ISSN: 2581 – 3633
PubMed - National Library of Medicine - ID: 101745081

International Journal of Medical Science and Advanced Clinical Research (IJMACR)

Available Online at:www.ijmacr.com

Volume – 8, Issue – 6, December - 2025, Page No.: 132 – 139

A Prospective Study of Correlation Between Shock Index and Adverse Maternal Outcomes in Post Partum Hemorrhage in Department of Obstetrics and Gynaecology, SMS Medical College, Jaipur

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How to citation this article: Dr Vaishali Dadwaria, Dr Reena Pant, Dr Shalini Sahay, Dr Indira Lamba, Dr Sunita Joshi, Dr Parul Sawariya, "A Prospective Study of Correlation Between Shock Index and Adverse Maternal Outcomes in Post Partum Hemorrhage in Department of Obstetrics and Gynaecology, SMS Medical College, Jaipur", IJMACR- December - 2025, Volume – 8, Issue - 6, P. No. 132 – 139.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Background: Postpartum hemorrhage (PPH) is one of the leading causes of maternal morbidity and mortality worldwide, particularly in low- and middle-income countries. Conventional hemodynamic parameters such as heart rate (HR) and systolic blood pressure (SBP) often fail to detect early hemodynamic compromise due to physiological adaptations in pregnancy. The shock index (SI), defined as HR/SBP, has emerged as a potential early predictor of adverse outcomes, but its utility in PPH remains underexplored.

Objectives: To evaluate the correlation between SI and maternal outcomes in PPH and compare its predictive value with conventional parameters (HR and SBP).

Methods: A prospective observational study was conducted in the Department of Obstetrics and Gynaecology, SMS Medical College, Jaipur, from April 2023 to March 2024. Forty women with PPH (≥500 mL blood loss after vaginal delivery or ≥1000 mL after cesarean) were enrolled after ethical clearance and informed consent. Demographic, clinical, and hemodynamic parameters (HR, SBP, mean arterial pressure [MAP], and SI) were recorded at 15-minute intervals during the first postpartum hour. Maternal outcomes assessed included transfusion requirements (>4 units), surgical interventions, intensive care unit (ICU) admission, vasopressor or ventilatory support, disseminated intravascular coagulation (DIC), multi-organ dysfunction syndrome (MODS), and maternal mortality. Data were analyzed using SPSS v29.0. Receiver operating characteristic (ROC) curves and area under the curve (AUROC) were used to evaluate diagnostic accuracy.

Results: The mean age of participants was 27.2 ± 3.8 years, with most women residing in rural areas (92.5%) and 60% being unbooked. Trauma was the most common cause of PPH (65%), followed by uterine atony (27.5%) and retained placenta (7.5%). Hemodynamic assessment showed that SI was elevated at 15 minutes (1.06 ± 0.27) and declined to 0.70 ± 0.18 at 60 minutes, while SBP increased and HR decreased over time. An SI >1.08 predicted transfusion of ≥4 units with high accuracy (AUROC 0.89, sensitivity 84.2%, specificity 90.1%). An SI >1.5 predicted massive transfusion (>10 units) with AUROC 0.90 and NPV 98.8%. SI values >1.6–1.7 were strongly associated with ventilator support (AUROC 0.98), vasopressor use (AUROC 0.93), MODS (AUROC 0.91), and DIC, all with excellent sensitivity and negative predictive value. An SI >1.72 predicted maternal mortality with an AUROC of 0.98, 100% sensitivity, and 97.9% specificity.

Conclusion: Shock index is a simple, rapid, and reliable bedside tool that outperforms conventional parameters in predicting adverse maternal outcomes in PPH. Its incorporation into routine obstetric practice and early warning systems can enhance timely recognition, facilitate appropriate interventions, and reduce preventable maternal morbidity and mortality.

Keywords: Postpartum Hemorrhage, Shock Index, Maternal Outcomes, Hemodynamic Monitoring, Massive Transfusion, Maternal Mortality, Obstetric Emergencies.

