRC only contains erythrocyte[22]. We acquired two WB packs and two PRC from donor blood transfusion unit, Jambi Branch of Palang Merah Indonesia after passing license procedures and obtaining approval from the Jambi blood bank. We simulated this study at midwifery education clinic of the Health Ministry Polytechnic, Jambi province. Because a limited amount of blood, this simulation was started by spilling 50 mL each of human blood into three underpads, and further specific amounts of blood were added to obtain pre-determined volumes. Each underpad contaminated by blood was coated by a checkered pattern (each small box size was 1 cm x 1 cm and each thick striped box size was 10 cm x 10 cm) and captured in each clinical scenario simulation to assist midwives in estimating blood loss visually. These pictures were then showed to the three groups of midwives taking part in the simulation and asked to estimate the volume of blood loss.

In the gravimetric method, the underpad' weights before and after blood contaminations as well as the weight changes in each scenario were measured and noted. While in the direct method using delivery drape, we demonstrated some clinical scenarios and observed the artificial blood collected in the delivery drape. Data collection was conducted from March 2018 to February 2019.

RESULTS

Visual blood loss estimation

Clinical scenario simulation with artificial blood: Spilling artificial blood in specific volumes on underpad (60 cm x 90 cm) was done to identify the volume of blood contamination. This simulation produced four pictures, and 276 midwives then estimated the blood volume on those underpads (table 2). The results showed that blood loss estimation by midwife educators and midwife practitioners tended to be overestimated while a tendency of underestimated was found in midwife students' estimation results.

Clinical scenario simulation with human blood: 21 clinical scenario simulations were conducted by WB that divided into nine scenarios on SensiPad, eight scenarios on ProCare, and four scenarios on non-branded underpads. While 15 scenarios were undertaken using PRC, including seven scenarios on SensiPad and eight scenarios on ProCare). The less number was due to the blood amount in PRC being less than WB's pack. SensiPad and ProCare were used for this study since they were more often used in Indonesia (Table 1).

Table 2: Frequency (percentage) of visual blood loss estimation by three groups of midwives

	Midwife educators (N=46)	Midwife practitioners (N=110)	Midwife students (N=120)
Volume of 100 mL			
Underestimated	3 (6.5)	14 (12.7)	49 (40.8)
Precise	3 (6.5)	14 (12.7)	14 (11.7)
Overestimated	40 (87.0)	82 (74.5)	57 (47.5)
Volume of 150 mL			
Underestimated	11 (23.9)	38 (34.5)	68 (56.7)
Precise	6 (13.0)	4 (3.6)	9 (7.5)
Overestimated	29 (63.0)	68 (61.8)	43 (35.8)
Volume of 200 mL			
Underestimated	16 (34.8)	49 (44.5)	76 (63.3)
Precise	8 (17.4)	16 (14.5)	10 (8.3)
Overestimated	22 (47.8)	45 (40.9)	34 (28.3)
Volume of 300 mL			
Underestimated	11 (23.9)	38 (34.5)	70 (58.3)
Precise	8 (17.4)	15 (13.6)	8 (6.7)
Overestimated	27 (58.7)	57 (51.8)	42 (35.0)

Furthermore, nine pictures from each volume completed with a checkered pattern (each small box size is 1 cm x 1 cm, and each full striped box size is 10 cm x 10 cm) were selected randomly from the three brands of underpads (Fig. 2). After that, the pictures were shown to midwife educators, midwife practitioners, and midwife students who were asked to estimate the amount of blood. The inclusion criteria for midwife students were students who have experienced in midwifery clinical practice.

Two hundred forty-three respondents estimated blood volume, including 48 midwife educators, 119 midwife practitioners, and 76 midwife students. Midwife educators and midwife practitioners have different years of clinical experiences while midwife student had non-clinical experience as a midwife. Data were processed by Microsoft Excel 2013 and Statistical Package for the Social Sciences (SPSS) 19.0. Testing data used Cramer's V (non-parametric) test to determine the correlation between variables of midwife groups and years of clinical experiences and accuracy of blood loss estimation. The results are presented in frequencies, percentages, and p-value Cramer's V. Blood loss estimation by these three groups of midwives using human blood tended to be underestimated. We identified a significant correlation between midwife groups and years of clinical experience, but it was only at volume 100 mL and 150 mL (Table 3 and 4).

