ORIGINAL ARTICLE

Visual Blood Loss estimation using artificial blood versus human blood

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ABSTRACT

Background. Visual blood loss estimation (BLE) is the most common method used globally.
Aim: To evaluate the accuracy of BLE using artificial blood and human blood as well as consider the correlations, if any, between midwife groups and years of clinical experiences.
Methods. In this observational study, 27 scenarios using artificial blood and 21 scenarios using human blood have been addressed to answer the research question. The primary outcome assessed was the accuracy of visual BLE. The accuracy of which was then correlated to the midwife group and the duration of clinical experience using Cramer's V test.
Results. A total of 232 participants estimated the blood loss volume, and a trend toward overestimation was found in the visual estimation with artificial blood (AB), but when the simulation used human blood (HB), it tended to be underestimated. There were significant correlations between the midwife groups and estimation accuracy with AB at all volumes, but the correlations were only found at volume 100 mL and 150 mL when the simulation was using HB.
Conclusion. Visual BLE may produce overestimated or underestimated results. Midwives' skills in estimating blood loss in clinical scenarios using artificial blood cannot be representative of their skills in real labor. The duration of clinical experience does not correlate to the accuracy of BLE. We recommend further studies in order to identify another method that can be implemented in general practice.
Keywords: Visual estimation, blood loss volume, artificial blood, human blood, labor

INTRODUCTION

For centuries, the position of postpartum hemorrhage (PPH), which is defined as a blood loss of 500 mL or more[1, 2], has been the leading cause of maternal mortality in the world, particularly in developing countries, but it has remained stable[3-5]. The maternal mortality rate in Indonesia experienced a dramatic increase by over 50% from 228 per 100,000 births in 2007[6] to reach a peak of 359 per 100,000 births in 2012[7] before a slight decrease to around 305 per 100,000 births in 2015[8]. However, the percentage of maternal deaths due to PPH remains stable at 30.1% in 2013[9] and 30.3% in 2019[10].

Delay in the diagnosis of PPH causes further delay in its management and often leads to an increased risk of poor outcomes[11,12], such as hypovolemic shock, cardiopulmonary arrest, and death[1,13]. Both the velocity and accuracy of blood loss estimation (BLE) during childbirth are vital in the diagnosis of PPH[11] and the early detection of clotting disorders[14].

For several decades, the issue regarding the appropriate method in assessing blood loss is questionable[15]. However, visual BLE[1,11,12,16-19]. is the most common method used throughout the world[11.16]. The purpose of the study was to evaluate the correlation between midwife groups and years of clinical experiences along with the accuracy of BLE using both artificial and human blood.

MATERIAL AND METHODS

The clinical scenario simulations were done using artificial blood (AB)[20] and human blood (HB). The AB consists of glycerin, food coloring, and emulsifier, while the HB used in the simulations was whole blood (WB) that contains plasma, red blood cells, white blood cells, and platelets[21]. WB packs were acquired from the donor blood transfusion unit, Jambi Branch of Palang Merah Indonesia, after passing license and ethic procedures and obtaining approval from the Jambi blood bank. The clinical reconstructions conducted at the midwifery education clinic of the Health Ministry Polytechnic, Jambi province, were executed using three brands of underpads that Indonesian midwives frequently used, namely, non-branded, SensiPad, and ProCare[22].

We spilled AB and HB in specific volumes on underpads (60cmx90cm) and then compared the characteristics of their contaminations. Twenty-seven clinical scenario simulations in total (nine simulations for each underpad brand) were performed using AB, while only twenty-one clinical scenario simulations were applied using HB due to the limited amount of the HB. They were divided into nine simulations on SensiPad, eight simulations on ProCare, and four simulations on non-branded underpads.

We coated underpads that were contaminated by blood by a transparent checkered pattern plastic to assist midwives in estimating blood loss visually. Each small box was 1 cm x 1 cm, and each thick striped box was 10 cm x 10 cm. Each simulation result was photographed using a digital camera. The pictures were then shown to midwife educators, midwife practitioners, and midwife students to be estimated. The midwife educators and midwife practitioners who have clinical experience in the maternity room as well as midwife students who have a clinical internship experience in the maternity room were eligible for this study. Forty-six midwife educators, one hundred and ten midwife practitioners, and seventy-six midwife students have estimated that the blood volume contaminated the underpad. Cramer's V test was used to determine the correlation between midwife groups as well as the duration of clinical experiences and the accuracy of BLE.

