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ORIGINAL ARTICLE

Predictors of Maternal, Neonatal, and Clinicopathological Factors Associated with Postoperative Complications Following Emergency Cesarean Section Under General Anesthesia: A Retrospective Cohort Study

MUHAMMAD ATHIF AKRAM[1], MAMOONA SARWAR[2], HINA[3], SHAZIA BAHAR[4], MUHAMMAD IMRAN[5], HAMID NAWAZ KHOKHAR[6*]
[1]*Abu Umara Medical and Dental College / Ali Fatima Teaching Hospital, Lahore, Pakistan.*
[2]*Department of Obstetrics and Gynaecology, Ittefaq Hospital Trust, Model Town, Lahore, Pakistan.*
[3]*Department of Anaesthesia, Ameer-ud-Din Medical College / Lahore General Hospital, Lahore, Pakistan.*
[4]*Department of Paediatrics, Khyber Teaching Hospital, Peshawar, Pakistan.*
[5]*Department of Medicine, Services Hospital, Lahore, Pakistan.*
[6]*Department of Pathology, Sahara Medical College, Narowal, Pakistan.*
Correspondence to: Dr. Shazia Bahar, Email: shaziabahar1129@gmail.com

ABSTRACT

Background: Emergency cesarean section under general anesthesia is associated with increased maternal and neonatal risk because of underlying obstetric emergencies, maternal comorbidities, and anesthesia-related physiological changes. Perioperative predictors may facilitate risk stratifications, preparedness, and multidisciplinary intervention in a timely manner. This study evaluated maternal, anesthetic, operative, clinicopathological, and neonatal predictors of adverse outcomes.

Materials and Methods: This retrospective cohort study included 120 women who underwent emergency cesarean section under general anesthesia from January 2022 to January 2023. Demographic, obstetric, laboratory, anesthetic, operative, postoperative and neonatal data were examined. Independent predictors for maternal postoperative complications and adverse neonatal outcomes were determined by utilizing multivariable logistic regression with a statistical significance of $p<0.05$.

Results: The mean maternal age was 29.6 ± 5.1 years. The overall incidence of at least one postoperative complication was 41 women (34.2%) and adverse outcome was 39 neonates (32.5%). Postpartum hemorrhage (14.2%), intensive care admission (7.5%) and neonatal intensive care admission (22.5%) occurred in the respective patients. Preoperative hemoglobin level less than 10 g/dL, ASA physical status III–IV, estimated blood loss more than 1000 mL, and operative time greater than 60 minutes were independently associated with maternal complications. Adverse neonatal outcomes were independently associated with prematurity, maternal intraoperative hypotension, and an induction-to-delivery interval >10 minutes.

Conclusion: Emergency cesarean delivery (under general anesthesia) is associated with significant maternal and infant morbidity. Early identification of risk, correction of anaemia, emergency haemorrhage preparedness, haemodynamic optimization and induction-to-delivery delay reduction may result in better outcomes peroperatively and safer emergency obstetric care.

Keywords: Cesarean section; General anesthesia; Maternal complications; Neonatal outcomes; Postpartum hemorrhage; Obstetric anesthesia; Risk factors.

INTRODUCTION

Cesarean section is one of the most frequently performed surgical procedures in obstetric practice and is often required on an emergency basis when rapid delivery is necessary to protect maternal or fetal health[1]. Although neuraxial anesthesia is the preferred form of anesthesia for cesarean delivery, general anesthesia is still necessary in the following circumstances: severe fetal compromise, maternal hemodynamic instability, major obstetric hemorrhage, contraindication to regional anesthesia, failed neuraxial block, and immediate need for operative delivery. Emergency cesarean section under general anesthesia is therefore frequently used for women with already large numbers of obstetric or medical risk factors, and may be associated with an increased risk of complications during and after surgery[2,3].

General anesthesia is more difficult during pregnancy because of several physiological changes. Mucosal edema of the upper airway, weight gain and changes in upper airway anatomy, and increased oxygen consumption and decreased functional residual capacity may contribute to the risk for difficult tracheal intubation and rapid oxygen desaturations on induction[4]. In pregnant women, there is also an increased risk of pulmonary aspiration, especially during parturition and in the case of delayed gastric emptying as the result of an emergency surgery. All these factors warrant careful assessment of the airway, proper preoxygenation, appropriate induction technique, continuous monitoring of mother and preparedness for difficult airway management[5].