Figure 2. Blood spills per volume on underpads equipped with a checkerboard pattern

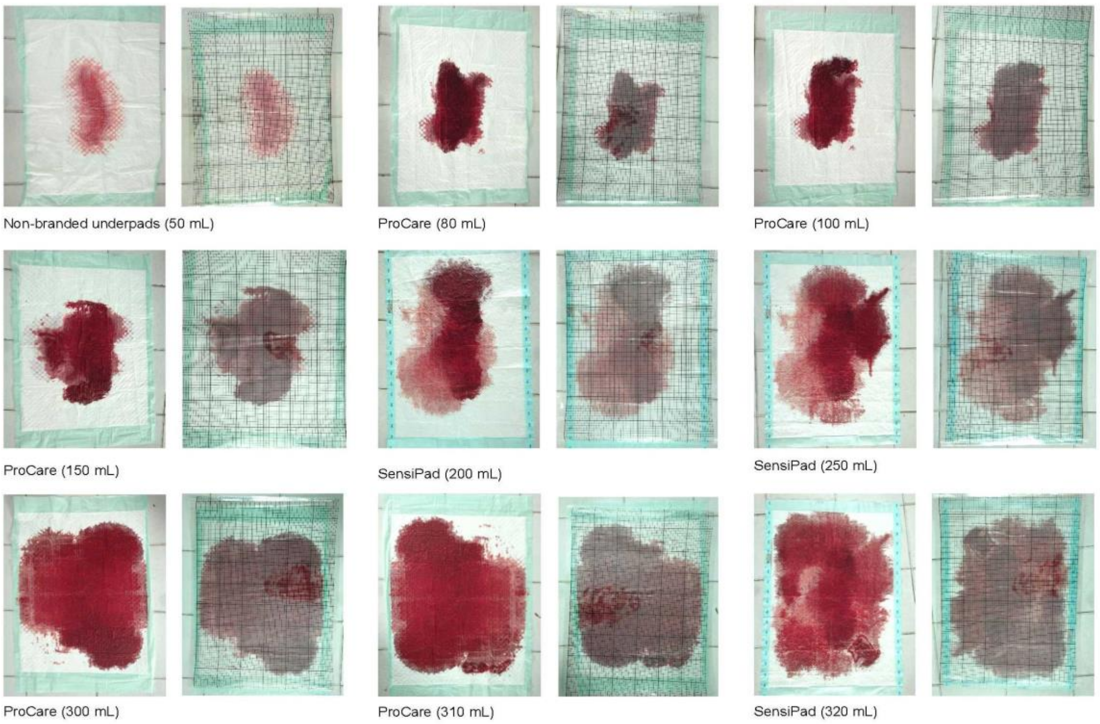


Table 3. Frequency (percentage) and Cramer's V by midwife groups

Assessment		Midwife educators (N=48)	Midwife Practitioners (N=119)	Midwife Students (N=76)	Cramer's V
50 mL	Underestimated	23 (47.9)	77 (64.7)	50 (65.8)	.175
	Precise	9 (18.8)	15 (12.6)	13 (17.1)	
	Overestimated	16 (33.3)	27 (22.7)	13 (17.1)	
80 mL	Underestimated	22 (45.8)	70 (58.8)	50 (65.8)	.133
	Precise	1 (2.1)	4 (3.4)	4 (5.3)	
	Overestimated	25 (52.1)	45 (37.8)	22 (28.9)	
100 mL	Underestimated	19 (39.6)	75 (63.0)	53 (69.7)	.016*
	Precise	12 (25.0)	19 (16.0)	8 (10.5)	
	Overestimated	17 (35.4)	25 (21.0)	15 (19.7)	
150 mL	Underestimated	24 (50.0)	88 (73.9)	59 (77.6)	.005*
	Precise	7 (14.6)	14 (11.8)	4 (5.3)	
	Overestimated	17 (35.4)	17 (14.3)	13 (17.1)	
200 mL	Underestimated	32 (66.7)	88 (73.9)	58 (76.3)	.729
	Precise	6 (12.5)	15 (12.6)	8 (10.5)	
	Overestimated	10 (20.8)	16 (13.4)	10 (13.2)	
250 mL	Underestimated	29 (60.4)	92 (77.3)	54 (71.1)	.222
	Precise	3 (6.3)	7 (5.9)	5 (6.6)	
	Overestimated	16 (33.3)	20 (16.8)	17 (22.4)	
300 mL	Underestimated	23 (47.9)	79 (66.4)	53 (69.7)	.050
	Precise	3 (6.3)	11 (9.2)	5 (6.6)	
	Overestimated	22 (45.8)	29 (24.4)	18 (23.7)	
310 mL	Underestimated	25 (52.1)	80 (67.2)	52 (68.4)	.127
	Precise	0 (0.0)	0 (0.0)	0 (0.0)	
	Overestimated	23 (47.9)	39 (32.8)	24 (31.6)	
320 mL	Underestimated	27 (56.3)	87 (73.1)	50 (65.8)	.198
	Precise	0 (0.0)	1 (0.8)	0 (0.0)	
	Overestimated	21 (43.8)	31 (26.1)	26 (34.2)	

Note: *Significant at .05 level

This simulation also revealed that although blood volume spilled on underpads was the same, but the extensive blood contamination was a significant difference. The material and absorption of underpad influence it (Fig. 3). These factors cause it difficult to make visual blood loss estimation precisely.

