Section: Anaesthesiology

Original Research Article

COMPARISION OF BOLUS MEPHENTERMINE, EPHEDRINE AND PHENYLEPHRINE FOR THEMANAGEMENT OF HYPOTENSION DURING SPINAL ANESTHESIA FOR LSCS

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ABSTRACT

Background: Spinal anesthesia is the preferred anesthetic technique for lower segment cesarean section (LSCS) due to its rapid onset, reliability, and safety profile. However, maternal hypotension remains one of the most common complications following spinal anesthesia, occurring due to sympathetic blockade and resulting in adverse maternal and fetal outcomes. Vasopressors such as mephentermine, ephedrine, and phenylephrine are routinely used for the treatment of spinal-induced hypotension, but their comparative efficacy and safety remain a subject of clinical interest. The aim is to compare the efficacy and safety of bolus doses of Mephentermine, Ephedrine, and Phenylephrine in the management of hypotension during spinal anesthesia for lower segment cesarean section (LSCS). The primary objective is to evaluate and compare the ability of Mephentermine, Ephedrine, and Phenylephrine to maintain blood pressure during spinal anesthesia in LSCS. The secondary objective is to assess and compare the heart rate response associated with each vasopressor. To evaluate the neonatal outcome using the Apgar score at1 and5 minutes post-delivery. To analyze the incidence of side effects (e.g., bradycardia, tachycardia, arrhythmias, nausea, vomiting) associated with each drug. To determine the optimal drug for effective management of hypotension with minimal adverse effects in this clinical setting.

Materials and Methods: This was a Prospective Comparative Clinical Study. The study will be conducted for a period of1 year in department of Anaesthesia in Kurnool Medical College, Kurnool. Parturient coming for elective and emergency lower segmental caesarean section. The study will be conducted for aperiod of 1year in department of Anaesthesia in Kurnool Medical College, Kurnool. Maternal systolic blood pressure, heart rate, number of vasopressor boluses required, incidence of nausea and vomiting, and neonatal Apgar scores at 1 and 5 minutes were recorded and analyzed.

Results: This was a prospective comparative clinical study conducted over a period of one year in the Department of Anaesthesia, Kurnool Medical College, Kurnool. The study included parturients undergoing elective and emergency lower segment cesarean sections. Atotal of 90 patients were randomly divided into three groups of 30 each. Group 1 received Inj. Mephentermine 6 mg IV bolus, Group 2 received Inj. Ephedrine 6 mg IV bolus, and Group 3 received Inj. Phenylephrine 100 µg IV bolus. The study aimed to compare the hemodynamic and neonatal effects of these vasopressors. phenylephrine causes a more pronounced and sustained reduction in heart rate post-administration compared to ephedrine and mephentermine, which is consistent with its strong α-adrenergic activity. Phenylephrine caused an early transient spike in both SBP and DBP, followed by a decline and stabilization. In contrast, ephedrine and

mephentermine demonstrated more consistent and sustained BPcontrol, suggesting superior stability in prolonged intraoperative management. Ephedrine yielded the highest APGAR scores at 5 minutes, suggesting better neonatal adaptation. Sensory block levels were significantly higher in the Ephedrine group. No significant age-related demographic differences were observed. Overall, mephentermine showed the best maternal tolerability, while phenylephrine demonstrated superior neonatal perfusion profiles.

Conclusion: Mephentermine, ephedrine, and phenylephrine are all effective agents for the treatment of hypotension during spinal anesthesia for LSCS. However, phenylephrine provides superior hemodynamic stability with fewer maternal side effects and comparable neonatal outcomes, making it a preferred vasopressor for the management of spinal anesthesia-induced hypotension in cesarean deliveries.

Keywords: Spinal anesthesia, Cesarean section, Hypotension, Mephentermine, Ephedrine, Phenylephrine, Vasopressors, Maternal hemodynamics, Neonatal outcome.

INTRODUCTION

The delivery of an infant into the arms of a conscious and pain-free mother is one of the most rewarding moments in medicine. The safety and well-being of both the mother and the neonate during delivery are paramount, necessitating careful planning and execution of the anesthetic technique. With the global increase in cesarean section rates, anesthesiologists face the critical task of selecting an anesthetic approach that ensures maternal and fetal safety while providing optimal conditions for surgery.[1]

In recent decades, there has been a worldwide shift in obstetric anesthesia practice, favoring regional anesthesia over general anesthesia. Spinal anesthesia, introduced into clinical practice by German surgeon Karl August Bier in 1898, has become the most popular technique for cesarean sections due to its rapid onset, simplicity, and effectiveness in providing profound sensory and motor blockade.[2] It allows the mother to remain conscious and minimizes the risks associated with general anesthesia, such as aspiration and delayed maternal recovery.[3]

Despite its advantages, spinal anesthesia is associated with a high incidence of hypotension, reported in as many as 85% of patients undergoing cesarean sections. Maternal hypotension occurs due to sympathetic blockade, resulting in vasodilation and a subsequent drop in systemic vascular resistance and venous return.[4] This can lead to symptoms such as dizziness, nausea, and vomiting, which not only compromise maternal comfort but may also interfere with the surgical procedure. More critically, maternal hypotension can cause reduced uteroplacental perfusion, leading to fetal bradycardia and acidosis, which are significant concerns during cesarean deliveries.[5]

The management of spinal anesthesia-induced hypotension is a cornerstone of obstetric anesthesia practice. The primary approach involves the use of vasopressors, which help restore maternal blood pressure and maintain uteroplacental perfusion.6 Among the various vasopressors available, mephentermine, ephedrine, and phenylephrine are the most commonly used. Each drug has distinct pharmacological properties, mechanisms of action, and effects on maternal and fetal outcomes, making their selection critical in the anesthetic management of cesarean sections.[7]

Mephentermine is a sympathomimetic agent that primarily stimulates beta-adrenergic receptors and, to a less erextent, alpha-adrenergic receptors. It increases cardiac output and systolic blood pressure, making it effective in treating hypotension. However, it is associated with an increased heart rate, which may not be ideal in patients where tachycardia is undesirable.[8,9]

Ephedrine has been traditionally considered the vasopressor of choice in obstetric anesthesia due to its mixed alpha-and beta-adrenergic activity, which helps maintain uteroplacental perfusion. While effective in raising blood pressure, it is associated with side effects such as maternal tachycardia, nausea, and potential depression of fetal pH and base excess.[10]

Phenylephrine is a selective alpha-adrenergic agonist that causes vasoconstriction and increases systemic vascular resistance. It has a rapid onset and peak effect, making it highly effective in treating hypotension.[11] Unlike ephedrine, phenylephrine reduces heart rate, which can be advantageous in patients with pre-existing tachycardia. It also has less impact on fetal pH, making it a safer option for the neonate.[12]

Given the high incidence of hypotension during spinal anesthesia and its associated maternal and fetal complications, selecting the most effective vasopressor is crucial.

This study aims to compare the efficacy of mephentermine, ephedrine, and phenylephrine in the management of hypotension during cesarean sections. The study will assess their impact on maternal heart rate, blood pressure, incidence of nausea and vomiting, and neonatal outcomes, including APGAR scores.[13-17]

Aims And Objective

Aim: To compare the efficacy and safety of bolus doses of Mephentermine, Ephedrine, and Phenylephrine in the management of hypotension

during spinal anesthesia for lower segment cesarean section (LSCS).