It is not only the type of anesthetic chosen for cesarean section that affects the risk of bad outcomes during surgery, but also the maternal and obstetric health[6]. Women can complain about fetal distress, hypertension during pregnancy, placental abruption, placenta previa, obstructed or prolonged labour, previous uterine surgery, maternal anaemia or active bleeding. These conditions can lead to increased risk of blood loss, blood transfusion, post-operative infection, respiratory problems, intensive care unit, and/or extended stay in the hospital[7].

Post-operative morbidity may also influence the clinicopathological factors quite considerably. Low preoperative hemoglobin concentration may impair the ability to withstand acute blood loss during surgery and may be associated with other laboratory abnormalities such as thrombocytopenia, leukocytosis, impaired coagulation, renal dysfunction and may reflect disease severity. Likewise, higher anesthetic risk status, hypotension during surgery, longer operating time and excessive blood loss could be used to indicate more physiological stress and higher risk for postoperative complications[8,9].

Maternal anemia is especially important in emergency obstetric surgery, as the hemoglobin concentration provides a buffer for physiological reserve, and insufficient hemoglobin levels may cause a greater effect from the perioperative blood loss[10]. Women who have a severe anemia may need blood transfusion more often, and may be more likely to experience fatigue after surgery, and cardiovascular stress and longer hospital stays. Thus, identifying anemia and other correctable abnormalities early in the surgical process may enhance the planning and post-surgery care[11].

Maternal outcomes may also be impacted by anesthetic and operative factors. Perioperative risk may be higher if the airway is difficult to manage, intubation attempts are unsuccessful, oxygen

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saturation is inadequate, there is instability, induction is prolonged, and the surgery is long. Moreover, significant blood loss during surgery may result in hypovolemia, hypotension, tissue hypoperfusion, need for transfusion, and admission to intensive care. Efficient interaction between anesthetic team and the surgical team is, therefore, crucial during emergency cesarean delivery[12,13].

Maternal status, urgency of delivery, gestational age, fetal status prior to surgery and in-utero anesthetic exposure also impact neonatal outcomes. General anesthetic agents are known to cross the placenta, and may be responsible for transient neonatal depression, especially if the time between induction of anesthetic and delivery is long. But, poor neonatal outcome can also be due to premature delivery, fetal distress, inadequate placental function, maternal hypotension, bleeding, or longstanding fetal compromise prior to surgery[14,15].

Adverse neonatal outcomes associated with emergency cesarean delivery are low Apgar scores, need for active resuscitation, respiratory distress, NICU admission, and early neonatal complications. Immaturity of respiratory and cardiovascular systems may make premature neonates more vulnerable. During surgery, hypotension in the mother could also decrease uteroplacental perfusion and lead to fetal compromise, so oxygenation and hemodynamic stability in the mother should also be maintained[16-18].

Emergency cesarean section under general anesthesia is hence a composite phenomenon of maternal factors, obstetric emergencies, anaesthetic management, laboratory abnormalities, surgical factors and the neonatal condition. Prediction of adverse outcomes can help clinicians identify high-risk patients, ensure proper blood product preparation, adequate critical care services, avoid unnecessary anesthetic and surgical delays, and provide prompt neonatal support[19,20].

The current study was therefore carried out to assess the incidence of maternal complications after emergency cesarean section under general anesthesia and adverse neonatal outcomes, and to identify maternal, obstetric, anesthetic, operative and clinicopathological factors associated with them.

MATERIALS AND METHODS

Study Design and Setting: This retrospective cohort study was conducted at Ali Fatima Teaching Hospital, Lahore, Pakistan, and the Department of Obstetrics and Gynaecology, Ittefaq Hospital Trust, Model Town, Lahore, Pakistan. Data on women who had cesarean section under GA during an emergency situation from January 2022 to January 2023 were analyzed. The study was aimed at assessing maternal, obstetric, anesthetic, operative, clinicopathological and neonatal factors influencing the occurrence of postoperative maternal complications and adverse neonatal outcomes.

Study Population: Study population consisted of women undergoing emergency cesarean delivery under general anesthesia in the study period. Operating-theatre registers, obstetric admission records, anesthesia charts and hospital medical records were all sources for identification of cases. Women of reproductive age, who had an emergency cesarean section (CS) and general anesthesia (GA) was the primary anesthetic technique or was needed due to an urgent clinical indication, were considered for inclusion.

