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Comparison of Visual Evaluation vs. Lactate and Base Deficit in Obstetric Hemorrhagic Shock.

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ABSTRACT:

Introduction: The Maternal Mortality Rate estimate for 2017 shows that, on average, 211 women died for every 100,000 live births globally, with a rate of 415 in low-resource countries. Primary postpartum hemorrhage is defined as blood loss from the genital tract greater than 500 mL after birth or 1000 mL at Caesarean section within the first 24 hours after birth.

Material and Method: A comparative study was carried out in 21 patients with a history of an obstetric hemorrhagic shock to assess the correlation of the observational vs. arterial blood gases (lactate and DB during a period from March 2022 to January 2023. Statistical analysis: Descriptive and parametric statistics were used for the variables included.

Results: Twenty-One patients were studied, patients with obstetric hemorrhage (100%) whose data are presented in Table 1. 7 patients (33%) were transfused with less than 1000 mL and 14 patients (66.6%) with more than 1000 mL, the range was 2500 mL, the minimum transfusion of 500 mL and the maximum of 3000 mL, a total of 24,700 mL were transfused in these patients, there were no maternal deaths. Conclusions: The use of blood gases is recommended in all patients with acute obstetric hemorrhage.

Discussion: The registry of Intraoperative blood loss plays a central role in the daily routine of doctors. Therefore, for the safety of the patient, we should aim for the highest possible measurement accuracy.

Conclusion: Routine use of blood gases is recommended for patients with acute obstetric hemorrhage.

KEYWORDS: Estimation of blood loss; Visual estimation; gravimetric method; Colorimetric estimation; Gasometry; Basis deficit; Lactate.

INTRODUCTION

The estimate of the Maternal Mortality Index (MMI) for 2017 shows that, on average, 211 women died for every 100,000 live births worldwide, with an MMI of 415 in low-resource countries [1, 2]. Primary postpartum hemorrhage PPHPP is defined as blood loss from the genital tract greater than 500 ml after birth or 1000 ml at cesarean section within the first 24 hours after birth. Severe HPPP is defined as more than 1000 mL of blood loss within 24 hours of birth [3]. Uterine atony accounts for the majority of PPPH (80%), followed by genital tract trauma (13%), retained placental debris (5%), and coagulation disorders (2%) [1-3].

Linde LE, et al. [4] found that maternal, fetal, and obstetric characteristics had differential effects on PPH types. The risk of recurrence differed between PPH types, with the greatest risks of recurrence for PPH being dystocia, retained placenta, and atony. PPH due to retained placenta was more likely to develop into severe PPH. The retained placenta was recorded more frequently with severe PPH and sex showed a stronger effect; the delivery of a boy was associated with a lower risk of PPH. Previous cesarean sections increased the risk of PPH due to dystocia. The recurrence risk of PPH suggests that it can be inherited.

Most maternal complications develop during pregnancy, and many can be prevented or treated. Complications, such as maternal obesity, curettage in a previous pregnancy, hypertension diseases, and hemoglobin (Hb) level ≤ 10 g/dL may exist before pregnancy and may pose problems during pregnancy leading to Postpartum Hemorrhage (PPH). PPH is known to be the consequence of several different factors that can occur in isolation or combination, such as uterine atony, retained placental debris, genital tract trauma, and coagulation dysfunction (the 4T mnemonic: tone, tissue, trauma, and thrombin) [5, 6].

Gong J et al., [7] found the following to be risk factors for PPH: placenta previa, gestational age, PT, TT, fibrinogen, anemia antepartum, placenta accrete, uterine atony, placental abruption, and pregnancy with uterine fibroids were identified as risk factors for PPH after cesarean delivery.

It is estimated that in patients admitted hypotensive, with major abdominal trauma requiring laparotomy, for every 3 minutes of delay in surgical intervention increases mortality at 1% [8].

Comparison of Visual Evaluation vs. Lactate and Base Deficit in Obstetric Hemorrhagic Shock.