We also compared the width of blood contamination on different underpads that are produced from the simulation of artificial blood and human blood and blood in a real labor (Fig. 4) and characteristics of blood contamination. The results are illustrated in table 5.

Figure 3. Human blood spills in three different underpads (60 cm x 90 cm)

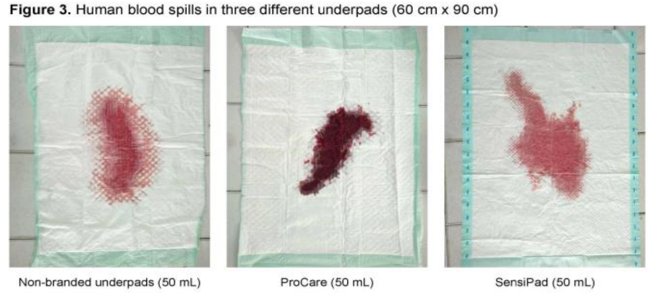
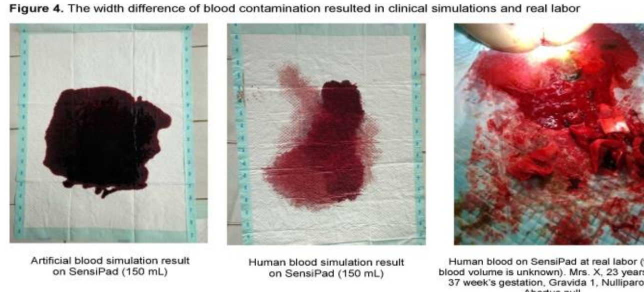


Figure 4. The width difference of blood contamination resulted in clinical simulations and real labor



According to the findings in table 5, we can conclude that the midwives' ability in estimating blood loss in a clinical scenario simulation cannot describe their ability in assessing blood loss in the real labor situation. In other words, midwives may be able to estimate blood loss in the clinical simulation correctly, but it is not necessarily accurate during actual labor.

