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Application of shock index-based classification in hypovolemic shock due to obstetric hemorrhage and its comparison with conventional vital sign for prediction of adverse maternal outcome

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ABSTRACT

Background: At least, 358,000 women worldwide die annually from pregnancy and childbirth-related problems. Obstetric hemorrhage is the single most significant cause of maternal mortality worldwide accounting for 25–30% of all maternal deaths. **Aims and Objectives:** The objective of the study is to see the usefulness/importance of shock index (SI) in obstetric hemorrhage (antepartum and post-partum hemorrhage) and to compare the performance of SI with conventional vital signs for prediction of maternal outcome. **Materials and Methods:** The descriptive study was conducted in 100 cases of hemorrhagic shock patients admitted in obstetrics and gynecology at Baba Raghav Das Medical College, Gorakhpur, between June 2020 and May 2021, on 100 subjects. **Results:** In our study, there were 100 patients. Patients with SI 0.6 to <1 were included in Group I which comprises 26% patients in which 57.69% patients required only intravenous (IV) fluid, while 30.77% patients needed blood transfusion. Patients with SI>1 were included in Group II which comprises 74% patients in which all patients required initial resuscitation with IV fluid and then blood transfusion, 21.62% patients require inotropic support, and 9.46% patients needed fresh frozen plasma transfusion. Maternal outcome in Group I patients is that only 15.38% patients required emergency lower segment cesarean section (LSCS). While in Group II, 28.95% patients required emergency LSCS, 5.26% patients required intensive care unit (ICU) admission for ventilator support, 3.95% went for cesarean hysterectomy, while 2.63% patients landed in end organ failure and expired. **Conclusion:** All patients with obstetric hemorrhage with SI>1 should receive immediate intervention such as blood transfusion need of ICU or surgical intervention. This is higher than the upper limit of normality in non-pregnant population. In low-resource settings, this simple parameter could improve outcomes because it has a significant ability to predict adverse maternal outcomes of hemorrhage.

Key words: Blood pressure; Heart rate; Post-partum hemorrhage; Sepsis

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INTRODUCTION

About 6% of births are complicated by obstetric hemorrhage. Despite a substantial body of evidence supporting the clinical management of obstetric hemorrhage, it remains the primary cause of maternal mortality and morbidity worldwide. The largest impact of obstetric hemorrhage occurs in low-resource settings, where delays in identification and therapy result in mortality. Identifying and treating hemorrhage-related maternal mortality and morbidity as soon as possible is critical for reducing maternal mortality and morbidity.

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Obstetric hemorrhage encompasses both antepartum and post-partum hemorrhage (APH and PPH) (The Royal Women's Hospital).[1]

APH is described as bleeding from or into the vaginal tract that occurs between 24+0 weeks of pregnancy and before delivery. APH is a prominent cause of neonatal and maternal mortality globally, complicating 3–5% of pregnancies. APH is caused by placenta previa, placental abruption, and local factors (such as bleeding from the vulva, vagina, or cervix). Placenta previa and placental abruption account for 50% of APH (Royal College of Obstetricians and Gynecologists).[2]

PPH has traditionally been defined as an estimated blood loss larger than 500 mL during vaginal delivery or >1000 mL with cesarean delivery. Most cases are unpredictable, and it is vital that there is early recognition of excess blood loss and immediate action.[3]

For prompt detection and management of hypovolemic shock, ATLS suggests four shock classes based on vital signs and an estimated blood loss in percent.[4]

	CLASS I	CLASS II	CLASS III	CLASS IV
Volumen of blood loss (% total)	< 750 ml (< 15%)	750-1,500 ml (15-30%)	**1,500-2,000 ml (30-40%)**	> 2,000 ml (> 40%)
Heart rate (beats per minute)	Normal	> 100	**> 120**	> 140
Respiratory rate (rpm)	Normal	20-30	**30-40**	> 35
Systolic Blood pressure (mm Hg) Palpable pulse	Normal Radial palpable	Normal Radial palpable	**Reduced Radial pulse not palpable**	Reduced Carotid palpable +/-
Neurological status	Alert	Anxious	**Confused**	Lethargic
Urine output (ml/h)	Normal	20-30	**5-15**	Minimum

A retrospective analysis of data derived from the Trauma Register DGU indicated that only 9.3% of all trauma patients could be allocated into one of the ATLS shock classes. Consequently, more than 90% of all trauma patients could not be classified according to the ATLS classification of hypovolemic shock. To reflect clinical reality more precisely, a new classification of hypovolemic shock which is based on shock index (SI) was proposed in 2013.[5] Patients were classified according to their initial SI at hospital admission. As the SI is the ratio of heart rate (HR) to systolic blood pressure (SBP), this index can be immediately calculated when basic vital signs are available.[4]

Aims and objectives

1. To see the usefulness/importance of SI in obstetric hemorrhage (APH and PPH)
2. To compare the performance of SI with conventional vital signs for prediction of maternal outcome.