MATERIAL AND METHODS

A comparative study was carried out on 21 patients with a history of a hemorrhagic obstetric shock to assess the correlation of the calculation of bleeding between observational and laboratory methods during a period from March 2022 to January 2023 in the gynecology and obstetrics service of the General Hospital Playa of Carmen. Exclusion criteria. Mothers who presented other diseases that could increase acid levels lactic acid (sepsis, liver disease, diabetic ketoacidosis, heart disease, use of recognized drugs to increase the level of lactic acid). Statistical analysis: Descriptive of central tendency and parametric statistics were used for the included variables. From a clinical point of view, gasometry of these patients with severe obstetric hemorrhage is very important because it may indicate that the patient is in hypovolemic shock, or even that she is not yet, but has already started on the road to being so. This is verified when we have a patient with obstetric hemorrhage with inconclusive clinical signs and symptoms, but with an altered base deficit and later with increased lactate (Lactate normal values < 2 mmol/L, and Base Excess in a range of -1 to + 2 mEq/L.)

In decompensated metabolic acidosis, to these values is added the decrease in pH for which the gasometric standard most frequently found is the reduction of pH, HCO_3^- and blood CO_2 (Tables 1, 2).

Li Y, et al. [22]

PRIMARY COMPENSATION	SECUNDARY COMPENSATION	DESCOMPENSATION
pH CO_2 HCO_3 Lactate	Ph CO_2 HCO_3 Lactate	pH CO_2 HCO_3 Lactate
Normal Normal ↓ Normal	Normal ↓ ↓ ↑	↓ ↓ ↓ ↑

Hypovolemic shock, grades (Davis) [23].

MILD	MODERATE	SEVERE
2-5 mmol/L	5-15 mmol/L	≥15 mmol/L
3-5 mEq/L	6-9 mEq/L	≥10 mEq/L

RESULTS

Twenty-one patients with obstetric hemorrhage (100%) were studied, the data of which are presented in Table 1. 7 patients (33.3%) were transfused with less than 1000 mL and 14 patients (66.6%) with more than 1000 mL; the range was 2,500 mL, the minimum transfusion was 500 mL and the maximum was 3,000 mL. In total, 24,700 mL were transfused in these 21 patients. There was no maternal mortality.

Characteristics	Data summary	Percentage
Patients Age (years) Weight (kg)	21 28.3±5.3 67±10.1	100
Shock grade		
I II II IV	2 9 4 6 21	9.5 42.8 19.04 28.5 100
Causes of obstetric hemorrhage		
Ectopic pregnancy Uterine atony pathological puerperium Ameu Preeclampsia Post Lui	9 6 3 1 1 1 21	42.8 28.5 14.2 4.7 4.7 4.7 100
	Procedures	
Exploratory laparotomy Caesarean section Vaginal delivery	9 9 1 21	52.3 42.8 4.7 100
	Blood values	
Admission hemoglobin Calculated bleeding (visual, mL) Discharge hemoglobin Transfused globular packages	10.1±2.3 1176±588 8.9±1.9 2±1.4	

Shock index		
≥0.7 ≥0.9 ≥1.0 ≥1.25 ≥1.50 ≥1.75	8 6 3 1 2 1 21	38.0 28.5 14.2 4.7 9.5 4.7 100
Lactate	9.1±13.4	
Basis Deficit	3.9±3.2	

DISCUSSION

The recording of intraoperative blood loss plays a central role in the daily routine of physicians. Consequently, for the safety of the patient, we must aim for the highest possible measurement accuracy. Visually and gravimetric blood loss estimation measurements show a high degree of bias, so their use cannot be recommended. Colorimetric technology offers real-time measurements and has a high degree of correlation.

Despite the awareness of the inaccuracy of visual estimation by anesthetists and surgeons, it remains the mainstay for estimating surgical blood loss. This review aims to highlight the strengths and weaknesses of currently used measurement methods. Visual estimation of blood loss by physicians is not only one of the most widely used methods but also the most examined. This includes the estimation of blood volumes in sponges and suction cups. Forty-eight studies addressed the accuracy and improvement of visual assessment and 29 of these were conducted in obstetrics. The results of the study are heterogeneous, so there are different results about the influence of different factors of professional experience, gender, and age, on the accuracy of the estimate. The gravimetric method is an indirect measure of blood loss. Blood loss can be inferred by weighing blood-contaminated surgical material and subtracting dry weights. By adding the measured weight of the blood and estimating the amount (mL) of mixed fluids (eg, blood, rinse fluid) in the suction cup, blood loss can be calculated with a conversion of 1 g = 1 mL of blood [9].