Table 4: Frequency (percentage) and Cramer's V by years of clinical experiences

Assessment		No experience (N=76)	≤2 years (N=37)	>2-4 years (N=28)	>4-6 years (N=19)	>6-8 years (N=11)	>8-10 years (N=24)	>10 years (N=48)	Cramer's V
50 mL	Underestimated	50 (65.8)	26 (70.3)	16 (57.1)	13 (68.4)	5 (45.5)	13 (54.2)	27 (56.3)	.323
	Precise	13 (17.1)	3 (8.1)	4 (14.3)	4 (21.1)	3 (27.3)	1 (4.2)	9 (18.8)	
	Overestimated	13 (17.1)	8 (21.6)	8 (28.6)	2 (10.5)	3 (27.3)	10 (41.7)	12 (25.0)	
80 mL	Underestimated	50 (65.8)	21 (56.8)	17 (60.7)	13 (68.4)	5 (45.5)	9 (37.5)	27 (56.3)	.180
	Precise	4 (5.3)	3 (8.1)	1 (3.6)	0 (0.0)	1 (9.1)	0 (0.0)	0 (0.0)	
	Overestimated	22 (28.9)	13 (35.1)	10 (35.7)	6 (31.6)	5 (45.5)	15 (62.5)	21 (43.8)	
100 mL	Underestimated	53 (69.7)	22 (59.5)	18 (64.3)	13 (68.4)	5 (45.5)	9 (37.5)	27 (56.3)	.040*
	Precise	8 (10.5)	9 (24.3)	4 (14.3)	4 (21.1)	3 (27.3)	2 (8.3)	9 (18.8)	
	Overestimated	15 (19.7)	6 (16.2)	6 (21.4)	2 (10.5)	3 (27.3)	13 (54.2)	12 (25.0)	
150 mL	Underestimated	59 (77.6)	26 (70.3)	22 (78.6)	13 (68.4)	6 (54.5)	11 (45.8)	34 (70.8)	.031*
	Precise	4 (5.3)	4 (10.8)	0 (0.0)	2 (10.5)	4 (36.4)	4 (16.7)	7 (14.6)	
	Overestimated	13 (17.1)	7 (18.9)	6 (21.4)	4 (21.1)	1 (9.1)	9 (37.5)	7 (14.6)	
200 mL	Underestimated	58 (76.3)	27 (73.0)	22 (78.6)	15 (78.9)	9 (81.8)	13 (54.2)	34 (70.8)	.731
	Precise	8 (10.5)	5 (13.5)	3 (10.7)	2 (10.5)	1 (9.1)	6 (25.0)	4 (8.3)	
	Overestimated	10 (13.2)	5 (13.5)	3 (10.7)	2 (10.5)	1 (9.1)	5 (20.8)	10 (20.8)	
250 mL	Underestimated	54 (71.1)	26 (70.3)	22 (78.6)	13 (68.4)	8 (72.7)	14 (58.3)	38 (79.2)	.642
	Precise	5 (6.6)	3 (8.1)	1 (3.6)	3 (15.8)	1 (9.1)	1 (4.2)	1 (2.1)	
	Overestimated	17 (22.4)	8 (21.6)	5 (17.9)	3 (15.8)	2 (18.2)	9 (37.5)	9 (18.8)	
300 mL	Underestimated	53 (69.7)	23 (62.2)	17 (60.7)	13 (68.4)	6 (54.5)	13 (54.2)	30 (62.5)	.751
	Precise	5 (6.6)	3 (8.1)	4 (14.3)	0 (0.0)	2 (18.2)	1 (4.2)	4 (8.3)	
	Overestimated	18 (23.7)	11 (29.7)	7 (25.0)	6 (31.6)	3 (27.3)	10 (41.7)	14 (29.2)	
310 mL	Underestimated	52 (68.4)	23 (62.2)	20 (71.4)	13 (68.4)	8 (72.7)	12 (50.0)	29 (60.4)	.650
	Precise	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
	Overestimated	24 (31.6)	14 (37.8)	8 (28.6)	6 (31.6)	3 (27.3)	12 (50.0)	19 (39.6)	
320 mL	Underestimated	50 (65.8)	25 (67.6)	20 (71.4)	15 (78.9)	8 (72.7)	12 (50.0)	34 (70.8)	.353
	Precise	0 (0.0)	0 (0.0)	1 (3.6)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	
	Overestimated	26 (34.2)	12 (32.4)	7 (25.0)	4 (21.1)	3 (27.3)	12 (50.0)	14 (29.2)	

Note: *Significant at .05 level

Table 5: Characteristics of blood contamination

Blood type	Characteristics of blood contamination
Simulation with artificial blood	It has a clear form All blood is absorbed to underpad It has the same depth
Simulation with human blood	It has an unclear form All blood is absorbed to underpad It has a different depth. There is blood absorbed from the base of the underpad although there was blood absorbed on the underpad's surface only (slight)
Blood in actual labor	It has an irregular shape that is difficult to measure Not all of the blood is absorbed to underpad. Unabsorbed blood clots on the underpad's surface while absorbed blood has a different depth where there is blood absorbed up to the underpad base while there is blood absorbed on the underpad's surface only (slight)

Blood loss assessment by gravimetric: This simulation conducted human blood. Gravimetric is conducted by weighing the underpad or delivery pad and all equipment such as gauze and swab before and after blood contamination[8,18]. Mass deviation is believed to be an accurate measurement of blood loss. Further, to obtain volume calculation, mass deviation (∆ mass) is divided by blood density (ρ).

$$V_{calculated} : \frac{\Delta \text{ mass}}{\rho}$$

Notes:
$V_{calculated}$: Blood volume calculated
∆ Mass : Mass deviation between the weight of the underpad exposed to blood and dry underpad
ρ (rho) : Blood density

We first weighed each underpad in dry condition and after blood contaminated using two digital scales; a Harnic Heles scale, model HL-4350 (maximum 5000 g) and a CMOS scale, model DS-03K (maximal 3000 g). Thirty-six underpads exposed to blood were weighed including 21 underpads exposed to WB (that are 9 SensiPad, 8 ProCare and 4 non-branded underpads) and 15 underpads exposed PRC (that are 7 SensiPad and 8 ProCare). This simulation revealed volume deviation for each underpad.

