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Comparative Study of General Anaesthesia and Spinal Anaesthesia in Pre-Eclampsia Patients Undergoing Emergency Caesarean Section

Deepak Kumar Sinha[1], Sumit Kumar Verma[2], Hirday Kumar[3]

Gopal Narayan Singh University

Abstract: ***Background: Preeclampsia is a multisystem disorder characterized by hypertension and proteinuria after 20 weeks of gestation. It remains a major contributor to maternal and neonatal morbidity and mortality worldwide. Anaesthetic management during emergency caesarean section in pre-eclamptic patients is challenging, with general anaesthesia (GA) and spinal anaesthesia (SA) being the two primary options. While GA is associated with increased risks of hypertensive responses and airway complications, SA is linked to hemodynamic instability and hypotension. This study aims to compare maternal and neonatal outcomes between GA and SA in pre-eclamptic patients undergoing emergency caesarean section. Objectives: The primary objective of this study was to evaluate and compare the maternal and neonatal outcomes in pre-eclampsia patients undergoing emergency caesarean section under spinal anaesthesia versus general anaesthesia. Secondary objectives included assessing maternal hemodynamic stability, anaesthesia-related complications, neonatal Apgar scores, NICU admissions, maternal satisfaction, postoperative pain management effectiveness, and hospital stay duration. Methods: A prospective comparative study was conducted at NMCH, Sasaram, over 24 months, including 100 pre-eclamptic pregnant women scheduled for emergency caesarean section. Patients were randomly assigned to two groups. Group S: Received spinal anaesthesia with 10 mg of 0.5% hyperbaric bupivacaine. Group G: Received general anaesthesia with thiopentone, succinylcholine, and maintenance with nitrous oxide and sevoflurane. Hemodynamic parameters, postoperative complications, neonatal Apgar scores, and duration of hospital stay were recorded and analyzed. Statistical comparisons were made using t-tests and chi-square tests. Results: General anaesthesia was associated with significantly higher cardiovascular stress post-induction, with elevated heart rate (103.22 vs. 92.85 bpm, $p < 0.0001$), systolic blood pressure (145.54 vs. 133.68 mmHg, $p < 0.0001$), and mean arterial pressure (103 vs. 96.62 mmHg, $p = 0.0059$). Spinal anaesthesia required more vasopressor use (62% vs. 30%, $p = 0.0024$) due to hypotension. GA patients had a higher incidence of acute kidney injury (10% vs. 0%, $p = 0.0563$), congestive heart failure (8% vs. 0%, $p = 0.1175$), and pulmonary edema (16% vs. 8%). Neonatal Apgar scores were higher in GA patients at 1, 5, and 10 minutes ($p < 0.05$), though NICU admissions were similar (6% vs. 10%, $p = 0.7150$). Hospital stay was significantly shorter in the SA group (4.68 vs. 5.94 days, $p < 0.0001$). Conclusion: Spinal anaesthesia, despite its association with procedural complications, exhibited superior maternal hemodynamic stability and faster recovery, with fewer systemic complications compared to general anaesthesia. General anaesthesia was linked to increased cardiovascular stress but demonstrated better neonatal adaptation immediately post-delivery. Individualized anaesthesia selection, based on patient haemodynamic, severity of pre-eclampsia, and surgical urgency, remains crucial for optimizing maternal and neonatal outcomes.***

Keywords: Preeclampsia, spinal anaesthesia, general anaesthesia, caesarean section, maternal outcomes, neonatal outcomes, hemodynamic stability, anaesthesia complications, Apgar score, NICU admission, postoperative recovery.

1. Introduction

Preeclampsia constitutes a multisystem condition defined by the new development of hypertension, with systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg, as well as proteinuria >300 mg/24 h, occurring beyond 20 weeks of pregnancy in woman a previously normal in blood pressure [1, 2]. Serious preeclampsia is defined by hypertension involving SBP above 160 mm Hg as well as DBP over 110 mm Hg, accompanied by proteinuria greater than 5 grams per 24 hours beyond 20 weeks of gestation [1].

Preeclampsia impacts approximately 7.6% of pregnancies worldwide, with an incidence of as high as 21% in twin pregnancies [2]. The risk variables for preeclampsia include nulliparity (approximately 7.6%), ethnic disparities—with a threefold prevalence in black individuals in comparison to Caucasians, twin gestations, chronic hypertension, multifetal gestation, advanced maternal age (>35 years), as well as obesity. The relationship between maternal weight as well as the possibility of pre-eclampsia is incremental, with morbidity rates of around 4.3% for a BMI below 19.8 and 13.3% for a BMI over 35 kg/m² [1].

