# Shock Index As a Predictor of Adverse Maternal Outcome In Postpartum Hemorrhage

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## ABSTRACT

**Objective** *To determine the accuracy of shock index in predicting adverse maternal outcome in women with postpartum hemorrhage (PPH).*

**Study design** *Retrospective observational study*

**Place & Duration of study** *Department of Obstetrics & Gynecology Unit-II, Dr. Ruth K.M Pfau, Civil Hospital Karachi, from October 2018 to March 2021.*

**Methodology** *All women who were referred with the diagnosis of PPH were included. Blood loss > 500 ml after vaginal delivery, and > 1000ml after cesarean section was labeled as PPH. Shock index was calculated by dividing heart rate with systolic blood pressure. Adverse maternal outcome were classified according to the WHO criteria and included blood transfusion, intensive care admission, obstetric hysterectomy and maternal death.*

**Results** *A total of 197 women of primary PPH with a mean age 28.71± 5.33 year and mean body mass index 28.14±3.27 kg/m$^2$ were managed. Majority of the women were delivered by vaginal route (n=184 - 93%) with parity <3 (n=105 – 93%). For blood transfusion, ICU admission, obstetric hysterectomy and maternal death optimal cutoff values of SI were considered as 1.15, 1.28, 1.37 and 1.42, respectively. A SI of 1.42 had 90% specificity and 80% sensitivity for predicting maternal death.*

**Conclusion** *A raised SI of > 1 predicts adverse maternal outcome among patients presenting with PPH.*


**Key words** *Postpartum hemorrhage, Shock index, Obstetric hysterectomy, Adverse maternal outcome.*

**INTRODUCTION:**

Hemorrhage, hypertensive disorders and sepsis are the important causes of maternal death globally. Almost 90% of these deaths occur in low and middle income countries (LMIC). Shock index (SI), assessed by dividing heart rate with systolic blood pressure, is an indicator of hypovolemia and act as a predictor of hemodynamic stability. It has also been used in trauma, sepsis and hypertensive disorders of pregnancy to identify the critically ill patients. This simple calculation helps in identifying the cardiovascular stability and seriousness of patient's condition. Recently it has also been incorporated in devices, for appropriate referral and early transfer to the health care units with proper facilities.

A shock index of 0.4-0.7 is considered normal in non-pregnant women, whereas, a range of 0.7-0.9 is considered as normal in pregnant women. An increase in SI has been linked to severe adverse maternal outcome, including massive transfusion requirements, critical care admission and maternal

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mortality.[5] Nathan et al in a retrospective cohort of 233 women, with postpartum hemorrhage of >1500ml, found SI of > 0.9 of having 100% sensitivity and 43% specificity for critical care admission.[6] SI has also been evaluated in the low resource settings. El Ayadi et al identified a SI of >0.9 for the needs of referral, > 1.4 for tertiary care referral and > 1.7 for adverse maternal outcome. SI performed better than other vital sign parameters including heart rate, systolic blood pressure and mean arterial blood pressure.[7] The rationale of this study was to identify the performance of SI among women with postpartum hemorrhage in predicting adverse maternal outcome.

**METHODOLOGY:**

This study was carried out at the Department of Obstetrics & Gynecology Unit-II, Dr. Ruth K.M Pfau, Civil Hospital Karachi. This is the largest tertiary care hospital of the province OF Sindh. This was retrospective observational study that was conducted from October 2018 to April 2021. The study included all women who were referred in emergency with primary postpartum hemorrhage. Patients with secondary PPH, or those receiving anticoagulant therapy and with known hematological disorders were excluded from the study.

PPH was defined as blood loss > 500 ml after vaginal delivery and > 1000ml after cesarean section. Variables collected included the age, parity, mode of delivery, body mass index, place of delivery and referral. Etiological factors for postpartum hemorrhage, including trauma, uterine atony, coagulation disturbances, and retained products of conception were also recorded. Vital signs at the time of admission including heart rate, blood pressure, mean arterial blood pressure and shock index were calculated. Case files were also reviewed for medical or surgical management carried out and adverse maternal outcome including deaths. Adverse maternal outcome was defined according to World Health Organization (WHO) critical intervention criteria.[8] It includes intensive care admission, blood transfusion of > 4 units and emergency obstetric hysterectomy. All variables were entered into a pre designed form.