Sample size and sampling technique: Finally, 120 patients who met the inclusion criteria were analyzed. The sampling method was consecutive sampling, where the entire population of eligible medical records was sampled for the given period of the study until the sample size was obtained. Records were first filtered for complete data before being imported into the study database.

Inclusion Criteria: All women who had cesarean section during the study period were included even if performed under general anesthesia. Patients who were eligible had documentation of the reason for cesarean delivery, anesthesia technique, pertinent laboratory findings before cesarean delivery, course of delivery, maternal outcome after cesarean delivery, and neonatal outcome. Consistent with this, both first and repeat cesarean sections were included if carried out under general anesthesia.

Exclusion Criteria: Patients who had an elective cesarean section, cesarean delivery under spinal or epidural anesthesia only, and other procedures other than cesarean deliveries were excluded. Records that were missing significant data on anesthesia, intra-operative findings, post-operative maternal status or neonatal outcome were also excluded. Patients who were transferred to another facility immediately after surgery and had no adequate postoperative documentation were not included in the final analysis.

Data Collection Procedure: Data were collected by retrospectively using a structured data collection form which was specifically developed for the study. The information was taken from obstetric case files, anesthesia records, operative notes, laboratory reports, recovery-room records, intensive care records, neonatal records, and discharge summaries. All qualified records were carefully evaluated and data was systematically collected in a pre-designed database following the exclusion of direct patient identifiers.

Maternal demographic and clinical factors included age, parity, gravidity, gestational age, history of cesarean delivery, known comorbidities, antepartum hemorrhage, diabetes mellitus, and maternal anemia, and American Society of Anesthesiologists physical status. Obstetric variables included primary indication for emergency cesarean section (fetal distress), obstructed labor, prolonged labor, placenta abruption, placenta previa, previous uterine scar with acute obstetric indication and preterm delivery.

Clinicopathological Assessment: Available preoperative laboratory parameters were recorded to determine their association with postoperative complications. These were hemoglobin concentration, total leukocyte count, platelet count, serum creatinine and other clinically relevant laboratory investigations that were available in the medical record. To investigate the association of a low hemoglobin concentration with maternal anemia, a Hb of less than 10g/dl was used as a clinically significant indicator for maternal anemia. The reference ranges defined by the participating hospital laboratories were used to classify abnormal platelet counts, leukocytes, or renal parameters.

Anesthetic Assessment: Anesthetic data was retrieved from anesthetic chart and anaesthetic documentation. These variables included indication for GA, preoperative anesthetic risk assessment, airway assessment (when available), induction of anesthetic, endotracheal intubation, number of intubation attempts, difficult airway events, oxygen desaturation, intra-operative maternal hypotension, vasopressors used, and other anesthetic complications.

Time from induction of general anesthesia to delivery of the neonate was documented when sufficient information was available. For analysis, an induction-to-delivery interval of more than 10 minutes was considered prolonged. Anesthetic was given as per patient's clinical status and as per the standard practice in the institution at the time of the surgery. The study was retrospective and the investigators did not change the anesthetic technique or the choice of anesthetic drugs or the use of an airway-management strategy or the course of treatment given to any patient.

Operative Variables: Operative data consisted of surgical time, estimated blood loss, need for blood transfusion, surgical difficulty, and documented intraoperative complications. Operative time was determined from the operative or anesthesia record. For the purpose of the risk-factor analysis, a duration of > 60 minutes was defined as prolonged.

The amount of blood lost was estimated from the operative and anesthesia records. Intraoperative blood loss ≥ 1000 mL was defined as major blood loss. The need for packed red blood cells or any other blood products during the perioperative period were also documented.

Maternal Postoperative Outcomes: The main maternal outcome was one or more clinically significant complications that occurred

while the patient was in hospital for the index procedure. Postoperative fever, wound infection, surgical-site infection, respiratory complications, intensive care unit admission, the need for reoperation or another major surgical procedure, and a prolonged postoperative hospital stay were each a separate maternal complication assessed.

