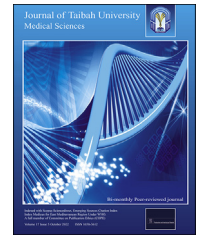




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Original Article

## Estimating blood loss during cesarean delivery: A comparison of methods

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### المخلص

**أهداف البحث:** يساهم النزيف عند الولادة بشكل كبير في المضاعفات المرضية ووفيات الأمهات. يعد تقييم كمية الدم المفقود أثناء العمليات القيصرية مهما في خفض المضاعفات والوفيات، ولكن هذه الكمية غالبا يتم التقليل منها من قبل الجراح ومن المحتمل من طبيب التخدير أيضا.

**طرق البحث:** تتناول هذه الدراسة هذه المسألة من خلال مقارنة ثلاثة طرق منفصلة لتقييم فقدان الدم أثناء الولادة القيصرية. لكل من 97 سيدة حامل كامل المدة خضعن لعملية قيصرية اختيارية، تم قياس الدم المفقود من خلال التالي: التقدير البصري من قبل كل من طبيب التوليد وطبيب التخدير، وزن الفوط الجراحية قبل الجراحة وبعدها، وبالمعادلات الحسابية (ضرب الفرق في قيم الهيموجلوبين قبل الجراحة وبعدها حسب حجم الدم المقدر للمريضة).

**النتائج:** أظهرت هذه الدراسة أن أقل قيمة تقديرية لفقدان الدم جاءت من التقدير البصري، بينما جاءت أعلى قيمة من المعادلة الحسابية. كان أطباء التخدير أكثر دقة في تقديرهم البصري لكمية الدم المفقود من أطباء التوليد.

**الاستنتاجات:** وجدت هذه الدراسة أن كمية الدم المفقود أثناء العملية القيصرية يتم المبالغة في تقديرها بالمعادلات الحسابية والتقليل من تقديرها من قبل أطباء

التوليد. ومع ذلك، كان التقدير الذي قدمه أطباء التخدير قريبا من الذي تم الحصول عليه من وزن الفوط. هذا يؤكد الحاجة إلى اعتماد طرق أكثر دقة لتقدير الدم المفقود أثناء الولادات القيصرية.

**الكلمات المفتاحية:** الولادة القيصرية؛ فقدان الدم؛ تركيز الهيموجلوبين؛ التقدير البصري؛ أطباء التوليد

### Abstract

**Objectives:** Obstetrical hemorrhage contributes significantly to maternal morbidity and mortality. Assessment of blood loss while undergoing cesarean sections (CS) is essential in lowering the morbidity and mortality, however this amount is commonly underestimated by the surgeon and probably the anesthetist too.

**Methods:** This study addresses this issue by comparing three separate ways of assessing blood loss during cesarean sections. For each of 97 full-term pregnant women undergoing elective CS, blood loss was measured by the following: visual estimation by both the obstetrician and the anesthetist, weighing surgical pads pre operatively and post operatively and by calculations (multiplying the difference of pre-operative and post-operative hemoglobin values by the patient's estimated blood volume).

**Results:** The results of this study indicated that the lowest estimated value for blood loss came from visual

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estimation, while the highest value came from the mathematical formula. Anesthetists were more accurate in their visual estimation of blood loss than were obstetricians.

**Conclusion:** This study found the amount of blood loss during CS to be overestimated by the mathematical calculation and underestimated by obstetricians. However, the estimate given by anesthetists was close to that obtained by weighing pads. This underscores the need for more accurate methods of blood loss estimation in cesarean sections to be adopted.

**Keywords:** Blood loss; Caesarean delivery; Hemoglobin concentration; Obstetrician; Visual estimation

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## Introduction

Globally, delivery by cesarean section (CS) ranks among the most common obstetric surgical procedures.<sup>1</sup> Despite its prevalence, women undergoes CS are exposed to the increased risks of surgical complications that accompany abdominal surgery, namely, infection, VTE, visceral organs injury, bleeding and the need for blood transfusion.<sup>1</sup> In late pregnancy, uterine blood flow typically ranges from 500 to 750 ml/min. During CS delivery, the average blood loss is about 500 ml,<sup>2</sup> although it varies from below 500 ml to above 1000 ml.<sup>3</sup>

Although obstetric hemorrhage as a cause of maternal morbidity and mortality is rising, it is potentially preventable.<sup>4</sup> An essential component of lowering morbidity during CS delivery is the prevention and early recognition of blood loss through an effective means of measurement. If accurate, this assessment of blood loss can prevent the risks linked to unnecessary blood transfusion.<sup>5</sup>

