ORIGINAL RESEARCH

Evaluating the Shock Index as a Predictive Tool for Adverse Maternal Outcomes in Postpartum Hemorrhage: A Prospective Observational Study

[1]Dr. Raja Rajeswari, [2]Dr. Meena Priyadharshini V, [3]Kannuschruthi, [4]Dr. Thiruveni Senthilvel, [5]Dr. Reema Bhatt

[1]Clinical Fellow in Fetal Medicine, Department of Fetal Medicine, Amrita Institute of Medical Sciences Faridabad, Delhi NCR, India
[2]HOD & Professor, Department of OBG, KMCH Institute of Health Sciences, Coimbatore, India
[3]Final Year MBBS, Coimbatore Medical College, Coimbatore, India
[4]Senior Consultant, Sri Ramakrishna Hospital, Coimbatore, India
[5]HOD & Professor, Department of Fetal Medicine, Amrita Institute of Medical Sciences Faridabad, Delhi NCR, India

Corresponding author
Dr. Raja Rajeswari
Clinical Fellow in Fetal Medicine, Department of Fetal Medicine, Amrita Institute of Medical Sciences Faridabad, Delhi NCR, India

Received: 25 October, 2024 Accepted: 17 November, 2024

Abstract

Background: Postpartum hemorrhage (PPH) remains a leading cause of maternal mortality worldwide. Traditional methods of estimating blood loss and monitoring vital signs often delay intervention. The Shock Index (SI), calculated as heart rate divided by systolic blood pressure, is a potential early indicator of hemodynamic instability in PPH.Aim was to evaluate the role of SI and other vital signs like mean arterial pressure (MAP), pulse pressure (PP) and diastolic blood pressure (DBP) in predicting adverse maternal outcomes following PPH.

Methods: This prospective observational study included 70 women with PPH at a tertiary care hospital. Monitoring occurred at 15, 30 and 60 minutes postpartum. Blood loss was measured gravimetrically. SI thresholds and vital signs were analyzed to assess their correlation with blood loss severity and maternal outcomes.

Results: SBP, DBP and MAP showed significant declines with increasing blood loss. SI values rose consistently, with higher thresholds correlating with adverse outcomes. An SI ≥1 was linked to the need for operative interventions, while an SI >1.3 indicated ICU admissions and increased morbidity. AMTSL reduced PPH incidence but required strict adherence to protocols.

Conclusion: SI is a reliable and cost-effective tool for early identification of hemodynamic instability in PPH. It aids in timely interventions, especially in resource-limited settings. Standardizing SI in clinical practice can improve maternal outcomes. Future studies should validate these findings across diverse settings and populations.

Keywords: Postpartum hemorrhage, Shock Index, Maternal outcomes, Systolic blood pressure, Diastolic blood pressure, Mean arterial pressure, Hemodynamic instability

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 12, 2024

Introduction

Postpartum hemorrhage (PPH) remains a leading cause of maternal mortality worldwide, responsible for approximately 70,000 deaths annually. In India, PPH accounts for about 38% of maternal deaths, underscoring the urgent need for timely diagnosis and effective management. Recent statistics indicate that approximately 14 million women experience PPH each year, highlighting the critical nature of this issue in maternal health care. Despite advances in medical interventions, the persistent incidence of PPH reflects systemic challenges, including inadequate training, poor adherence to protocols and limited access to essential medications.Traditional methods of estimating blood loss during childbirth are often inaccurate, leading to delays in intervention. Monitoring vital signs such as systolic blood pressure (SBP) and heart rate (HR) is essential in assessing haemodynamic status. However, physiological adaptations during pregnancy can mask early signs of hypovolemia, complicating the timely detection of haemodynamic instability. [1-3]

The Shock Index (SI), calculated as the ratio of HR to SBP, has emerged as a valuable tool in this context. Studies have demonstrated that an SI threshold of ≥0.9 is associated with an increased risk of adverse outcomes in women with PPH, indicating the need for urgent intervention. This metric offers a simple, non-invasive means to identify patients at risk, facilitating prompt and appropriate care. [4,5]

This study aims to monitor SI and conventional vital signsMean Arterial Pressure (MAP), Pulse Pressure (PP) and Diastolic Blood Pressure (DBP)within the first 60 minutes following PPH. The aim is to establish SI thresholds that predict adverse maternal outcomes, thereby aiding in the early identification of patients who require referral to higherlevel care facilities or immediate intervention, regardless of the setting.