As previously explained, knowledge about blood density (ρ or rho) is needed to convert the deviation of blood mass into statistic volume[23]. It is because the same volume of different substances commonly have different mass so that its density depends on its substance properties[24]. ρ (rho) is a Greek letter that symbolizes mass density or mass per unit volume. Mass density (ρ) is mass (m) of the substance divided with its volume (V)[24].

$$\rho_{\text{human blood}} : \frac{\Delta \text{ mass}}{V}$$

Notes:
$\rho_{\text{human blood}}$: Mass density of human blood
∆ Mass : Mass deviation between the weight of underpad exposed to blood and dry underpad
V : Blood volume spilled

Erythrocyte (red blood cell) density describes hemoglobin (erythrocyte protein) concentration[25] while whole-body blood density is a combination of plasma density, hematocrit, and erythrocyte density[26]. Current existing data about the mean density of red blood cell is 1.110 g/mL[22]. while whole-body blood density is 1.043 g/mL[26] and 1.060 g/mL[24, 27, 28]. However, Vitello et al. oppose the data and claims that whole blood density almost equals distilled water that is 0.0489 g/mL[23]. Furthermore, to determine which the best ρ was for calculating blood volume, the results are presented in table 6.

We then calculated and compared the volume deviation between actual volume and calculated volume using mean ρ (rho) as in table 4 and ρ (rho) from previous studies. The result of the calculations is presented in table 7 and illustrated as boxplot in figure 5. However, because the calculated volume used ρ=0.0489 g/mL, which has a higher deviation compared to the actual volume, we do not put this data in the boxplot in figure 5.

Table 6: Mean ρ (rho) human blood (g/mL) based on the types of blood and underpad

	Whole blood				Erythrocyte		
	n	**Sensi**	**ProCare**	**All**	**Sensi**	**ProCare**	**All**
Mean ρ (rho)*	1.006	0.987	1.084	1.028	1.028	1.257	1.150

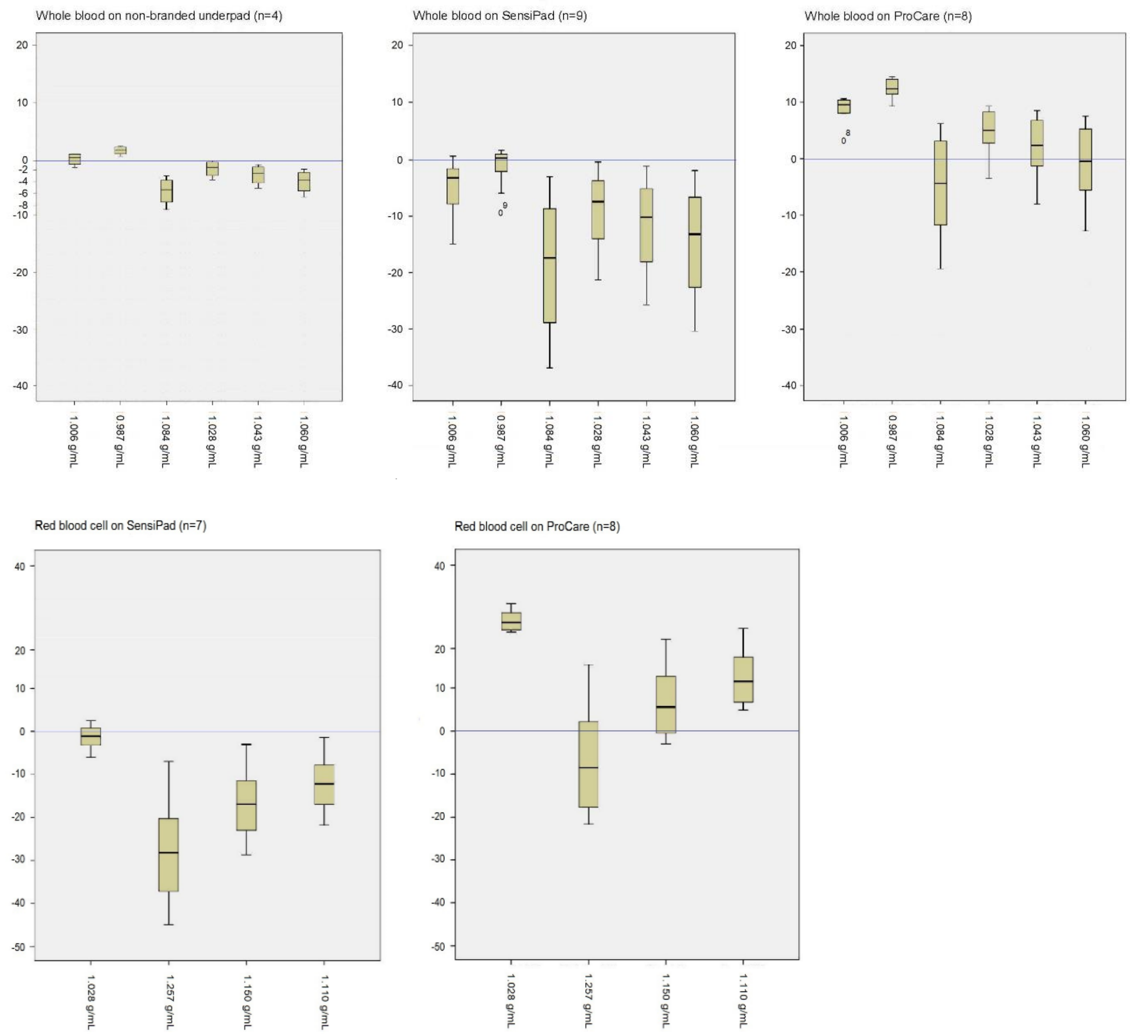
Note: *Based on the calculation, mass deviation (Δ mass) is divided by blood volume spilled (V)