The volume of blood lost is at times estimated by obstetric caregivers or measured in different ways, including calculating changes in lab results (such as levels of hemoglobin or hematocrit), mechanical means (drape or pad counts), radioactive methods, and dye dilution techniques.<sup>6,7</sup> Despite research casting doubt on the effectiveness of visual estimation of blood loss by the obstetric operating team,<sup>8</sup> this practice is prevalent, being practiced by anesthetists, obstetricians, and nurses.<sup>9</sup>

In order to realize obstetric hemorrhage in its early stages, it is crucial that ongoing blood loss be accurately assessed. However, researchers have reported that obstetricians may underestimate blood loss by up to 50%,<sup>10</sup> and these underestimations may result in errors in making decisions about giving the patient blood and or its products. This in turn may result in low hemoglobin levels and decreased blood volume, with a risk of kidney and other vital organs damage.<sup>11</sup> To explore this problem further, this study

compared three separate techniques of estimating blood loss during CS delivery:

- 1 Visual estimation by members of the operative team: the obstetrician and anesthetist estimate blood loss by close monitoring of the operating theater during surgery and report this amount postoperatively.
- 2 Weighing of dry and blood-soaked surgical pads (sponges & swabs) before and after surgery, taking the difference as the amount of blood loss (absorbed by the sponges and swabs).
- 3 Application of a blood loss estimation formula used to calculate the intraoperative blood loss through the use of pre-operative and postoperative hemoglobin values.<sup>12,13</sup>

## Materials and Methods

This prospective observational study involved 97 full-term pregnant women with planned elective lower segment CS between January 1 and June 30, 2019 at the Maternity and Children's Hospital (MCH), in Makkah, KSA. The study protocol was reviewed and approved by the Committee of Biomedical Research and Ethics Unit at Umm Al-Qura University (HAPO-02-K-012-2016-01-137). Written informed consent was obtained from all participants. Women who underwent an emergency CS or were in trial of labor ended by a CS were excluded from the study. We excluded also women with known disorders of hemostasis or any cause of bleeding during pregnancy, preeclampsia, eclampsia, or those taking anticoagulants. Complete history was taken, and clinical examinations were carried out on each patient, after which a CS was done using general anesthesia or regional anesthesia based on patients wish and the anesthetist judgment. Each participant's age, parity, and history of complications were noted along with the type of CS (primary or repeat) and kind of anesthesia. The preoperative hemoglobin concentration of the participants was also measured and recorded. We used the Hemoglobin balance formula (Hemoglobin balance method). The formula uses the difference between pre - and post-operative hemoglobin levels divided by the preoperative hemoglobin level to calculate an estimation of blood loss. Nadler's formula was used to estimate blood volume.

Intraoperative blood loss was assessed by three separate techniques for each participant:

1st method (visual estimation): after closing the incision, the anesthetist and obstetrician were each asked to estimate the amount of blood they noticed being lost by the patient (in ml) during surgery. The circulating nurse kept these recorded values.

2nd method (weighing of sponges and swabs): the circulating nurse weighed the dry laparotomy sponges and swabs before surgery and weigh it again after surgery when soaked with blood. The difference in preoperative and postoperative weight was estimated to almost equal the volume of lost blood on the basis of 1 gm of blood equaling 1 ml of blood.<sup>14</sup> The scrub nurse was tasked with soaking up all blood in the surgical area using the same surgical sponges and swabs, with no suction being used unless necessary, in which case, the blood accumulated in the

suction canister was added to the blood in the absorbent material. Attention was given to collecting all or almost all the amniotic fluid with a different suction device. In addition, the placenta was not included in the calculations of blood loss. The circulating nurse weigh the material and recorded the relevant data.

3rd method (blood loss estimation formula): blood loss was calculated by multiplying the perioperative difference of hemoglobin (or hematocrit) (upon hospital admission for CS and 24-h postoperatively) by the patient's estimated blood volume.<sup>13</sup>

#### Statistical analysis

The mean and standard deviation were used to describe the continuous variables at 95% confidence interval. Categorical variables were expressed in terms of frequencies and percentages. The paired samples t-test was used to compare each participant's measured hemoglobin values before and after surgery and to compare their documented and expected allowable blood loss. A chi-square test was used to assess the association between the three methods of measuring blood loss (estimates by anesthetists and obstetricians, weight of absorbent pads, and calculated blood loss from hemoglobin concentration). The SPSS IBM version 21 statistical analysis program was used, and the alpha significance level was set at 0.05.