RESULTS

For the simulations using AB, the estimation by midwife educators and midwife practitioners inclined to overestimations, but it tended to be underestimated by the midwife students. There were significant correlations between the midwife groups and the accuracy of visual BLE in all volumes (Table 1). While for the simulations using HB, the estimation by all three midwife groups tended to be underestimated. The significant correlations between the midwife groups and the estimation accuracy were only found at volume 100 mL and 150 mL (Table 1). Moreover, there were no correlations between the years of clinical experiences and the accuracy of visual BLE using HB (Table 2).

Table 1: Results of Cramer's V test on midwife groups (N=232)

		Artificial Blood				Human Blood			
		Midwife educators (N=46)	Midwife practitioners (N=110)	Midwife students (N=76)	Cramer's V	Midwife educators (N=46)	Midwife practitioners (N=110)	Midwife students (N=76)	Cramer's V
50 mL	Underestimated	4 (8.7)	14 (12.7)	30 (39.5)	.000***	22 (47.8)	71 (64.5)	50 (65.8)	.169
	Precise	1 (2.2)	5 (4.5)	5 (6.6)		8 (17.4)	14 (12.7)	13 (17.1)	
	Overestimated	41 (89.1)	91 (82.7)	41 (53.9)		16 (34.8)	25 (22.7)	13 (17.1)	
80 mL	Underestimated	11 (23.9)	11 (10.0)	32 (42.1)	.000***	21 (45.7)	65 (59.1)	50 (65.8)	.144
	Precise	2 (4.3)	4 (3.6)	6 (7.9)		1 (2.2)	4 (3.6)	4 (5.3)	
	Overestimated	33 (71.7)	95 (86.4)	38 (50.0)		24 (52.2)	41 (37.3)	22 (28.9)	
100 mL	Underestimated	3 (6.5)	14 (12.7)	34 (44.7)	.000***	18 (39.1)	69 (62.7)	53 (69.7)	.016*
	Precise	3 (6.5)	14 (12.7)	8 (10.5)		12 (26.1)	18 (16.4)	8 (10.5)	
	Overestimated	40 (87.0)	82 (74.5)	34 (44.7)		16 (34.8)	23 (20.9)	15 (19.7)	
150 mL	Underestimated	11 (23.9)	38 (34.5)	46 (60.5)	.000***	22 (47.8)	81 (73.6)	59 (77.6)	.003**
	Precise	6 (13.0)	4 (3.6)	7 (9.2)		7 (15.2)	13 (11.8)	4 (5.3)	
	Overestimated	29 (63)	68 (61.8)	23 (30.3)		17 (37.0)	16 (14.5)	13 (17.1)	
200 mL	Underestimated	16 (34.8)	49 (44.5)	51 (67.1)	.005**	31 (67.4)	79 (71.8)	58 (76.3)	.825
	Precise	8 (17.4)	16 (14.5)	5 (6.6)		6 (13.0)	15 (13.6)	8 (10.5)	
	Overestimated	22 (47.8)	45 (40.9)	20 (26.3)		9 (19.6)	16 (14.5)	10 (13.2)	
250 mL	Underestimated	5 (10.9)	47 (42.7)	49 (64.5)	.000***	27 (58.7)	84 (76.4)	54 (71.1)	.210
	Precise	7 (15.2)	12 (10.9)	5 (6.6)		3 (6.5)	7 (6.4)	5 (6.6)	
	Overestimated	34 (73.9)	51 (46.4)	22 (28.9)		16 (34.8)	19 (17.3)	17 (22.4)	
300 mL	Underestimated	11 (23.9)	38 (34.5)	49 (64.5)	.000***	22 (47.8)	72 (65.5)	53 (69.7)	.058
	Precise	8 (17.4)	15 (13.6)	3 (3.9)		3 (6.5)	11 (10.0)	5 (6.6)	
	Overestimated	27 (58.7)	57 (51.8)	24 (31.6)		21 (45.7)	27 (24.5)	18 (23.7)	
310 mL	Underestimated	11 (23.9)	45 (40.9)	47 (61.8)	.000***	24 (52.2)	73 (66.4)	52 (68.4)	.157
	Precise	0 (0.0)	2 (1.8)	2 (2.6)		0 (0.0)	0 (0.0)	0 (0.0)	
	Overestimated	35 (76.1)	63 (57.3)	27 (35.5)		22 (47.8)	37 (33.6)	24 (31.6)	
320 mL	Underestimated	12 (26.1)	48 (43.6)	47 (61.8)	.002**	25 (54.3)	79 (71.8)	50 (65.8)	.203
	Precise	3 (6.5)	2 (1.8)	2 (2.6)		0 (0.0)	1 (0.9)	0 (0.0)	
	Overestimated	31 (67.4)	60 (54.5)	27 (35.5)		21 (45.7)	30 (27.3)	26 (34.2)	