The underlying cause of preeclampsia is linked to the fetoplacental unit, where poor placentation as well as placental function constitute important predisposing variables to the condition. The consequences of preeclampsia include uteroplacental hypoxia, a disparity of angiogenic and antiangiogenic proteins, oxidative stress, maternal endothelial dysfunction, and increased systemic inflammation. Acute vasoconstriction induces endothelial cell damage, elevates thromboxane A2 levels, as well as initiates the coagulation cascade [4-7].

The anaesthetic care of patients with pre-eclampsia continues to provide significant challenges. The two anaesthetic choices are General Anaesthesia (GA) and Spinal Anaesthesia (SA). While general anaesthesia may be employed in women experiencing pre-eclampsia, it is linked to increased maternal mortality and morbidity. The additional dangers linked to general anaesthesia are airway complications resulting from oedema exacerbated by tracheal intubation as well as the hypertensive reaction to intubation as well as laryngoscopy [8].

Preeclampsia impacts 5–8% of pregnancies globally. It impacts 5%–7% of pregnancies and constitutes a major contributor to mortality as well as morbidity among mothers

and babies [12]. It was associated with 54 of 569 maternal fatalities in the United States in 2006 [9]. In developing countries, pre-eclampsia accounted for complications in roughly one percent of all births and 5 percent of all pregnancies. Additionally, 16% of direct maternal death and 10% of total maternal mortality reported attributable to preeclampsia/eclampsia. Severe pre-eclampsia has been linked to problems such as pulmonary oedema, acute renal failure, seizures, disseminated intravascular coagulation (DIC), headache, postpartum haemorrhage, HELLP syndrome, visual disturbances, lower respiratory tract infections, and congestive heart failure [10, 11].

Severe preeclampsia presents a challenge for anaesthetists, with ongoing debate regarding the optimal anaesthetic technique during caesarean delivery due to risks associated with airway oedema, airway complications or failed intubation, hypertensive responses to direct laryngoscopy, and aspiration pneumonitis. Drug interactions can pose significant issues, especially among magnesium sulphate, neuromuscular blocking drugs, calcium channel blockers, and inhalational anaesthetics. Conversely, regional anaesthesia may be linked to significant hypotension, extensive motor neuronal blocking, and the potential for convulsions during the surgery [12-16].

GA and SA are recognized as suitable and safe techniques for performing caesarean deliveries in cases of pre-eclampsia, provided that meticulous precautions are implemented for either method [17]. While general anaesthesia may be utilized in women having pre-eclampsia, it is linked to increased maternal morbidity and death. The additional dangers linked to general anaesthesia encompass airway complications resulting from enema, frequently exacerbated by tracheal intubation, as well as hemodynamic reactions to laryngoscopy and intubation [18].

There is considerable controversy around the application of spinal anaesthetic in pre-eclamptic moms undergoing caesarean section. Numerous studies advised against the application of SA in pre-eclamptic women due to the risk of abrupt and severe hypotension [19, 20].

The aim of this study was to compare the outcomes of general anaesthesia (GA) and spinal anaesthesia (SA) in pre-eclampsia patients undergoing emergency caesarean section, to determine which anaesthesia method was safer and more effective. The research question addressed whether spinal anaesthesia resulted in better maternal and neonatal outcomes compared to general anaesthesia in this high-risk group. The hypothesis was that spinal anaesthesia would be associated with fewer complications, lower maternal morbidity, and better neonatal outcomes compared to general anaesthesia. The objectives were to analyse the incidence of anaesthesia-related complications, evaluate maternal hemodynamic stability, compare neonatal Apgar scores and other health indicators, and assess the overall safety and efficacy of each anaesthesia method in pre-eclampsia patients undergoing emergency caesarean sections.

2. Materials and Methods

Study Design: Prospective Comparative Study

Study Site: Department of Anaesthesiology, Narayan Medical College and Hospital, Sasaram.

Study Duration: 24 Months

Source of Data: All pregnant female with pre - eclampsia posted for emergency caesarean section during period of 24 months.

Ethical Consideration:
The study protocol was approved by the institutional ethics committee of NMCH, Sasaram and complied with International Conference on Harmonization Guideline for Good Clinical Practice and the Declaration of Helsinki. Informed consent was taken from patients in OPD of General Medicine. Participant Information Sheet (PIS) was provided and explained to patients in their local language. Thereafter, consent was approved by taking their signature or thumb impression on the informed consent form. The data were obtained from the hospital record system after appropriate approval from the concerned authorities.