Materials and Methods

This prospective observational study at a tertiary care hospital included 70 women with postpartum haemorrhage (PPH). Strict preventive protocols like Active Management of the Third Stage of Labour (AMTSL) and efficient resuscitative measures influenced the smaller sample size. Women aged 19–34 years, with a gestational age of 37–42 weeks and blood loss ≥500 mL (vaginal delivery) or ≥1000 mL (cesarean delivery), were included. Exclusion criteria covered age <19 or >35 years, gestational age outside the range, hemorrhagic disorders and complications like placenta previa. Postpartum monitoring occurred at 15, 30 and 60 minutes, assessing shock index (SI, HR/SBP >0.7), pulse, blood pressure and SpO_2. Blood loss was measured gravimetrically: for cesareans, it included mop weight differences and suctioned blood volume; for vaginal deliveries, only mop weight differences. Amniotic fluid and pre-placental blood loss were excluded. Vital signs were systematically recorded, with elevated SI values prompting immediate observation and management, ensuring timely intervention.

Results

Table 1: Trends in Systolic Blood Pressure (SBP) Across Different Blood Loss Groups and Time Intervals

Time Interval (minutes)	Blood Loss <1000 ml	Blood Loss 1001-1500 ml	Blood Loss >1500 ml
15	120	110	100
30	110	100	90
45	115	105	95
60	118	108	98

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 12, 2024

Systolic blood pressure (SBP) decreases as blood loss increases, indicating that patients with severe blood loss experience more significant drops in SBP. At 15 minutes, SBP is highest in the group with <1000 ml blood loss (120 mmHg) and lowest in the group with >1500 ml blood loss (100 mmHg). Over time, SBP drops further in all groups by 30 minutes, stabilising slightly by 45 and 60 minutes. These patterns suggest that as haemorrhage progresses, SBP responds to blood loss severity and subsequent interventions.

Table 2: Changes in Diastolic Blood Pressure (DBP) in Relation to Blood Loss Groups and Time Intervals

Time Interval (minutes)	Blood Loss <1000 ml	Blood Loss 1001-1500 ml	Blood Loss >1500 ml
15	80	70	60
30	70	60	50
45	75	65	55
60	78	68	58

Diastolic blood pressure (DBP) shows a similar trend to SBP. It is highest in the group with <1000 ml blood loss at all time intervals (80 mmHg at 15 minutes) and lowest in the >1500 ml group (60 mmHg at 15 minutes). Between 15 and 30 minutes, DBP drops significantly in all groups, reflecting the acute impact of blood loss. By 45 and 60 minutes, DBP starts to recover slightly in all groups, suggesting the effect of physiological compensation or medical intervention.

Table 3: Mean Arterial Pressure (MAP) Variations Across Blood Loss Groups and Time Intervals

Time Interval (minutes)	Blood Loss <1000 ml	Blood Loss 1001-1500 ml	Blood Loss >1500 ml
15	93	83	73
30	83	73	63
45	88	78	68
60	91	81	71

Mean arterial pressure (MAP), which represents the average pressure in the arteries, decreases with increasing blood loss. At 15 minutes, MAP is highest in the <1000 ml group (93 mmHg) and lowest in the >1500 ml group (73 mmHg). At 30 minutes, MAP drops further, with the largest decline in the >1500 ml group, indicating greater circulatory compromise. From 45 to 60 minutes, MAP improves slightly in all groups, reflecting possible stabilisation due to interventions like fluid resuscitation or blood transfusion.

