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Original Research Article

Assessment of perioperative hemodynamic changes following spinal anesthesia in patients undergoing surgery for ruptured ectopic pregnancy

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ABSTRACT

Background: Ruptured ectopic pregnancy requires urgent surgical intervention, and sympathetic blockade following spinal anaesthesia may exacerbate haemodynamic instability in patients with significant blood loss. Objective was to assess perioperative hemodynamic changes and factors associated with hypotension following spinal anesthesia in patients undergoing surgery for ruptured ectopic pregnancy.

Methods: This prospective observational study enrolled 46 women undergoing emergency surgery under spinal anaesthesia at Addin Momin Medical College and Hospital over 12 months (January 2015-February 2026). Heart rate (HR), systolic and diastolic blood pressure (SBP, DBP), mean arterial pressure (MAP), and oxygen saturation (SpO₂) were monitored perioperatively. Repeated-measures ANOVA and binary logistic regression were used for statistical analysis.

Results: The mean age was 27.4±5.2 years. HR, SBP, DBP, and MAP declined significantly following spinal anaesthesia (all p<0.001), with SBP decreasing from 108.4 to 92.1 mmHg and MAP from 80.9 to 68.1 mmHg at 10 minutes. SpO₂ remained stable (p=0.324). Hypotension occurred in 37.0% of patients and bradycardia in 10.9%; 37.0% received ephedrine and 60.9% required blood transfusion. Estimated blood loss >1000 ml (OR=3.56, p=0.008), preoperative hemoglobin <9 gm/dl (OR=2.84, p=0.021), and ASA III status (OR=2.31, p=0.047) were significant predictors of hypotension.

Conclusions: Spinal anesthesia was associated with significant perioperative hemodynamic changes, particularly hypotension. Adequate resuscitation, careful monitoring, and prompt management are essential to optimise patient outcomes.

Keywords: Hemodynamic changes, Perioperative hypotension, Ruptured ectopic pregnancy, Spinal anesthesia

INTRODUCTION

Ruptured ectopic pregnancy (REP) is one of the most life-threatening obstetric emergencies and remains a leading cause of maternal morbidity and mortality during the first trimester of pregnancy.¹ Ectopic pregnancy occurs when a

fertilized ovum implants outside the uterine cavity, with approximately 95% occurring in the fallopian tube.² Delayed diagnosis may result in tubal rupture, massive intra-abdominal hemorrhage, hypovolemic shock, and the need for emergency surgical intervention.³ Prompt

resuscitation and timely surgery are therefore essential to improve maternal outcomes.

Spinal anesthesia is widely used for surgical management of ruptured ectopic pregnancy because it provides rapid onset, effective analgesia, reduced airway manipulation, and early postoperative recovery compared with general anesthesia.⁴ However, sympathetic blockade following spinal anesthesia frequently causes vasodilation, decreased systemic vascular resistance, hypotension, and bradycardia, effects that may be exacerbated in patients with pre-existing blood loss and hypovolaemia.⁵ These perioperative haemodynamic alterations may compromise tissue perfusion and increase the risk of adverse maternal outcomes if not recognised and managed promptly.

Careful assessment of perioperative haemodynamic parameters- including heart rate, systolic and diastolic blood pressure, mean arterial pressure, oxygen saturation, and vasopressor requirements- is therefore crucial during spinal anesthesia for ruptured ectopic pregnancy.⁶ Despite advances in anaesthetic monitoring and perioperative care, evidence specifically describing haemodynamic changes following spinal anesthesia in women undergoing surgery for ruptured ectopic pregnancy remains limited, particularly in low- and middle-income countries where delayed presentation is common.^{7,8} Evaluating these haemodynamic responses may help optimise anaesthetic management, guide fluid and vasopressor therapy, and improve perioperative safety.

Therefore, this study aimed to assess perioperative haemodynamic changes following spinal anesthesia in patients undergoing surgery for ruptured ectopic pregnancy.

METHODS

This hospital-based observational prospective study was conducted in the Department of Anaesthesiology of Addin Momin Medical College and Hospital in Bangladesh over a period of 12 months from January 2015 to February 2026. A total of 46 consecutive patients diagnosed with ruptured ectopic pregnancy and scheduled for emergency surgical management under spinal anesthesia were enrolled using purposive sampling. Patients aged 18-45 years with American Society of Anesthesiologists (ASA) physical status II-III who provided informed written consent from themselves or their legal attendants were included. Patients with contraindications to spinal anesthesia, coagulation disorders, pre-existing cardiovascular disease, severe pre-eclampsia, or incomplete perioperative data were excluded.