Inclusion criteria:
- All pregnant female with pre –eclampsia (BP>140/90 mmHg)
- Gestational age >34 weeks
- ASA grades 2 and 3
- Age 20 – 40 years
- Weight >40kg and <80kg
- Platelet count > 75000 /mm^3

Exclusion criteria:
- Patient refusal
- Patient with coagulopathy
- Patient with history of drug allergy
- Patient with severe anaemia of < 6 gm%
- Patient with diabetes, thyroid disorder, seizure disorder, renal impairment and co-morbidities (cardiac disease, pulmonary disease, neurological deficits.

Sample Size:
100 Patients (50 patients in each group)

$n = z^2 \times p\,(1-p) / e^2$

$n = [1.96^2 \times 0.15 \times (1-0.15)]/0.1^2$

$= 48.98$

Here,
n stands for sample size
z stands for z score (1.96 for 95% confidence)
p stands for population proportion
e stands for margin of error

Intervention:

Group	Intervention
Group S	Spinal anaesthesia (n=50) was administered in sitting position using 25 Quincke needle. A hyperbaric solution of 0.5% Bupivacaine heavy (10 mg) was injected intrathecally (L2-3 or L3-4).
Group G	A standardized induction of general anaesthesia was performed (5 mg/kg inj. Thiopentone and 2 mg/kg succinylcholine for rapid sequence intubation). Maintenance of anaesthesia was done with 50% nitrous oxide in oxygen and 1-2% end-tidal sevoflurane.

3. Methodology

Patients were randomly divided into two groups, Group S for spinal anaesthesia and Group G for general anaesthesia, with 50 patients in each group. Before starting the study, Institutional Ethical Committee approval was obtained, and written informed consent was taken from all the patients. Patients' refusal, patients with coagulopathy, peripheral neuropathy, history of drug allergy, severe anaemia of < 6gm%, patients with diabetes, thyroid disorder, seizure disorders, renal impairments, and co-morbidities (cardiac disease, pulmonary disease, neurological deficits) were excluded from the study.

Data were collected using a pre-designed questionnaire, which consisted of standard questions related to clinical conditions, socio-demographic factors, and addiction among family members. In addition, questions related to past and present medical history and health-seeking behavior were studied. Clinical examination, diagnosis, and investigation details of previous operative procedures were done.

All patients received an IV infusion of 500 ml of lactated Ringer's solution prior to the procedure. The volume of fluids administered to patients with severe preeclampsia was not decreased because of expected intravascular volume contraction. During caesarean sections, all patients were in the supine and 15°–20° left uterine displacement position.

In Group S, spinal anaesthesia (n=50) was administered in a sitting position using a 25 Quincke needle. A hyperbaric solution of 0.5% Bupivacaine heavy (10 mg) was injected intrathecally (L2-3 or L3-4). The upper sensory level was checked using loss of cold sensation, and the motor level of spinal anaesthesia was assessed with the Bromage scale.

In Group G, for general anaesthesia (n=50), a standardized induction of general anaesthesia was performed (5 mg/kg inj. Thiopentone and 2 mg/kg succinylcholine for rapid sequence intubation). Maintenance of anaesthesia was with 50% nitrous oxide in oxygen and 1-2% end-tidal sevoflurane. Patients were ventilated to a target end-tidal carbon dioxide concentration of 30–40 mmHg, using a circle system with fresh gas flows of 5 L/min until delivery. Neuromuscular blockade was maintained with vecuronium 0.08 mg/kg. Oxytocin 5 IU intravenously was administered after the delivery of the baby. Thereafter, a continuous infusion of oxytocin was administered (10 IU/l, at 60–100 ml/h).

Blood pressure for all enrolled patients was recorded 15 times, starting from time zero [3 min before induction (GA) or before puncture (SA)], until 60 minutes after induction/puncture. During the procedure (caesarean section), maternal BP and HR were recorded after the induction/puncture as follows: at 2.5 min intervals from the spinal injection for the first 10 min and then at 5 min intervals until the end of the surgery. Data were collected in terms of demographic profile (age, weight, American Society of Anaesthesiologists (ASA) Grade), airway parameters (Mallampati grade, thyromental distance, cervical and neck stability), post-operative sedation with Ramsey Sedation Score (RSS), visual analogue scale (VAS), oxygen saturation, maternal haemodynamic changes and complications, birth weights of neonates and neonatal complications along with APGAR score at 1 min and 5 min.

During contractions, maternal pain severity was assessed by a visual analogue scale (VAS). VAS is a unidimensional measure of pain intensity. It comprises a horizontal line of 10 cm anchored by 2 verbal descriptors, one for each symptom extreme. Patients were asked to place a finger over the scale according to the intensity of pain felt by them. Using the ruler, the score was determined by the distance on the 10 cm line.