Introduction

Postpartum hemorrhage (PPH) is a life-threatening obstetric emergency that complicates approximately 1–10% of all deliveries worldwide, underscoring the critical need for effective preventive, diagnostic, and management strategies [1]. The Society of Obstetricians and Gynaecologists of Canada (SOGC) defines PPH as blood loss exceeding 500 mL after vaginal delivery or 1000 mL following cesarean delivery, whereas the World Health Organization (WHO) considers any blood loss ≥500 mL after childbirth as PPH. In contrast, the American College of Obstetricians and Gynecologists (ACOG) sets the threshold at 1000 mL, irrespective of delivery mode [2].

The etiology of postpartum hemorrhage (PPH) is commonly summarized by the "four Ts": tone, trauma, tissue, and thrombin. Uterine atony accounts for about 70% of cases, genital tract trauma for 15–20%, retained placenta for 10–40% (with a 3.5-fold higher risk), and coagulation disorders for around 1% [3]. Risk factors include prolonged labor, multiple pregnancies, multiparity, fetal macrosomia, operative deliveries, uterine rupture, placental abruption, and abnormal placentation [4]. Despite advances in obstetric care, PPH remains a leading cause of maternal morbidity and mortality worldwide, with higher incidence in low- and middle-income countries (10–15%) compared to high-income regions (1–5%) [5–9]. Importantly, 54–93% of maternal deaths from obstetric hemorrhage are considered preventable with timely, standardized interventions [10].

If not recognized and managed promptly, PPH can rapidly progress to life-threatening complications. Severe blood loss, compounded by preexisting anemia, can lead to hypovolemic shock, impaired tissue perfusion, and metabolic acidosis, which may culminate in multi-organ dysfunction syndrome (MODS) and maternal death within just 2–6 hours if untreated [11]. Early recognition is therefore vital, yet the conventional method of visual estimation of blood loss (VEBL) is often inaccurate, with a tendency to underestimate actual losses. This limitation is especially concerning in regions with high anemia prevalence, such as India, where more than 50% of pregnant women are affected [8,9]. Even modest blood loss in these populations can precipitate significant hemodynamic compromise.

Traditional hemodynamic parameters such as systolic blood pressure (SBP) and pulse rate are widely used in early warning systems to detect hemodynamic instability [13]. However, the physiological adaptations of pregnancy, including increased circulating blood volume and enhanced cardiac output, may mask early signs of hypovolemia, leading to delayed recognition of PPH. The shock index (SI), defined as the ratio of heart rate (beats per minute) to SBP (mmHg), has emerged as a potentially more sensitive parameter. In healthy adults, SI typically ranges between 0.5 and 0.7 [15], while values above 0.9 are associated with increased morbidity and mortality in trauma and obstetric populations [16,17]. Although SI has mainly been applied to assess the severity of established PPH, evidence supporting its predictive role for the occurrence of PPH in general obstetric populations is limited [20–23]. Some studies have suggested that SI values ≥0.9–1.0 in the immediate postpartum period may serve as early indicators of impending hemorrhage, with acceptable diagnostic accuracy (AUROC > 0.70) [22]. However, in most studies, SI was measured after PPH had already occurred, thus functioning more as a detection tool than as a true predictor.

Materials and Methods

This was a prospective observational study conducted in the Department of Obstetrics and Gynaecology, SMS Medical College and Associated Hospitals, Jaipur, from April 2023 to March 2024, following approval by the Institutional Ethics Committee.

Study population and site: The study included **40 women** with postpartum hemorrhage (PPH) who delivered after 28 weeks of gestation at SMS Medical College and Associated Hospitals, Jaipur. Participants were enrolled after informed consent.

Inclusion criteria: Women >18 years with PPH (≥500 mL blood loss after vaginal delivery or ≥1000 mL after cesarean) who consented and were not enrolled in other studies.

Exclusion criteria: Women with hypertensive disorders of pregnancy, coagulation abnormalities, severe anemia (Hb <7 g/dL), pre-existing cardiac/organ dysfunction, sepsis, or those who had received antenatal blood transfusion.