Following standard preoperative assessment and resuscitation, spinal anesthesia was administered under aseptic precautions using hyperbaric 0.5% bupivacaine via the subarachnoid route at the L3-L4 or L4-L5 intervertebral space. Standard intraoperative monitoring included heart rate (HR), systolic blood pressure (SBP),

diastolic blood pressure (DBP), mean arterial pressure (MAP), oxygen saturation (SpO₂), respiratory rate, and electrocardiography. Hemodynamic parameters were recorded at baseline (before spinal anesthesia), immediately after administration, every 5 minutes during surgery, and at the end of the procedure. Episodes of hypotension, bradycardia, vasopressor use, intravenous fluid administration, blood transfusion, and perioperative complications were documented using a structured data collection sheet. Ethical approval was obtained from the institutional review board of the hospital before commencement of the study, and confidentiality of patient information was strictly maintained.

Statistical analysis

Collected data were checked for completeness, coded, and entered into SPSS version 26.0 for analysis. Continuous variables were expressed as mean±standard deviation (SD) or median (interquartile range) where appropriate, while categorical variables were presented as frequencies and percentages. Changes in haemodynamic parameters over time were analysed using repeated-measures analysis of variance (ANOVA). Binary logistic regression analysis was performed to identify independent predictors of perioperative hypotension. A p value of less than 0.05 was considered statistically significant.

Operational definitions

Ruptured ectopic pregnancy (REP)

A confirmed ectopic pregnancy associated with tubal rupture and intra-abdominal bleeding requiring emergency surgical intervention.

Perioperative period

The period extending from preoperative assessment through intraoperative management until the patient is transferred to the postoperative recovery unit.

Spinal anesthesia

A regional anesthetic technique involving injection of hyperbaric 0.5% bupivacaine into the subarachnoid space to produce sensory and motor blockade for surgery.

Hypotension

A decrease in systolic blood pressure of $\geq 20\%$ from the baseline value or an absolute systolic blood pressure < 90 mmHg following spinal anesthesia.

Bradycardia

A heart rate of less than 60 beats per minute during the perioperative period.

Mean arterial pressure (MAP)

The average arterial pressure during one cardiac cycle, calculated as: $MAP = \text{diastolic blood pressure} + \frac{1}{3}(\text{systolic blood pressure} - \text{diastolic blood pressure})$.

Perioperative hemodynamic changes

Variations in heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, oxygen saturation, and respiratory rate measured before, during, and immediately after surgery.

Vasopressor requirement

Administration of a vasopressor agent (e.g., ephedrine or phenylephrine) to treat spinal anesthesia-induced hypotension during the perioperative period.

RESULTS

Among the 46 study participants, the largest proportion belonged to the 18-25 years age group (39.1%, n=18), followed by 26-30 years (32.6%, n=15). Participants aged 31-35 years constituted 19.6% (n=9), while those older than 35 years accounted for 8.7% (n=4). Overall, 71.7% of the patients were between 18 and 30 years of age.

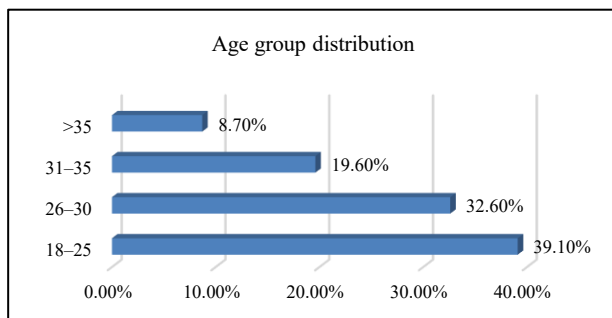


Figure 1: Age group distribution of the study population (n=46).

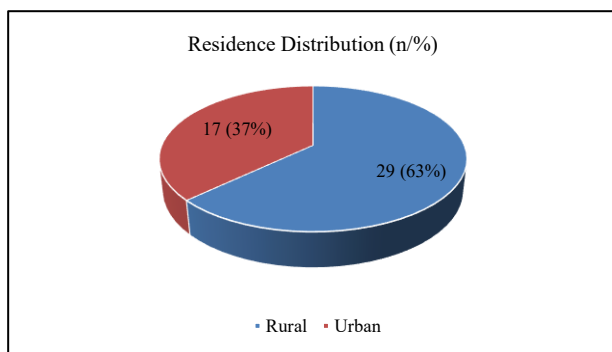


Figure 2: Residence distribution of the study population (n=46).