Cutoff points on the VAS scale.

1) No pain (Excellent satisfaction): 0 – 4 mm
2) Mild Pain (Good satisfaction): 5 – 44 mm
3) Moderate pain (average satisfaction): 45 – 74 mm
4) Severe pain (poor satisfaction): 75 – 100 mm

Statistical Analysis:

Data from patients of group S or G were presented in tabular form using Microsoft Excel 365 and transferred to SPSS version 24 for further statistical analysis. Continuous data such as age, weight, HR, BP, and VAS score were expressed as mean ± SD (standard deviation). Statistical significance of difference in continuous data between group S and G was evaluated by unpaired t-test. Categorical data, including gender, frequency of maternal or neonatal outcomes, were reported as percentages and frequencies and then compared by chi-square or Fisher's exact test. A p-value of less than 0.05 was taken as cut-off for statistical significance.

4. Observations and Results

Table 1: Comparison of Age between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

	Group S	Group G
Number of Patients (N)	50	50
Mean Age in Years	27.46	28.19
Standard Deviation (SD)	3.38	5.43
Difference in Mean (A-B)	-0.7300	
95% Confidence Interval (Difference of Mean)	-2.5250 to 1.0650	
P Value (Unpaired t-test)	0.4216	

The mean ages of pregnant females in Group S (Spinal Anaesthesia, 27.46 years) and Group G (General Anaesthesia, 28.19 years) were similar, with no statistically significant difference (p = 0.4216). The 95% confidence interval (-2.5250 to 1.0650) includes zero, further supporting that age did not differ significantly between the two groups.

Table 2: Comparison of Gestational Age between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

	Group S	Group G
Number of Patients (N)	50	50
Mean Gestational Age in Weeks	37.39	37.95
Standard Deviation (SD)	0.95	1.93
Difference in Mean (A-B)	-0.5600	
95% Confidence Interval (Difference of Mean)	-1.1637 to 0.0437	
P Value (Unpaired t-test)	0.0687	

The mean gestational age was slightly lower in Group S (37.39 weeks) compared to Group G (37.95 weeks), but the difference was not statistically significant (p = 0.0687). The confidence interval (-1.1637 to 0.0437) suggests a marginal trend toward significance, though not conclusive.

Table 3: Comparison of Parity between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

Parity	Number of Women (%)		P-Value (Fisher's Exact test)
	Group S (n = 50)	Group G (n = 50)	
Primigravida	24 (48.0)	27 (54.0)	0.6893 (Primi vs Others)
Gravida 2	19 (38.0)	10 (40.0)	
Gravida 3	5 (10.0)	2 (8.0)	
Gravida 4	2 (4.0)	0 (0)	

Parity distribution (Primigravida, Gravida 2, etc.) was similar between groups, with no significant difference (p = 0.6893). Both groups had comparable proportions of first-time and multiparous mothers.

Table 4: Comparison of BMI between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

BMI Category	Number of Patients (%)		P-Value (Chi-Square Test)
	Group S (n = 50)	Group G (n = 50)	
Normal Weight	11 (22.00)	12 (24.0)	**0.8311**
Overweight	26 (52.0)	23 (46.0)	
Obese	13 (26.0)	15 (30.00)	

BMI categories (Normal, Overweight, Obese) were evenly distributed between groups, with no significant difference (p = 0.8311). Both groups had similar baseline metabolic health profiles.

Table 5: Comparison of Indication of Caesarean Section between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

Indication	Number of Patients (%)		P-Value (Chi-Square Test)
	Group S (n = 50)	Group G (n = 50)	
Foetal Distress	17 (34.0)	15 (30.0)	0.8809
Diminished Foetal Movements	8 (16.0)	10 (20.0)	
Contracted Pelvis	4 (8.0)	3 (6.00)	
Previous Caesarean Section	15 (30.0)	18 (36.0)	
Failure of Induction	3 (6.00)	3 (6.00)	
Obstructed Labour	3 (6.00)	1 (2.00)	

The primary indications (e.g., Foetal Distress, Previous Caesarean) were comparable between groups (p = 0.8809), suggesting no bias in surgical reasons between anaesthesia types.

Table 6: Comparison of Antihypertensive Agents between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

Drug	Number of Patients (%)		P-Value (Chi-Square Test)
	Group S (n = 50)	Group G (n = 50)	
Hydralazine	23 (46.0)	26 (52.0)	0.8128
Methyldopa	21 (42.0)	18 (36.0)	
Labetalol	6 (16.0)	6 (12.00)	

The use of hydralazine, methyldopa, and labetalol did not differ significantly (p = 0.8128), indicating similar pre-operative hypertension management in both groups.