Objectives Primary Objective:

To evaluate and compare the ability of Mephentermine, Ephedrine, and Phenylephrine to maintain blood pressure during spinal anesthesia in LSCS.

Secondary Objectives:

To assess and compare the heart rate response associated with each vasopressor. To evaluate the neonatal outcome using the APGAR score at1 and5 minutes post-delivery.

To analyze the incidence of side effects (e.g., bradycardia, tachycardia, arrhythmias, nausea, vomiting) associated with each drug.To determine the optimal drug for effective management of hypotension with minimal adverse effects in this clinical setting.

MATERIALS AND METHODS

The study will be conducted for a period of1 year in department of Anaesthesia in Kurnool Medical College, Kurnool. Parturient coming for elective and emergency lower segmental caesarean section. The study will be conducted for aperiod of 1year in department of Anaesthesia in Kurnool Medical College, Kurnool.

Study design: Prospective Comparative Clinical Study

Duration of study: Patients coming from elective and emergency lower segmental caesarean section. The study will be conducted for a period of one year in department of Anesthesia in Kurnool Medical College, Kurnool.

Study population: A Total of 30 cases each were randomly allocated to one of the following three groups of study.

Study material:

Group E: Received Injection Ephedrine 6 mg IV bolus. GroupM: Received Injection Mephentermine 6mg IVbolus. Group P:Received InjectionPhenylephrine100µgIVbolus.

Study Settings

Inclusion Criteria

Participants included in the study are selected based on the following criteria: Patients scheduled for elective lower segmental caesarean section.

Patients aged between 20 and 35years.

Patients classified as ASA class1 or 2, indicating a healthy or mildly systemic disease condition.

Systolic blood pressure:100-140 mmHg

Diastolic blood pressure:70-89mmHg

Exclusion Criteria

Patients with medical complications like diabetie smellitus, cardiovascular diseases, severe anemia, Cerebrovascular diseases.

- Shortstature<140cm
- Obese>90kg
- Patients with obstetrical complications like antepartum hemorrhage, pregnancy induced hypertension, cord complications (nuchal cord or cord prolapse), foetal malformations or mal presentations.
- Patients with autonomal neuropathy spinal deformities other neurological diseases, patients with local site active infection in lumbar area, coagulation abnormalities and hypovolemia due to any cause.

Investigations Required

Urine albumin sugar, Random bloodsugar, Blood urea, Urine albumin sugar./PCV,BT, CT, Platelet count

Study Protocol for Lower Segment Caesarean Section

Premedication

For Elective Surgery:

TabletRanitidine150mgorally.

Tablet Metoclopramide 10 mg orally with sips of water, administered 2 hours prior to surgery.

For Emergency Surgery:

Injection Ranitidine 50mgIV.

Injection Metoclopramide10 mgIV, administered 30 minutes prior to surgery. Preparation in the Operation Theatre

Upon arrival in the operation theatre, the following preparations were ensured: Appropriate airway management equipment and emergency drugs were kept readily available.

The operating table was checked to confirm it was in a horizontal position. Patients were positioned supine with a pillow placed under the head.

Monitoring Setup: Patients were connected to anon-invasive sphygmomanometer, ECG, and pulse oximeter for continuous monitoring.

Intravenous access was secured using an18-gaugeIV cannula.

All patients were preloaded with Ringerlactate solution at a doseof15ml/kg administered rapidly.

Subarachnoid Block (SAB)

The subarachnoid block was performed by ananesthesiologist who was blinded to the study drug allocation:

Patients were positioned in the right lateral decubitus position.

The skin over the lumbar region wasprepared with an antiseptic solution anddraped using a sterile towel.

The L3-L4 intervertebral space was identified, and a23 GQuicke-Babcock needle was inserted using the midline approach.

Once the needle entered the subarachnoid space and cerebrospinal fluid (CSF) flow was confirmed, the stylet was removed, and 1.8mL of 0.5% Bupivacaine was injected intrathecally.

The patients were repositioned to the supine position, and a wedge was placed under the right flank to prevent aortocaval compression.

Oxygen was administered via a facemask at a rate of 6 liters per minute.

Intraoperative Management

Following delivery, Injection Ergometrine 0.25 mg IV (slow) and Injection Oxytocin10 U in 5%

Dextrose were administered after clamping the umbilical cord.

Intravenous fluids were administered at a rate of 1000mL/hour throughout the surgery.

Baseline Measurements: Heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure (MAP), and oxygen saturation (SpO2) were recorded as baseline values after preloading.

Monitoring: These parameters were monitored continuously and recorded: Every minute until the onset of hypotension.

Every two minutes for the next ten minutes.

Every five minutes thereafter until the end of the surgery. Management of Hypotension and Bradycardia

Hypotension was defined as either a reduction in systolic blood pressure of more than 20% from baseline or a systolic blood pressure below 90 mmHg. In cases of hypotension, the allocated study drug was administered as an IV bolus, and the following parameters were recorded:

Time of onset of hypotension post-SAB. Lowest recorded systolic blood pressure.

Total number of bolus doses and cumulative dosage of vasopressors used. Bradycardia was defined as a heart rate below 60 beats per minute and was managed with Injection Atropine0 .3mg IV bolus. The time of onset of bradycardia was documented.

Sensory Block Assessment: The highest level of sensory block was determined using the pinprick method, five minutes after administering SAB. The interval from subarachnoid block to delivery was recorded.

Neonatal Outcome: Neonatal assessment was performed by a pediatrician using the APGAR scoring system at 1 minute and 5 minutes after birth.

Additional Observations: Incidence and onset of tachycardia (heartrate>150bpm) were noted.

Incidence of hypertension (increase in systolic BP > 20% from baseline) was documented.

Occurrence and onset of nausea and vomiting were recorded.

Total volume of intravenous fluids administered and urine output were measured.

Study Groups

A total of 90 patients were randomly allocated in to three equal groups of 30cases each:

Group E: Received Injection Ephedrine 6 mg IV bolus. Group M:Received Injection Mephentermine 6mg IV bolus. Group P: Received Injection Phenylephrine100µgIVbolus. Statistical Methods

Descriptive statistics included summarizing categorical variables as frequencies and percentages and continuous variables as mean±standard deviation. Chi-square and Fisher's exact tests were used for categorical data. For continuous data, one-way ANOVA was applied when comparing three groups, while Student's t-test was used for pairwise comparisons. Mann-Whitney Uor Wilcoxon tests were employed fornon-parametric data. Statistical significance was set at a p-value < 0.05.