Postpartum hemorrhage was determined by the diagnosis made by treating team, estimated blood loss, need for special management of postpartum hemorrhage, and blood transfusion. Postoperative fever is documented as fever after surgery by the caring team. Wound infection was detected by recording the presence of wound discharge, erythema, wound separation, antibiotic treatment and/or surgical intervention. Respiratory complications consisted of clinically significant oxygen desaturation, respiratory distress, suspected aspiration, prolonged oxygen supplementation, mechanical ventilation and other documented postoperative respiratory morbidity.

A composite variable for maternal postoperative complications was created. Adverse maternal postoperative outcomes were defined as at least one of the predefined complications occurring during the hospitalization of the woman.

Neonatal Outcomes: Neonatal data collected from delivery records, neonatal resuscitation notes, pediatric assessments and neonatal intensive care records. Variables were birth status, Apgar scores at 1 and 5 minutes, need for active neonatal resuscitation, admission to neonatal intensive care unit, respiratory distress and early neonatal death during hospital stay.

An adverse neonatal composite outcome was assigned when one or more of the following clinically significant neonatal complications were recorded: 5 minute Apgar score less than 7, need for active resuscitation, admission to neonatal intensive care unit, clinically diagnosed respiratory morbidity or early neonatal death.

The predictor variables: Predictors were chosen because of their clinical relevance to emergency cesarean delivery under general anesthesia. Maternal factors studied were age, parity, preoperative anemia, medical and obstetric morbidity, and ASA physical status. Obstetric factors were fetal distress, prematurity, and hypertension disorders, antepartum hemorrhage, placenta problems, and prolonged or obstructed labour.

Anesthetic and operative factors included intraoperative hypotension, airway problems, induction to delivery interval, operative time, estimated blood loss of 1000 mL or more, and blood-transfusion requirement. Preop lab abnormalities were each evaluated separately to see if they were associated with postop outcomes.

Control of Bias and Data Quality: Consecutive records in the participating centers that met the inclusion criteria and no exclusion criteria were evaluated to minimize selection bias. To ensure consistency in the variables being extracted, a standardised data collection form was used. Records with missing information on important outcome variables were not included in the final analysis. Data entries were checked for completeness and consistency prior to statistical analysis. Where discrepancies were found the original medical record was reviewed again prior to the finalisation of the dataset.

Statistical Analysis: IBM SPSS Statistics version 26.0 was used to enter and analyse data. Normally distributed continuous variables (maternal age and gestational age) were summarized as mean ± standard deviation. Categorical variables were displayed as frequencies and percentages.

Categorical predictor variables were compared to maternal and/or neonatal outcomes using the chi-square test or Fisher's exact test as appropriate. Independent-samples t-test or a non-parametric test (as determined by data distribution) was used to compare continuous variables.

Binary logistic regression analysis was performed to determine factors associated with maternal postoperative complications and adverse neonatal outcomes. Univariate regression analysis was first done for each individual predictor. All variables with a p value <0.20 on univariate analysis and those which were clinically relevant were selected for inclusion in the multivariable logistic regression model. Adjusted odds ratios (ORs) and 95% confidence intervals (CI) were reported as independent predictors. A two-sided p value of <0.05 was considered statistically significant.

Ethical Considerations: The study was approved by the appropriate institutional review boards prior to study data collection. This study was a retrospective review of available clinical records without any changes in the management of the patients or direct interventions. In accordance with the approving ethics committees, waiver of the need for individual informed consent was granted, as only anonymous, retrospective data were used. All patient data was kept confidential and personalising data was removed from the analytical database.

RESULTS

Baseline Maternal, Obstetric, and Perioperative Characteristics: We included 120 women who had an emergency cesarean section under general anesthesia in the final analysis. The average maternal age was 29.6 ± 5.1 years and average gestational age at delivery was 37.4 ± 2.2 weeks. 38 women (31.7%) were primigravida, 46 women (38.3%) had a previous cesarean section and 30 women (25.0%) delivered before 37 completed weeks of gestation.

Thirty-five (29.2%) patients had hemoglobin less than 10 g/dL preoperatively. Twenty-seven (22.5%) women had hypertensive disorders of pregnancy, 12 (10.0%) had diabetes mellitus and 13 (10.8%) had antepartum hemorrhage. Thirty-three patients were judged as physical status III–IV of the American Society of Anesthesiologists (ASA) classification system (27.5%). The most common obstetric indication or accompanying indication for emergency cesarean delivery was fetal distress, which occurred in 53 (44.2%) patients. Torsion was found in 21 (17.5%) cases, placental abruption or placenta previa in 15 (12.5%) and an acute obstetric indication in the women with a previous uterine scar in 17 (14.2%) cases (Table 1).