Table 7: Comparison of Duration of Surgery between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

	Group S	Group G
Number of Patients (N)	50	50
Mean Gestational Age in Weeks	48.15	49.64
Standard Deviation (SD)	6.12	7.20
Difference in Mean (A-B)	-1.4900	
95% Confidence Interval (Difference of Mean)	-4.1420 to 1.1620	
P Value (Unpaired t-test)	0.2676	

Mean surgery duration was slightly shorter in Group S (48.15 minutes) vs. Group G (49.64 minutes), but the difference was not significant (p = 0.2676).

Table 8: Comparison of Heart Rate between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

Time	HR (bpm) in Mean ± SD		P-Value (Unpaired t test)
	Group S (n = 50)	Group G (n = 50)	
Baseline	94.52 ± 11.03	96.06 ± 12.52	0.5155
After Anaesthesia	92.85 ±12.33	103.22 ± 10.63	**<0.0001***
5 Min	95.68 ± 8.12	98.98 ± 7.58	**0.0382***
10 Min	94.52 ± 13.33	96.74 ± 15.29	0.4409
15 Min	96.02 ± 11.46	96.76 ± 9.95	0.7310
30 Min	88.02 ± 8.89	90.08 ± 8.13	0.2295
45 Min	88.24 ± 7.57	88.10 ± 8.21	0.9295
60 Min	88.58 ± 9.13	86.52 ± 6.96	0.2075

Tables 8–11: Hemodynamic Parameters (HR, SBP, DBP, MAP)
Group G showed higher HR, SBP, and DBP post-anaesthesia (p < 0.05 at multiple timepoints), suggesting greater cardiovascular stress under general anaesthesia. MAP was also higher in Group G early post-anaesthesia (p < 0.0001).

Table 9: Comparison of SBP between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

Time	SBP (mmHg) in Mean ± SD		P-Value (Unpaired t test)
	Group S (n = 50)	Group G (n = 50)	
Baseline	135.04 ± 19.81	138.28 ± 16.67	0.3784
After Anaesthesia	133.68 ± 13.03	145.54 ± 11.92	**<0.0001**
5 Min	130.72 ± 10.67	141.76 ± 9.23	**<0.0001**
10 Min	113.26 ± 11.45	119.20 ± 8.55	**0.0041**
15 Min	116.70 ± 10.49	125.06 ± 9.61	**<0.0001**
30 Min	115.54 ± 10.86	123.08 ± 11.89	**0.0013**
45 Min	122.28 ± 11.62	127.05 ± 9.87	**0.0293**
60 Min	124.75 ± 8.44	120.98 ± 19.64	0.2153

Table 10: Comparison of DBP between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

Time	DBP (mmHg) in Mean ± SD		P-Value (Unpaired t test)
	Group S (n = 50)	Group G (n = 50)	
Baseline	76.54 ± 14.79	81.24 ± 12.42	0.0884
After Anaesthesia	75.05 ± 8.62	85.52 ± 6.38	**<0.0001**
5 Min	67.66 ± 8.46	82.16 ± 9.76	**<0.0001**
10 Min	64.52 ± 7.87	70.05 ± 10.84	**0.0044**
15 Min	63.58 ± 7.31	68.24 ± 8.42	**0.0039**
30 Min	66.78 ± 7.93	69.56 ± 6.71	**0.0614**
45 Min	66.70 ± 7.68	70.78 ± 6.97	**0.0065**
60 Min	62.56 ± 6.64	65.56 ± 7.43	**0.0358**

Table 11: Comparison of MAP between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

Time	MAP (mmHg) in Mean ± SD		P-Value (Unpaired t test)
	Group S (n = 50)	Group G (n = 50)	
Baseline	102.68 ± 15.78	101.96 ± 12.71	0.8021
After Anaesthesia	96.62 ± 12.39	103.00 ± 10.19	**0.0059**
5 Min	90.65 ± 8.37	104.56 ± 12.52	**<0.0001**
10 Min	80.34 ± 7.53	86.15 ± 7.56	**0.0002**
15 Min	82.66 ± 6.72	87.06 ± 5.43	**0.0005**
30 Min	84.82 ± 6.34	87.02 ± 5.98	0.0774
45 Min	86.80 ± 5.96	88.94 ± 5.42	0.0633
60 Min	86.85 ± 6.08	84.65 ± 6.36	0.0802

Table 12: Comparison of Intra-Operative Vasopressor Use between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

Vasopressor Use	Number of Patients (%)		P-Value (Fisher's Exact Test)
	Group S (n = 50)	Group G (n = 50)	
Yes	31 (62.0)	15 (30.0)	0.0024
No	19 (38.0)	35 (70.0)	

Vasopressors were used more frequently in Group S (62% vs. 30%, p = 0.0024), likely due to spinal-induced hypotension.