**STATISTICAL ANALYSIS:**

Mean and standard deviation were reported for continuous variable such as age, body mass index (BMI), estimated blood loss and vital signs. Frequency and percentages were reported for categorical variable such as parity and mode of delivery. Blood transfusion (low=<4 units, high=>4units), intensive care stay, obstetric hysterectomy and maternal death were considered as outcome variables to assess massive PPH. Assumption of normality was checked by using Shapiro-Wilk test. Areas under the curve (AUC) were evaluated for vital sign predictors and for each outcome of massive PPH using receiver-operating curve (ROC) analysis. Significance testing was performed to assess differences among AUC by unadjusted Chi-square test, keeping shock index as reference. Chi-square test and Mann-Whitney tests were run to check proportional and mean differences between the groups of shock index. Statistical significance was considered at p-value <0.05. Stata version 14.0 was used for statistical analysis.

**RESULTS:**

The file records of 197 pregnant women were reviewed. Demographic and delivery related characteristics are reported in table I. The age of the patients was between 17 and 45 years with the mean age of 28.71±5.33 year. The BMI was between 21.50 - 38.00 Kg/$m^2$. Ninety-two (46.7%) women had parity of more than three. Most of the women had vaginal delivery. (n=184 – 93.4%). Overall shock index of the women was between 0.40 and 2.72.

Areas under the curve (AUC) with 95% confidence interval (CI) based on ROC analysis are reported in table II to assess the usefulness of each vital sign parameter in prediction of massive PPH. For blood transfusion, values of AUC were high for SI, systolic blood pressure and mean arterial pressure (0.74 - 95% CI 0.63-0.84). This was significantly higher than the pulse pressure (p=0.003). For ICU admission, SI and systolic blood pressure had highest AUC values (0.78 - 95% CI 0.67-0.88) which was significantly higher than the heart rate (p=0.032) and pulse pressure (p=0.022). For obstetric hysterectomy, the value of AUC was high for SI (0.76 - 95% CI 0.64-0.89). For maternal death, shock index and heart rate showed highest AUC values (0.91 - 95% CI 0.83-0.98) which was significantly higher than the diastolic blood pressure (p=0.006) and pulse pressure (p=0.003).

SI remained consistent in predicting all outcomes of massive PPH. Optimal cutoff values of SI were assessed for each outcome of massive PPH and predictive values are reported in table III. For blood transfusion, ICU admission, obstetric hysterectomy and maternal death optimal cutoff values were considered as 1.15, 1.28, 1.37 and 1.42, respectively. Highest sensitivity (80.0%) and specificity (89.3%) were observed for maternal death. Negative predictive values for all the outcomes were high.

**Table I. Characteristics of the Participants (n=197)**

| Characteristics | Values |
|---|---|
| **Demographic and Delivery Details** | |
| Age (year) | 28.71 ± 5.33 |
| BMI (Kg/m)$^2$ | 28.14 ± 3.27 |
| Parity | |
| < 3 | 105 (53.3%) |
| > 3 | 92 (46.7%) |
| Mode of Delivery | |
| Vaginal delivery | 184 (93.4%) |
| Cesarean section | 13 (6.6%) |
| Estimated Blood Loss (ml) | 995.69 ± 319.78 |
| Hospital Stay (days) | 2.99 ± 2.01 |
| Vital Sign Details | |
| Mean Shock index | 1.06 ± 0.34 |
| Mean Heart Rate (beats / minute) | 103.10 ± 16.21 |
| Mean Systolic Blood Pressure (mmHg) | 102.21 ± 20.62 |
| Mean Diastolic Blood Pressure (mmHg) | 64.73 ± 14.99 |
| Mean arterial pressure (mmHg) | 77.35 ± 16.42 |
| Pulse Pressure (mmHg) | 37.53 ± 11.34 |