Direct measurement of blood loss is a simple, long-established method. Nine studies focused on specially designed calibrated collection bags for vaginal deliveries. The collection bag is placed under the woman's buttocks immediately after the birth of the child and collects all mixed fluids (for example, blood or amniotic fluid). At the bottom of the plastic sheet is a calibrated collection bag with a scale on which current is measured and blood loss can be read. This method is easy to use and, especially in under-resourced areas, in combination with visual assessment, can somewhat improve the quantification of total blood volume during delivery. However, the study results still show significant deviations from the actual blood volume when used [10].

Visual estimation and gravimetric methods are commonly used to quantify the volume of blood lost during cesarean delivery. However, the correlation between blood loss and post-cesarean section hemoglobin (Hb) is poorly studied, and it is not clear whether the correlation varies depending on how blood loss is measured. A prospective study of 61 women undergoing CE was conducted to assess the relationships between post-CD Hb and blood loss measured using four modalities: gravimetric blood loss (gBL) measurement, visual blood loss estimation by an obstetrician blinded (oBL) and an anesthesiologist (aBL), and the Triton System (tBL). Hb was measured before the operation and within 10 minutes after the cesarean section. gBL was quantified as the volume of blood in a suction canister in addition to the weight of blood-soaked sponges. tBL was measured with the Triton System by photographing blood-soaked sponges and the contents of the suction cup. To assess the relationship between blood loss and post-CD Hb, we performed correlation analyzes and compared the magnitude of the correlations between the four measurement modalities. Since they only observed weak correlations between each modality with post-CD Hb and no significant differences in the magnitude of the correlations between the four modalities, there may be limited clinical utility in estimating post-cesarean Hb from Hb values. Blood loss measured with any of these modalities [11].

Accurate estimation of the BL is paramount, as it can substantially alter the timing of interventions to control bleeding. The study by Anya SU, et al. [12], compares the intraoperative BL assessment by visual estimation with the BL calculated from hemoglobin estimation using the HemoCue®201+. A total of 60 full-term pregnant patients undergoing elective cesarean section under spinal anesthesia were enrolled in the study. In the operating room, the hemoglobin level of the patients was determined before and after surgery using the HemoCue®201+; and a modified Gross formula was used to calculate the BL. BL was also estimated and documented visually by counting the blood-soaked abdominal packs and gauze pads and multiplying them by the estimated volume of blood that would fit on each; the visually estimated mean BL (EBL) and HemoCue-calculated BL (CBL) were 470 ± 221 mL and 563 ± 204 mL, respectively (p = 0.125). The bias was negligible (45.25 ml), and the limit of agreement between both methods was −222.20-275.43 mL. The discrepancy between the two methods increased when BL was ≥500 mL. This study showed that EBL was visually closely related to HemoCue CBL when the amount of BL was <500 mL.

In one study the authors indicated that the lower estimated value for blood loss came from the visual estimate, while the higher value came from the mathematical formula. The anesthetists were more accurate in their visual estimate of blood loss than the obstetricians. This study found that the amount of blood lost during cesarean section was overestimated by mathematical calculation and underestimated by obstetricians. However, the estimate given by the anesthesiologists was close to that obtained with the weighing pads. This underscores the need to adopt more accurate methods of estimating blood loss in cesarean sections [13].

Visual estimation of postpartum blood loss is often underestimated and to improve accuracy, quantitative measurement of blood loss was introduced for all births at the 12 hospitals providing maternity care. This intervention was incorporated into a quality improvement program (Obstetric Bleeding Strategy for Wales, OBS Cymru). They reported the incidence of postpartum hemorrhage in Wales over one year. Data from the biannual audit demonstrated an increase in quantitative measurement from 52.1 to 87.8% ($p < 0.001$). The incidence of postpartum hemorrhage >1000 mL, >1500 mL, and >2000 mL were 8.6, 3.3, and 1.3%, respectively, versus 5, 2, and 0.8% in the year before OBS Cymru. The incidence of bleeding >1000 mL was similar across the 12 hospitals despite the widely varying size, staffing levels, and case mix. The incidence of PPH varied with the type of delivery and was a mean of 4.9% for unassisted vaginal deliveries, 18.4% for instrumental vaginal deliveries, 8.5% for elective cesarean delivery, and 19.8% for non-elective cesarean delivery [14].