Table 7: The volume deviation between the actual volume and the calculated volume with different ρ (rho)

	Whole blood							Red blood cell			
	Current findings				**Hinghofer Szalkay**	**Cutnell & Johnson**	**Vitello et al.**	**Current findings**			**Norouzi et al.**
	1.006 g/mL	**0.987 g/mL**	**1.084 g/mL**	**1.028 g/mL**	**1.043 g/mL**	**1.060 g/mL**	**0.0489 g/mL**	**1.028 g/mL**	**1.257 g/mL**	**1.150 g/mL**	**1.110 g/mL**
Non-branded	-0.2±1.07	1.3±0.72	-5.6±2.46	-1.8±1.47	-2.9±1.74	-4.0±2.04	1463.9±386.95				
SensiPad	-5.0±5.28	-1.3±3.69	-18.8±12.13	-9.1±7.20	-11.8±8.55	-14.7±10.04	3724.0±1960.51	-1.3±3.14	-27.9±13.29	-16.8±9.03	-12.1±7.23
ProCare	8.7±2.48	12.4±1.76	-4.9±9.08	4.7±4.23	2.0±5.54	-0.9±7.01	3702.9±1931.99	26.6±2.52	-6.9±13.38	7.1±8.85	13.0±6.93

Note: Mean±SD

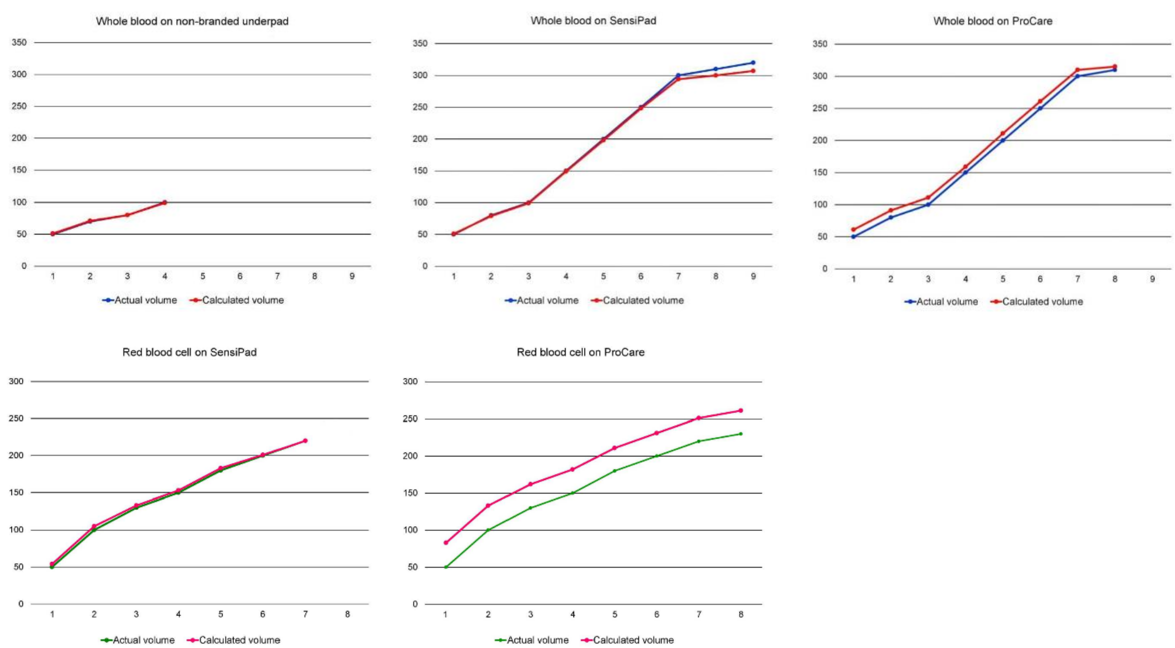
Fig. 5: The volume deviation between the actual volume and the calculated volume with some different ρ (rho)



This study found that the different material and absorption of each underpad has influenced the weight of underpad exposed blood so that we recommend *ρ* (rho) used for each underpad should be different.