**Table II: Area Under the Curve with 95% Confidence Interval of Vital Sign predictors for Each Outcome**

| | Outcomes of Massive PPH | | | |
|---|---|---|---|---|
| **Vital Sign** | **Blood Transfusion** | **ICU Admission** | **Obstetric Hysterectomy** | **Maternal Death** |
| Shock Index | 0.74 (0.63 - 0.84) | 0.78 (0.67 - 0.88) | 0.76 (0.64 - 0.89) | 0.91 (0.83 - 0.98) |
| Heart Rate | 0.69 (0.58 - 0.81) | 0.73 (0.61 - 0.84)* | 0.75 (0.61 - 0.89) | 0.91 (0.83 - 0.98) |
| Systolic Blood Pressure | 0.74 (0.63 - 0.84) | 0.78 (0.69 - 0.87) | 0.75 (0.62 - 0.87) | 0.82 (0.66 - 0.99) |
| Diastolic Blood Pressure | 0.71 (0.60 - 0.82) | 0.73 (0.62 - 0.83) | 0.73 (0.60 - 0.86) | 0.76 (0.62 - 0.90)* |
| Mean Arterial pressure | 0.74 (0.63 - 0.85) | 0.76 (0.66 - 0.86) | 0.75 (0.62 - 0.88) | 0.81 (0.66 - 0.96) |
| Pulse Pressure | 0.55 (0.43 - 0.66)* | 0.61 (.050 - 0.73)* | 0.60 (0.44 - 0.75) | 0.67 (0.47 - 0.87)* |

(p<0.05)*

As for all outcome variables the cutoff values of shock index were greater than 1 so the shock index was divided into two groups, less than or equal to 1 and greater than 1, to further evaluate its association with demographic and delivery related variables (table IV). It was noted that mean estimated blood loss, packed cell volume and heart rate were increased in women who had shock index greater than 1 and these variables with other vital signs showed statistically significant mean differences between the groups of shock index (p=<0.001). However, age, BMI, parity and mode of delivery were not significantly related with shock index.

**DISCUSSION:**

In this study the women who were referred with the diagnosis of PPH had a raised SI. The BMI of women indicated that most of them fell either in overweight or obese category. Obesity has been linked with PPH and increased risk for blood transfusion. Previously, a BMI of < 30 has been found to be associated with severe PPH.[8,9] In our study, BMI was not independently associated with a raised SI.

**Table III: Performance of Shock Index in Prediction of the Outcomes of Massive PPH**

| Outcomes | Sensitivity % (95% CI) | Specificity % (95% CI) | PPV % (95% CI) | NPV (95% CI) | Prevalence (%) |
|---|---|---|---|---|---|
| **Blood Transfusion** | | | | | |
| SI = 1.15 | 65.6 (46.8-81.4) | 79.4 (72.4-85.3) | 38.2 (25.4-52.3) | 92.2 (86.6-96.1) | 16.24 |
| **ICU Admission** | | | | | |
| SI = 1.28 | 64.5 (45.4-80.8) | 87.9 (82.0-92.5) | 50.0 (33.8-66.2) | 92.9 (87.8-96.4) | 15.73 |
| **Obstetric Hysterectomy** | | | | | |
| SI = 1.37 | 55.6 (30.7-78.4) | 88.8 (83.2-93.0) | 33.3 (17.2-52.8) | 95.2 (90.7-97.9) | 9.14 |
| **Maternal Death** | | | | | |
| SI = 1.42 | 80.0 (44.4-97.5) | 89.3 (83.9-93.3) | 28.6 (13.2-48.7) | 98.8 (95.8-99.9) | 5.07 |

PPV= Positive predictive values, NPV= Negative predictive values.