Intraoperative blood loss is estimated daily in the operating room and is performed primarily by visual techniques. Surgical sponge colors may vary (eg, white in the US, green in Germany). The influence of sponge color on estimation accuracy has not been established in the research focus yet. A total of 53 anesthetists participated in the study. Visual estimate moderately correlated with baseline blood loss in white and green. The visually estimated mean blood loss was greater in white sponges 250ml than in green sponges (150ml compared to reference blood loss (103ml). For both color types, gross underestimation and overestimation were observed. Multivariate statistics show that the colors of the cloths have a significant influence on the estimation, as well as the level of qualification of the physician and the amount of RBL to be estimated. The deviation from the correct estimate of blood loss was less with white surgical sponges compared to green sponges In general, the deviations were so severe for both types of sponges that it seems advisable to refrain from estimating blood loss visually whenever possible and instead uses other techniques such as colorimetric estimation [15].

To assess the ability of estimated blood loss (EBL) and quantitative blood loss (QBL) to predict the need for blood transfusions in postpartum patients. In general, the baseline characteristics between the EBL and QBL groups were similar. Although there was a higher rate of blood loss ≥1000 mL in QBL vs. EBL (6.5% vs. 2.1%), there was no difference in the rate of blood transfusions (2.0% vs. 2, 0%). Among cesarean deliveries, QBL outperformed EBL in predicting blood transfusion and/or a ≥ 10-point drop in hematocrit. QBL also outperformed EBL in predicting transfusion after vaginal delivery. QBL is a more sensitive test for detecting clinically significant blood loss, which could lead to the recognition of bleeding and interventions [16].

This study examined the precision, sources of error, and limitations of gravimetric quantification of blood loss (QBL) during cesarean delivery. Blood loss determined by hemoglobin content tests on sponges and suction cannulas were compared with QBL in 50 parturient. QBL was moderately correlated with actual blood loss ($r=0.564$; $p<0.001$). Compared to the reference trial, QBL overestimated blood loss in 44 patients (88%). QBL deviated from the analyzed blood loss by more than 250 mL in 34 patients (68%) and by more than 500 mL in 16 cases (32%). The blood loss analyzed was more than 1,000 ml in four patients. For three of these, QBL was more than 1000 mL (sensitivity=75%). QBL was > 1,000 ml in 12 patients. While three of these had tested blood loss of more than 1000 mL, 9 of the 46 patients with blood loss of less than 1000 mL per trial (20%) were incorrectly identified as having postpartum hemorrhage by QBL (false positive). The specificity of quantitative QBL for the detection of blood loss ≥1000 mL was 80%. QBL was only moderately correlated with the reference trial. Time overestimation was more common than an underestimation, so the QBL was particularly inaccurate when significant bleeding occurred [17].

Ruiz-Labarta J, et al. [18], evaluated whether a quantification of obstetric blood loss based on clinical-workshop simulation for undergraduate medical students improves theoretical and practical knowledge, along with security and self-confidence. The participants were volunteer students in the fourth year of a Medicine degree. The study period was divided into stages: pre-workshop, intra-workshop, 2 weeks post-workshop, and 6 months post-workshop. In the pre-workshop stage, students completed a short online course in preparation for the workshop. The effectiveness of the workshop was assessed through multiple-choice tests and self-administered questionnaires. Data were compared between time points using statistical tests for paired samples. Of the 142 invited students, 138 accepted the workshop offer (97%) and 85% had no experience in managing blood loss.

Between the pre- and 2-week post-workshop stages, significant improvements were observed in theoretical-practical knowledge (= 1,109), security, and self-confidence. In the 6-month post-workshop stage, theoretical-practical knowledge decreased compared to 2 weeks after the workshop, returning to pre-workshop levels, while self-confidence and confidence did not vary significantly over the longer term. The obstetrics workshop improved the theoretical-practical knowledge and the self-confidence and confidence of the medical students. The results 2 weeks after the workshop were maintained up to 6 months after the training intervention. The workshop based on clinical simulation was perceived by the students as useful and necessary.

