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ORIGINAL ARTICLE

Hemodynamic variables of obstetric hemorrhagic shock and their relationship with massive transfusión

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ABSTRACT

Introduction: severe obstetric hemorrhage is the leading cause of preventable pregnancy-related death worldwide.
Objective: to demonstrate the relationship between hemodynamic variables of obstetric hemorrhagic shock and massive transfusion in patients admitted to Intensive Care Unit 3 of the General Teaching Hospital "Abel Santamaría Cuadrado," from January 2020 to March 2024.
Methods: a descriptive, retrospective, longitudinal, cross-sectional study was conducted in mothers with obstetric hemorrhagic shock. Data were obtained from medical records; the universe consisted of 125 mothers with obstetric hemorrhage. The sample included 58 with severe obstetric hemorrhagic shock. Statistical processing used absolute and relative frequency, chi-square, and mean.
Results: severe obstetric hemorrhage was more frequent in cesarean deliveries (51,73 %), with uterine atony predominating (41,38 %). In the ICU, length of stay was less than five days (81,03 %). At admission, the most representative macrocirculatory variable was the shock index (1,85 ± 0,5), and in microcirculation, the base deficit (-16 ± 4). High statistical significance ($p < 0.001$) was found for pH, base deficit, central venous oxygen saturation, and delta PCO_2 in predicting the use of massive transfusion, as well as the shock index, which showed greater predictive value than cardiac output. Cardiac output decreased and systemic vascular resistance increased in relation to the magnitude of bleeding.
Conclusions: knowledge and management of microcirculatory variables and the shock index correlate with the use of massive transfusion in severe obstetric hemorrhage.

Keywords: Shock; Hemorrhage; Obstetrics; Transfusion.

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INTRODUCTION

Severe obstetric hemorrhage is the leading preventable cause of direct maternal death worldwide, representing approximately 27,1 % of these deaths.[1,2] The prevalence varies from region to region, from 7,2 % in Oceania, 8 % in Latin America, and 25,7 % in Africa.

In Latin America it represents 21 % of cases, while one in five maternal deaths in the Americas is due to obstetric hemorrhage during or immediately after childbirth.[3] In Cuba in the year 2023 the rate of direct maternal mortality per 100,000 live births was 25,4 and related to hemorrhagic complications a rate of 7,7 representing 15,5 % of the direct causes. In Pinar del Rio during the study period there was one death from obstetric hemorrhage, representing 25 % of the direct deaths.[4]

Although the World Health Organization (WHO) has developed guidelines on contemporary prevention and treatment of obstetric hemorrhage, the mortality associated with postpartum bleeding has decreased in high-income countries; however, the implementation of these recommendations has not translated into a significant decrease in morbidity and mortality from obstetric hemorrhage in developing countries. Additionally, there is a roadmap to reduce obstetric hemorrhage between the period 2023-2030 but there have been scarce advances in this area, especially in low- and middle-income countries.[5] The American College of Obstetricians and Gynecologist (ACOG) defines it as blood loss equal to or greater than 1000 ml or, in lesser amounts, that is accompanied by signs and symptoms of hypovolemia in the first 24 hours after childbirth regardless of the delivery route. The Royal College of Obstetricians and Gynecologists of Canada considers any blood loss that has the potential to produce hemodynamic instability.[6,7]

The cardiovascular system undergoes changes considered physiological during pregnancy progression that prepares it to increase its cardiac output, decrease systemic resistances, and prepare maternal hemodynamics to assimilate a new vascular bed such as the placental one, tolerate the hormonal influence on vascular tone, and thus compensate for blood losses during childbirth.[8] Regardless of adaptive cardiovascular changes, there are macro and microcirculation evaluation elements that can indicate cellular failure and hypoxia. The shock index (SI) as a macrocirculation element is calculated by dividing the heart rate by the systolic blood pressure and its normal values range between 0,5 and 0,7 in healthy adults; this has been proposed as an early marker of left cardiac dysfunction, hypovolemia, or blood loss in patients with trauma; in obstetrics in the immediate postpartum period its range oscillates between 0,5 and 0,9 with a mean of 0,7.[9]

Regarding hemodynamic variables, delta PCO_2 reflects venous return in the capillary bed and the adequacy of microcirculation; this indicator in particular shows the relationship of venous blood flow to eliminate CO_2, indirectly reflecting the state of Cardiac Output; changes in CO_2 occur faster than changes in lactate levels, making it a more sensitive marker of hemodynamic alteration.[10,11] $SvcO_2$ is a variable dependent on the VO_2/DO_2 relationship (oxygen consumption/oxygen availability); $SvcO_2$ decreases parallel to the decrease in DO_2, from there the onset of anaerobic metabolism can generate disproportionate changes due to tissue hypoxia, secondary to delayed appropriate interventions.