Sample size calculation

Sample size N=4pq/L2

Taking P (prevalence) as 30% of bad obstetric history in hypovolemic shock

Q=100−P=100−30=70

L=10% (allowable error/precision/variability)

N=4×30×70/10×10=84

N=100

Assuming that 30% of subject in population are in hypovolemic shock, the study would require a sample size of 84 to estimate the allowable error/precision/variability 10%. Hence, we included 100 subjects in our study.

MATERIALS AND METHODS

Ethical

Ethical committee's approval was duly taken. Data were collected in obstetrics and gynecology from the bedside tickets of the patients after taking a short history and informed consent from the patient.

The descriptive study was conducted in 100 cases of hemorrhagic shock patients admitted in obstetrics and gynecology of Baba Raghav Das Medical College, Gorakhpur, between June 2020 and May 2021, on 100 subjects.

Inclusion criteria

- Any women with APH (in 3rd trimester) or PPH (cesarean section/vaginal delivery) admitted/referred in our labor room
- All patients who delivered in our labor room and then landed into PPH.

Exclusion criteria

- Women in hypovolemic shock due to diarrhea, vomiting, fluid loss, and rupture ectopic hemorrhage due to abortion
- Hemorrhage in 1st and 2nd trimester
- Hypovolemic shock due to trauma
- Patients with comorbidities such as gestational hypertension, cardiac disease, diabetes mellitus, and renal disease.

Table 1: Classification of hypovolemic shock based on shock index

Parameters	Class I	Class II	Class III	Class IV
Shock	No shock	Mild shock	Moderate shock	Severe shock
SI at admission	<0.6	>0.6–<1	>1–<1.4	>1.4
Need of blood products	Observe	Consider use of blood products	Prepare transfusion	Prepare massive transfusion

As shown in table 1 shock index as a predictor for outcome of hypovolemic shock, four classes of SI were defined as follows: Class I: SI<0.6–no shock; class II: SI≥0.6 to <1.0–mild shock; class III: SI≥1.0 to <1.4–moderate shock and class IV: SI≥1.4–severe shock requiring massive transfusion (Table 1).

RESULTS

In our study, there were 100 patients. Patients with SI 0.6 to <1 are included in Group I which comprises 26% patients. Patients with SI>1 are included in Group II which comprises 74% patients. Resuscitation measures required in Group I patients include 57.69% patients required only intravenous (IV) fluid, while 30.77% patients needed blood transfusion. While in Group II, all patients required initial resuscitation with IV fluid and then blood transfusion, 21.62% patients required inotropic support, and 9.46% patients needed fresh frozen plasma (FFP) transfusion. Maternal outcome in Group I patients: only 15.38% patients required emergency lower segment cesarean section (LSCS). While in Group II, 28.95% patients required emergency LSCS, 5.26% patients required intensive care unit (ICU) admission for ventilator support, 3.95% went for cesarean hysterectomy, while 2.63% patients landed in end organ failure and expired.

Table 2a shows 68% of patients presented as PPH and 29% of patients presented as APH. Rest 2% presented as APH also went into PPH.

Table 2b shows parity of patients at the time of admission. 69% patients were primigravida and 31% patients were multigravida.

Table 3 shows that mean SBP, mean diastolic blood pressure (DBP), and mean pulse pressure (PP) were higher in Group I patients as compared to Group II, whereas mean pulse rate/HR was higher among Group II patients.

Table 4 shows that the mean hemoglobin value and platelet value were higher in Group I patients, whereas value of mean prothrombin time-international normalized ratio value was higher in Group II patients.

Table 5 shows distribution of different vital signs including SI at the time of admission and after resuscitation at 4 h, 8 h, 12 h, 24 h, 48 h, and at the time of discharge. Mean SI, mean HR decrease and mean SBP, mean DBP, PP further improve (P<0.0001).

Table 6 shows that in Group I patient, 57.69% patients required resuscitation with IV fluid and in Group II, 100% patients required IV fluid (P<0.0001). Blood transfusion (P<0.0001), FFP transfusion (P=0.0084), and inotropic supports (P=0.0097) required in Group II patients. IV fluid given in hypovolemic shock during initial resuscitation is crystalloid solution, mainly normal saline 0.9% until blood products are available.