**Table IV: Association of Shock Index With Demographic and Delivery Related Characteristics (n=197)**

| Characteristics | Shock Index | | p-value* |
|---|---|---|---|
| | SI = 1 (n=113) | SI > 1 (n=84) | |
| Age (Years) | 28.44 ± 4.92 | 29.06 ± 5.85 | 0.439 |
| BMI (Kg/m$^2$) | 27.83 ± 3.21 | 28.56 ± 3.32 | 0.129 |
| Parity | | | |
| <3 | 61 (54.0) | 44 (52.4) | 0.824! |
| >3 | 52 (46.0) | 40 (47.6) | |
| **Mode of Delivery** | Vaginal Delivery | 103 (91.2) | 81 (96.4) |
| | Cesarean Section | 10 (8.8) | 3 (3.6) |
| Estimated Blood Loss (ml) | 888.05 ± 218.28 | 1140.48 ± 374.44 | < 0.001 |
| Packed Cell Volume | 1.64 ± 1.24 | 3.06 ± 2.10 | < 0.001 |
| Heart Rate | 94.34 ± 10.00 | 114.89 ± 15.51 | < 0.001 |
| Systolic Blood Pressure | 113.10 ± 18.47 | 87.56 ± 12.85 | < 0.001 |
| Diastolic Blood Pressure | 72.30 ± 13.16 | 54.54 ± 10.67 | < 0.001 |
| Mean Arterial Pressure | 86.09 ± 14.32 | 65.60 ± 10.77 | < 0.001 |
| Pulse Pressure | 40.71 ± 12.01 | 33.26 ± 8.79 | < 0.001 |

Mean ± standard deviation or n (percentage) are reported. *p-value was calculated by Mann-Whitney U test. !p-value was calculated by Chi-square test.

Majority of the women in this study delivered vaginally. In a retrospective cohort of more than 30,000 vaginal deliveries, comparison of individual vital signs with SI, showed later to be a better parameter with 69% accuracy.[9] When compared with operative delivery, we did not find mode of delivery to be significant factor. In a retrospective case-control study, investigators found intrapartum SI to be raised in women who delivered vaginally.[10]

The SI was consistently found high with different adverse outcome. SI has been compared with individual vital signs in predicting adverse maternal outcome, in women with PPH and has been found to be more sensitive and specific than individual parameters. Our study also found individual comparison of vital signs with SI, better indicator for adverse outcome, when compared with heart rate and mean arterial pressure.

Our study found SI of > 1.15 (95% CI 0.63-0.84) for blood transfusion. In a study of 130 women with

PPH, reported SI of 0.9125 (0.815 sensitivity, 0.923 specificity) for blood transfusion.[11] In another study SI >1.1, predictive of blood transfusion in 89% of the cases.4 SI thus not only identifies blood loss, at the same time an increased SI also indicates need for blood transfusion. Hence, this can help in situations where hematologist is not available for guidance. Investigators have found raised SI more sensitive indicator of transfusion in dilutional coagulopathy, as compared to consumptive coagulopathy.[12]

Increase shock index in immediate postpartum period may help in identifying patients who are at increased risk of hemorrhage related complications.[13] We found SI of > 1.37 for obstetrical hysterectomy in study population. Maneschi et al observed SI of 1.5 as significant for obstetric hysterectomy.[14] A SI of 1.42 had high sensitivity (80%) and specificity (90%) for maternal death. Other investigators have also found SI >1.7 to be associated with all severe adverse maternal outcomes, including maternal death.[2,15]

**LIMITATIONS OF THE STUDY**

Our study did not take into account the presence of anemia and hypertension in women. Both conditions are known to have effect on SI, as pulse and systolic blood pressure are altered. If we assume these conditions might be higher in our study group, then the overall higher average SI in the study sample might be due to these underlying conditions. There might be some uncontrolled confounding effects of these characteristics on the study findings.

**CONCLUSION:**

SI is an important tool in the identification of critically ill patient. In obstetric practice, it not only helps in assessing the hemodynamic stability of the patient but also alerts about the need for blood transfusion and medical intervention and warns for appropriate referral.