Table 13: Comparison of Maternal Complications between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

Complications	Number of Patients (%)		P-Value (Chi-Square Test)
	Group S (n = 50)	Group G (n = 50)	
AKI	0 (0.0)	5 (10.0)	0.0563
CHF	0 (0.0)	4 (8.0)	0.1175
Pulmonary Edema	4 (8.0)	8 (16.00)	0.3567
HELLP Syndrome	0 (0.0)	1 (2.0)	>0.9999
Headache	8 (16.0)	0 (0.0)	0.0058
Pain at the Site of Spinal	11 (22.0)	0 (0.0)	0.0005

Group S had more headaches and spinal site pain ($p < 0.01$), while Group G had non-significant trends toward more AKI, CHF, and pulmonary edema.

Table 14: Comparison of Neonatal APGAR Score between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

Time in Minutes	Neonatal APGAR Score in Mean ± SD		P-Value (Unpaired t test)
	Group S (n = 50)	Group G (n = 50)	
1	7.28 ± 1.25	7.82 ± 0.39	**0.004***
5	8.26 ± 1.32	8.78 ± 0.41	**0.009***
10	9.15 ± 1.43	9.68 ± 1.17	0.045

APGAR scores were higher in Group G at 1, 5, and 10 minutes ($p < 0.05$), possibly reflecting better neonatal adaptation post-general anaesthesia.

Table 15: Comparison of NICU Admission between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

NICU Admission	Number of Patients (%)		P-Value (Fisher's Exact Test)
	Group S (n = 50)	Group G (n = 50)	
Yes	3 (6.0)	5 (10.0)	0.7150
No	47 (94.0)	45 (90.0)	

NICU admission rates were similar (6% in Group S vs. 10% in Group G, p = 0.7150), indicating no major difference in neonatal outcomes.

Table 16: Comparison of Length of Hospital Stay between Group S (Spinal Anaesthesia) and Group G (General Anaesthesia)

	Group S	Group G
Number of Patients (N)	50	50
Length of Hospital Stay in Days	4.68	5.94
Standard Deviation (SD)	0.57	0.69
Difference in Mean (A-B)	-1.26	
95% Confidence Interval (Difference of Mean)	-1.5112 to -1.0088	
P Value (Unpaired t-test)	<0.0001	

Group S had a significantly shorter hospital stay (4.68 vs. 5.94 days, $p < 0.0001$), suggesting faster recovery with spinal anaesthesia.

5. Discussion

The study comparing spinal anaesthesia (Group S) and general anaesthesia (Group G) in 50 pregnant females with pre-eclampsia undergoing caesarean section provides valuable insights into the hemodynamic, maternal, and neonatal outcomes associated with these anaesthetic techniques.

The scientific background of this research is rooted in the pathophysiological challenges posed by pre-eclampsia, a hypertensive disorder of pregnancy characterized by systemic vascular dysfunction, endothelial injury, and multi-organ involvement [21]. These factors complicate anaesthetic management, as both the disease and the chosen anaesthetic technique can significantly impact maternal and fetal well-being.

Pre-eclampsia is associated with increased systemic vascular resistance, reduced plasma volume, and heightened sensitivity to vasopressors, making hemodynamic stability a critical concern during caesarean delivery [22].

Spinal anaesthesia, while preferred for its simplicity and avoidance of airway manipulation, can precipitate hypotension due to sympathetic blockade [23], whereas general anaesthesia, though ensuring rapid onset and controlled airway, introduces risks such as hypertensive responses during intubation and extubation , as well as potential fetal drug exposure [24]. The study's findings must be interpreted within this context, where balancing maternal safety and neonatal outcomes is paramount.

The clinical significance of the results is multifaceted. Hemodynamically, Group G exhibited higher heart rates, systolic and diastolic blood pressures, and mean arterial pressures post-anaesthesia, indicating greater cardiovascular stress under general anaesthesia. This aligns with the known catecholamine surge and hypertensive response during laryngoscopy and intubation [25].

In contrast, Group S required more vasopressor use (62% vs. 30%), reflecting the challenge of spinal-induced hypotension, a common complication due to the abrupt sympathetic blockade in pre-eclamptic patients with already compromised vascular adaptation [23]. These findings underscore the importance of meticulous hemodynamic monitoring and proactive management of hypotension in spinal anaesthesia, as well as the need for careful titration of anaesthetic depth in general anaesthesia to mitigate hypertensive crises.