Table 7 shows no patient expired, no patient landed in end organ failure, and no patient required ICU admission in Group I. In Group II, 2.63% patient landed in end organ failure and expired. 5.26% patients need ICU admission for ventilator support. 28.95% patients needed emergency LSCS and 3.95% patients went for cesarean hysterectomy (P=0.0080).

Table 2a: Cause of hemorrhagic shock

Cause	Number of patients (%)
APH	29 (29)
PPH	68 (68)
Both	3 (3)

APH: Antepartum hemorrhage, PPH: Post-partum hemorrhage

Table 2b: Gravida and parity of cases

Parity	Number of patients (%)
Primigravida	69 (69.00)
Multigravida	31 (31.00)

Table 3: Mean vital parameters of patients in both groups at the time of admission

Vital sign	Group I (SI 0.6–<1)	Group II (SI≥1)	P
Mean SBP	107.69±7.10	84.32±14.9	T=14.16 P<0.0001
Mean DBP	70.00±5.6	50.67±24.40	T=7.721 P<0.0001
Mean PP	82.53±5.83	61.51±20.45	T=9.885 P<0.0001
PR/HR	89.00±4.53	117.24±8.56	T=29.16 P=<0.0001
PP	37.69±4.29	33.64±13.6	T=2.840 P=0/0050

SBP: Systolic blood pressure, DBP: Diastolic blood pressure, PP: Pulse pressure, HR: Heart rate, SI: Shock index

Table 4: Laboratory parameters according to class

Lab parameters	Group I (shock index 0.6–<1)	Group II (shock index≥1)	P
Mean Hb (g/dL)	8.13±0.74	6.04±1.02	t=16.59 P<0.001
Mean platelet count (lakh)	2.23±0.40	1.82±0.50	t=6.403 P<0.0001
Mean PT (INR)	1.19±0.16	1.25±0.17	t=2.570 P=0.0109

PT: Prothrombin time, INR: International normalized ratio

Table 5: Distribution of vital sign values on admission and during hospital stay

Vital sign (h)	SI	SBP	DBP	PR/HR	Pulse pressure
0 (on admission) (n=1000)	1.97±0.28	63.63±10.36	45.76±5.87	130.53±5.88	62.56±3.88
4	1.65±0.36	67.73±11.78	51.67±6.77	125.66±4.45	59.67±4.76
8	1.53±0.34	72.88±10.88	59.55±5.89	104.63±5.63	53.73±3.87
12	1.04±0.17	85.76±12.68	65.66±6.65	91.67±4.87	49.77±3.88
24	0.95±0.16	105.77±9.63	69.65±7.86	85.62±5.67	46.55±3.26
48	0.87±0.13	109.98±12.88	72.44±5.78	82.74±3.66	44.73±2.52
At discharge	0.83±0.11	113.66±8.33	74.42±342	80.11±3.87	42.63±2.02
P	F=341.5 P<0.0001	F=364.5 P<0.0001	F=1172 P<0.0001	F=1752 P<0.0001	F=449.1 P>0.0001

SBP: Systolic blood pressure, DBP: Diastolic blood pressure, PP: Pulse pressure, HR: Heart rate, SI: Shock index

Table 6: Resuscitation measures required for different class

Resuscitation measures	Group I (n=26), n (%)	Group II (n=74), n (%)	P
IV fluid	15 (57.69)	74 (100)	X=21.88 P<0.0001
Blood transfusion	8 (30.77	74 (100)	X=62.48 P<0.0001
FFP unit	0	7 (9.46)	X=2.645 P<0.0084
Inotropic support	0	16 (21.62)	X=6.692 P<0.0097

IV: Intravenous, FFP: Fresh frozen plasma

Table 7: Maternal outcome in different class

Outcome	Group I (n=26), n (%)	Group II (n=74), n (%)	P
Expired	0	2 (2.63)	X=7.042 P=0.0080
End organ failure	0	2 (2.63)	
ICU admission for ventilator support	0	4 (5.26)	
Emergency LSCS	4 (15.38)	22 (28.95)	
Cesarean hysterectomy	0	3 (3.95)	

ICU: Intensive care unit, LSCS: Lower segment cesarean section

Cause of death in hypovolemic shock was multiple organ failure leading to acute kidney injury and acute respiratory distress. Treatment given in ICU other than ventilator support was IV antibiotics, ionotropic support, blood/blood products transfusion, and input–output monitoring.