RESULTS

Table 1: Age Distribution Across Study Groups

AGE	Group E	Group M	Phenylephrine	Total
<21	2 (2.22%)	2 (2.22%)	2 (2.22%)	6 (6.67%)
21–25	8 (8.89%)	8 (8.89%)	9 (10.00%)	25 (27.78%)
26–30	14 (15.56%)	16 (17.78%)	11 (12.22%)	41 (45.56%)
31–35	6 (6.67%)	4 (4.44%)	8 (8.89%)	18 (20.00%)
Grand Total	30 (33.33%)	30 (33.33%)	30 (33.33%)	90 (100.00%)
Comparison		Chi-square	p-value	
Between 3 Groups		2.34	0.886	
Mephenterminevs Ephedrine		0.533	0.912	
Mephenterminevs Phenylephrine		0.705	0.872	
Ephedrine vs Phenylephrine		2.318	0.509	

The age-wise distribution of patients across the three groups—Ephedrine (GroupE), Mephentermine (GroupM), and Phenylephrine (Group P)—was fairlyuniform, with the majority falling in the 26–30 years range (45.56%). The21–25years group was the next most represented, comprising 27.78% of the total sample. Only 6.67%ofpatients were younger than 21, and 20% were in the 31–35 years category. Each group had an equal sample size of 30 patients (33.33%).Statistical comparison using the Chi-square test revealed no significant differences in age distribution between the three groups (χ^2=2.34,p=0.886).Pair wise comparisons between groups (EvsM, MvsP, EvsP)also showed no statistical significance(p>0.05).This indicates that age distribution was well balanced across the study groups, minimizing confounding effects related to age.

Table 2: Comparison of Mean Weight Among Groups

Weight	Mean	Standard Deviation
Group E	66.67	6.33
Group M	62.70	4.72
Group P	61.33	5.54
Total	63.57	5.96
Between 3 group	F-statistic15.467Pvalue<0.001	

Mephentermine vsEphedrine	0.003
Mephentermine vs Phenylephrine	<0.001
Ephedrine vs Phenylephrine	0.015

The comparison of mean body weight among the three study groups revealed statistically significant differences. GroupE (Ephedrine)had the highest mean weight (66.67 ± 6.33 kg), followed by Group M (Mephentermine) at 62.70 ± 4.72 kg, and Group P (Phenylephrine) with the lowest mean of 61.33 ± 5.54 kg. The overall mean weight across all groups was 63.57 ± 5.96 kg. ANOVA testing showed a significant difference between the groups (F = 15.467, $p < 0.001$). Pair wise comparisons indicated that the difference in mean weight between Mephentermine and Ephedrine ($p = 0.003$), Mephentermine and Phenylephrine ($p < 0.001$), and Ephedrine and Phenylephrine ($p = 0.015$) were all statistically significant. These findings suggest a non-homogeneous weight distribution that could influence outcomes and may require statistical adjustments.

Table 3: Comparison of Mean Height Among Groups

Height	**Mean**	**Standard Deviation**
GroupE	155.97	5.52
GroupM	160.73	3.64
GroupP	154.93	6.19
Total	157.21	5.76
Between3 group	F-statistic16.319Pvalue<0.001	
Mephentermine vs Ephedrine	<0.001	
Mephenterminevs Phenylephrine	0.948	
Ephedrine vs Phenylephrine	<0.001	

Group M (Mephentermine) had the highest mean height (160.73 ± 3.64 cm), followed by Group E (Ephedrine) at 155.97 ± 5.52 cm, and Group P (Phenylephrine) at154.93±6.19cm.Theoverallmeanheightwas157.21± 5.76cm.ANOVArevealed a statistically significant difference in mean height between the groups ($F=16.319, p < 0.001$). Post-hoc comparisons showed significant differences between Mephentermine and Ephedrine ($p < 0.001$) and between Ephedrine and Phenylephrine ($p < 0.001$), while the difference between Mephentermine and Phenylephrine was not statistically significant ($p = 0.948$).

Table 4: Distribution of Maximum Sensory Block Level

Sensory Block	**Group M**	**Group E**	**Group P**	**Total**
T4	10 (11.11%)	4 (4.44%)	9 (10.00%)	23 (25.56%)
T5	8 (8.89%)	12 (13.33%)	11 (12.22%)	31 (34.44%)
T6	8 (8.89%)	10 (11.11%)	7 (7.78%)	25 (27.78%)
T7	4 (4.44%)	4 (4.44%)	3 (3.33%)	11 (12.22%)
GrandTotal	30 (33.33%)	30 (33.33%)	30 (33.33%)	90(100.00%)
Comparison	**Chi-square**	**p-value**		
Between3Groups	4.276	0.639		
Mephenterminevs Ephedrine	3.594	0.309		
Mephenterminevs Ephedrine	3.594	0.309		
Ephedrine vs Phenylephrine	2.639	0.451		

The most common Sensory block level achieved overall was T5 (34.44%), followed byT6 (27.78%) and T4 (25.56%), with T7 being the least frequent (12.22%). Withinthe groups,T4 was most frequent in Group M(11.11%) and Group P (10.00%), while Group E had a higher incidence at T5(13.33%). Chi-square analysis showed no statistically significant difference between the groups regarding sensory block level($\chi^2 = 4.276, p=0.639$).Similarly, all pair wise comparisons (MvsE,MvsP,EvsP)yielded non-significant p-values (>0.05), indicating a comparable distribution of block levels across the three groups. Thus, the type of vasopressor did not significantly influence the level of sensory block achieved.

Table 5: Time to Development of Hypotension

Time to develop hypotension	**Group E**	**Group M**	**Group P**	**Total**
1	1 (1.11%)	1 (1.11%)	0 (0.00%)	2 (2.22%)
2	21 (23.33%)	16 (17.78%)	15 (16.67%)	52 (57.78%)
4	8 (8.89%)	7 (7.78%)	13 (14.44%)	28 (31.11%)
6	0 (0.00%)	5(5.56%)	2 (2.22%)	7 (7.78%)
8	0 (0.00%)	1 (1.11%)	0 (0.00%)	1 (1.11%)
Total	30 (33.33%)	30 (33.33%)	30 (33.33%)	90 (100.00%)
Comparison Between 3 Groups Mephentermine vs Ephedrine		**Chi-square**	**p-value**	
Mephentermine vsPhenylephrine		0.835	0.094	
Ephedrine vs Phenylephrine		5.19	0.158	
		6.076	0.108	
		5.118	0.163	

The majority of hypotensive episodes occurred at 2 minutes (57.78%), with Group E having the highest frequency at this time point (23.33%).At 4minutes, 31.11% of patients developed hypotension, most notably in Group P (14.44%). A smaller proportion of cases developed hypotension at 6 minutes (7.78%), primarily in Group M. Very few cases were observed at 1 and 8 minutes. Chi-square analysis revealed no statistically significant difference in the timing of hypotension between the groups ($\chi^2 = 0.835$, $p = 0.094$), and all pairwise comparisons also yielded non-significant p values (>0.05). These results suggest a similar temporal pattern in the onset of hypotension among the vasopressor groups.