Table 4: Stability of Pulse Pressure (PP) Across Blood Loss Groups and Time Intervals

Time Interval (minutes)	Blood Loss <1000 ml	Blood Loss 1001-1500 ml	Blood Loss >1500 ml
15	40	40	40
30	40	40	40
45	40	40	40
60	40	40	40

Pulse pressure (PP), the difference between systolic and diastolic blood pressure, remains constant at 40 mmHg across all groups and time intervals. This constancy suggests that while

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 12, 2024

SBP and DBP decrease with blood loss, their proportional decline maintains a steady PP. This may indicate that PP is not an immediate indicator of blood loss severity in postpartum haemorrhage.

Table 5: Shock Index (SI) Trends in Different Blood Loss Groups Over Time

Time Interval (minutes)	Blood Loss <1000 ml	Blood Loss 1001-1500 ml	Blood Loss >1500 ml
15	0.6	0.7	0.8
30	0.8	0.9	1.0
45	0.7	0.8	0.9
60	0.65	0.75	0.85

Shock index (SI), the ratio of heart rate to systolic blood pressure, increases with blood loss. At 15 minutes, SI is lowest in the <1000 ml group (0.6) and highest in the >1500 ml group (0.8). By 30 minutes, SI peaks in all groups, with the >1500 ml group reaching a value of 1.0, indicating significant cardiovascular stress. By 45 and 60 minutes, SI decreases slightly, reflecting stabilisation or intervention. This trend highlights SI as a potential marker for identifying patients requiring urgent care.

Figure 1: Comparison of SBP, DBP and MAP at 30 Minutes

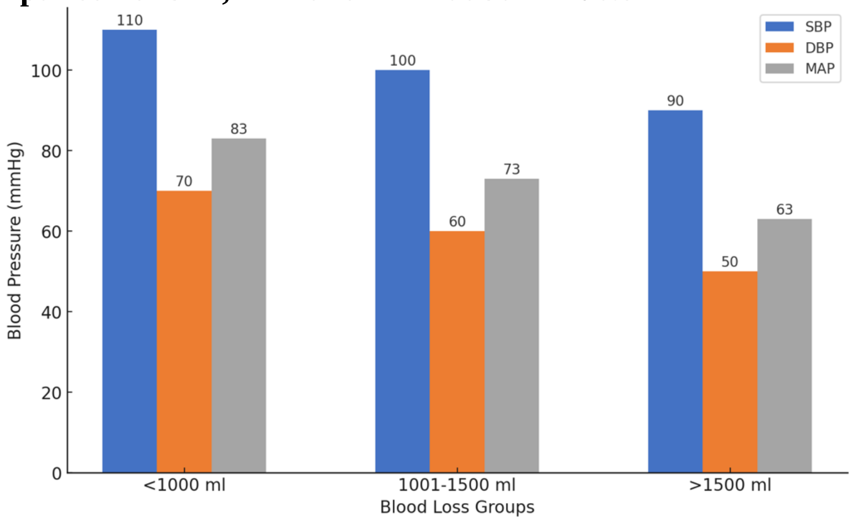
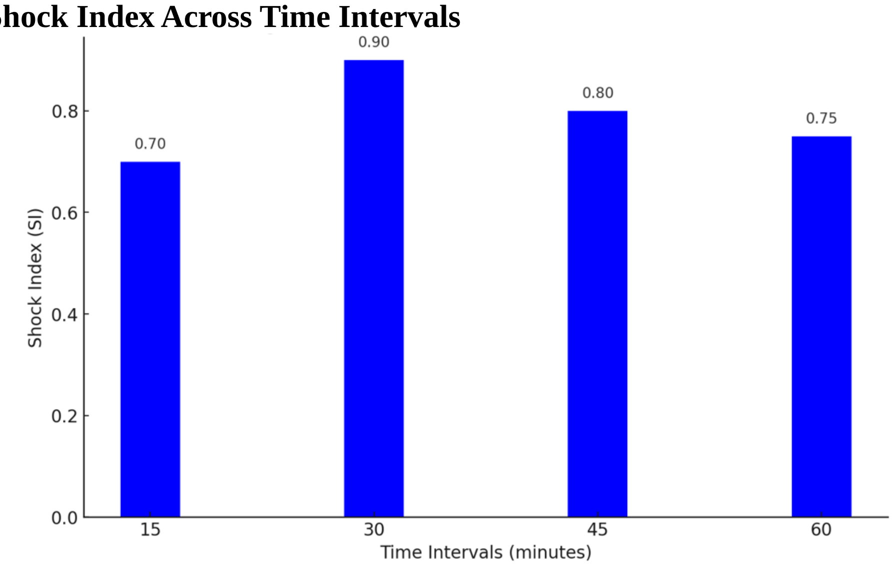