#### Results

A total of ninety-seven consecutive term pregnant Saudi patients undergoing elective CS were enrolled consecutively in this study, ranging in age from 19 to 45 (mean =  $31 \pm 5.9$  years). More than half (51.5%) of the studied sample were >31 years, while 48.5% were <30 years. Of the 97 participants, 37 (38.1%) women had no history of previous CS, while 60 (61.9%) women had between one and three previous CS deliveries but all were elective. Ninety-three (96.9%) of the cesarean sections were carried out using regional anesthesia

**Table 1: Descriptive analysis of the women's sociodemographic characteristics.**

	Participants (n = 97) Mean $\pm$ SD
Age (years)	31.0 $\pm$ 5.90
Gestational age at CS (weeks)	38.35 $\pm$ 2.10
Weight (kg)	62.52 $\pm$ 8.16
Height (cm)	163.78 $\pm$ 5.50
Body Mass Index (kg/m <sup>2</sup> )	23.30 $\pm$ 2.83
Parity	2.13 $\pm$ 2.12
Previous miscarriage	1.65 $\pm$ 0.99
	N (%)
Primary CS	37 (38.1)
Repeated CS	60 (61.9)
Comorbidity	
No	55 (91.6)
Yes	5 (8.3)
Type of comorbidity	
Diabetes Mellitus	4 (6.7)
Morbid obesity	1 (1.66)

**Table 2: Hemoglobin values and blood loss estimated by different methods (ml).**

	Participants (n = 97) Mean $\pm$ SD	P-value
<b>Hemoglobin values (gm/L)</b>		
Preoperative	11.23 $\pm$ 1.56	0.001
Postoperative	9.92 $\pm$ 1.46	
Difference	1.31 $\pm$ 1.1	
<b>Visually estimated blood loss</b>		
Anesthetist	560.1 $\pm$ 248.4	0.001
Obstetrician	525.2 $\pm$ 244.4	
<b>Blood loss estimated by</b>		
Average visual method	547.10 $\pm$ 221.4	0.001
Weight of pads	568.10 $\pm$ 239.1	
Calculation	646.44 $\pm$ 711.91	

while only the other four patients (4.1%) had general anesthesia. The mean weight of the subjects was  $62.52 \pm 8.16$  kg, while the mean parity was  $2.13 \pm 2.12$  babies with a range of 0–4 (Table 1). A review of the women's medical history showed that 6.7% had diabetes mellitus, and 1.7% of the women were morbidly obese.

Table 2 presents the mean blood loss estimated by visual and weighing methods and the calculated estimate from preoperative and postoperative hemoglobin levels. The mean blood loss estimate made by anesthetists was  $560.1 \pm 248.4$  ml, while that of obstetricians was  $525.2 \pm 244.4$  ml. The difference between blood loss estimations by anesthetists and those made by obstetricians reached statistical significance ( $P = 0.001$ ). The mean calculation of blood loss using the mathematical formula was  $646.4 \pm 712$  ml. Significant differences in blood loss estimates appeared when the three estimation techniques were compared. The lowest volumes came from estimates based on visual monitoring, while the highest volumes came from calculations using the mathematical formula ( $P = 0.001$ ) (Table 2). There was a statistically significant difference between blood loss estimated visually by obstetricians in comparison to values of blood lost measured by pad weighing ( $P = 0.004$ ). However, the difference in visual estimates made by anesthetists and blood loss estimates made by weighing the surgical pads was not statistically significance ( $P = 0.45$ ). The mean preoperative hemoglobin level was  $11.23 \pm 1.56$  gm/L, dropping to a postoperative value of  $9.92 \pm 1.46$  gm/L, giving a mean hemoglobin difference of  $1.31 \pm 1.1$  gm/L. The decline in the participants' hemoglobin after surgery was statistically significant  $P = 0.001$  (Table 2).

#### Discussion

Obstetrical hemorrhage is a common cause of maternal mortality due probably the tendency of underestimating the amount of blood lost and subsequently failing to replace it adequately in a timely manner.<sup>15</sup> Deliveries by CS are especially prone to blood loss in varying amounts.<sup>1</sup> It is crucial that blood loss estimation during CS to be accurate since insufficient blood volume may result in orthostatic changes and negatively impact the amount of oxygen reaching the vital organs. These abnormal hemostatic factors could also lead to additional bleeding.<sup>16</sup> In contrast, accurate estimates of blood loss enable adequate blood replacement in

a timely manner, lowering the likelihood of disseminated intravascular coagulation occurring and renders the impact of hemorrhagic shock less severe.<sup>17</sup>