For volume calculation of WB with non-branded underpad (ρ=1.006 g/mL), SensiPad (ρ=0.987 g/mL) and ProCare (ρ=0.060 g/mL) while for volume calculation of erythrocyte with SensiPad dan ProCare, we recommend respectively ρ=1.028 g/mL dan ρ=1.150g/mL. Another interesting finding was that the volume calculation of WB using non-branded underpad and SensiPad tended to be more precise at lower volumes, respectively up to 100 mL and 300 mL while using ProCare tended to be more accurate with higher volumes. A different finding on volume calculation of erythrocyte indicated that SensiPad is more precise than ProCare (Fig. 6).

Fig. 6: The line graph of volume deviation between the actual volume and the calculated volume among three underpads



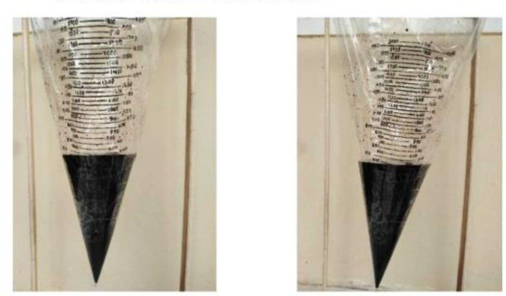
Blood loss measurement by the delivery drape

This method utilized a drape made of transparent plastic, was cone-shaped with wire encircles on the top of its funnel, and calibrated. Blood collected in the drape was assessed based on readable levels of calibrated drape. Six scenarios with artificial blood were undertaken for this method. In each scenario, the drape was hanged in different positions before filled with artificial blood. The blood volume was then measured on readable levels on the calibrated drape, and its result was compared to actual blood volume to obtain the mean (27mL) and range of the volume deviation (0-50 mL). The readable volume on the calibrated drapes was depended on the position of the hanging drape and wire that encircles its funnel due to its flexible material of drape (Fig. 7).

DISCUSSION

The major advantage of the visual method is that it is easy and quick to do, but it is difficult to interpret. This study found that visual estimation carried out by three groups of midwives on underpads exposed to human blood tended to be underestimated. Conversely, estimation on underpads exposed artificial blood was prone to be overestimated. The midwives may be able to estimate blood volume in simulation but not necessarily in real labor. It is because in real labor, not all blood is absorbed to the underpad, and blood contamination commonly generates the irregular shape. Besides, material and absorption of underpad differ and affect blood contamination results. It concurs with the finding of previous studies that visual method was too inaccurate[29], full of errors[2] and tended to be underestimated[30,31,32] with an increase in an underestimation in volumes >100Ml[31] and >300-500mL[32]. Interestingly, this finding is quite different but similar to the finding of Kavle et al. that midwives can estimate blood loss

Figure 7. The discrepancy in the hanging drape position and the shape of wire on the drape produces a different volume



The wire was not arranged in a circular position (oval form) but an upright position

The wire was set in a circular position, but it was hung in a slightly titled position

accurately with mean underestimation by midwives being 4.90mL. However, the inaccuracies rise at higher volume, particularly in volume ≥200 mL[33]. Blood loss during general labor is in the range of 200-300 mL[32]. It is in line with Schorn study that visual method did not only often cause underestimation but also overestimated since there was no certain pattern[13,34]. Tall et al. also reported that a significant overestimated was found on visual blood loss estimation at the volume of 100mL[29]. Whether overestimated or underestimated, this has clinical implications[9]. Many studies have reported the inaccuracy of the visual method[2,13,29,32,34]. Interestingly, although the inaccuracy of this method has been proven in many studies, it is still the most frequently used in daily practice.

The next finding of this study, a significant correlation between midwife groups and duration of clinical experiences and the accuracy of blood loss estimation visually found at volume 100 mL and 150 mL, but the correlation was absent in other volumes. It showed that the accuracy of blood loss estimation does not depend on the duration of clinical experience[2,10,29,35,36]. All groups of midwives could not estimate blood loss accurately in multiples of 10mL. Prasertcharoensuk et al. asserted that visual estimation is not sensitive in detecting postpartum hemorrhage, and it has underestimated the incidence of PPH by 88.88%[20]. It should not be ignored since the accuracy of blood loss assessment is a critical factor in PPH management. The visual method should no longer be used in assessing blood loss[9,13] and should be replaced with other more useful and accurate methods. Preserving this method is an of little benefit and medically dangerous[13,7].