Arterial blood gases in the management of severe obstetric hemorrhage have become an essential tool for the correct interpretation of the clinical picture presented by the patient. Its knowledge has been shown to reduce maternal morbidity and mortality, managing to identify patients who have not yet developed alterations in the usual clinical variables, or who are difficult to interpret given the replacement and treatment protocols that are usually applied to these clinical cases. This tool not only allows for the diagnosis of hemorrhagic shock but also informs those patients who are on their way to shock if the clinical conditions are maintained, in addition to identifying patients with occult bleeding, which will allow activating massive transfusion protocols and active search for the source of the hemorrhage, to stop it [19].

"Postpartum hemorrhage continues to be one of the leading causes of maternal morbidity and mortality worldwide, an estimated 358,000 women die during childbirth each year in the Americas secondary to postpartum bleeding. For the treatment of these patients, hemodynamic and microcirculation parameters are used, which have been extrapolated from the general population to mothers as measures of resuscitation in postpartum hemorrhage. Lactic acid is an indirect marker of tissue hypoxia and anaerobic metabolism, used as a resuscitation guide in hemorrhagic shock and sepsis; demonstrating the decrease in mortality in patients with tissue hypoperfusion when values decreased or normalized with resuscitation strategies. The measurement of lactic acid and its progressive decrease has been considered as one of the objectives of resuscitation [20].

Dockree S et al., [21] in your study describe the normative distribution of lactate levels around the time of delivery. Lactate in labor and the puerperium is commonly elevated above the levels expected in healthy pregnant or non-pregnant women (>2 mmol/l), but it is rarely >4 mmol/l. However, these measurements were used to be able to calculate the possibility of an infectious process, unlike our work focused on the state of hemorrhagic shock and the possibility of its use to assess the severity of the patients and take the necessary measures for the decision awareness about the corresponding treatment according to the severity of the case.

It is very important to recognize the patient with hypovolemic shock in a timely manner, to enter it into a “code red" soon. It is estimated that in patients admitted hypotensive, with major abdominal trauma requiring laparotomy, for every 3 minutes of delay in surgical intervention increases mortality in 1% [22]. CONCLUSIONS. Routine use of blood gases is recommended for patients with acute obstetric hemorrhage.

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REFERENCES

1) World Health Organization, Trends in maternal mortality 2000 to 2017: estimates by WHO, UNICEF, UNFPA, World Bank Group, and the United Nations Population Division. 2019.
2) Tiruneh B, Fooladi E, McLelland G, Plummer V. Incidence, mortality, and factors associated with primary postpartum hemorrhage following in-hospital births in northwest Ethiopia. PLOS ONE. 2022; 17(4): e0266345. https://doi.org/10.1371/journal.pone.0266345
3) Feduniw S, Feduniw S, Warzecha D, Szymusik I, Wielgos M. Epidemiology, prevention and management of early postpartum hemorrhage-a systematic review. Ginekol Polska. 2020; 91(1):45-51. https://doi.org/10.5603/GP.2020.0010
4) Linde LE, Rasmussen S, Moster D, Kessler J, Baghestan E, Gissler M, et al. Risk factors and recurrence of cause-specific postpartum hemorrhage: A population-based study. PLOS ONE. 2022; 17(10): e0275879. https://doi.org/10.1371/journal.pone.0275879
5) Sebghati M, Chandraharan E. An Update on the Risk Factors for and Management of Obstetric Haemorrhage. Women's Health. 2017; 13(2):34-40. https://doi.org/10.1177/1745505717716860
6) Bazirete O, Nzayirambaho M, Umubyeyi A, Karangwa I, Evans M. Risk factors for postpartum hemorrhage in the Northern Province of Rwanda: A case-control study. PLOS ONE. 202; 17(2): e0263731. https://doi.org/10.1371/journal. puts.0263731
7) Gong J, Chen Z, Zhang Y, et al. Risk-factor model for postpartum hemorrhage after cesarean delivery: a retrospective study based on 3498 patients. Scientific Rep. 2022; 12:22100. https://doi.org/10.1038/s41598-022-23636-5
8) Kirkpatrick AW, Ball CG, D’Amours SK, Zygun D. Acute resuscitation of the unstable adult trauma patient: bedside diagnosis and therapy. Can J Surg. 2008 Feb; 51(1):57-69.
9) Gerdessen L, Meybohm P, Choorapoikayil S, et al. Comparison of common perioperative blood loss estimation techniques: a systematic review and meta-analysis J Clin Monitor Comput. 2021; 35:245-58. https://doi.org/10.1007/s10877-020-00579-8
10) López-Picado A, Albinarrate A, Barrachina B. Determination of perioperative blood loss: accuracy or approximation? Anesth Analg. 2017; 125:280-6. https://doi.org/10.1213/ANE.0000000000 001992.
11) Fedoruk K, Seligman KM, Carvalho B, Butwick AJ. Assessing the Association between Blood Loss and Postoperative Hemoglobin after Cesarean Delivery: A Prospective Study of 4 Blood Loss Measurement Modalities. Anest Analg. May 2019; 128(5):926-32.
12) Anya SU, Onyekwulu FA, Onuora EC. Comparison of visual estimation of intraoperative blood loss with hemoglobin estimation in patients undergoing cesarean section. Nigerian Postgraduate Med J. 2019; 26:25-30. Doi: 10.4103/npmj.npmj_164_18
13) Gari A, Hussein K, Daghestani M, Aljuhani S, Bukhari M, Alqahtani A, et al. Estimating blood loss during cesarean delivery: A comparison of methods. J Taibah Univ Med Sc. 2022; 17(5):732e736.