Table 6: Comparison of Heart Rate at VariousTime Intervals

Time	Group P	Group E	Group M	Between 3 grops	P_E	P_M	E_M
0 minute	92.9±10.0	90.3±18.2	99.1±15.7	0.117	0.863	0.292	0.114
2 minutes	91.1±17.4	93.0±21.5	103.9±18.3	0.067+	0.997	0.115	0.100
4 minutes	95.0±17.7	91.7±20.1	95.0±19.8	0.875	0.943	0.981	0.866
6 minutes	84.4±16.3	97.5±19.4	93.3±21.0	0.059*	0.060+	0.179	0.858
8 minutes	71.8±16.3	97.0±22.7	93.5±15.8	<0.001**	<0.001**	0.001**	0.818
10 minutes	77.2±18.1	98.8±21.5	95.3±14.4	<0.001**	0.002**	0.007**	0.902
12 minutes	81.9±16.7	96.6±17.2	92.2±13.8	0.019*	0.020*	0.090+	0.807
14 minutes	82.1±16.8	96.0±15.9	92.5±12.7	0.024*	0.025*	0.106	0.936
16 minutes	78.0±19.0	100.5±14.8	95.6±13.1	<0.001**	<0.001**	<0.001**	0.793
18 minutes	75.0±18.1	98.6±11.0	98.5±10.0	<0.001**	<0.001**	<0.001**	0.972
20minutes	72.0±18.6	103.5±14.1	98.7±11.2	<0.001**	<0.001**	<0.001**	0.695
25 minutes	71.3±18.6	100.1±14.9	97.0±14.7	<0.001**	<0.001**	<0.001**	0.735
30 minutes	66.2±18.1	96.3±18.1	96.7±15.2	<0.001**	<0.001**	<0.001**	0.970

The comparison ofheart rate across the three groups—Phenylephrine (Group P), Ephedrine (Group E), and Mephentermine (Group M)—at multiple time intervals showed significant differences, especially from 8 minutes onwards. At baseline (0 minutes), no significant difference was observed among the groups ($p = 0.117$). However, from 8 minutes to 30 minutes, Group P consistently showed significantly lower heart rates compared to Groups E and M($p<0.001$at most intervals).Group E generally maintained the highest heart rate, followed closely by Group M. Pairwise comparisons revealed Group P vs E and P vs M showed statistically significant differences from 8 minutes onward, with$p<0.001$indicating lower HR in Group P.Group E vs M comparisons remained non-significant at most intervals ($p > 0.05$), suggesting similar heart rate trends between these two groups. These results indicate that phenylephrine causes a more pronounced and sustained reduction in heart rate post-administration compared to ephedrine and mephentermine. This bradycardic effect is consistent with phenylephrine'sstrong α-adrenergic activity.

Table 7: Comparison of Systolic Blood Pressure (SBP) OverTime

Time	GroupP	GroupE	GroupM	Overall P value	P_E	P_M	E_M
0 minute	114.3±8.2	111.9±11.2	117.0±11.3	0.375	0.782	0.725	0.339
2minutes	103.8±8.5	101.0±11.8	96.0±12.1	0.162	0.995	0.225	0.235
4 minutes	113.0±7.2	103.2±13.0	100.8±13.9	0.006**	0.017*	0.014*	0.931
6 minutes	112.5±8.8	105.5±13.9	105.5±13.7	0.065+	0.109	0.096+	0.999
8 minutes	114.8±10.8	108.6±11.5	107.4±17.5	0.288	0.331	0.349	0.999
10 minutes	101.2±9.4	112.8±11.2	114.8±11.2	0.010**	0.036*	0.042*	0.932
12 minutes	102.6±10.4	108.5±13.7	106.4±12.6	0.020*	0.067+	0.062+	0.924
14 minutes	100.5±9.5	111.2±12.5	108.8±12.6	0.028*	0.019*	0.198	0.589
16 minutes	100.3±6.4	106.0±9.8	102.9±9.5	0.025*	0.015*	0.236	0.484
18 minutes	103.1±6.0	108.4±11.5	106.9±14.2	0.318	0.285	0.624	0.820
20 minutes	106.9±10.4	109.1±12.5	105.8±10.5	0.286	0.319	0.327	0.944
25 minutes	104.1±9.3	108.3±10.0	107.4±8.5	0.212	0.181	0.560	0.732
30 minutes	106.5±6.2	110.1±8.6	109.1±9.6	0.081+	0.067+	0.608	0.394

Comparison of Systolic Blood Pressure (SBP) Over Time

At baseline (0 min), no significant difference was observed ($p = 0.375$). However, at 4, 10, 12, 14, and 16 minutes, Group P had notably lower SBP compared to Groups E and M:At 4 min,Group P had significantly higher SBP than E and M($p= 0.006$ overall), with significant differences in P vs E and P vs M.At 10 min, Groups E and M had significantly higher SBP than Group P ($p = 0.010$).At 12–16 min, SBP remained significantly higher in Group E compared to Group P (p values between 0.015–0.067).

No significant differences were seen in later time points (18–30min), indicating stabilization.

Overall, phenylephrine caused an earlier spike (at 4 min), but later maintained comparatively lower SBP, while ephedrine and mephentermine sustained morestable and higher SBP profiles post 10 minutes.

Comparison of Diastolic Blood Pressure (DBP) Over Time.

Table 8: Comparison of Diastolic Blood Pressure (DBP) Over Time

Time	GroupP	GroupE	GroupM	OverallP value	P_E	P_M	E_M
0 minute	70.7±7.2	75.9±6.7	74.3±6.0	0.145	0.122	0.549	0.612
2 minutes	59.8±6.2	61.8±10.6	58.0±11.3	0.176	0.721	0.513	0.153
4 minutes	72.2±8.8	63.2±9.5	62.6±11.5	<0.001**	<0.001**	<0.001**	0.804
6 minutes	75.1±9.2	64.6±11.3	63.5±10.3	0.003**	0.034*	0.002**	0.608
8 minutes	71.4±11.1	68.3±9.9	63.5±13.4	0.216	0.434	0.207	0.882
10 minutes	60.5±9.2	66.1±9.4	66.9±14.0	0.063+	0.106	0.097+	0.999
12 minutes	60.3±10.3	66.8±9.3	65.0±6.5	0.094	0.091	0.491	0.812
14 minutes	60.9±9.3	66.1±8.4	61.2±7.6	0.104	0.096+	0.804	0.306
16 minutes	59.5±7.1	63.4±7.8	59.1±10.7	0.100	0.174	0.718	0.833
18 minutes	57.9±7.9	61.2±9.7	60.0±9.5	0.422	0.399	0.741	0.831
20 minutes	62.1±9.4	60.8±9.2	61.4±9.9	0.074	0.079+	0.097+	0.952
25 minutes	60.3±7.8	59.3±9.0	64.2±6.3	0.347	0.905	0.577	0.333
30 minutes	65.1±5.1	64.3±3.8	63.2±7.9	0.977	0.987	0.977	0.999

Comparison of Diastolic Blood Pressure (DBP) Over Time

At baseline (0 min), there was no significant difference among thegroups (p = 0.145). However:At 4and 6 minutes, Group P had significantly higher DBP than both Ephedrine and Mephentermine (p < 0.001 and p = 0.003 respectively). This reflects the potent vasoconstrictive effect of phenylephrine. From 8 minutes onward, differences in DBP among the groups diminished,with nostatistically significant variation observed, although trends suggest slightly higher DBP in the phenylephrine group at some points.By30 minutes, DBP values across all groups converged, indicating similar hemodynamic profiles in the later postoperative phase (p = 0.977). At 4 and 6 minutes, Group P had significantly higher DBP than both Ephedrine and Mephentermine (p<0.001and p=0.003respectively).This reflects the potent vasoconstrictive effect of phenylephrine.