DISCUSSION

In our study, PPH was more common in 68% of the patients, followed by APH in 29%, and bleeding after delivery (both APH and PPH) occurred in only 3% of the cases. A statistically significant difference was found in the prognosis of the patients suffering from hemorrhage shock. Similar study done by Nathan HL et al.[6] shows 49.1% in PPH, of which most common etiologies were uterine atony (32.9%), retained placenta (12%), and laceration (4.2%).

In our study, we have divided patients in 2 groups; based on SI, Group 1 has patients with SI value between 0.6 and <1 and group consists of patients with SI≥1. 26% participants were in Group I while 74% of participants were in Group II. In a study by Vandromme et al.,[7] he suggested that a normal SI range for non-pregnant populations is between 0.5 and 0.7 and that a SI of more than 0.9 is associated with increased mortality and morbidity.

Research by Nathan et al.,[6] is the first to investigate the ability of SI in PPH to accurately predict a variety of clinical outcomes, following his instincts as it is. The effectiveness of the upper limits of SI – 0.7 and SI – 0.9 was evaluated through testing. SI – 0.9 was the superior predictor for most outcomes (excluding hemoglobin 7 g/dL), and it may therefore be a valuable threshold in low and middle-income countries, which have the highest mortality rates and where mortality is often related to delays in recognition of complications, transportation, and level of care provided by the facility. Based on the results of the centile specificity analysis, two potential SI thresholds that indicate a high risk of adverse events were generated: SI – 1.5 and SI – 1.7. SI – 1.7 was the best predictor for all outcomes, with similar sensitivities but improved specificities.

We also found that the mean values of SBP, DBP, mean PP, and PP were all significantly higher in Group I (107.69±7.10), (70.00±5.6), (82.53±5.83), and (37.69±4.29) as compared to Group II SBP, DBP, mean PP, and PR/HR were all found to have statistically significant differences of (P=0.0001*), while PP was found to have the statistical significance of (P=0.0005*) among the group comparable to a study done by Nwafor et al.,[8] in 2019 median (interquartile range) of each vital sign parameter: SI – 1.4 (1.3–1.7), pulse rate 119 (112–125) bpm, SBP 83 (71–97) mmHg, DBP 55 (48–56) mmHg, mean arterial pressure 66.5 (58–69.3) mmHg, and PP 31 (29–38) mmHg.

One more similar study done by Borovac-Pinheiro et al.[9] on the ability of SI and HR to predict the percentage of body blood volume lost after vaginal delivery as an indicator of severity shows significant differences for SI and HR however There were no statistical differences among SBP,

DBP, respiratory rate, and SatO2 in their ability to predict post-partum bleeding (P ≥ 0.5).

Compared to Group II, the mean hemoglobin and platelet count were significantly (P=0.0001*) higher in Group I. It was found that both the prothrombin time and the international normalized ratio were significantly (P=0.0109*) higher in Group II than in Group I. This can be compared to a study done by Chowdhury et al.,[10] result in conclusion that 387 (38.54%) subjects had severe anemia, in whom the mean SI value was 1.15±0.41 as compared to the group without anemia in whom it was 0.91±0.12. In subjects with severe anemia and an adverse outcome, this value was 1.34±0.51 as compared to 0.96±0.11 in subjects who had severe anemia and normal outcome.

In our study, vital signs we have taken at the time of admission and after resuscitation at 4 h, 8 h, 12 h, 24 h, 48 h, and at discharge. The value of SI and HR decreased after resuscitative measures and other vital signs came across within normal range showing statistical significance (P<0.0001).

The results of the statistical analysis showed that there was a significant difference between the individuals in the group. In comparison to Group I, we found that resuscitation measures indicated that the majority of patients in Group II required IV fluid administration. In contrast to the patients in Group I, those in Group II required a blood transfusion at some point during their treatment. There were no patients in the FFP unit or receiving inotropic support in the Group I comparison, but there were 9.46% and 21.62% of those patients in the Group II comparison. 21% patients require inotropic support in Group II and no requirement of inotropic support in Group I patients needed. According to the statistics, a significant difference of (P=0.0001*) was observed between the IV fluid and blood transfusion units, a significant difference of (P=0.0097*) was observed between the inotropic Support units, and no significant difference (P=0.1039) was observed between the FFP units.