Methodology: Eligible patients were assessed through clinical history, examination, and routine investigations (CBC, ESR, KFT, LFT, RA factor, HsCRP, IL-6, NLR, and PLR). Blood loss was estimated using soaked pads, drapes, and containers, with standardized volume equivalents. Systolic blood pressure (SBP) and heart rate (HR) were recorded every 15 minutes in the first hour. Shock index (SI = HR/SBP) and mean arterial pressure (MAP) were calculated, and outcomes such as need for transfusion (>4 units), surgical interventions, ICU admission, disseminated intravascular coagulation (DIC), multi-organ dysfunction syndrome (MODS), and maternal mortality were documented until discharge.

Statistical analysis: Data were analyzed using SPSS version 29.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± SD or median (IQR), depending on distribution (Shapiro–Wilk test). Group comparisons used Chi-square or Fisher's exact test for categorical variables, and Student's t-test or Mann–Whitney U test for continuous data. Receiver operating characteristic (ROC) curves were generated to evaluate SI, HR, and MAP for predicting adverse outcomes; AUROC with 95% confidence intervals was calculated. Optimal SI cut-off values were determined using Youden's index, and diagnostic accuracy was expressed as sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV). A $p < 0.05$ was considered statistically significant.

Results

A total of 40 women with postpartum hemorrhage (PPH) were included in the study. The mean age of participants was 27.23 ± 3.76 years. Most women (92.5%, n=37) were from rural areas, while only 7.5% (n=3) resided in urban settings. The majority were homemakers (75%, n=30), and the remaining 25% (n=10) were employed in occupations such as teaching, manual labor, tailoring, or hospital work. Socioeconomic assessment showed that 60% (n=24) belonged to the upper middle class, 35% (n=14) to the lower middle class, and 5% (n=2) to the upper class. Regarding antenatal care, 16 patients (40%) were booked, whereas 24 (60%) were unbooked. Twenty-four women (60%) were referred from peripheral centers, while 16 (40%) presented directly to the hospital.

With respect to obstetric history, 19 patients (47.5%) were primigravida, six (15%) were G2P1L1, seven (17.5%) were G3P2L2, and smaller proportions were G2A1 (5%), G3A2 (2.5%), G3P1L1A1 (7.5%), and G4P1L1A2 (2.5%). Most deliveries were vaginal (67.5%, n=27), while 32.5% (n=13) were by cesarean section. The majority (67.5%, n=27) experienced blood loss exceeding 500 mL, and 32.5% (n=13) had blood loss greater than 1000 mL. The most frequent cause of PPH was traumatic injury (65%, n=26), followed by uterine atony (27.5%, n=11) and retained placenta (7.5%, n=3).

Hemodynamic parameters showed that the mean systolic blood pressure (SBP) was 99.5 ± 13.96 mmHg at 15 minutes, rising progressively to 117.6 ± 8.4 mmHg at 60 minutes. Conversely, mean heart rate (HR) was initially elevated (102.48 ± 17.3 bpm at 15 minutes) and decreased over time to 81.45 ± 15.65 bpm at 60 minutes. The mean shock index (SI) was 1.06 ± 0.27 at 15 minutes, indicating early hemodynamic instability, and declined steadily to 0.70 ± 0.18 at 60 minutes.

Regarding interventions, cervical or vaginal tear repair was the most common procedure (75%, n=30), while balloon tamponade, manual removal of placenta, compression sutures, and stepwise devascularization/hysterectomy were required in 7.5% (n=3) each. One patient (2.5%) required internal iliac artery ligation. Overall, 52.5% (n=21) of women required ICU admission, with 19.05% (n=4) of these requiring ventilatory support. Only one patient (2.5%) required vasopressor therapy. MODS and DIC developed in two patients each (5%), and there was one maternal death (2.5%).