Table 9: Comparison of Mean Arterial Pressure (MAP) OverTime

Time	Group P	GroupE	Group M	Overall P-value	P_E	P_M	E_M
0 minute	94.2±8.3	93.2±9.5	93.3±9.0	0.134	0.895	0.276	0.158
2 minutes	78.1±7.8	81.0±6.4	74.7±8.0	0.026*	0.021*	0.013*	0.081+
4 minutes	89.6±7.7	82.0±7.2	81.5±7.6	<0.001**	<0.001**	<0.001**	0.754
6 minutes	88.0±8.0	86.4±7.6	88.6±6.7	0.204	0.291	0.267	0.872
8 minutes	87.9±6.6	89.6±6.6	91.0±8.0	0.116	0.442	0.133	0.912
10 minutes	84.4±7.3	89.3±7.8	91.1±8.3	0.089+	0.079+	0.091+	0.887
12minutes	87.6±7.8	91.2±6.5	89.5±7.7	0.041*	0.036*	0.047*	0.902
14 minutes	84.3±7.3	89.6±7.4	89.7±7.3	0.048*	0.049*	0.050*	0.888
16 minutes	85.8±6.0	90.3±7.0	89.3±7.6	0.056+	0.068+	0.071+	0.862
18 minutes	84.2±6.8	88.5±7.9	88.3±7.4	0.063+	0.084+	0.063+	0.879
20 minutes	81.6±7.3	88.7±6.2	87.1±7.0	0.072+	0.091+	0.077+	0.845
25 minutes	81.6±7.2	87.1±6.0	85.4±7.6	0.080+	0.101	0.089+	0.829
30 minutes	82.1±6.7	84.7±7.9	85.2±7.7	0.092+	0.110	0.093+	0.811

At 2 minutes, MAP was significantly lower in Group M compared to Groups P and E (p = 0.026), suggesting an early dip with mephentermine.

At 4 minutes, Group P showed significantly higher MAP than Groups E and M (p < 0.001), reflecting phenylephrine's early vasoconstrictive effect.

At 12 and 14 minutes, MAP remained significantly higher in Group E compared to Group P (p = 0.041 and p = 0.048 respectively), indicating better maintenance of pressure with ephedrine during this period.

From 6 minutes onward, MAP differences narrowed with no major fluctuations, and overall p-values approached non-significance (e.g., p = 0.204 at 6 min, p = 0.092 at 30 min), suggesting stabilization across all groups.

These trends indicate that phenylephrine causes an early sharp rise in MAP, ephedrine maintains more consistent elevations, and mephentermine initially results in lower MAP but catches up later.

Table 10: Number of Vasopressor Boluses Required

No of Bolus	Group P	Group E	Group M
1	2 (6.7%)	3 (10.0%)	4 (13.3%)
2	1 (3.3%)	5 (16.7%)	6 (20.0%)
3	5(16.7%)	6 (20.0%)	5 (16.7%)
4	7 (23.3%)	4 (13.3%)	3 (10.0%)
5&above	15(50.0%)	12(40.0%)	12(40.0%)
Total	30(100.0%)	30(100.0%)	30(100.0%)
Mean±SD	4.07±1.20	3.57±1.43	3.43±1.52
Comparison	Chi-square	p-value	Significance
Between3Groups	31.19	<0.00001	HighlySignificant
MephenterminevsEphedrine	10	0.0067	Significant

Mephenterminevs Phenylephrine	28.155	<0.00001	HighlySignificant
EphedrinevsPhenylephrine	7.738	0.0209	Significant

The comparison of vasopressor bolus requirements across the three groups—Phenylephrine (Group P), Ephedrine (Group E), and Mephentermine (Group M)—showed statistically significant differences. The majority of patients in all groups required5or more boluses, especially in Group P (50%), compared to40%inboth Groups E and M. Group P also had the highest mean bolus count (4.07 ± 1.20), indicating greater vasopressor need.Chi-square analysis revealed a highly significant difference between the groups (χ^2 = 31.19, p < 0.00001). Pair wise comparisons showed: Mephentermine vs Phenylephrine: p<0.00001(highly significant), Ephedrine vs Phenylephrine: p = 0.0209 (significant), Mephentermine vs Ephedrine: p = 0.0067 (significant). These findings suggest that Phenylephrine required the highest number of boluses, while Mephentermine was the most efficient in terms of lower bolus requirement, closely followed by Ephedrine. This indicates better hemodynamic stability with Mephentermine and Ephedrine compared to Phenylephrine.

Table 11: Side effects

Side Effect	Group M	Group E	Group P	Total
Bradycardia	1 (3.3%)	0(0%)	6 (20%)	7 (7.8%)
Tachycardia	4 (13.3%)	9 (30%)	1 (3.3%)	14(15.6%)
Nausea	3 (10%)	8 (26.7%)	1 (3.3%)	12(13.3%)
Vomiting	2 (6.7%)	6 (20%)	1 (3.3%)	9 (10.0%)
Shivering	4(13.3%)	2 (6.7%)	3 (10%)	9 (10.0%)
Headache	2 (6.7%)	3 (10%)	1 (3.3%)	6 (6.7%)
P value	All 3 groups	Mephenterminevs Ephedrine	Mephenterminevs Phenylephrine	Ephedrine vs Phenylephrine
Bradycardia	0.02*	0.03*	0.01*	0.4
Tachycardia	0.01*	0.04*	0.01*	0.02*
Nausea	0.03*	0.05*	0.02*	0.04*
Vomiting	0.04*	0.03*	0.06	0.02*
Shivering	0.09	0.2	0.12	0.45
Headache	0.08	0.22	0.1	0.33

Tachycardia was most common with Ephedrine (30%), followed by Phenylephrine (13.3%) and Mephentermine (3.3%). The overall comparison was statistically significant (p = 0.01), with significant differences in all pair wise comparisons except between Ephedrine and Phenylephrine. Nausea and vomiting were also more frequent in the Ephedrine group (26.7% and20%, respectively). These symptoms were significantly different among groups (p = 0.03 and p = 0.04 respectively), with Mephentermine consistently showing the least incidence. Shivering and headache occurred with similar frequency across all groups and did not reach statistical significance (p > 0.05), indicating these symptoms were likely unrelated to the choice of vasopressor.Bradycardia (data mentioned only in p-values) was significantly more frequent in Phenylephrine group compared to Mephentermine and Ephedrine (p = 0.02 overall), consistent with phenylephrine's known alpha-agonist action causing reflex bradycardia.

Overall, Ephedrine was associated with more tachycardia, nausea,andvomiting,while Phenylephrine showed higher bradycardia, and Mephentermine was better tolerated with the lowest overall incidence of side effects.

Table 12: Mean Time to Recovery from Hypotension

Group	Mean Time to Recovery(minutes)	Standard Deviation(± SD)
GroupM	4.6	±1.2
GroupE	3.8	±1.1
GroupP	2.9	±0.9
Statistical Test	p-value	
Pvalue(amongall3groups)	0.001*	
Mephentermine vs Ephedrine	0.04*	
Mephenterminevs Phenylephrine	0.0008*	
Ephedrine vs Phenylephrine	0.03*	

Group Mhad the longest recovery time (4.6± 1.2 minutes), followed by Group E(3.8±1.1minutes), while Group P had the shortest recovery time (2.9±0.9minutes). The overall difference between the three groups was highly significant (p = 0.001), indicating that the type of vasopressor significantly influenced recovery duration. Mephentermine vs Ephedrine: p = 0.04 (significant), Mephentermine vs Phenylephrine:p=0.0008 (highly significant), Ephedrine vs Phenylephrine: p = 0.03 (significant).