Maternal hypotension was recorded in 29 (24.2%) patients during the operation. At least 1000 mL of estimated blood loss was documented in 24 (20.0%) women and in 17 (14.2%) a blood transfusion was required during the perioperative period. Thirty-four (28.3%) cases had an operative time > 60 minutes. Thirty-two (26.7%) patients had an interval of >10 minutes between induction and delivery (Table 1).

Maternal Postoperative Outcomes: Among the 120 women, 41 (34.2%) experienced at least one maternal postoperative complication overall. The most common complication reported was postpartum hemorrhage in 17 (14.2%) patients. There were 13 (10.8%) cases of postoperative fever and 10 (8.3%) cases of wound or SSI.

Respiratory complications occurred in 8 (6.7%) patients, and 9 (7.5%) went to the intensive care unit post surgery. 19 women (15.8%) had a postoperative stay of more than four days. Three patients (2.5%) needed reoperation or another major surgical procedure during the admission for the index surgery. Table 2 shows the frequencies of maternal postoperative complications.

Neonatal Outcomes: Among the 120 neonates, 31 (25.8%) had an Apgar score below 7 at 1 minute, whereas 14 (11.7%) had an Apgar score below 7 at 5 minutes. 29 (24.2%) required active neonatal resuscitation and 27 (22.5%) neonates were admitted to neonatal intensive care unit.

In 16 cases (13.3%) neonatal respiratory distress was reported. Two (1.7%) neonates had early neonatal deaths. Thirty-nine (32.5%) neonates had at least one of the predefined adverse neonatal outcomes: 5-minute Apgar score <7, need for active resuscitation, admission to neonatal intensive care unit, respiratory morbidity, or early neonatal mortality (Table 2).

Association of Maternal and Perioperative Factors With Postoperative Complications: Women who were anemic preoperatively, had higher American Society of Anesthesiologists

physical status, high intraoperative blood loss, and longer operative times were more likely to experience maternal postoperative complications. These risk factors were then analyzed by multivariable logistic regression to identify independent association with postoperative morbidity.

Hemoglobin concentration <10 g/dL was a significant independent predictor of maternal postoperative complications. A hemoglobin concentration of less than 10 g/dL was associated with an adjusted OR of 2.71 (95% CI 1.10–6.70, P=0.030) for a postoperative complication in women who had anemia preoperatively (Table 3).

Maternal postoperative morbidity was also independently related to American Society of Anesthesiologists physical status III–IV. The women in the higher-risk categories had 2.58 times higher adjusted odds of postoperative complications (95% CI 1.01-6.60; P=0.048) (Table 3).

The most significant correlation with maternal postoperative complications was the estimated blood loss of ≥1000mL. Women with this amount of EBL had an adjusted odds ratio of 5.62 (95% CI 1.92–16.45; P=0.002) for postoperative morbidity, which was more than 5fold higher than for women with lower EBL. Operative time >60 minutes was also independently associated with maternal complications, with an adjusted OR of 2.76, 95% CI of 1.05–7.28 and p=0.040 (Table 3).

Predictors of Adverse Neonatal Outcomes: Independent associations with adverse neonatal outcome remained for gestational age < 37 completed weeks, maternal intraoperative hypotension, and induction-to-delivery interval > 10 minutes after adjustment for potential confounding variables.

The adjusted odds of experiencing an adverse neonatal outcome were greater by 3.41 for preterm neonates than those born at or after 37 weeks of gestation. This association was statistically significant (95% confidence interval 1.39-8.37, p=0.007, Table 3).

There was an independent association between neonatal morbidity and maternal intraoperative hypotension. Neonates delivered to mothers who experienced intraoperative hypotension had 2.86 times higher adjusted odds of an adverse neonatal outcome, with a 95% confidence interval of 1.13–7.23 and p=0.026. Likewise, having an induction to delivery interval of >10 minutes was associated with about threefold higher adjusted odds of adverse neonatal outcomes (adjusted odds ratio 3.09, 95% confidence interval 1.28 to 7.48, p=0.012; Table 3).

Fetal distress was correlated with elevated risks of neonatal morbidity, which did not achieve conventional level of statistical significance after multivariable adjustment. The adjusted odds ratio was 2.34, with a 95% confidence interval of 0.98–5.59 and p=0.056 (Table 3).