In the present study, the Shock Index (SI) was evaluated as a predictor of blood transfusion requirements, intensive care needs, operative interventions, and maternal mortality in obstetric hemorrhage. As shown in Table 1**,** an SI cutoff of >1.08 effectively predicted the need for more than four units of blood with an AUROC of 0.89, sensitivity of 84.17%, and specificity of

90.05% (p = 0.01). For massive transfusion exceeding ten units, an SI cutoff of >1.5 demonstrated an AUROC of 0.90, sensitivity of 90.1%, and specificity of 87.3% (p = 0.01), indicating a strong predictive value of SI for transfusion volume. Similarly, SI showed excellent performance in predicting the need for intensive care interventions Table 2**.** An SI cutoff of >1.7 accurately predicted the requirement for ventilator support and vasopressors, with AUROC values of 0.98 and 0.93, respectively. For multi-organ dysfunction syndrome (MODS) and disseminated intravascular coagulation (DIC), SI cutoffs of >1.6 and >1.7 achieved AUROC values of 0.91 and 0.90. All results were statistically significant (p = 0.01), with sensitivities and specificities above 85%, confirming that SI is a valuable early marker for anticipating ICU admission and organ support.

As presented in Table 3, SI was also a strong predictor of maternal mortality. A cutoff value of >1.72 showed an AUROC of 0.98, with 100% sensitivity and 97.95% specificity (p = 0.01). The positive and negative predictive values were 81.3% and 99.6%, respectively, making SI a highly reliable indicator for identifying patients at risk of maternal death.

In predicting operative interventions Table 4**,** elevated SI values were associated with an increased likelihood of surgical management. The most accurate predictions were seen for hysterectomy (cutoff >1.31, AUROC 0.97, p = 0.01) and manual removal of placenta (cutoff >1.5, AUROC 0.9, p = 0.01). Significant associations were also found for cervical or vaginal tear repair (cutoff >1.3, AUROC 0.68, p = 0.01), internal artery ligation (cutoff >1.3, AUROC 0.8, p = 0.01), and compression sutures (cutoff >1.17, AUROC 0.8, p = 0.01), whereas balloon tamponade did not reach statistical significance (p = 0.41).

Overall, the Shock Index emerged as a simple, rapid, and highly reliable clinical tool with excellent sensitivity and specificity for predicting transfusion needs, ICU admission, operative intervention, and maternal mortality in obstetric hemorrhage. Its strong correlation with these outcomes underscores its potential value for early triage, timely intervention, and improved maternal prognosis.

Discussion

This prospective observational study, conducted at the Department of Obstetrics and Gynaecology, SMS Medical College, Jaipur, evaluated the role of shock index (SI) in predicting maternal outcomes among women with postpartum hemorrhage (PPH). Forty women with PPH were studied, and their demographic, clinical, and hemodynamic parameters were analyzed.

The majority of participants were young, with a mean age of 27.2 years, most of whom belonged to rural areas and were homemakers. Despite 60% being from an upper middle socioeconomic class, antenatal care utilization was low, as 60% of patients were unbooked. This reflects a gap between socioeconomic status and health-seeking behavior, possibly linked to limited awareness and barriers to accessing maternal health services. Similar findings were reported by Kaur et al., who highlighted the influence of poor health literacy and sociocultural factors on antenatal registration [28]. Our data further revealed that 60% of women were referred from peripheral centers, supporting the “three delays” model, wherein delays in decision-making, transportation, and timely care access significantly contribute to PPH-related morbidity and mortality. These findings are consistent with Rajeshwari et al. [26] and Gora et al. [9], who also reported higher PPH prevalence in rural populations, underlining the importance of strengthening referral pathways and obstetric care in peripheral areas.

Regarding obstetric profile, nearly half of the participants were primigravida, demonstrating that PPH is not confined to multiparous women. Previous studies, including those by Sheldon et al.[29], have similarly reported considerable PPH incidence among primigravidas, largely due to trauma, hypertensive disorders, and delivery-related complications. In our cohort, trauma emerged as the leading cause of PPH (65%), followed by uterine atony (27.5%) and retained placenta (7.5%). This contrasts with institutional studies by Shah et al. [31] and Ramani et al. [33], where uterine atony was the predominant etiology, though it aligns with reports by Say et al.[32]that highlight trauma as an often under-recognized contributor, particularly in settings with limited access to skilled birth attendants.