**REFERENCES:**


1. El-Menyar A, Goyal P, Tilley E, Latifi R. The clinical utility of shock index to predict the need for blood transfusion and outcomes in trauma. J Surg Res. 2018;227:52-9. doi: 10.1016/j.jss.2018.02.013.

2. Nathan HL, Seed PT, Hezelgrave NL, De Greeff A, Lawley E, Anthony J, et al. Shock index thresholds to predict adverse outcomes in maternal hemorrhage and sepsis: A prospective cohort study. Acta Obstet Gynecol Scand. 2019;98:1178-86. doi: 10.1111/aogs.13626.

3. Nathan HL, Vousden N, Lawley E, de Greeff A, Hezelgrave NL, Sloan N, et al. Development and evaluation of a novel Vital Signs Alert device for use in pregnancy in low-resource settings. BMJ Innov. 2018;4:192-8. doi: 10.1136/bmjinnov-2017-000235.

4. Le Bas A, Chandraharan E, Addei A, Arulkumaran S. Use of the "obstetric shock index" as an adjunct in identifying significant blood loss in patients with massive postpartum hemorrhage. Int J Gynaecol Obstet. 2014;124:253-5. doi: 10.1016/j.ijgo.2013.08.020.

5. Chaudhary M, Maitra N, Sheth T, Vaishnav P. Shock Index in the prediction of adverse maternal outcome. J Obstet Gynaecol India. 2020;70:355-9.

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;122:268-75. doi: 10.1111/1471-0528.13206.

7. El Ayadi AM, Nathan HL, Seed PT, Butrick EA, Hezelgrave NL, Shennan AH, et al. Vital sign prediction of adverse maternal outcomes in women with hypovolemic shock: the role of shock index. PloS one. 2016;11(2):e0148729. doi: 10.1371/journal.pone.0148729.

8. Say L, Souza JP, Pattinson RC. Maternal near miss-towards a standard tool for monitoring quality of maternal health care. Best Pract Res Clin Obstet Gynaecol. 2009;23:287-96. doi: 10.1016/j.bpobgyn.2009.01.007.

9. Ushida T, Kotani T, Imai K, Nakano-Kobayashi T, Nakamura N, Moriyama Y, et al. Shock Index and postpartum hemorrhage in vaginal deliveries: a multicenter retrospective study. Shock. 2021;55:332-7.

10. Kohn JR, Dildy GA, Eppes CS. Shock index and delta-shock index are superior to existing maternal early warning criteria to identify postpartum hemorrhage and need for intervention. J Matern Fetal Neonatal Med. 2019;32:1238-44. doi: 10.1080/14767058.2017.1402882.

11. Tanacan A, Fadiloglu E, Unal C, Beksac MS. Importance of shock index in the evaluation of postpartum hemorrhage cases that necessitate blood transfusion. Women Health. 2020;60:1070-8. doi: 10.1080/03630242.2020.1802638.

12. Era S, Matsunaga S, Matsumura H, Murayama Y, Takai Y, Seki H. Usefulness of shock indicators for determining the need for blood transfusion after massive obstetric hemorrhage. J Obstet Gynaecol Res. 2015;41:39-43. doi: 10.1111/jog.12480.

13. Ann W, Michael S, Bridget L, Chieko K, Reni S. Postpartum shock index as a predictor of postpartum hemorrhage morbidity. Obstet Gynecol. 2018;131:127S. DOI:10.1097/01.AOG.0000533532.21165.73.

14. Maneschi F, Perrone S, Di Lucia A, Ianiri P. Shock parameters and shock index during severe post-partum haemorrhage and implications for management: a clinical study. J Obstet Gynaecol. 2020;40:40-5. DOI:10.1080/01443615.2019.1603210.

15. Agarwal V, Suri J, Agarwal P, Gupta S, Mishra PK, Mittal P. Shock Index as a predictor of maternal outcome in postpartum hemorrhage. J South Asian Fed Obstet Gynaecol. 2021;13: https://doi.org/10.5005/jp-journals-10006-1894

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