Table 1: Baseline maternal, obstetric, anesthetic, and operative characteristics of the study population (n=120)

Characteristic	n (%) or Mean ± SD
Maternal age, years	29.6 ± 5.1
Gestational age, weeks	37.4 ± 2.2
Primigravida	38 (31.7)
Previous cesarean delivery	46 (38.3)
Gestational age <37 weeks	30 (25.0)
Preoperative hemoglobin <10 g/dL	35 (29.2)
Hypertensive disorder of pregnancy	27 (22.5)
Diabetes mellitus	12 (10.0)
Antepartum hemorrhage	13 (10.8)
American Society of Anesthesiologists physical status III–IV	33 (27.5)
Fetal distress	53 (44.2)
Obstructed or prolonged labor	21 (17.5)
Placental abruption or placenta previa	15 (12.5)
Acute obstetric indication with previous uterine scar	17 (14.2)
Intraoperative maternal hypotension	29 (24.2)
Estimated blood loss ≥1000 mL	24 (20.0)
Blood transfusion	17 (14.2)
Operative duration >60 minutes	34 (28.3)
Induction-to-delivery interval >10 minutes	32 (26.7)

Table 2: Maternal postoperative and neonatal outcomes among the study population (n=120)

Outcome	n (%)
Maternal postoperative outcomes	
Any maternal postoperative complication	41 (34.2)
Postpartum hemorrhage	17 (14.2)
Postoperative fever	13 (10.8)
Wound or surgical-site infection	10 (8.3)
Respiratory complication	8 (6.7)
Intensive care unit admission	9 (7.5)
Postoperative hospital stay >4 days	19 (15.8)
Reoperation or additional major intervention	3 (2.5)
Neonatal outcomes	
1-minute Apgar score <7	31 (25.8)
5-minute Apgar score <7	14 (11.7)
Active neonatal resuscitation	29 (24.2)
Neonatal intensive care unit admission	27 (22.5)
Neonatal respiratory distress	16 (13.3)
Early neonatal mortality	2 (1.7)
Composite adverse neonatal outcome	39 (32.5)

Table 3. Multivariable logistic regression analysis of predictors of maternal postoperative complications and adverse neonatal outcomes

Outcome and predictor	Adjusted odds ratio	95% confidence interval	p value
Maternal postoperative complications			
Preoperative hemoglobin <10 g/dL	2.71	1.10–6.70	0.030
American Society of Anesthesiologists physical status III–IV	2.58	1.01–6.60	0.048
Estimated blood loss ≥1000 mL	5.62	1.92–16.45	0.002
Operative duration >60 minutes	2.76	1.05–7.28	0.040
Adverse neonatal outcomes			
Gestational age <37 weeks	3.41	1.39–8.37	0.007
Maternal intraoperative hypotension	2.86	1.13–7.23	0.026
Induction-to-delivery interval >10 minutes	3.09	1.28–7.48	0.012
Fetal distress	2.34	0.98–5.59	0.056

About a third of the study population experienced maternal postoperative complications, and postpartum hemorrhage was the most common complication. Maternal morbidity was independently associated with preop anemia, high anesthetic risk status, large amount of blood loss, and longer duration of surgery. In the same manner, almost one-third of the neonates had an unfavorable neonatal outcome. Prematurity, maternal intraoperative hypotension and prolonged induction to delivery interval came out as important independent predictors of adverse neonatal outcomes. Estimated blood loss of ≥1000mL was the strongest association of maternal predictors with postoperative complications, while prematurity was the strongest association with neonatal morbidity.

DISCUSSION

The current study aimed to assess the maternal, obstetric, anesthetic, operative, clinicopathological and neonatal factors that are associated with adverse outcomes after emergency cesarean section under general anesthesia[1]. Maternal postoperative complications were observed in approximately one-third of the study population, while a similar proportion of neonates experienced adverse outcomes. Independent factors that were associated with maternal postoperative morbidity were preoperative anemia, higher American Society of Anesthesiologists physical status, excessive intraoperative blood loss, and longer operative time. Several factors were found to be significantly associated with adverse neonatal outcome including prematurity, maternal hypotension during surgery and long induction to delivery interval[2,3].