Therefore, $SvcO_2$ reliably translates the state of cellular oxygenation.[12] The analysis of arterial blood gasometry has become a common tool to evaluate the behavior of hemorrhagic states; pH and base excess allow us to evaluate the acid-base state in patients in shock states, resulting in metabolic acidosis as an element of tissue hypoperfusion.[13]

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Massive transfusion is typically defined as a transfusion of ≥ 10 units of red blood cells in 24 hours or patients with massive bleeding that leads to hemodynamic instability and vital risk; other definitions include 3 units of packed cells in one hour or 4 units of blood products in 30 minutes. This consists of type O Rh negative red cell packs, FFP (fresh frozen plasma) of type AB, and platelets. Although these are the main components, there remain controversies about which is the appropriate administration ratio of products (1:1:1); this protocol is the one that has been accepted in most countries including Cuba.(14,15)

Considering the high mortality globally that this phenomenon occupies, it is of vital importance to have studies that validate behaviors and procedures once obstetric hemorrhage is established; from there stems the objective of our work which is to demonstrate the relationship between hemodynamic variables of obstetric hemorrhagic shock and massive transfusion in patients admitted to intensive care unit 3 of the "Abel Santamaría Cuadrado" General Teaching Hospital. January 2020 to March 2024.

METHODS

A descriptive, retrospective, longitudinal, cross-sectional study was conducted in patients diagnosed with severe obstetric hemorrhagic shock who were admitted to the Intensive Care Unit (ICU) of the "Abel Santamaría Cuadrado" General Teaching Hospital, during the period from January 1, 2020 to March 31, 2024. Data were obtained from medical records; the universe was represented by 125 mothers with obstetric hemorrhage admitted to the ICU. The sample consisted of 58 mothers with severe obstetric hemorrhage. Other causes of ICU admission that did not present obstetric hemorrhages were excluded.

The selected variables were: age, skin color, weeks of gestation, number of previous pregnancies, etiology, ICU stay, macrocirculatory hemodynamic variables (mean arterial pressure, shock index, central venous pressure, urinary output, level of consciousness, capillary refill) and microcirculatory variables (pH, base deficit (BD), oxygen saturation (StaO2), central venous oxygen saturation (SvcO2), delta PCO2), cardiac output (CO), systemic vascular resistance (SVR), and massive transfusion.

The research methods employed were empirical methods, including: information collection through observation, as well as documentary analysis. As theoretical research methods, the hypothetical-deductive method, the historical-tendency method, and the scientific procedures of analysis-synthesis, induction-deduction were used.

The information was stored in a Microsoft Office Excel database on a personal Pentium 5 computer that supports specialized programs in statistics (SPSS for Windows), and for its processing, the digital and educational statistical package for epidemiological, statistical Piloto was used, with Chi-square and mean for continuous quantitative data (range series) being the tools used. Additionally, percentages were used as summary measures and tables of absolute and relative frequency distribution.

The investigation received approval from the Ethics Committee of the responsible institution. The confidentiality of the information obtained was respected, guaranteeing its use solely for the development of this research.

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RESULTS

In the period from January 2020 to March 2024, a total of 496 mothers in critical condition were admitted to the intensive care unit, of these 125 (25,20 %) with obstetric hemorrhage and 58 (11,69 %) with severe obstetric hemorrhage. The average age in years of the studied sample was (29,1 ± 5), with white skin color predominating in 41 patients for a (70,69 %), with a mean gestational age in weeks of (35 ± 6), with 62,1 % between 37-42 weeks (peripartum and immediate postpartum hemorrhages), the mean number of previous pregnancies was (3,3 ± 1,2), regarding the delivery route a higher number of severe hemorrhages was reported in cesarean patients 30 (51,73 %), with uterine atony 24 (41,38 %) and ruptured ectopic 22 (37,93 %) predominating as the main triggers, in ICU the stay was less than five days in 47 (81,03 %) once the hemodynamic imbalance was restored and the cause corrected.