These results suggest that Phenylephrine facilitates faster recovery, while Mephentermine is associated with prolonged recovery time. This could be due to differing pharmacodynamic profiles, with phenylephrine's shorter duration of action contributing to quicker hemodynamic normalization post-procedure.

Table 13: APGAR Scores at 1 and 5 Minutes

APGAR score	Group M	Group P	Group E
At1min	7.6±0.4	7.7±0.6	7.8±0.7
At5min	8.5±0.6	8.4±0.5	8.6±0.7
p-value	At1min	At5min	
Between3 Groups (ANOVA)	0.139	0.012	
Mephenterminevs Ephedrine	0.401	0.326	
Mephenterminevs Phenylephrine	0.051	0.055	
Ephedrine vs Phenylephrine	0.269	0.005	

The comparison of APGAR scores at 1 and 5 minutes among the three groups—Mephentermine (GroupM), Phenylephrine (Group P), and Ephedrine(Group E)—showed:

At 1 minute, all groups had comparable APGAR scores (ranging from 7.6 to 7.8), with no statistically significant difference (p=0.139). Pairwise comparisons were also non-significant, although Mephentermine vs Phenylephrine approached borderline significance (p = 0.051).

At 5minutes, the difference became statistically significant (p=0.012), withthe highest score in the Ephedrine group (8.6 ± 0.7) and the lowest in the Phenylephrine group (8.4 ± 0.5).

Ephedrine vs Phenylephrine was significantly different (p = 0.005), indicating better neonatal adaptation at 5 minutes with ephedrine.

Otherpairwise comparisons (Mvs E and MvsP) were not statistically significant.

In summary, while all groups showed good APGAR scores overall, Ephedrine resulted in slightly better neonatal outcomes at 5 minutes, possibly due to more stable maternal hemodynamics.

Table 14: Umbilical Arterial Blood Gas Parameters

Parameter	Group M	Group E	Group P	p-value
Ph	7.26±0.04	7.24±0.05	7.30±0.03	0.001*
pCO□(mmHg)	42.5± 4.1	45.2± 5.3	39.8± 3.6	0.002*
HCO□□(mmol/L)	21.8± 2.2	22.1± 2.5	20.5± 1.9	0.045*
Parameter	Mephentermine vs Ephedrine	Mephentermine vs Phenylephrine	Ephedrine vs Phenylephrine	
pH	0.2077	0	0	
pCO2	0.0301	0.0418	0.0002	
HCO3	0.1049	0.0064	0.0001	Group P

The comparison of umbilical arterial blood gas parameters among the three groups—Mephentermine (GroupM), Ephedrine (GroupE), and Phenylephrine (Group P)—revealed several statistically significant findings:

pH levels were highest in Group P (7.30 ± 0.03), indicating better acid-base status in neonates born to mothers who received phenylephrine. The overall p value was highly significant (p = 0.001), with pairwise comparisons showing:

Phenylephrinev s Mephentermine and Phenylephrine vs Ephedrine both highly significant (p = 0.000), suggesting better fetal oxygenation. Mephentermine vs Ephedrine showed nosignificant difference (p=0.2077).

pCO_2 values were lowest in Group P(39.8 ±3.6 mmHg) and highest in Group E (45.2 ± 5.3 mmHg), with significant overall variation (p = 0.002). Pair wise comparisons indicated: Ephedrine vs Phenylephrine was highly significant (p = 0.0002), Both Mephentermine vs Ephedrine (p = 0.0301) and Mephentermine vs Phenylephrine (p = 0.0418) were also statistically significant.

HCO_3^- levels were significantly lower in Group P (20.5±1.9mmol/L) compared to others, though all values remained within acceptable physiological limits. The overall difference was statistically significant (p = 0.045), especially: Between Phenylephrine and Ephedrine(p=0.0001) And Phenylephrine and Mephentermine (p=0.0064).

Phenylephrine (Group P) demonstrated superior fetal acid-base status, with significantly better pH and lower pCO_2 , indicating less fetal acidosis and improve dgas exchange. This supports the notion that phenylephrine provides better utero placental perfusion, though it's maternal bradycardia effect should be monitored.

DISCUSSION

This was a prospective comparative clinical study conducted over a period of one year in the Department of Anaesthesia, Kurnool Medical College, Kurnool. The study included parturients undergoing elective and emergency lower segment cesarean sections. A total of 90 patients were randomly divided into three groups of 30 each. Group 1 received Inj. Mephentermine 6 mg IV bolus, Group 2 received Inj. Ephedrine 6 mg IV bolus, and Group 3 received Inj. Phenylephrine 100 µg IV bolus. The study aimed to compare the hemodynamic and neonatal effects of these vasopressors. The study aimed to analyze the age distribution of patients in three groups: Ephedrine (Group E), Mephentermine (Group M), and Phenylephrine (Group P).

Age

The majority of patients were aged between26-30 years, with the21-25 years group comprising 27.78% of the total sample. The age distribution was fairly uniform across the three groups, with no significant differences in age distribution. The comparison of

mean weight among the three groups revealed statistically significant differences. Group E had the highest mean weight (66.67 ± 6.33 kg), followed by Group M (Mephentermine) at 62.70 ± 4.72 kg, and Group P (Phenylephrine) with the lowest mean of 61.33 ± 5.54 kg. This is similar to other studies.

In Dr. Kamalakannan's study,13the age distribution among the three groups (Group I, II, III) was statistically similar, with no significant difference ($p = 0.52$). The mean ages ranged from 24.1 to 25.0 years across groups, and standard deviations were also comparable. Median ages were nearly identical, and age ranges overlapped. Pair wise comparisons confirmed no significant differences between any two groups.

Weight and Height

The overall mean weight across all groups was 63.57±5.96 kg. The comparison of mean height among the three groups revealed a notable height disparity, particularly between Ephedrine and the other two groups. Post-hoc comparisons showed significant differences between Mephentermine and Ephedrine and between Ephedrine and Phenylephrine, while the difference between Mephentermine and Phenylephrine was not statistically significant. This highlights a notable height disparity particularly between Ephedrine and the other two groups, which may need consideration in further outcome analyses.

Sensory block

The distribution of maximum sensory block level was also examined. The study found that the maximum sensory block level was significantly higher in the Ephedrine group than in the other groups. This suggests that the Ephedrine group may have a more significant effect on the overall sensory block level than the other groups. In conclusion, the study provides valuable insights into the age distribution, weight distribution, and maximum sensory block levels of patients in a study. These findings can help inform future research and treatment strategies for patients with epilepsy. The study compared the effects of phenylephrine, ephedrine, and mephentermine on the distribution of maximum sensory block levels. The most common sensory block level was T5 (34.44%), followed by T6 (27.78%) and T4 (25.56%), with T7 being the least frequent (12.22%).Within the groups,T4 was most frequent in Group M(11.11%) and Group P (10.00%), while Group E had a higher incidence at T5 (13.33%). Chi-square analysis showed no statistically significant difference between the groups regarding sensory block level.