In terms of residence, 29 (63.0%) participants were from rural areas, whereas 17 (37.0%) resided in urban areas.

Thus, nearly two-thirds of the study cohort presented from rural settings.

Table 1 presents the body mass index (BMI) distribution of the study participants. The majority of patients (65.2%, n=30) had a normal BMI (18.5-24.9 kg/m²). Underweight (<18.5 kg/m²) and overweight (25.0-29.9 kg/m²) participants each accounted for 17.4% (n=8) of the study population.

Table 1: BMI distribution of the study participants (n=46).

BMI Category (kg/m ²)	Frequency	Percentage
Underweight (<18.5)	8	17.4
Normal (18.5-24.9)	30	65.2
Overweight (25.0-29.9)	8	17.4

Table 2: Clinical and perioperative characteristics of the patients (n=46).

Variable / Parameter	Value [mean±SD or N (%)]
Gestational age (weeks)	7.9±1.4
Preoperative hemoglobin (gm/dl)	8.9±1.2
ASA physical status II	31 (67.4)
ASA physical status III	15 (32.6)
Estimated intraoperative blood loss (ml)	864±296
Duration of surgery (minutes)	63.5±14.8
Intravenous crystalloids administered (ml)	1885±425
Blood transfusion required	28 (60.9)
Peak sensory block level: T4-T6/T7-T8	33 (71.7)/13 (28.3)

Table 2 summarizes the baseline clinical and perioperative characteristics of the patients. The mean gestational age was 7.9±1.4 weeks, and the mean preoperative hemoglobin level was 8.9±1.2 gm/dl. Most patients were classified as ASA II (67.4%, n=31), while 32.6% (n=15) were ASA III. The mean estimated blood loss was 864±296 ml, and the mean duration of surgery was 63.5±14.8 minutes. Blood transfusion was required in 60.9% (n=28) of patients. Peak sensory block between T4 and T6 was achieved in 71.7% (n=33) of cases, while 28.3% (n=13) reached T7-T8.

Serial measurements of hemodynamic parameters from baseline through 20 minutes and at the end of surgery are presented in Table 3. Baseline mean heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and oxygen saturation were 108.2±13.4 beats/min, 108.4±11.2 mmHg, 67.2±8.6 mmHg, 80.9±8.4 mmHg, and 98.4±0.9%, respectively. The lowest mean SBP (92.1±10.8 mmHg) and MAP (68.1±7.7 mmHg) occurred at 10 minutes following spinal anesthesia. Oxygen saturation remained stable above 98% throughout the operative procedure.

Table 3: Comparison of hemodynamic parameters at different time intervals (n=46).

Time point	Heart rate (beats/minute)	SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	SpO ₂ (%)
Baseline	108.2±13.4	108.4±11.2	67.2±8.6	80.9±8.4	98.4±0.9
5 minutes	102.5±12.9	95.6±12.1	58.3±8.1	70.7±8.3	98.2±1.0
10 minutes	99.8±12.5	92.1±10.8	56.1±7.6	68.1±7.7	98.3±0.9
15 minutes	97.5±11.7	94.4±10.3	57.8±7.2	70.0±7.4	98.4±0.8
20 minutes	96.8±11.2	97.8±9.8	60.2±6.9	72.7±6.9	98.5±0.7
End of surgery	93.4±10.6	103.6±9.1	64.1±6.8	77.3±6.5	98.7±0.6

Data are expressed as Mean±standard deviation. SBP: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; SpO₂: peripheral oxygen saturation.

Table 4: Changes in haemodynamic parameters following spinal anaesthesia (repeated measures ANOVA).

Variables / Parameters	Baseline (Mean±SD)	Lowest (Mean±SD)	F-value	P value
Heart rate (beats/min)	108.2±13.4	93.4±10.6	15.74	<0.001*
Systolic blood pressure (mmHg)	108.4±11.2	92.1±10.8	42.51	<0.001*
Diastolic blood pressure (mmHg)	67.2±8.6	56.1±7.6	39.83	<0.001*
Mean arterial pressure (mmHg)	80.9±8.4	68.1±7.7	45.27	<0.001*
Oxygen saturation, SpO₂ (%)	98.4±0.9	98.2±1.0	1.12	0.324 (NS)

*Statistically significant (p<0.05); NS: not significant; SD: standard deviation.