The hemodynamic variables during patient reception showed that they were in class III-IV hemorrhagic shock, with high prediction for massive transfusion. In macrocirculation the most representative was the shock index, this not being the case in microcirculation where all variables showed compromise of tissue perfusion. (Table 1).

Table 1. Hemodynamic variables at admission.

Variables	Media ± DS
Macro circulatoria	
Mean Arterial Pressure (MAP)	56 ± 5
Central Venous Pressure (CVP)	7 ± 2
Urinary Output (UO)	0,5 ± 0,2
Level of Consciousness (LC)	10 ± 1
Shock index	1,85 ± 0,5
Capillary refill	4 ± 2
Microcirculatory	
pH	7,01 ± 0,5
Base Deficit	-16 ± 4
$SatO_2$	81 ± 16
$SvcO_2$	54 ± 9
△ PCO_2 (v-a)	+13 ± 3

The use of microcirculatory hemodynamic variables in the management of severe obstetric hemorrhage was determinant when predicting the use of massive transfusion, having high statistical significance with a p value <0.001, for pH, base deficit (DB), central venous oxygen saturation ($SvcO_2$) and delta PCO_2, this not being the case for arterial oxygen saturation ($StaO_2$) although with significant results with a p value < 0,05. Table 2.

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Table 2. Relationship between microcirculation variables and massive transfusion.

Variable	Massive Transfusion Used		Not Used		Total		Value of "p"
	Nº	%	Nº	%	Nº	%	
pH							
Less than 7,25	28	48,27	6	10,34	34	58,62	p <0.001
Major or equal to 7,25	9	15,52	15	25,86	24	41,38	
Total	37	63,79	21	36,20	58	100	
Base Deficit							
Less than - 6	30	51,72	2	3,45	32	55,17	p <0.001
Major or equal to - 6	6	10,34	20	34,48	26	44,83	
Total	36	62,06	22	37,93	58	100	
SvcO2							p <0.001
Less than 70 %	10	17,24	15	25,86	25	43,10	
Major or equal to 70 %	2	3,45	31	53,45	33	56,90	
Total	12	20,69	46	79,31	58	100	
$StaO_2$							p < 0.05
Less than 90 %	30	51,72	6	10,35	36	62,07	
Major or equal to 90 %	7	12,07	15	25,86	22	37,93	
Total	37	63,79	21	36,21	58	100	
△ **PCO_2 (v-a)**							p <0.001
Less than 6	7	12,07	12	20,69	19	32,76	
Major or equal to 6	35	60,34	4	6,90	39	67,24	
Total	42	72,41	16	27,59	58	100	

Source: Medical Records

The shock index was the macrocirculatory hemodynamic variable that was farthest from its normal range, therefore we associated it with the need for massive transfusion, its relationship being highly significant (P <0.001) and even with greater prediction than cardiac output.

Table 3. Relationship between shock index, cardiac output and massive transfusion.

Variable	Massive Transfusion Used		Not used		Total		Value of "p"
Shock Index	Nº	%	Nº	%	Nº	%	
Less than 0,7	3	5,17	23	39,65	26	44,83	P <0.001
Major or equal to a 0,9	25	43,10	7	12,07	32	55,17	
Total	28	48,27	30	51,72	58	100	
Cardiac output							P <0.05
Less than 5	46	79,31	6	10,34	52	89,65	
Major or equal to a 5	2	3,45	4	6,90	6	10,35	
Total	48	82,76	10	17,24	58	100	

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Cardiac output (CO) and systemic vascular resistance (SVR) were monitored by echocardiogram, demonstrating their compromise in severe obstetric hemorrhage, behaving with a significant fall in cardiac output and increase in systemic vascular resistance in relation to the magnitude of bleeding. Figure 1.