Hypotension

The time to develop hypotension was also similar across the three groups.The majority of hypotensive episodes occurred at 2minutes (57.78%), with Group E having the highest frequency at this time point (23.33%). At 4 minutes, 31.11% of patients developed hypotension, most notably in Group P (14.44%). A smaller proportion of cases developed hypotension at 6 minutes (7.78%), primarily in Group M. Chi-square analysis revealed no statistically significant difference in the timing of hypotension between the groups.

Heart rate

The comparison of heart rate among the three vasopressor groups—Phenylephrine (Group P), Ephedrine (Group E), and Mephentermine (Group M)—revealed statistically significant differences across various time intervals, particularly fromthe8-minute mark onward. Group P consistently demonstrated. lower heart rates compared to the othertwo groups, with p-values < 0.001 at most intervals, indicating a highly significant reduction. This bradycardic effect observed with phenylephrine aligns with its pure α-adrenergicagonist mechanism, which induces reflex bradycardia through barorecept or-mediated vagal activation in response to vasoconstriction.14 In contrast, Ephedrine maintained the highest average heart rates, followed closely by Mephentermine. These agents possess mixed α and β-adrenergic activity, with β_1 stimulation contributing to increased heart rate and cardiac output. Pair wise comparisons between Phenylephrine vs Ephedrine and Phenylephrine vs Mephentermine were consistently significant from 8 minutes to 30 minutes ($p<0.001$), affirming the pronounced heart rate-suppressing effect of phenylephrine. However, comparisons between Ephedrine and Mephentermine were not statistically significant at most intervals, indicating similar trends in heart rate response between these two agents.

In conclusion, phenylephrine induces a sustained decrease in heart rate due to its strong α-agonist effect, whereas ephedrine and mephentermine produce more stable or elevated heart rates, making them preferable in patients where preserving cardiac output is essential. However, phenylephrine's heart rate-lowering effect may bebeneficial in select clinical situations, particularly where reflext achycardianeedsto be avoided.

Systolic blood pressure (SBP)

In the present study, the systolic blood pressure (SBP) at the baseline (0 minutes)was statistically comparable across all three groups—Phenylephrine(Group P), Ephedrine (Group E), and Mephentermine (Group M)—with a p-value of 0.375, indicating no significant difference before drug administration. However, notable variations in SBP emerged during subsequent time intervals. At the 4-minute mark, Group P (Phenylephrine) demonstrated a significantly higher systolic pressure than both Group E and Group M, highlighting an early hypertensive response typically associated with the potent vasoconstrictive action of phenylephrine.

Interestingly, this initial spike in SBP with phenylephrine did not persist. From the 10-minute interval onward, Group P exhibited a significant decline in systolic pressure compared to the other two groups. Between 10 and 16 minutes, both the Ephedrine and Mephentermine groups maintained relatively higher and more stable SBP values, whereas the phenylephrine group showed a

downward trend. This suggests that while phenylephrine rapidly elevates SBP shortly after administration, its effect diminishes faster than that of ephedrine or mephentermine. By18minutes and beyond, no statistically significant differences in SBP were observed among the three groups, indicating a return to hemodynamic equilibrium across all treatment arms.

These findings show partial agreement with previous research. Sushree Das reported that although there was a rise in systolic blood pressure following drug administration in all groups, the changes did not lead to statistically significant long-term differences. Annet That al56also observed that systolic blood pressure fluctuated slightly across groups, with phenylephrine showing higher readings at some points.

Diastolic blood pressure (DBP)

In the current study, diastolic blood pressure (DBP) readings at baseline (0 minutes) were found to be statistically comparable across all three groups—Phenylephrine (Group P), Ephedrine(Group E), and Mephentermine (Group M)—with no significant variation noted ($p = 0.145$). However, a significant rise in DBP was observed in Group Pat 4 and 6 minutes post-administration of the drug. Specifically, phenylephrine produced a marked increase in DBP compared to both ephedrine and mephentermine ($p < 0.001$ and $p = 0.003$, respectively), which highlights its potent vasoconstrictive effect in the early postoperative period.

Beyondthe8-minutemark, although DBP values in Group P remained slightly higher on average, the differences among the three groups were no longer statistically significant. This suggests that the initial hypertensive effect of phenylephrine begins to normalize as time progresses. By the 30-minute interval, DBP levels had equalized across all groups ($p = 0.977$), indicating that hemodynamic profiles of all three vasopressors became comparable during the later postoperative phase.

These findings are supported by previous studies. Ann et That al also observed that DBP was slightly higher in the phenylephrine group at various time intervals, though the differences were not statistically significant,with p-values ranging from 0.08 to0.23.Similarly, Sushree Das15reported a significant post-administration rise in DBP, especially pronounced in the phenylephrine group, while ephedrine and mephentermine induced more moderate and stable elevations. Notably, both studies agreed that there was no significant difference in DBP at baseline among the groups and that the overall DBP response to ephedrine and mephentermine was comparable throughout.

In summary, while phenylephrine caused a sharper and earlier rise in DBP, particularly during the initial 6 minutes, all three drugs demonstrated a trend toward hemodynamic equilibrium in the later phases of observation, with no significant long-term differences in diastolic pressure.

Mean arterial pressure (MAP): The mean arterial pressure (MAP) values across all groups converged by 30 minutes, indicating similar hemodynamic profiles in the later postoperative phase. At 4 and 6 minutes, Group P had significantly higher DBP than both Ephedrine and Mephentermine, indicating the potent vasoconstrictive effect of phenylephrine. In conclusion, phenylephrine has a potent vasoconstrictive effect on blood pressure and MAP over time. However, it is important to note that these findings may not be applicable to other types of medications or conditions.

The study aimed to analyze the effects of phenylephrine and ephedrine on the mean arterial pressure (MAP) in patients. The results showed that phenylephrine caused an early sharp rise in MAP, while ephedrine maintained more consistent elevations. Mephentermine initially resulted in lower MAP but catchesuplater. The comparison of vasopressor bolus requirements across the three groups—Phenylephrine (Group P), Ephedrine (Group E), and Mephentermine (Group M)—showed statistically significant differences.The majority of patients in all groups required 5 or more boluses, especially in Group P (50%), compared to 40% in both Groups E and M. Group P also had the highest mean bolus count (4.07 ± 1.20), indicating greater vasopressor need.

Chi-square analysis revealed a highly significant difference between the groups ($\chi^2=31.19, p<0.00001$).Pair wise comparisons showed that Mephentermine was the most efficient interms of lower bolus requirement, closely followed by Ephedrine.This indicates better hemodynamic stability with Mephentermine and Ephedrine compared to Phenylephrine.

Their findings align closely with the present study, reinforcing the idea that while phenylephrine quickly restores blood pressure, it may not maintain it as consistently as the other two agents.

Annet Thatal16observed that ephedrine and mephentermine maintained more stable systolic and diastolic pressures over time, with fewer bolus requirements.They reported similar MAP responses among the three agents in the long term but emphasized the greater frequency of intervention required with phenylephrine. This also aligns with the current study's conclusion that phenylephrine's rapid but short-lived action necessitates repeated dosing.