Maternal complications revealed distinct patterns: Group S had higher incidences of headache (16% vs. 0%) and pain at the spinal site (22% vs. 0%), likely attributable to post-dural puncture headache and local tissue trauma. Conversely, Group G showed non-significant trends toward acute kidney injury (10% vs. 0%), congestive heart failure (8% vs. 0%), and pulmonary edema (16% vs. 8%), which may reflect the cumulative stress of general anaesthesia on already compromised renal and cardiac systems in pre-eclampsia [24]. Although these differences did not always reach statistical significance, they highlight the divergent risk profiles of the two techniques, with spinal anaesthesia posing more procedural-related morbidity and general anaesthesia potentially exacerbating systemic complications.

Neonatal outcomes presented a nuanced picture. While Group G had higher APGAR scores at 1, 5, and 10 minutes, this may reflect transient neonatal depression from spinal anaesthesia-induced hypotension or differences in placental drug transfer. However, the lack of significant difference in NICU admissions (6% vs. 10%) suggests that these APGAR disparities may not translate into clinically meaningful neonatal morbidity.

The shorter hospital stay in Group S (4.68 vs. 5.94 days) is a notable advantage, possibly due to faster recovery, fewer systemic complications, or reduced post-operative pain, emphasizing the potential benefits of spinal anaesthesia in enhancing postpartum recovery.

Comparative Discussion of Results with Previous Studies

The findings of the present study align with and diverge from previous research in several key aspects, particularly regarding hemodynamic stability, maternal complications, neonatal outcomes, and recovery parameters in pre-eclamptic women undergoing caesarean section under spinal (SA) versus general anaesthesia (GA).

1) Hemodynamic Stability and Vasopressor Use

Our study observed significantly higher heart rate (HR), systolic (SBP), and diastolic blood pressure (DBP) in the GA group post-induction, consistent with the hypertensive response to laryngoscopy and intubation. This mirrors findings by **Elawad OA (2024)**, who reported greater hemodynamic instability under GA, and **Adugna Aregawi et al. (2018)**, who concluded that SA provides more stable vital signs [131]. However, our study also noted a higher vasopressor requirement in the SA group (62% vs. 30%, *p=0.0024*), similar to **Elawad OA (2024)** (60% vs. 30%, *p=0.013*), reinforcing that spinal-induced hypotension remains a challenge [31]. Interestingly, **Yetneberk Alemaye et al. (2020)** and **Sintayehu Mulugeta Tamiru et al. (2022)** found that pre-eclamptic women experience *less* hypotension under SA compared to normotensive parturient, suggesting that pre-existing vasoconstriction may mitigate severe drops in blood pressure [26, 27]. The study by **Xian Wang et al. (2019)** further supports optimized vasopressor management (e.g., norepinephrine) to counteract SA-induced hypotension safely [28].

2) Maternal Complications

Our results demonstrated that GA was associated with non-significant trends toward acute kidney injury (AKI) (10% vs. 0%, *p=0.0563*), congestive heart failure (CHF) (8% vs. 0%, *p=0.1175*), and pulmonary edema (16% vs. 8%, *p=0.3567*), aligning with **Elawad OA (2024)**, who reported significantly higher AKI (10% vs. 0%, *p=0.0414*) and pulmonary edema (17.5% vs. 10%, *p=0.0528*) in the GA group [31]. **Fatungase OM (2023)** also noted higher mortality under GA (73% of perioperative deaths) [32], while **Suman Chattopadhyay et al. (2014)** found that severe pre-eclamptic mothers under GA required more critical care [148]. Conversely, our SA group had higher rates of headache (16% vs. 0%, *p=0.0058*) and spinal site pain (22% vs. 0%, *p=0.0005*), complications rarely reported in GA studies but consistent with procedural risks of neuraxial anaesthesia.

3) Neonatal Outcomes

Our study found higher APGAR scores in the GA group at 1, 5, and 10 minutes ($p<0.05$), contrasting with **Al Dallal AJ (2024)**, who reported *lower* APGAR scores under GA (27.3% vs. 57.4% at 1 min, *p=0.006*), and **Chadha H (2023)**, who observed better neonatal scores with SA [29]. This discrepancy may stem from differences in anaesthetic protocols, severity of pre-eclampsia, or timing of delivery. However, the lack of difference in NICU admissions (6% vs. 10%, *p=0.7150*) suggests that short-term APGAR variations may not always translate into clinically significant neonatal morbidity, a finding supported by **Deratu Neme et al. (2022)**, who noted comparable ICU admissions but higher neonatal mortality under GA [30].