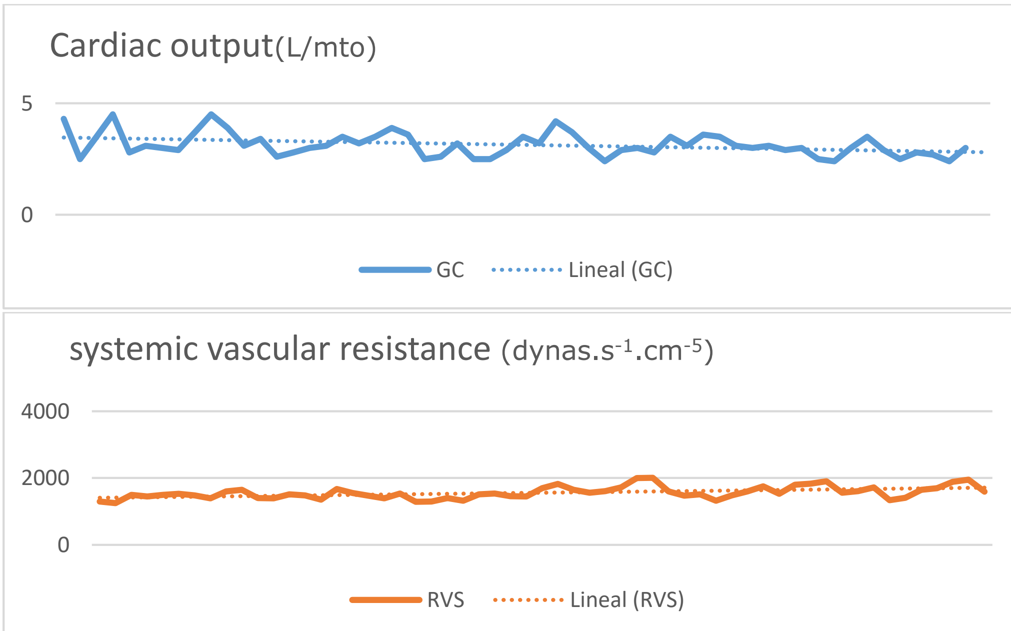

Fig. 1 Behavior of cardiac output and systemic vascular resistance in severe obstetric hemorrhage.

DISCUSSION

Severe obstetric hemorrhage remains the leading preventable cause of maternal death worldwide, mainly affecting developing countries. In our study we analyzed a group of critical mothers with life-threatening hemodynamic compromise secondary to massive severe hemorrhages with even need for massive transfusion, where the main cause that triggered the event was uterine atony as a consequence of loss of uterine muscle contraction capacity, similar results were shown by Salmanian et al.,[16] in their study Massive Transfusion Protocols in Obstetric Hemorrhage: Theory versus Reality, where the most common etiology of massive hemorrhage was this with 34 %. The ICU stay for severe obstetric hemorrhage is a critical indicator of the quality of maternal care, in the present work it was found to be less than 5 days having correlation with Vogel et al.,[17] in their study Effectiveness of care bundles for prevention and treatment of postpartum hemorrhage: a systematic review, demonstrating that timely correction and treatment results in fewer complications.

The shock index is a useful clinical tool to evaluate the severity of hemorrhage and the hemodynamic response in obstetric patients, being more sensitive than traditional vital signs to detect early blood losses. The mean found at reception was 1.85 ± 0.5 demonstrating the need for immediate intervention, Yiyu Pan et al.,[18] in a meta-analysis of 20 studies found that the combined sensitivity and specificity of the shock index to predict severe postpartum hemorrhage were 76 % (95 % confidence interval [CI]: 67% - 83 %) and 78 % (95 % CI: 5-24) and the AUC was 0,84 (95 % CI: 0.80 - 0.87), mainly in low- and middle-income countries compared to high-income countries.