The most common maternal postoperative complication in the study was postpartum hemorrhage. Emergency cesarean delivery is often indicated in women with conditions that may raise the risk for blood loss during delivery, such as placental disorders, prolonged labour, fetal distress, high blood pressure disorders and prior surgery on the uterus[4]. Moreover, emergency situations may allow only a brief interval to achieve optimal correction of maternal anaemia, coagulation defects or haemodynamic instability prior to surgery. Postpartum hemorrhage therefore is a reflection of underlying obstetric disease, emergency operative intervention, and decreased physiological reserve in this population[5].

Low pre-operative Hb level (Hb<10 g/dL) was an independent risk factor for maternal postoperative complications. Maternal anemia reduces the ability to cope with sudden losses of blood in the immediate periparturient period and can increase the likelihood of early onset of tissue hypoxia, circulatory instability and eventual transfusion[6]. Anemia in women can also lead to delayed recovery post surgery and the risk of extended hospital stays. These findings highlight the need to identify and manage anaemia at the Antenatal Care (ANC) level if at all possible. During emergencies, a quick determination of haemoglobin concentration can help the clinician to predict the need for transfusion, and prepare the required blood components before surgery[7].

Another independent predictor of postoperative morbidity was the higher ASA physical status. Women ASA III–IV tend to have more advanced systemic diseases, major pregnancy complications or major obstetric pathologies[8]. These patients have lower cardiac, pulmonary and haematological reserve and may be less tolerant of the physiological stress of emergency surgery and general anaesthetic. It is thought that early recognition of higher ASA status prior to induction can help in earlier involvement of higher cadre of anesthesia staff, better monitoring of haemodynamics, readiness for intensive care in the postoperative period, and preparedness to encounter possible complications in the post-anaesthesia period[9,10].

An estimated blood loss of ≥1000 mL was most strongly associated with maternal postoperative complications. Significant blood loss can lead to rapid onset of hypovolemia, hypotension, inadequate tissue perfusion, coagulopathy, and organ dysfunction[11]. It can also lead to a greater requirement for blood transfusion and intensive care management. The close association of excessive blood loss with postoperative morbidity emphasizes the importance of early identification of bleeding risk; blood component availability without delay; appropriate uterotonic therapy; efficient surgical hemostasis, and coordinated management between obstetric, anaesthetic and transfusion teams[12].

Operative time was also an independent risk factor for maternal complications. Operations > 60 minutes may be a reflection of greater surgical complexity, more dense adhesions from previous operations, more difficult extraction of fetus, abnormal placentation, extension of uterine incisions, uncontrolled bleeding, or the need for additional surgical procedures[13]. Extended surgeries mean more time under anesthesia and can lead to more blood loss, fluid movement, a risk of infection and a longer recovery. Hence, the length of operation could serve as a direct measure of the perioperative stress response as well as an indirect measure of difficult surgery[14].

A smaller and clinically important number of women had respiratory complications. Airway management during general anesthesia is especially difficult in pregnant women due to physiologic changes associated with pregnancy[15]. Because of reduced functional residual capacity and increased oxygen consumption, as well as airway edema and rapid desaturations, the risk of inducing hypoxemia is increased during induction and intubation. There may also be an increased risk in emergency situations where there may not be sufficient time prior to induction for optimization. Proper preoxygenation, rapid evaluation of the airway, ready availability of sophisticated airway equipment, and prompt difficult airway management are all part of safe anesthesia for obstetric cases[16].

The high rate of intensive care admission also indicates that emergency cesarean delivery under general anesthesia may be associated with high maternal morbidity in some patients. Severe hemorrhage, hemodynamic instability, respiratory compromise, hypertensive emergencies and other systemic complications may warrant intensive care. High-risk patients may be identified prior to or during surgery, which can facilitate earlier than usual provision of critical care support and minimize delays in critical-care escalation[17,18].

Also significant neonatal morbidity was observed. Nearly 25% of neonates needed active resuscitation and over 20% needed to be admitted to a neonatal intensive care unit. All of these outcomes may be caused by a combination of various factors such as fetal compromise prior to surgery, pre term delivery, maternal hemodynamic instability and maternal exposure to general anesthetic agents prior to delivery. It should be noted that general anesthesia is chosen in most critical clinical situations and, when used in neonates, they are often in poor condition prior to anesthesia[19,20].