Maternal comorbidities further influenced outcomes. Anemia (27.5%) and thrombocytopenia (12.5%) were frequent in our study and were associated with greater severity of bleeding. This finding corroborates previous evidence from Mangla et al. [30] and Shah et al. [31], who noted that pre-existing anemia worsens PPH outcomes by reducing physiological reserves.

In terms of hemodynamic monitoring, we observed that systolic blood pressure (SBP) tended to normalize rapidly, while heart rate (HR) decreased over time, making these conventional markers less reliable for early detection of hemodynamic compromise. Conversely, the shock index (SI) demonstrated superior predictive value. An SI >1.08 accurately predicted the requirement for transfusion of ≥4 units of blood (AUROC 0.89, sensitivity 84.2%, specificity 90.1%), while an SI >1.5 predicted massive transfusion (>10 units) with high diagnostic accuracy (AUROC 0.90). These findings are in line with earlier studies by Agarwal et al. [20,22] and Guerrero-De León et al. [37], who reported similar cut-off values (SI ≥1.1–1.3) as reliable thresholds for predicting significant transfusion needs.Furthermore, elevated SI values (>1.6–1.7) in our study were strongly associated with critical care requirements, including ventilatory support, vasopressor use, MODS, and DIC, all with excellent sensitivity and negative predictive value. An SI >1.72 predicted maternal mortality with an AUROC of 0.98, 100% sensitivity, and 97.9% specificity, highlighting its utility in early risk stratification. These results corroborate the observations of Nathan et al. [18] and Agarwal et al. [20], who emphasized SI >0.9 as an early warning threshold and SI >1.7 as a marker of severe illness and poor prognosis.

Our findings also extend the clinical application of SI to predicting the need for surgical interventions. An SI >1.31 showed excellent accuracy for predicting hysterectomy (AUROC 0.97), while an SI >1.30 was predictive of internal iliac artery ligation (AUROC 0.80). Manual removal of placenta was best predicted with SI >1.5 (AUROC 0.90, NPV 100%). In contrast, SI demonstrated lower predictive performance for balloon tamponade and compression sutures (AUROC <0.60), suggesting its primary role as a screening tool rather than a definitive predictor in these interventions. These trends are comparable to reports by Kohn et al. [38], who noted variability in SI performance across different clinical scenarios.

Overall, the study highlights the importance of SI as a simple, rapid, and reliable bedside parameter for early recognition and risk stratification in PPH. Given the limited accuracy of conventional vital signs and the high burden of preventable maternal mortality, particularly in rural and resource-constrained settings, incorporation of SI into obstetric early warning protocols could strengthen timely diagnosis, guide escalation of care, and improve maternal outcomes.

Conclusion

Our study highlights the significant correlation between the Shock Index (SI) and postpartum haemorrhage (PPH), underscoring its value as a simple yet effective tool for early identification of women at risk of severe maternal outcomes. By facilitating timely recognition of critical cases, SI enables prompt clinical intervention, which can substantially reduce maternal morbidity and mortality. Training frontline healthcare providers—including nurses, midwives, and general practitioners—in the calculation and interpretation of SI can lead to improved triage, timely referrals, and appropriate escalation of care. The integration of SI into routine obstetric practice represents a practical and impactful strategy to enhance emergency response and strengthen maternal healthcare systems across all levels of care.