Figure 2: Shock Index Across Time Intervals



ISSN: 0975-3583,0976-2833 VOL15, ISSUE 12, 2024

Discussion

The study showed significant trends in vital signs, including shock index (SI), systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial pressure (MAP) related to blood loss severity. As blood loss increased, SI values rose, indicating greater haemodynamic compromise. SBP, DBP and MAP consistently declined with higher blood loss. This reflects the physiological impact of haemorrhage and highlights a strong correlation between blood loss severity and changes in vital signs. These findings underline the importance of monitoring these parameters for effective management of postpartum haemorrhage (PPH).

The Shock Index (SI), calculated as heart rate divided by SBP, is a reliable early indicator of haemodynamic instability in PPH. In healthy adults, SI typically ranges from 0.5 to 0.7. Elevated SI can signal hypovolemia and impending shock before noticeable blood pressure changes, allowing timely intervention. A study by Nathan et al. found SI ≥0.9 predicted adverse outcomes in PPH better than traditional vital signs. [6] Butt et al. reported SI of 1.42 had 90% specificity and 80% sensitivity for predicting maternal death. [7] These studies show SI is a simple, non-invasive tool that helps detect patients at risk, enabling early and effective interventions.

In PPH, haemodynamic parameters like SBP, DBP and MAP change significantly with blood loss volume. [8] As haemorrhage worsens, SBP and DBP decrease due to reduced cardiac output and systemic vascular resistance. MAP also falls, indicating lower perfusion pressure. These changes are clinically important as they show the body's compensatory mechanisms during haemorrhage and help assess blood loss severity. Understanding these patterns is key to guiding resuscitation and ensuring adequate tissue perfusion in PPH. [9,10]

Timely interventions are essential to stabilize patients with PPH. Administering uterotonic agents, starting fluid resuscitation and blood transfusion when needed are critical steps. Delays in recognizing or managing PPH increase maternal morbidity and mortality. [10] Shields et al. demonstrated that standardized PPH protocols, including early detection and quick interventions, significantly reduce severe maternal morbidity. [11] The World Health Organization (WHO) also emphasizes the importance of early management in preventing adverse outcomes. These findings reinforce that prompt action improves patient outcomes and saves lives.

Accurately measuring blood loss is vital in PPH management. The gravimetric method, which weighs blood-soaked materials, is commonly used and more accurate than visual estimation. Studies show visual estimation underestimates blood loss by about 30%, while the gravimetric method provides better precision. However, it has limitations, including potential inaccuracies from retained amniotic fluid and the need for careful collection and weighing. Despite these issues, it remains a reliable tool for clinical decision-making. It helps assess blood loss objectively and supports timely interventions in PPH management.

Our findings align with previous studies on SI's predictive role in PPH. An SI above 1 was linked to operative interventions and an SI above 1.3 correlated with ICU admissions and higher morbidity. [15] Nathan et al. found SI ≥0.9 had 100% sensitivity and 43.4% specificity for ICU admission, with higher SI thresholds indicating greater urgency. [6,11] Agarwal et al. reported similar associations, supporting SI's role as a marker for haemodynamic instability in PPH. Some studies, like Chaudhary et al., suggested different thresholds, such as SI >0.9 for referral and >1.1 for intervention in tertiary care settings. [16] These variations may reflect differences in study populations, settings and protocols. Overall, our study supports using SI to identify PPH patients at risk. However, optimal thresholds may vary, requiring tailored assessment and management.