Notes: *p< .05 **p< .01 ***p< .001 are significant

Table 2: Results of Cramer's V test on years of clinical experience (N=232)

	Assessment	No experience (midwife students) (N=76)	≤2 years (N=33)	>2-4 years (N=25)	>4-6 years (N=19)	>6-8 years (N=11)	>8-10 years (N=23)	>10 years (N=45)	Cramer's V
50 mL	Underestimated	50 (65.8)	22 (66.7)	14 (56.0)	13 (68.4)	5 (45.5)	13 (56.5)	26 (57.8)	.451
	Precise	13 (17.1)	3 (9.1)	3 (12.0)	4 (21.1)	3 (27.3)	1 (4.3)	8 (17.8)	
	Overestimated	13 (17.1)	8 (24.2)	8 (32.0)	2 (10.5)	3 (27.3)	9 (39.1)	11 (24.4)	
80 mL	Underestimated	50 (65.8)	17 (51.5)	15 (60.0)	13 (68.4)	5 (45.4)	9 (39.1)	27 (60.0)	
	Precise	4 (5.3)	3 (9.1)	1 (4.0)	0 (0.0)	1 (9.1)	0 (0.0)	0 (0.0)	.228
	Overestimated	22 (28.9)	13 (39.4)	9 (36.0)	6 (31.6)	5 (45.4)	14 (60.9)	18 (40.0)	
100 mL	Underestimated	53 (69.7)	18 (54.5)	15 (60.0)	13 (68.4)	5 (45.5)	9 (39.1)	27 (60.0)	
	Precise	8 (10.5)	9 (27.3)	4 (16.0)	4 (21.1)	3 (27.3)	2 (8.7)	8 (17.8)	.067
	Overestimated	15 (19.7)	6 (18.2)	6 (24.0)	2 (10.5)	3 (27.3)	12 (52.2)	10 (22.2)	
150 mL	Underestimated	59 (77.6)	22 (66.7)	19 (76.0)	13 (68.4)	6 (54.5)	11 (47.8)	32 (71.1)	
	Precise	4 (5.3)	4 (12.1)	0 (0.0)	2 (10.5)	4 (36.4)	4 (17.4)	6 (13.3)	.062
	Overestimated	13 (17.1)	7 (21.2)	6 (24.0)	4 (21.1)	1 (9.1)	8 (34.8)	7 (15.6)	
200 mL	Underestimated	58 (76.3)	23 (69.7)	19 (76.0)	15 (78.9)	9 (81.8)	12 (52.2)	32 (71.1)	
	Precise	8 (10.5)	5 (15.2)	3 (12.0)	2 (10.5)	1 (9.1)	6 (26.1)	4 (8.9)	.744
	Overestimated	10 (13.2)	5 (15.2)	3 (12.0)	2 (10.5)	1 (9.1)	5 (21.7)	9 (20.0)	
250 mL	Underestimated	54 (71.1)	22 (66.7)	19 (76.0)	13 (68.4)	8 (72.7)	14 (60.9)	35 (77.8)	
	Precise	5 (6.6)	3 (9.1)	1 (4.0)	3 (15.8)	1 (9.1)	1 (4.3)	1 (2.2)	.804
	Overestimated	17 (22.4)	8 (24.2)	5 (20.0)	3 (15.8)	2 (18.2)	8 (34.8)	9 (20.0)	
300 mL	Underestimated	53 (69.7)	19 (57.6)	15 (60.0)	13 (68.4)	6 (54.5)	13 (56.5)	28 (62.2)	
	Precise	5 (6.6)	3 (9.1)	4 (16.0)	0 (0.0)	2 (18.2)	1 (4.3)	4 (8.9)	.735
	Overestimated	18 (23.7)	11 (33.3)	6 (24.0)	6 (31.6)	3 (27.3)	9 (39.1)	13 (28.9)	
310 mL	Underestimated	52 (68.4)	19 (57.6)	18 (72.0)	13 (68.4)	8 (72.7)	12 (52.2)	27 (60.0)	