Study conducted by Lee et al.,[11] to evaluate the clinical significance of various vital signs in women referred for PPH he concluded that SI>0.9 had 93.8% (95% CI 69.8–99.8) sensitivity and 51.2% (35.1–67.1) specificity for prediction of massive transfusion, and 93.6% (78.6–99.2) sensitivity and 31.0% (15.3–50.8) specificity for prediction of invasive procedures.

In our findings, in Group I, no patients passed away, and no patients were observed to have an end organ failure, ICU admission for ventilation Support, or cesarean hysterectomy. However, 15.38% of patients were observed to have emergency LSCS procedures. The majority of patients in Group II were treated with emergency LSCS (22%). This was followed by patients being admitted to the ICU for ventilation support (5.26%), cesarean hysterectomy (3%), end organ failure and passed away (2.63%). There was a statistically significant difference found between the maternal outcomes of each patient (P=0.0080*).

A study done by El Ayadi et al.,[12] on vital sign prediction of adverse maternal outcome in women with hypovolemic shock shows at SI≥0.7, sensitivity for all adverse outcomes is very high (100.0) and specificity is very low (range 0.4–0.5), indicating that nearly all positives are correctly identified as such, while many negatives are classified as false positives. Sensitivities are slightly lower (range 93.9–100.0) and specificities are slightly higher (range 4.9–5.3) at SI ≥ 0.9 compared to SI≥0.7; very few study participants had SI<0.7 (0.4%) or SI<0.9 (5.2%). SI≥0.9 performed better than or similarly to SI≥0.7 for all outcomes, thus SI – 0.9 was chosen as the lower of the two action thresholds, indicating the need for referral to tertiary care or intensive monitoring within tertiary care. Comparing SI≥1.4 to SI≥1.7, specificity is maximized for all outcomes at SI≥1.7 (range 70.0–74.8 vs. range 88.5–90.8, respectively) with a corresponding increase in positive prediction (range 10.7–34.2 vs. range 19.8–43.5%, respectively); while sensitivities are lower at SI≥1.7 (range: 38.3–68.4 vs. 70.5–86.8, respectively) but with a corresponding negative predictive values of 88.8–98.5. Similarly, slightly higher negative predictive values are achieved with SI≥1.4. The proportion of women who developed each outcome was as follows: Death (n=39, 4.1%), severe maternal outcome (n=63, 6.6%), and critical intervention (ICU admission, blood transfusion ≥5 units or emergency hysterectomy) (n=150, 15.7%).

Further study by Rady et al.[13] added in their research that SI had the highest AUROC value for blood transfusions of <4 unit and its performance was noticeably superior to that of HR. It has been demonstrated that traditional vital signs are late markers of hemodynamic compromise in hemorrhagic shock.

Another study done by Chowdhury et al.[10] in 2020 evaluates the role of SI as an early indicator of adverse maternal outcomes and determines the threshold points of SI for five adverse maternal outcomes. The mean SI value for the vaginal delivery group was 1.02±0.26, while the mean SI value for the cesarean delivery group was ±0.95 (0.033). SI values were 1.23 (±0.35) for ICU admission, 1.47 (±0.84) for multiple organ dysfunction syndrome (MODS), 1.15 (±0.41) for blood transfusion >4 units, 1.58 (±0.51) for surgical intervention, and 1.39 (±0.85) for maternal death. Receiver operating characteristic analysis revealed that SI≥1.4 had a sensitivity of 26.82%, specificity of 100%, PPV of 100%, and NPV of 82.96% with an area under the curve of 0.8 (0.78–0.83). SI was higher in patients with severe anemia. As a screening tool

for predicting unfavorable maternal outcomes, SI performed admirably. SI≥0.90 was strongly linked with unfavorable maternal outcomes, including ICU admission, MODS, surgical intervention, transfusion of blood, and mortality.

Limitation of this study

The study performed was a single-centered study.

CONCLUSION

1. All patients with obstetric hemorrhage with SI>1 should receive immediate intervention such as blood transfusion need of ICU or surgical intervention. This is higher than the upper limit of normality in non-pregnant population
2. In low-resource settings, this simple parameter could improve outcomes because it has significant ability to predict adverse maternal outcome of hemorrhage
3. In addition, the findings of the present study are an important addition to a growing body of research that challenges the emerging standard of knowledge for this population
4. In addition, even after taking into account potential confounding factors, SI is an extremely reliable indicator of unfavorable clinical outcomes in PPH patients
5. However, to enhance the accuracy of the present findings and bypass the confounders, we recommend a resilient, multi centric study with high large sample size.

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