The traditional method of monitoring blood loss during cesarean sections and most of the surgical procedures has been visual estimation, which lacks objectivity and precision.<sup>18,19</sup> In studies comparing visual estimation to quantitative measurement, researchers reported that the former is more apt to result in underestimation at times of heavy blood loss and overestimation at times when blood loss is low.<sup>18–20</sup> During surgery, a key task for anesthesiologists and surgeons is to accurately monitor and estimate the patient's blood loss.<sup>21</sup> In this study, obstetricians significantly underestimated the volume of blood lost, whereas anesthesiologists—regardless of their expertise gave estimates closest to those of blood loss assessed by weighing pads. While overestimation of blood loss was more common among anesthesiologists, underestimation of blood loss occurred more frequently among obstetricians.<sup>22</sup> These stark differences may reflect the anesthesiologist's caution on the one hand and the obstetrician's meticulousness on the other hand. These observations are in line with findings from previous research on blood loss estimates by obstetricians and anesthesiologists.<sup>2,22,23</sup> Duthie et al.<sup>24</sup> reported that obstetricians' underestimation of blood loss was noticeable when the blood loss reached volumes of more than 600 ml. Clearly, obstetricians have different degrees of experience in assessing the blood loss, which may impact their assessment<sup>25</sup>; however, higher degrees of specialization, age, and longer clinical experience do not seem to increase the accuracy of visual estimation of blood loss.<sup>8,19</sup> In prior research comparing methods of estimating obstetric blood loss, weighing pads has been the gold standard compared to other methods used.<sup>2,26</sup> This is because pad weighing provides a real objective value, that does not rely on subjectivity (as with visual estimation) or hypothetical values (as with mathematical formulae). Several studies have involved comparisons of visual estimates to quantitative measurements in both clinical and simulated settings.<sup>8,18,20</sup> Concluding that the estimation of blood loss is more accurate when quantitative methods are used.<sup>8,18,27</sup> For instance, a study by Alkadri et al. on 150 women compared the visual estimation method to a gravimetric measurement of the blood loss which involved weighing blood-soaked items after surgery and subtracting it from that the preoperative dry weight of the items. Compared to the weighing method, visual estimation of blood loss resulted in an underestimates of about 30% (gravimetric mean blood loss of 304.1 ml compared to nurse- and physician-estimates of mean blood loss of 213 ml and 214.3 ml, respectively).<sup>8</sup>

In the current study, the accuracy of the pad-weighing method was improved by aspirating the amniotic fluid separately to prevent its volume being added to the blood soaked up and swabbed away. Doing this ensured that the pre- and postoperative difference in weight of the pads was due to the volume of blood loss only.

The estimation of perioperative blood loss using mathematical formulae depends on varying parameters: hemoglobin (Hb) level, hematocrit level, and body weight, in addition to the number of units of blood transfused.<sup>28</sup> In the current study,

the variable used in the blood loss estimation formula was Hb level. The mean decrease in Hb was 1.3 mg/dL, which is similar to that seen in other researches.<sup>2</sup> Methodologically, in this study postoperative Hb was measured 24 h after surgery to ensure an accurate measurement-estimation of intraoperative blood loss only. In our study, use of the mathematical formula generated an insignificant overestimation of blood loss during CS, a drawback mentioned for most of the formulae used to calculate blood loss.<sup>12,13</sup>

The strength of the current work is its prospective aspect. Assessment of intraoperative blood loss was carried out using three different techniques: visual estimation of the obstetrician with varying skill levels, weighing surgical pads and sponges pre- and postoperatively (a task performed by another care provider), and calculation by mathematical formula using Hb values. The data collected were highly accurate based on standardized objective measurements, removing any data collection bias. One limitation of this study is the relatively small sample size, so the results may not be generalizable. Additionally, the varying degrees of experience of the anesthesiologists and obstetricians may have impacted the accuracy of their blood loss estimation.

## Conclusion

The present study underscores the inaccuracy of visual estimation of blood loss during cesarean sections, with the error typically due to an underestimation by the obstetrician. A more accurate method, with an objective measurement (weighing of pads) or laboratory results (pre- and postoperative hemoglobin levels) might be used especially in cases with massive blood loss to minimize the operative morbidity and mortality related to bleeding. However, these methods are not always readily available in all the operating theaters. Hence trying to combine the Obstetrician and Anesthesiologist visual estimation of blood loss might be the best way to have an accurate estimate.

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## Conflict of interest

The authors have no conflict of interest to declare.

## Ethical approval

None.

## Authors contributions

AA, MB, MA, and SA were responsible of the patient recruitment, data collection, and literature review. KH participated in the literature review besides that she wrote the manuscript with SA and MB. MD analyzed the data. AG supervised the research overall and revised the revised the



manuscript. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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