Assessment		No experience (midwife students) (N=76)	≤2 years (N=33)	>2-4 years (N=25)	>4-6 years (N=19)	>6-8 years (N=11)	>8-10 years (N=23)	>10 years (N=45)	Cramer's V
	Precise	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	.654
	Overestimated	24 (31.6)	14 (42.4)	7 (28.0)	6 (31.6)	3 (27.3)	11 (47.8)	18 (40.0)	
320 mL	Underestimated	50 (65.8)	21 (63.6)	17 (68.0)	15 (78.9)	8 (72.7)	12 (52.2)	31 (68.9)	
	Precise	0 (0.0)	0 (0.0)	1 (4.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	.412
	Overestimated	26 (34.2)	12 (36.4)	7 (28.0)	4 (21.1)	3 (27.3)	11 (47.8)	14 (31.1)	

Note: *Significant at .05 level

Although the volume of blood shed on the underpads remained the same, the width of blood contamination showed significant difference. It is caused by the differences in material and absorption of the underpads. Additionally, artificial blood has different characteristics than human blood, particularly to the blood in a real labor (Figures 1 and 2). This study also found that human blood contaminations have irregular forms and no specific pattern (Figure 3).

Figure 1. The width difference of blood contamination produced from clinical simulations and real labor

Artificial blood (AB) simulation result on SensiPad (150 mL)

AB has a definite form. All blood is absorbed to underpad with the same depth.

Human blood (HB) simulation result on SensiPad (150 mL)

HB has an irregular shape. All blood is absorbed to underpad with a different depth. There is the blood that is absorbed to the underpad's bottom surface, while some other blood is absorbed on the underpad's surface only (slight).

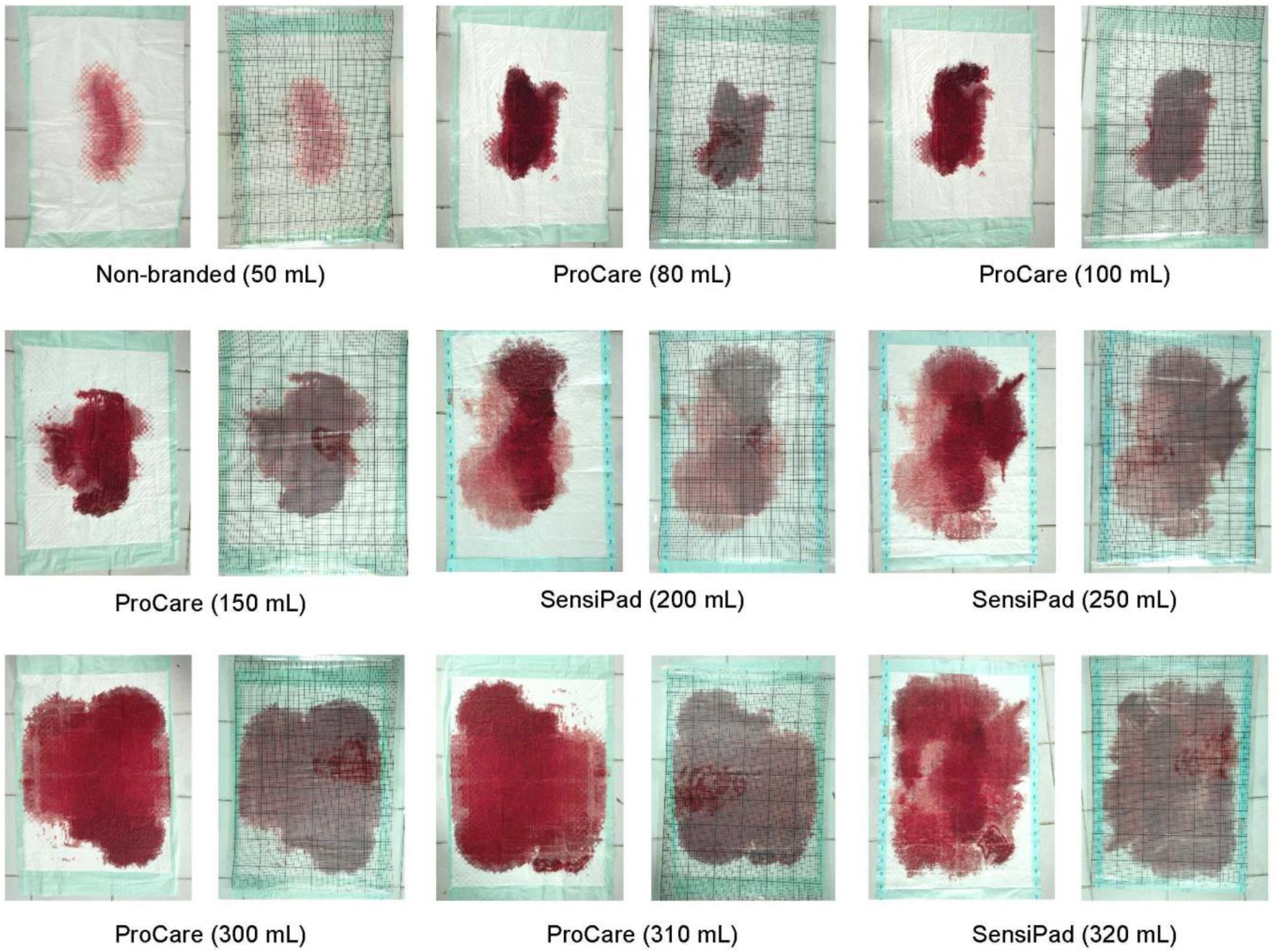
Human blood on SensiPad at real labor (the blood volume is unknown). Mrs. X, 23 years old, 37 weeks gestational age, Gravida 1, Nulliparous, Abortus null.