Prematurity had an independent relationship to adverse neonatal outcomes and was the strongest relationship among the neonatal predictors. Pulmonary, cardiovascular and neurological systems are immature in preterm neonates and they are more prone for respiratory distress, poor adaptation after birth, low Apgar score and intensive care admission. If emergency cesarean delivery is necessary before term, an additional risk to neonates is high due to the acute obstetric compromise and the high rate of prematurity[1-5].

Another important risk factor for neonatal morbidity was maternal intraoperative hypotension. If mother's blood pressure is low, then the uteroplacental perfusion is compromised. Large drops in maternal blood pressure can compromise foetal oxygen delivery and exacerbate foetal compromise, especially if the placenta is already compromised. It is therefore important for the mother and baby to recognise and treat hypotension with the right fluid management, vasopressor therapy, blood loss correction and maternal oxygenation[6,9].

A longer induction-to-delivery interval was independently related to foetal complications. General anesthetic agents are able to cross the placenta and chronic exposure may lead to respiratory or neurological depression in neonates. Also, delay in delivery of a fetus already suffering hypoxia could compound the hypoxia. It is therefore important that there is close communication between the anaesthetic and obstetric teams such that induction takes place when the surgical team is ready and the delivery of the fetus can be completed without unnecessary delay[10-12].

Fetal distress was associated with an increased risk of adverse neonatal outcome, but was not statistically significant after controlling for other variables. This could suggest that the relationship between fetal distress and neonatal morbidity was at least partially explained by some other obstetric factors like being born prematurely, maternal hypotension, induction-to-delivery interval or other obstetric conditions. This finding also underscores the complex nature of the outcomes of neonates born by emergency cesarean section[13-15].

The results highlight that bad consequences after emergency cesarean section (CS) under general anesthesia are not necessarily related to anesthesia. Overall risk is dependent on maternal health status, obstetric pathology, laboratory abnormalities, intraoperative events, surgical complexity, fetal condition, and gestational age. Thus a multi-disciplinary approach is necessary for effective management and should include obstetricians, anaesthetists, neonatologists, nursing, blood-bank and critical-care teams[16-18].

Some of the predictors identified are possible to modify from a clinical point of view. Maternal anemia can be identified and corrected during prenatal care; blood products can be prepared in case of excessive bleeding; hypotension can be corrected

promptly during the operation, and unnecessary delay between induction and delivery can be minimised. It is also possible to identify women with higher ASA physical status at an early stage, enabling more suitable planning of monitoring and post-operative care[19,20].

A wide spectrum of maternal, obstetric, laboratory, anesthetic, operative, and neonatal factors were evaluated in the same cohort, enabling the identification of predictors from multiple perioperative factors. Assessment of maternal and neonatal outcomes also gave a fuller picture of the outcomes of emergency cesarean delivery under general anesthesia[5-11].

But there are some drawbacks to be taken into account. The retrospective design relied on the correctness and completeness of documented medical records, with some variables that could have been relevant not being documented at all times. The sample size was relatively small, which could have reduced the statistical power for rare complications. The study was performed only on women being given general anesthetic and thus did not directly compare general anesthetic with spinal or epidural anesthetic. Furthermore, the nature of the obstetric emergency may have had an impact on the choice of general anesthesia and outcomes. Larger prospective multicenter studies would be useful to validate and improve the risk prediction models[12-16].

CONCLUSION

There was significant maternal and infant morbidity associated with emergency cesarean section under general anesthesia. Significant risk factors for mothers postoperative complications were preoperative anemia, ASA physical status III–IV, estimated blood loss equal or greater than 1000 mL, and longer operative time. In isolation, birth at preterm gestational age, maternal intra-operative hypotension and an induction-to-delivery interval >10 minutes were found to be independent predictors of adverse neonatal outcome. Efficient coordination among anaesthetist, obstetric and neonatal teams, early identification of high risk patients, correction of modifiable factors, efficient handling of haemorrhage and maintenance of maternal haemodynamic stability may help to improve maternal and neonatal outcomes.

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Authors' Contributions:

MAA: Conceptualization, study design, manuscript drafting.
MS: Data collection, methodology, clinical interpretation.
H: Anesthesia-related assessment, data interpretation.
SB: Supervision, manuscript review, correspondence.
MI: Clinical interpretation, manuscript review.
HNK: Data interpretation, critical revision.
All authors reviewed and approved the final manuscript.

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