4) Recovery and Hospital Stay

A key advantage of SA in our study was the significantly shorter hospital stay (4.68 vs. 5.94 days, $p<0.0001$), corroborating **Chadha H (2023)** (4 vs. 6 days, $p<0.05$) and **Deratu Neme et al. (2022)**. [29, 30] This likely reflects faster postoperative recovery, fewer systemic complications, and reduced need for intensive monitoring compared to GA, which often entails prolonged ventilation and hemodynamic instability.

The study highlights that both anaesthetic techniques have distinct advantages and risks in pre-eclamptic patients. Spinal anaesthesia, despite its association with hypotension and procedural complications, offers hemodynamic stability post-induction, fewer systemic complications, and shorter hospital stays. General anaesthesia, while ensuring immediate control, imposes greater cardiovascular stress and may exacerbate organ dysfunction.

The choice of anaesthesia should thus be individualized, considering maternal haemodynamic, severity of pre-eclampsia, and institutional expertise. These findings contribute to the broader goal of optimizing perioperative care in high-risk obstetric populations, where evidence-based decisions can significantly influence maternal and neonatal outcomes. Future research could explore combined techniques or novel vasopressor protocols to further refine anaesthetic strategies in this vulnerable cohort.

6. Limitations

The study's limitations include its relatively small sample size, which may affect the generalizability of the findings to a broader population. Additionally, the focus on pre-eclamptic women undergoing caesarean sections may limit the applicability of the results to other clinical contexts or populations. The study did not account for long-term maternal or neonatal outcomes, focusing instead on immediate post-operative parameters. Variability in clinical practice or peri-operative management across different institutions could also influence the results. Future studies with larger, more diverse cohorts and extended follow-up periods would help address these limitations and provide more comprehensive insights.

7. Summary

1) **Demographic Characteristics**: Age, gestational age, parity, BMI, and surgical indications showed no statistically significant differences between spinal anaesthesia (Group S) and general anaesthesia (Group G).
2) **Hemodynamic Parameters**: General anaesthesia led to greater cardiovascular stress, with significantly higher heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) post-anaesthesia.
3) **Neonatal Outcomes**: Neonatal APGAR scores were higher in Group G at 1, 5, and 10 minutes, indicating better adaptation post-general anaesthesia, though NICU admission rates remained similar.
4) **Maternal Complications**: Group G showed trends toward complications like acute kidney injury (AKI) and congestive heart failure (CHF), while Group S had higher occurrences of headache and pain at the spinal injection site.
5) **Intra-Operative Findings**: Vasopressors were used more often in Group S due to spinal-induced hypotension.
6) **Recovery**: Group S showed faster recovery and shorter hospital stays (4.68 days vs. 5.94 days), with a statistically significant difference.

8. Conclusion

In comparing spinal anaesthesia (Group S) and general anaesthesia (Group G) for caesarean sections in pre-eclamptic women, both methods demonstrated specific advantages and limitations. While demographic factors and pre-operative characteristics were similar between groups, general anaesthesia was associated with higher cardiovascular stress, as indicated by elevated heart rate, blood pressure, and mean arterial pressure post-anaesthesia. Neonatal outcomes, measured by APGAR scores, favoured general anaesthesia, although NICU admission rates showed no significant difference. However, spinal anaesthesia exhibited faster recovery, reflected by a significantly shorter hospital stay, and a reduced need for NICU admissions.

Maternal complications varied between the two groups. General anaesthesia showed trends toward more severe complications like acute kidney injury (AKI) and congestive heart failure (CHF), whereas spinal anaesthesia was linked to localized effects such as headaches and pain at the injection site. Additionally, vasopressor use was higher in spinal anaesthesia due to hypotension, a known side effect. Overall, the choice between these anaesthesia techniques should carefully weigh maternal and neonatal outcomes, along with individual patient profiles and clinical considerations.

Future recommendations should focus on optimizing anaesthesia choices for caesarean sections in pre-eclamptic women to balance maternal and neonatal outcomes. Implementing strategies to mitigate spinal-induced hypotension, such as preloading fluids or vasopressors, could further improve the safety and efficacy of spinal anaesthesia. Additionally, thorough risk assessments and individualized anaesthesia plans considering cardiovascular stress, recovery time, and maternal complications can guide better decision-making. Continuous research into anaesthesia protocols and innovations, coupled with multidisciplinary collaboration, will help refine practices and enhance outcomes for both mothers and neonates.

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