Managing PPH in tertiary care settings has unique challenges, even with advanced resources. Delays in recognizing and treating haemorrhage often worsen outcomes. Implementing standardized protocols reduces delays and improves maternal outcomes. [17] Preventive

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 12, 2024

measures like Active Management of the Third Stage of Labour (AMTSL) significantly lower PPH risk. AMTSL involves giving uterotonic drugs, controlled cord traction and uterine massage after delivery. Studies show AMTSL, especially with oxytocin, reduces severe PPH and blood transfusions. [18,19] However, factors like staff training, protocol adherence and drug availability affect its effectiveness. In some cases PPH still occurs due to underlying causes, needing immediate management. [20,21] Addressing delays, ensuring adherence to protocols and improving training are key to better outcomes in PPH.

Our findings show SI's critical role in detecting and managing PPH, especially in resource-limited settings. Elevated SI values indicate haemodynamic instability, helping healthcare providers identify at-risk patients early. This enables timely referrals and interventions, improving maternal outcomes. Using SI in routine practice enhances early detection, especially in low-resource areas where delays in managing PPH can increase risks. SI is cost-effective, easy to use and standardizes PPH severity assessment. Its integration into clinical workflows can improve management strategies and outcomes across different healthcare settings.

This study had some limitations. The small sample size may limit statistical power and generalizability. Conducting the study in a well-equipped tertiary care center with routine AMTSL use may not reflect outcomes in less-resourced settings. Exclusion criteria like age restrictions and preexisting conditions also narrow applicability. Future research should include larger, more diverse populations across varied healthcare settings. Exploring additional markers for adverse outcomes and validating SI in different environments can help develop universally applicable protocols for PPH management.

Conclusion

This study highlights the critical role of the Shock Index (SI) as an early and reliable predictor of adverse maternal outcomes in postpartum hemorrhage (PPH). SI, along with other vital signs like systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial pressure (MAP), demonstrated significant trends correlating with blood loss severity. SI's non-invasive and cost-effective nature makes it a valuable tool for timely risk identification and intervention, particularly in resource-constrained settings. Preventive measures like Active Management of the Third Stage of Labour (AMTSL) remain essential but require consistent implementation. Despite limitations like small sample size and specific study settings, the findings emphasize the importance of incorporating SI into routine clinical practice to improve maternal outcomes. Future research should focus on validating these findings across diverse settings and populations.

References

1. World Health Organization. Postpartum haemorrhage: a global public health concern. Geneva: World Health Organization; 2023. Available from: https://www.who.int/news-room/events/detail/2023/03/07/default-calendar/who-postpartum-haemorrhage-summit
2. World Health Organization. WHO recommendations for the prevention and treatment of postpartum haemorrhage. Geneva: World Health Organization; 2012. Available from: https://www.who.int/publications/i/item/9789241548504
3. Government of India. Guidance note on prevention & management of postpartum haemorrhage. New Delhi: Ministry of Health and Family Welfare; 2015. Available from: https://nhm.gov.in/images/pdf/programmes/maternal-health/guidelines/Guidance_Note_on_Prevention_&_Management_of_Postpartum_Haemorrhage.pdf
4. Kohn J, Dildy G, Eppes CS. Shock index and delta-shock index are superior to existing maternal early warning criteria to identify postpartum hemorrhage and need for

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 12, 2024

intervention. J Matern Fetal Neonatal Med. 2017;32(8):1-241. doi:10.1080/14767058.2017.1402882.