Repeated-measures ANOVA demonstrated statistically significant changes over time in heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure (p<0.001 for each parameter, Table 4). The greatest reductions were observed in systolic blood pressure and mean arterial pressure. Peripheral oxygen saturation showed minimal variation and was not statistically significant (p=0.324).

Table 5: Incidence of perioperative complications (n=46).

Complication	Frequency	Percentage
Hypotension	17	37.0
Shivering	10	21.7
Nausea	7	15.2
Bradycardia	5	10.9
Vomiting	3	6.5
High spinal block	1	2.2
No complications	18	39.1

As shown in Table 5, hypotension was the most frequently recorded perioperative complication, occurring in 37.0%

(n=17) of patients. Shivering was observed in 21.7% (n=10), nausea in 15.2% (n=7), bradycardia in 10.9% (n=5), vomiting in 6.5% (n=3), and high spinal block in 2.2% (n=1). Overall, 39.1% (n=18) of participants had an uneventful perioperative course with no complications.

Table 6 details the perioperative therapeutic interventions administered to manage haemodynamic instability and surgical conditions. Additional intravenous crystalloid boluses were administered in 65.2% (n=30) of patients, and blood transfusion was provided in 60.9% (n=28). Ephedrine was given to 37.0% (n=17) of cases, atropine to 10.9% (n=5), and supplemental oxygen therapy to 30.4% (n=14).

The relationship between estimated intraoperative blood loss and the incidence of perioperative hypotension is shown in Table 7. The frequency of hypotension progressively rose across blood loss categories: 10.0% (1/10) among patients with <500 ml loss, 37.5% (9/24) with 500-1000 ml loss, and 58.3% (7/12) among those with >1000 ml loss. This association was statistically significant ($\chi^2=7.89$, p=0.019).

Table 6: Perioperative therapeutic interventions required (n=46).

Intervention	Frequency	Percentage
Additional i.v. crystalloid administration	30	65.2
Blood transfusion	28	60.9
Ephedrine administration (vasopressor)	17	37.0
Oxygen supplementation	14	30.4
Atropine administration	5	10.9

Table 7: Association between estimated blood loss and perioperative hypotension.

Estimated blood loss (ml)	Hypotension Present (%)	Hypotension Absent (%)	Chi-square (χ^2)	P value
<500 (n=10)	1 (10.0)	9 (90.0)	7.89	0.019*
500-1000 (n=24)	9 (37.5)	15 (62.5)		
>1000 (n=12)	7 (58.3)	5 (41.7)		

*Statistically significant ($p < 0.05$) by Chi-square test.

Table 8: Binary logistic regression analysis for predictors of perioperative hypotension.

Variables/risk factors	Odds ratio (OR)	95% confidence interval (CI)	P value
Estimated blood loss (>1000 ml)	3.56	1.39-9.14	0.008*
Preoperative hemoglobin (<9.0 gm/dl)	2.84	1.18-6.92	0.021*
ASA physical status III	2.31	1.01-5.47	0.047*
Duration of surgery (>60 minute)	1.96	0.88-4.89	0.112 (NS)
BMI (<18.5 kg/m ²)	1.81	0.81-4.54	0.148 (NS)
Age (>30 years)	1.42	0.69-3.76	0.283 (NS)

*Statistically significant ($p < 0.05$); NS: not significant; CI: confidence interval.

Multivariable binary logistic regression analysis (Table 8) identified three significant independent predictors of perioperative hypotension: estimated blood loss >1000 ml (OR=3.56, 95% CI: 1.39-9.14, $p=0.008$), preoperative hemoglobin <9 gm/dl (OR=2.84, 95% CI: 1.18-6.92, $p=0.021$), and ASA physical status III (OR=2.31, 95% CI: 1.01-5.47, $p=0.047$). Maternal age >30 years, underweight BMI, and operative duration >60 minutes were not statistically significant predictors.