Table 1: Evaluating Shock Index as a Predictor of Blood Transfusion Volume

Parameter	>4 units	>10 units, (Massive blood transfusion)
SI Cut-off	>1.08	>1.5
AUROC	0.89	0.90
Sensitivity (%)	84.17	90. 1
Specificity (%)	90.05	87.3
PPV	82.1	57.9
NPV	93.1	98.8
P value	0.01	0.01

Table 2: Evaluating Shock Index as a Predictor of requirement of ICU admission

Parameter	Ventilator Support	Vasopressors	MODS	DIC
SI Cutoff	>1.7	>1.7	>1.6	>1.7
AUROC	0.98	0.93	0.91	0.90
Sensitivity (%)	93	87.3	95	100
Specificity (%)	90.2	90.1	88.75	82.3
PPV	74.2	62	64.3	24.1
NPV	95.3	95.2	100	100
P value	0.01	0.01	0.01	0.01

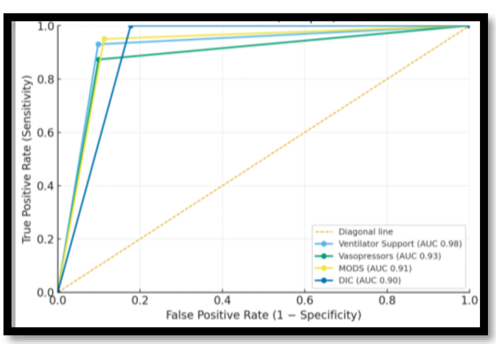
Table 3: Evaluating Shock Index as a Predictor of Maternal mortality

Parameter	Maternal Mortality
SI Cutoff	>1.72
AUROC	0.98
Sensitivity (%)	100
Specificity (%)	97.95
Positive Predictive Value	81.3
Negative Predictive Value	99.6
P value	0.01

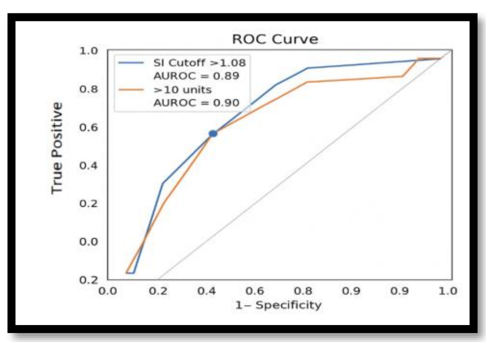
Table 4: Evaluating Shock Index as a Predictor of requirement for Operative Interventions

Parameter	Hysterectomy	Cervical/Vaginal Tear Repair	Internal Artery Ligation	Balloon tamponade	Manual removal of placenta	Compression sutures
S. I Cutoff	>1.31	>1.30	>1.30	>1.17	>1.5	>1.17
AUROC	0.97	0.68	0.80	0.56	0.9	0.8
Sensitivity (%)	80.2	73	85	53.5	100	100
Specificity (%)	86.3	79.44	76.2	64.3	82	67.4
PPV	69.3	31.7	30.2	15.1	20.4	21
NPV	96.3	96.9	97.2	88.2	100	100
P value	0.01	0.01	0.01	0.41	0.01	0.01

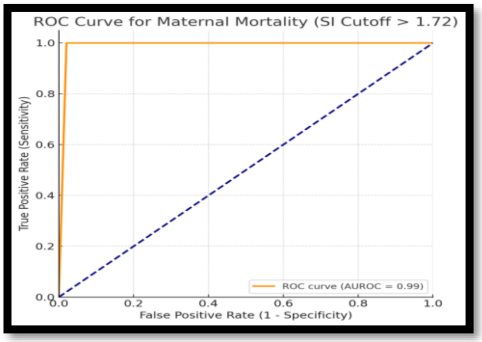
Graph 1:



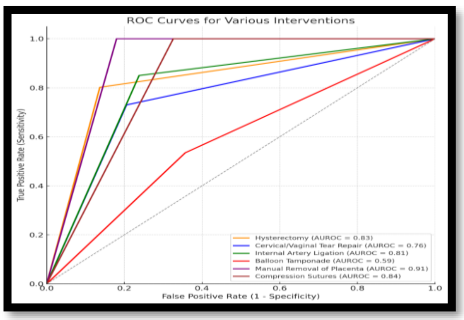
Graph 2:



Graph 3:



Graph 4:



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