14) Bell SF, Watkins A, John M, et al. Incidence of postpartum hemorrhage defined by quantitative blood loss measurement: a national cohort. BMC Pregnancy Childbirth. 2020; 20:271. https://doi.org/10.1186/s12884-020-02971-3
15) Piekarski F, Gerdessen L, Schmitt E, Tanner L, Wunderer F, Neef V, et al. Do we visually estimate intraoperative blood loss better with white or green sponges, and is the deviation from the real blood loss clinically acceptable? Results from a simulated scenario study. PLOS ONE. 2020; 15(10): e0240808. https://doi.org/10.1371/journal.pone.0240808
16) Blosser C, Smith A, Poole A T. Quantification of Blood Loss Improves Detection of Postpartum Hemorrhage and Accuracy of Postpartum Hemorrhage Rates: A Retrospective Cohort Study. Cureus. Feb 27, 2021; 13(2): e13591. DOI 10.7759/cureus.13591
17) Thurer RL, Doctorvaladan S, Carvalho B, Jelks AT. Limitations of Gravimetric Quantitative Blood Loss during Cesarean Delivery. AJP Rep 2022; 12:e36–e40.
18) Ruiz-Labarta J, Martínez Martín A, Pintado Recarte P, et al. Workshop on Blood Loss Quantification in Obstetrics: Improving Medical Student Learning through Clinical Simulation. Healthcare. 2022; 10:399. https://doi.org/10.3390/healthcare10020399
19) Rodríguez-Escudero F. Importance of gasometry in the management of obstetric hemorrhage. Arch Gynecol Obstet. 2021; 59(3):219-28.
20) García-Velásquez V, Rodas-Acosta D, González-Agudelo M, Ardila-Castellanos R. Lactic acid as a prognostic marker in postpartum obstetric hemorrhage. Scientific Letters Nov 2014; 38(8): 524-6. http://dx.doi.org/10.1016/j.medin.2013.11.002
21) Dockree S, O'Sullivan J, Shine B, James T, Vatish M. How should we interpret lactate in labor? A reference study. BJOG: Int J Obstet Gyn. 2022; 129(13):2150-6. https://doi.org/10.1111/1471-0528.17264.
22) Li YL, Chan CP, Sin KK, Chan SS, Lin PY, Chen XH, et al. Validating a pragmatic definition of shock in adult patients presenting to the ED. Am J Emerg Med. 2014 Nov; 32(11):1345-50.
23) Davis JW, Kaups KL, Parks SN. Base deficit is superior to pH in evaluating clearance of acidosis after traumatic shock. J Trauma. 1998 Jan; 44(1):114-8.