DISCUSSION

The present study evaluated perioperative hemodynamic changes following spinal anesthesia in 46 patients undergoing emergency surgery for ruptured ectopic pregnancy at a tertiary-level hospital in Bangladesh. The findings demonstrated that spinal anesthesia was associated with significant reductions in heart rate, systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) during the intraoperative period, while oxygen saturation remained stable throughout surgery. These observations are consistent with the well-established physiological effects of sympathetic blockade following spinal anesthesia.^{7,8}

Most participants were between 18 and 30 years of age (71.7%), with a mean gestational age of 7.9 ± 1.4 weeks. Similar demographic characteristics have been reported in studies from low- and middle-income countries, where ruptured ectopic pregnancy predominantly affects women of reproductive age.^{1,2} Preoperative anaemia was also common in our study, with a mean hemoglobin concentration of 8.9 ± 1.2 gm/dl, reflecting the substantial blood loss that accompanies tubal rupture. Previous reports have identified anaemia and hypovolaemia as important contributors to perioperative instability in these patients.^{3,9}

A significant decline in blood pressure was observed after administration of spinal anesthesia. Mean SBP decreased from 108.4 ± 11.2 mmHg at baseline to 92.1 ± 10.8 mmHg

at 10 minutes, while MAP declined from 80.9 ± 8.4 mmHg to 68.1 ± 7.7 mmHg ($p < 0.001$). These findings are consistent with previous studies showing that spinal anesthesia produces sympathetic blockade, leading to peripheral vasodilatation, reduced venous return, and transient hypotension.^{7,8} The gradual recovery of blood pressure toward the end of surgery reflects adequate fluid resuscitation, blood transfusion, and timely vasopressor administration.

The incidence of perioperative hypotension in the present study was 37.0%, whereas bradycardia occurred in 10.9% of patients. These rates are comparable to reports in obstetric anesthesia, where hypotension remains the most frequent complication following spinal anesthesia despite modern preventive strategies.¹⁰⁻¹² Ephedrine was administered in 37.0% of patients, corresponding exactly with the occurrence of hypotension, confirming prompt intraoperative management. Contemporary evidence supports the use of vasopressors for maintaining maternal blood pressure after neuraxial anesthesia, and ephedrine remains widely accessible and effective in hypovolaemic patients undergoing emergency surgery.^{10,11}

Blood transfusion was required in 60.9% of participants, and the mean estimated blood loss was 864 ± 296 ml. Logistic regression analysis demonstrated that estimated blood loss greater than 1000 ml (OR=3.56, $p=0.008$), preoperative hemoglobin below 9 gm/dl (OR=2.84, $p=0.021$), and ASA III physical status (OR=2.31, $p=0.047$) were independent predictors of perioperative hypotension. These findings are clinically plausible because hypovolemia limits compensatory cardiovascular responses following sympathetic blockade and increases susceptibility to profound hypotension.^{9,13}

Importantly, oxygen saturation remained above 98% throughout the perioperative period, and only one patient (2.2%) developed a high spinal block, indicating that spinal anesthesia was generally safe when performed after

adequate preoperative resuscitation and close hemodynamic monitoring. This observation supports recommendations that carefully selected, hemodynamically stabilized patients with ruptured ectopic pregnancy may undergo spinal anesthesia successfully in appropriately equipped centres, whereas severely unstable patients in refractory shock warrant general anesthesia.^{6,9,14-16}

This study was limited by its single-centre observational design and relatively modest sample size (n=46). In addition, invasive arterial pressure monitoring and advanced stroke volume variation tracking were not routinely available. Nonetheless, the findings provide vital real-world evidence from a low- and middle-income country context regarding the hemodynamic safety profile of spinal anesthesia in ruptured ectopic pregnancy.

CONCLUSION

Spinal anesthesia in patients undergoing surgery for ruptured ectopic pregnancy was associated with significant perioperative haemodynamic changes, particularly transient decreases in heart rate, systolic blood pressure, diastolic blood pressure, and mean arterial pressure. Perioperative hypotension was the most frequent haemodynamic complication and was significantly associated with greater blood loss (>1000 ml), lower preoperative hemoglobin levels (<9 gm/dl), and higher ASA physical status (ASA III). Despite these changes, oxygen saturation remained stable throughout the perioperative period. Careful preoperative resuscitation, continuous hemodynamic monitoring, aggressive fluid therapy, and prompt vasopressor administration are essential to optimize perioperative outcomes in these patients. Further multicentre studies with larger sample sizes are recommended to validate these findings.

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