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A Comparative Study of Phenylephrine Hydrochloride and Ephedrine Hydrochloride for Treating Post-Spinal Hypotension in Lower Abdominal Surgeries

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ABSTRACT

Background: Post-spinal hypotension is a common complication during lower abdominal surgeries under spinal anesthesia. This study compares the efficacy of phenylephrine hydrochloride and ephedrine hydrochloride in treating post-spinal hypotension.

Methods: Eighty patients aged 25–45 years with ASA physical status I or II, scheduled for elective lower abdominal surgeries under spinal anesthesia, were randomized into two groups. Group P received 100 µg intravenous phenylephrine, and Group E received 6 mg intravenous ephedrine upon a 30% drop in systolic blood pressure (SBP) from baseline. Hemodynamic parameters were recorded at specific intervals intraoperatively and postoperatively.

Results: Phenylephrine restored SBP more rapidly than ephedrine ($p<0.001$). However, phenylephrine was associated with significant bradycardia compared to ephedrine ($p<0.001$). Side effects such as headache and bradycardia were more prevalent in the phenylephrine group, whereas nausea and vomiting were more common in the ephedrine group.

Conclusion: Both phenylephrine and ephedrine are effective in managing post-spinal hypotension. Phenylephrine restores blood pressure more rapidly but has a higher incidence of bradycardia. Ephedrine maintains heart rate better but is less effective in rapidly increasing blood pressure.

Keywords: *Post-spinal hypotension, phenylephrine hydrochloride, ephedrine hydrochloride, spinal anesthesia, lower abdominal surgery.*

1. INTRODUCTION

Spinal anesthesia is widely favored for lower abdominal, perineal, obstetric, gynecological, and lower extremity surgeries due to its advantages such as ease of administration, reduced airway manipulation, decreased stress response, and lower incidence of postoperative respiratory complications [1]. Despite these benefits, spinal anesthesia is frequently associated with hypotension, defined as a systolic blood pressure (SBP) less than 90 or 100 mmHg or a 20% decrease from baseline [2].

Post-spinal hypotension occurs in up to 70–80% of patients if prophylactic measures are not employed [3]. The severity of hypotension depends on factors like block height, patient positioning, and intravascular volume status [4]. Untreated hypotension can lead to inadequate organ perfusion and adverse outcomes, making prompt management essential [5].

Vasopressors are the mainstay in treating spinal-induced hypotension. Ephedrine, a mixed alpha and beta-adrenergic agonist, increases heart rate and cardiac output but may cause fetal acidosis when used in obstetric patients [6]. Phenylephrine, a pure alpha-1 adrenergic agonist, increases systemic vascular resistance and may induce reflex bradycardia [7].

The choice between phenylephrine and ephedrine remains controversial, with studies showing varying degrees of efficacy and side effects [8]. This study aims to compare the effectiveness of phenylephrine hydrochloride and ephedrine hydrochloride in managing post-spinal hypotension in patients undergoing lower abdominal surgeries.

2. MATERIALS AND METHODS

Study Design

This analytical and observational study was conducted at PES Institute of Medical Sciences and Research, Kuppam, Andhra Pradesh from February 2021 to June 2022 after obtaining institutional ethics committee approval and written informed consent from all participants.

Patient Selection

Inclusion Criteria:

1. Patients aged 25–45 years.
2. ASA physical status I and II.
3. Undergoing elective lower abdominal surgeries under spinal anesthesia.
4. Both male and female patients.

Exclusion Criteria:

1. Patient refusal.
2. ASA physical status III and IV.
3. History of hypotension or cardiovascular diseases.
4. Patients on beta-blockers or with arrhythmias.
5. Bleeding disorders or on anticoagulant therapy.
6. Severe anemia or cerebrovascular disease.

Randomization and Grouping

Eighty patients were randomized into two groups of 40 each:

- **Group P:** Received 100 µg intravenous phenylephrine hydrochloride.
- **Group E:** Received 6 mg intravenous ephedrine hydrochloride.

Randomization was done using a lottery method by an anesthesiologist not involved in the study.

Anesthesia Technique

All patients were premedicated with oral alprazolam 0.5 mg two hours before surgery. Preloading was done with Ringer's lactate solution 10 mL/kg one hour prior to spinal anesthesia.