The present study's findings, when viewed alongside those of Sushree Das, AnnetThat al, 16 and Singh etal., consistently suggest that: Phenylephrine causes a rapid spikeinMAP but requires more frequent dosing. Ephedrine provides moderate, sustained BP control with fewer interventions. Mephentermine is the most efficient vasopressor with the least bolus requirement and good MAP maintenance.

This comparative evidence highlights that while phenylephrine is effective in rapidly correcting hypotension, ephedrine and mephentermine are better choices for sustained blood pressure

management with fewer bolus interventions during spinal anesthesia in cesarean deliveries.

Side effects: In the present study, side effects were observed in all three vasopressor groups, with significant differences in frequency and severity. The Phenylephrine group (Group P) required the highest number of bolus doses, reflecting a greater vasopressor requirement likely due to its short duration of action. In contrast, Mephentermine (Group M) emerged as the most efficient agent, requiring the least number of boluses, followed closely by Ephedrine (Group E). This suggests that Mephentermine and Ephedrine offer superior hemodynamic stability compared to Phenylephrine. When comparing cardiovascular side effects, tachycardia was most prevalent in the Ephedrine group (30%), followed by Phenylephrine (13.3%)and least in Mephentermine(3.3%).Bradycardia, consistent with the alpha-agonist mechanism of Phenylephrine, was significantly more frequent in the Phenylephrine group ($p = 0.02$). Nausea and vomiting were also more common in the Ephedrine group (26.7% and 20%, respectively), while Mephentermine had the lowest overall incidence of side effects. Shivering and headache occurred with similar frequency across all groups and did not show statistical significance, indicating these symptoms were likely unrelated to the choice of vasopressor.

The mean time to recovery from hypotension varied notably among the groups. Phenylephrine achieved the fastest recovery (2.9±0.9minutes), followed by Ephedrine (3.8±1.1minutes),and Mephentermine had the longest recovery time(4.6 ±1.2 minutes).Despite its rapid action, Phenylephrine's short-lived effect necessitated more frequent dosing, supporting the observed higher bolus requirement. Comparisons with previous studies corroborate these findings. Sushree Das et al.also reported higher bradycardia incidence with Phenylephrine and more tachycardia and nausea with Ephedrine, with Mephentermine showing the best overall tolerability. Similarly, Annet Thatal et al. found that Mephentermine was associated with stable hemodynamics and fewer sideeffects, while Phenylephrine and Ephedrine had higher rates of bradycardia and tachycardia, respectively.

Studies by Ngan Kee et al.further support the curren tfindings, noting that while Phenylephrine preserves fetal acid-base status well, it can significantly reduce maternal heart rate and cardiac output.Although Mephentermine was not assessed in Ngan Kee's trials, other Indian studies like Singh et al. (2019)14highlighted Mephentermine's favorable profile in terms of fewer boluses, fewer side effects, and sustained blood pressure control. Overall, the current study and supporting literature suggest that while Phenylephrine is effective for rapid correction of hypotension, Mephentermine and Ephedrine provide more consistent maternal stability with fewer adverse effects, making them preferable for sustained management during spinal anesthesia in obstetric settings

APGAR scores: In the present study, APGAR scores at 1 minute were comparable among the three groups—Phenylephrine, Ephedrine, and Mephentermine—showing no statistically significant difference, which indicates similar immediate neonatal well-being following cesarean delivery under spinal anesthesia. However, by 5 minutes, a statistically significant difference was observed. The Ephedrine group demonstrated

The highest average 5-minute APGAR score (8.6±0.7), while the Phenylephrinegroup had the lowest (8.4±0.5). The difference between Ephedrine and Phenylephrine was significant, suggesting better neonatal adaptation with ephedrine. This may be attributed to ephedrine's mixed α and β-adrenergic activity, which maintains better uteroplacental blood flow, in contrast to the pure α-agonistaction of phenylephrine that can cause uterine vasoconstriction, potentially reducing fetal oxygen delivery.

In summary, while all three vasopressors maintain acceptable neonatal outcomes, ephedrine appears to be superior in supporting better 5-minute APGAR scores, likely due to its favorable impact on uteroplacental circulation. Phenylephrine, though effective in controlling maternal hypotension, may require closer monitoring to avoid subtle compromises in neonatal perfusion.

Umbilical arterial blood gas parameters: The analysis of umbilical arterial blood gas parameters in the present study demonstrated statistically significant differences among the three vasopressor groups. The pH was highest in the Phenylephrine group (7.30 ± 0.03), followed by Mephentermine and Ephedrine, suggesting better neonatal acid-base status with phenylephrine. Pair wise comparisons confirmed that the differences between Phenylephrine vs Mephentermine and Phenylephrine vs Ephedrine were statistically significant, indicating improved fetal oxygenation and reduced acidosis in neonates whose mothers received phenylephrine during spinal anesthesia. Despite concerns about its alpha-agonist–mediated uterine vasoconstriction, this finding implies that phenylephrine can preserve neonatal acid-base balance effectively when hypotension is well managed.

Additionally, bicarbonate (HCO_3^-) levels were significantly lower in the Phenylephrine group (20.5±1.9mmol/L) compared to Ephedrine and Mephentermine, thoughall values remained withinthe normal physiological range.A lower bicarbonate level in this context may reflect a compensated respiratory or mild metabolic adjustment, yet does not necessarily indicate fetal distress. This further supports the notion that phenylephrine can provide favorable neonatal biochemical outcomes, although its maternal side effects—particularly bradycardia—may limit its overall clinical preference.

These findings are supported by previous literature. Ngan Kee et al. (2010) demonstrated that neonates born to mothers receiving phenylephrine had

significantly higher umbilical arterial pH compared to those who received ephedrine,attributing this to more effective blood pressure control and reduced fetal acidosis. Similarly, Saravanan et al.(2006)17found better fetala cid-base profiles with phenylephrine, though at the cost of increased maternal bradycardia. In contrast, ephedrine, while maintaining cardiac output, has been linked to higher fetal base deficits and lower pH, possibly due to increased placental metabolism or less precise blood pressure control. The current study aligns well with these observations, reinforcing the idea that phenylephrine, when titrated appropriately, offers the most favorable biochemical outcomes for neonates, even though clinical decisions must balance maternal side effects and bolus frequency.

CONCLUSION

This study comprehensively compared the effects of phenylephrine,ephedrine, and mephentermine on maternal hemodynamics and neonatal outcomes. Mephentermine and ephedrine provided better hemodynamic stability with fewer bolus requirements and lower incidence of adverse effects. Phenylephrine, though associated with more bradycardia and higher bolus need, resulted in better umbilical arterial pH, indicating favorable neonatal acid-base status. Ephedrine yielded the highest APGAR scores at 5 minutes, suggesting better neonatal adaptation. Sensory block levels were significantly higher in the Ephedrine group. No significant age-related demographic differences were observed. Overall, mephentermine showed the best maternal tolerability, while phenylephrine demonstrated superior neonatal perfusion profiles.

The sample size may be insufficient to generalize findings across diverse populations or high-risk pregnancies. The study focused only on elective caesarean sections, limiting applicability to emergency cases. Long-term neonatal outcomes beyond the immediate postnatal period were not assessed. The study did not account for potential confounding factors like maternal comorbidities or placental insufficiency. Blinding was not explicitly mentioned,which may introduce observer bias in assessing subjective outcomes like APGAR scoring.

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