In response to hypovolemia, arteriovenous shunts are activated at the microvascular level, diverting blood from nutritional capillary beds to veins, this worsens tissue oxygenation, especially in target organs. The behavior of microcirculatory variables at patient reception, as in predicting massive transfusion in our study showed highly significant results ($p < 0.001$), demonstrating their high relationship with severity and microcirculatory dysfunction, especially pH, base deficit (DB), delta PCO2 and central venous oxygen saturation (SvcO2).

pH and base deficit are essential parameters to evaluate the severity of obstetric hemorrhage and guide massive transfusion, according to the study by Díaz Aguilar FA, et al.,[13] Values of intraoperative arterial blood gasometry and serum lactate in patients with obstetric hemorrhage admitted to an intensive therapy unit, found that patients with bleeding over 3000 ml presented mean pH values of [7,18] correlated with DB of (-10,5) both with statistical significance in relation to the need for massive transfusion, other studies such as the HEMOMAS-II consensus document,[19] recommend serial monitoring of DB to estimate severity of bleeding, degree of hypoperfusion and tissue hypoxia.

Delta PCO2 is an early indicator of tissue hypoperfusion even before deep alterations in pH, base deficit or lactate manifest; an elevated value of this (> 6 mmHg) indicates that tissues are not receiving sufficient blood flow to eliminate the CO2 they generate, which is an important sign that the patient needs massive transfusion to improve oxygen transport capacity and cardiac output. Although literature is scarce in relation to delta PCO2 and obstetric hemorrhage, there are well-defined documents of its utility in tissue hypoperfusion. Ledezma Ruiz F and col.,[20] in an investigation related base deficit with delta PCO2 in hemorrhagic shock and found that delta PCO2 had a sensitivity of 76 % and specificity of 40 % and base deficit a sensitivity of 70 % and specificity of 50 %, demonstrating that there are no significant differences when establishing prognosis, but that both are of vital importance in follow-up and resuscitation.

Central venous oxygen saturation (SvcO2) is another hemodynamic variable that evaluates the oxygenation-perfusion balance in patients with massive hemorrhage requiring transfusion. A SvcO2 < 70 % is associated with tissue hypoperfusion and shock,[20] results that were shown in this way in the present investigation with highly significant results ($p < 0.001$). In 2024 Marie Werner et al.,[21] in the study Femoral Blood gas analysis, another tool to assess hemorrhage severity following trauma: an exploratory prospective study; demonstrated that SvcO2 was lower in patients who needed transfusion with significant results, thus demonstrating its validation together with the other microcirculatory hemodynamic variables as high predictors of massive transfusion and follow-up of goal-directed resuscitation.

Arterial oxygen saturation (StaO2) is a fundamental parameter that reflects the percentage of hemoglobin bound to oxygen in arterial blood. In massive hemorrhage and massive transfusion it acquires critical relevance as an indicator of tissue oxygenation and resuscitation efficacy. In massive transfusion protocols, StaO2 ≥ 95 % is sought to be maintained, as part of the objectives to prevent tissue acidosis and multiple organ failure, which is why the decrease in its values, despite being a late indicator, shows damage in deep perfusion associated with severe hemorrhage.

Cardiac output is the main compensation mechanism of the body in response to acute hemorrhage. The inability to maintain it is the sign that hemorrhage is massive and massive transfusion is imminent. In this section we compared its degree of prediction together with the shock index, showing that its relationship is vital, but with greater sensitivity the shock index ($p < 0{,}001$ / $P < 0{,}05$), this because CO is modified only when blood losses exceed 35 % with decrease in preload.

The integration of the two parameters is vital for goal-directed and focused resuscitation, allowing for more physiological management with fewer complications associated with resuscitation.[8,22] In a similar manner systemic vascular resistance (SVR) is expressed, which in the acute phase is elevated as a compensatory mechanism to maintain arterial pressure, which is why when it falls suddenly it means imminent circulatory collapse. Understanding this physiological aspect is crucial early and aggressively before hypotension is established and even more so decompensation of microcirculation that leads us to deterioration of deep perfusion with consequent multiple organ failure.

CONCLUSIONS

Knowledge and management of microcirculatory variables of tissue hypoperfusion and the shock index correlate with the use of massive transfusion in severe obstetric hemorrhage, thus demonstrating the importance of multimodal hemodynamic monitoring early from patient reception to damage control surgery and resuscitation, guiding the goals of goal-directed hemodynamic microcirculatory resuscitation, to avoid high rates of complications associated with treatment.

Conflict of interests

The authors declare that there is no conflict of interests.

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Author contributions

All authors participated in conceptualization, formal analysis, writing - original draft, writing - review, editing, and approval of the final manuscript.

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