The suitable method for an ordinary bed or a gynecological bed that function like an ordinary bed was the gravimetric method. This method was more accurate than the visual method[18]. It is strengthened by prior studies that there was a significant correlation between gravimetric and laboratory methods[38], thus reducing the incidence of PPH[8].

The next further interest finding is that the weight of underpad exposed blood was affected by brand and material of the underpad used. Non-branded underpad and SensiPads have a lower deviation volume (actual volume minus calculated volume) compared to ProCare. We recommend a different ρ (rho) in calculating the volume for each underpad. For volume calculation of whole blood for non-branded underpad (ρ=1.006 g/mL), SensiPad (ρ=0.987 g/mL) dan ProCare (ρ=0.060 g/mL). Volume calculation for erythrocyte should be ρ=1.028 g/mL for SensiPad and ρ=1.150 g/mL for ProCare. Whether the ρ for each underpad in blood volume calculation is different or the same remains an issue. This issue requires further scientific evidence.

Nonetheless, many studies have encouraged gravimetric use in assessing blood loss owing to accuracy[8,13,38], speed and cost compared to the laboratory method[38]. It is easy to do, can be taught and applied in all health facilities[8] and gravimetric method only requires simple equipment, namely an accurate scale[8,13]. Unfortunately, this advantage can be challenging when an accurate scale is not available. Another drawback of this method is that it requires calculation. Error in the calculation will naturally affect results. Thus, the gravimetric method is only recommended if an accurate scale is available at health facilities, and midwives can compute the volume using the volume formula.

Furthermore, we also recommend delivery drape for labor with a gynecological bed. The superiority of this method does not depend on other equipment and numeracy skills, costs less, done with ease, convenient, and more accurate than visual estimation. It concurs with Tourné et al. study that also recommended delivery drape to be utilized in routine labor as it is easy, cheapest, and accurate[39]. Some previous studies have also proven the accuracy of drape in measuring blood loss compared to visual estimation[17,39,40].

The delivery drape recommended in this study is calibrated drapes. Toledo et al. report that blood loss assessment using non-calibrated drapes generated underestimated blood loss with worse accuracy at higher volumes (16% error at 300 mL to 41% at 2000 mL). While the error of calibrated drape was <15% on all volumes[10]. This method is less suitable to be used on labor with an ordinary bed or gynecological bed that functions like an ordinary bed as it relies on the exact position of the hanging drape and wire. The material of the drape becomes relevant since a plastic drape is flexible so that the position of the drape will affect blood volume that is read off the calibrated drape.

Neither gravimetric methods nor delivery drapes cannot distinguish blood from amniotic fluid and urine[10,13]. Hence, the health providers should replace underpad (in gravimetric) or use delivery drape after the baby has been born and ask the woman to inform the health providers if she intends to urinate, so body liquid collected on the underpad or delivery drape is only blood. However, if there is an indication for episiotomy underpad or drape must be applied before the episiotomy procedures.

CONCLUSION

In the final analysis, we can conclude that the most suitable blood loss assessment method for an ordinary bed or a gynecological bed that functions like an ordinary bed is gravimetric method while for a gynecological bed the delivery drape is most suitable. We also summarize the advantages and disadvantages of both methods in table 8. To minimize the inaccuracy of the results of blood loss assessment using these methods, we recommend as in table 9.

Table 8: The advantages and disadvantages of gravimetric method dan delivery drape

Aspects	Gravimetric	Drapes
Delivery pad	Need delivery pad such as fabric or underpad	Do not need a delivery pad
Calculation	Need calculation where each underpad requires a different ρ (rho)	Do not require a calculation
Accuracy	Rely on an accurate scale	Rely on an exact position of hanging drape and wire

Table 9: Recommendation

Method	Aspect	Suggestions
Gravimetric	Variety and inaccuracy of scale	Provide at least two types of scales to confirm the weight of the delivery pad Standardization of the type of scales used in the delivery room Calibration of scales periodically
	Calculation error	Considering hemorrhage is an emergency case requires quick action, so the existence of a simple application that assists midwives in computing blood volume using volume formula is an excellent idea to avoid calculation error and shorten calculation time.
Delivery drape	The inaccuracy of hanging drape and wire position	Modification of delivery drape that not depend on the hanging drape and wire position will be a great solution to avoid assessment error of blood loss

Limitation of study: In gravimetric and visual methods, we did not use all type of delivery pads used Indonesian midwives in simulations since there was a limit on the amount of blood. We suggest other researchers identify the ρ (rho) for fabric and other brands of underpad used in labor.

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