5. Agarwal S, Pandey U, Kumar L. Shock index as a predictor of maternal outcome in postpartum hemorrhage: an experience from a tertiary care centre in Northern India. Int J Med Rev Case Rep. 2023;7(3):13-16. doi:10.5455/IJMRCR.172-1669772235.
6. Nathan HL, El Ayadi A, Hezelgrave NL, Seed P, Butrick E, Miller S, et al. Shock index: an effective predictor of outcome in postpartum haemorrhage? BJOG. 2015;122(2):268–75.
7. Butt S, Sattar S, Anbreen T. Shock Index as a Predictor of Adverse Maternal Outcome in Postpartum Hemorrhage. J Surg Pak. 2022;27(4):117-22
8. Borovac-Pinheiro A, Ribeiro FM, Morais SS, Pacagnella RC. Shock index and heart rate standard reference values in the immediate postpartum period: A cohort study. PLoS One. 2019 Jun 11;14(6):e0217907. doi: 10.1371/journal.pone.0217907.
9. Wormer KC, Jamil RT, Bryant SB. Postpartum Hemorrhage. [Updated 2024 Jul 19]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK499988/
10. Alonso-Burgos, A., Díaz-Lorenzo, I., Muñoz-Saá, L. et al. Primary and secondary postpartum haemorrhage: a review for a rationale endovascular approach. CVIR Endovasc 7, 17 (2024). https://doi.org/10.1186/s42155-024-00429-7
11. Nwafor JI. Comparison of performance of shock index and conventional vital sign parameters for prediction of adverse maternal outcomes following major postpartum hemorrhage in Abakaliki, Southeast Nigeria. Trop J Obstet Gynaecol. 2019;36(3):431. doi:10.4103/TJOG.TJOG_60_19.
12. World Health Organization. Title of the document. Geneva: World Health Organization; 2022. Available from: https://iris.who.int/bitstream/handle/10665/375198/9789240085411-eng.pdf
13. Al Kadri, H.M.F., Al Anazi, B.K. & Tamim, H.M. Visual estimation versus gravimetric measurement of postpartum blood loss: a prospective cohort study. Arch Gynecol Obstet 283, 1207–1213 (2011). https://doi.org/10.1007/s00404-010-1522-1
14. Osakwe CR, Mbachu II, Osakwe OJ, Ikpeze OC. Accuracy of gravimetric method of blood loss estimation during open myomectomy. Int J Med Health Dev. 2023;28(3):245-250. doi:10.4103/ijmh.IJMH_18_23.
15. Agarwal V, Suri J, Agarwal P, Gupta S, Mishra PK. Shock index as a predictor of maternal outcome in postpartum hemorrhage. J South Asian Feder Obst Gynae. 2021;13(3):131–6.
16. Chaudhary, M., Maitra, N., Sheth, T. et al. Shock Index in the Prediction of Adverse Maternal Outcome. J Obstet Gynecol India 70, 355–359 (2020). https://doi.org/10.1007/s13224-020-01355-z
17. Wormer KC, Jamil RT, Bryant SB. Postpartum Hemorrhage. [Updated 2024 Jul 19]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK499988/
18. Ushida T, Kotani T, Imai K, Nakano-Kobayashi T, Nakamura N, Moriyama Y, Yoshida S, Yamashita M, Kajiyama H, Kikkawa F. Shock Index and Postpartum Hemorrhage in Vaginal Deliveries: A Multicenter Retrospective Study. Shock. 2021 Mar 1;55(3):332-337. doi: 10.1097/SHK.0000000000001634.
19. Rath W. Aktive Leitung der Nachgeburtsperiode - Das Ende eines 50-jährigen Dogmas? [Active management of the third stage of labour (AMTSL) - the end of a 50 years-dogma?]. Z Geburtshilfe Neonatol. 2013 Oct;217(5):173-6. German. doi: 10.1055/s-0033-1351277. Epub 2013 Oct 29. PMID: 24170442.

ISSN: 0975-3583,0976-2833 VOL15, ISSUE 12, 2024

20. Gülmezoglu AM, Widmer M, Merialdi M, Qureshi Z, Piaggio G, Elbourne D, Abdel-Aleem H, Carroli G, Hofmeyr GJ, Lumbiganon P, Derman R, Okong P, Goudar S, Festin M, Althabe F, Armbruster D. Active management of the third stage of labour without controlled cord traction: a randomized non-inferiority controlled trial. Reprod Health. 2009 Jan 21;6:2. doi: 10.1186/1742-4755-6-2.
21. Güngördük K, Olgaç Y, Gülseren V, Kocaer M. Active management of the third stage of labor: A brief overview of key issues. Turk J Obstet Gynecol. 2018 Sep;15(3):188-192. doi: 10.4274/tjod.39049.