Blood in real labor has an unclear form. 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).

Figure 2: Human blood spills on three different underpads (60 cm x 90 cm)

Non-branded (50 mL) ProCare (50 mL) SensiPad (50 mL)

Figure 3: Blood spills from the different volumes on different underpads equipped with a checkerboard pattern



DISCUSSION

From the findings of this study, it has been shown that the visual BLE is easy to be implemented but difficult to be interpreted. These findings support the previous study that the visual BLE can generate an underestimated or overestimated result due to the absence of a clear pattern[23, 24]. Tall et al. stated that the tendency of overestimated rose at a volume of 100 mL[25]. Contrary to this, studies from Beer et al. and Razvi et al. indicated the tendency of underestimated respectively elevated at the volumes of more than 100mL[26] and 300-500mL[27].

Neither underestimated nor overestimated can be ignored as both may have harm effects[14]. Underestimation may postpone hemorrhage management, while overestimation may lead to unnecessary transfusion[1]. There was a significant correlation between the midwife groups and the accuracy of estimation using AB. However, the significance only found at volume 100 mL and 150 mL when the simulation was using HB. This study showed that midwives' skills in estimating blood loss in the clinical scenario using AB could not accurately represent their skills in real labor. In real labor, not all blood is merged to the underpad, and blood commonly forms in unclear patterns with different depths. Moreover, the width of blood contamination may differ with various types of underpads.

Further findings showed that the duration of clinical experiences did not correlate with the accuracy of visual BLE results. A similar finding was found in previous studies[1, 12, 25, 28, 29]. Prasertcharoensuk et al. added that the visual BLE had ignored the incidence of PPH by 88.88%[18].

Interestingly enough, this method remains the most frequently used in routine clinical practices even though many previous studies have shown the weakness of this method[1, 23-25, 27]. Bose et al. and Schorn asserted that this method should no longer be used to predict blood loss volume and should be replaced by another more accurate method[14, 23]. Maintaining this method is less beneficial and even medically harmful[23, 30].

CONCLUSION

The finding in this study indicate that visual BLE may be overestimated or underestimated. Midwives' skills in predicting blood loss in clinical scenarios using artificial blood cannot accurately be representative of their skills in real labor. The duration of clinical experience did not influence the accuracy of BLE. We recommend further studies to identify another method that would make it possible to be implemented in general practice.

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