Spinal anesthesia was administered at the L2-L3 interspace using a 25G Quincke needle with 0.5% bupivacaine heavy, dosed according to the patient's weight.

Monitoring and Data Collection

Hemodynamic parameters including SBP, diastolic blood pressure (DBP), mean arterial pressure (MAP), heart rate (HR), and oxygen saturation (SpO_2) were recorded preoperatively, immediately after spinal anesthesia, and at intervals of 1, 2, 3, 5, 10, 20, 30, 45, and 60 minutes intraoperatively.

Upon a 30% decrease in SBP from baseline, patients received the allocated vasopressor. Hemodynamic parameters were then recorded at 1, 2, 3, and 5 minutes after administration.

Statistical Analysis

Data were analyzed using SPSS version 20. Continuous variables were expressed as mean ± standard deviation, and categorical variables as percentages. Independent t-test and chi-square test were used for inferential statistics. A p-value <0.05 was considered statistically significant.

3. RESULTS

Demographic Data

There were no significant differences between the two groups regarding age, gender, baseline SBP, DBP, MAP, and HR ($p>0.05$).

Hemodynamic Parameters

Intraoperative Blood Pressure

- **1 Minute After Vasopressor Administration:** Group P had significantly higher SBP (148.3 ± 16.0 mmHg) compared to Group E (112.1 ± 9.3 mmHg, p<0.001).
- **3 Minutes After Vasopressor Administration:** SBP remained higher in Group P (138.0 ± 11.7 mmHg) versus Group E (114.2 ± 8.8 mmHg, p<0.001).

Heart Rate

- **1 Minute After Vasopressor Administration:** Group P showed significant bradycardia (58.6 ± 7.5 bpm) compared to Group E (85.3 ± 10.1 bpm, p<0.001).
- **Throughout Intraoperative Period:** Group P consistently had a lower HR than Group E (p<0.001).

Side Effects

- **Phenylephrine Group:** Higher incidence of bradycardia (67.5%) and headache (22.5%).
- **Ephedrine Group:** Higher incidence of nausea (12.5%) and vomiting (10%).
- **No Side Effects:** Observed in 77.5% of patients in Group E compared to 2.5% in Group P.

TABLES AND FIGURES

TABLE 1: DEMOGRAPHIC DATA

Parameter	Group P (n=40)	Group E (n=40)	p-value
Age (years)	34.2 ± 5.8	33.5 ± 6.1	0.57
Gender (M/F)	9/31	5/35	0.24
Weight (kg)	68.5 ± 7.2	69.3 ± 8.1	0.63
ASA I/II	28/12	30/10	0.61

TABLE 2: COMPARISON OF SBP BETWEEN GROUPS AT VARIOUS INTERVALS.

Time Interval	Group P SBP (mmHg)	Group E SBP (mmHg)	p-value
Baseline	119.8 ± 10.3	117.6 ± 12.2	0.386
1 min after vasopressor	148.3 ± 16.0	112.1 ± 9.3	<0.001*
3 min after vasopressor	138.0 ± 11.7	114.2 ± 8.8	<0.001*

(*Statistically significant)

There were no significant differences between the two groups regarding age, gender, baseline SBP, DBP, MAP, and HR (p>0.05).

Hemodynamic Parameters

Intraoperative Blood Pressure

- **1 Minute After Vasopressor Administration:**

TABLE 3: SBP COMPARISON AT 1 MINUTE POST-VASOPRESSOR

Time Interval	Group P SBP (mmHg)	Group E SBP (mmHg)	p-value
Baseline	119.8 ± 10.3	117.6 ± 12.2	0.386
1 min post	**148.3 ± 16.0**	**112.1 ± 9.3**	**<0.001**

Phenylephrine significantly increased SBP compared to ephedrine.

- **3 Minutes After Vasopressor Administration:**

TABLE 4: SBP COMPARISON AT 3 MINUTES POST-VASOPRESSOR

Time Interval	Group P SBP (mmHg)	Group E SBP (mmHg)	p-value
3 min post	**138.0 ± 11.7**	**114.2 ± 8.8**	**<0.001**

The elevated SBP in Group P remained significant at 3 minutes.

Heart Rate

- **1 Minute After Vasopressor Administration:**

TABLE 5: HR COMPARISON AT 1 MINUTE POST-VASOPRESSOR

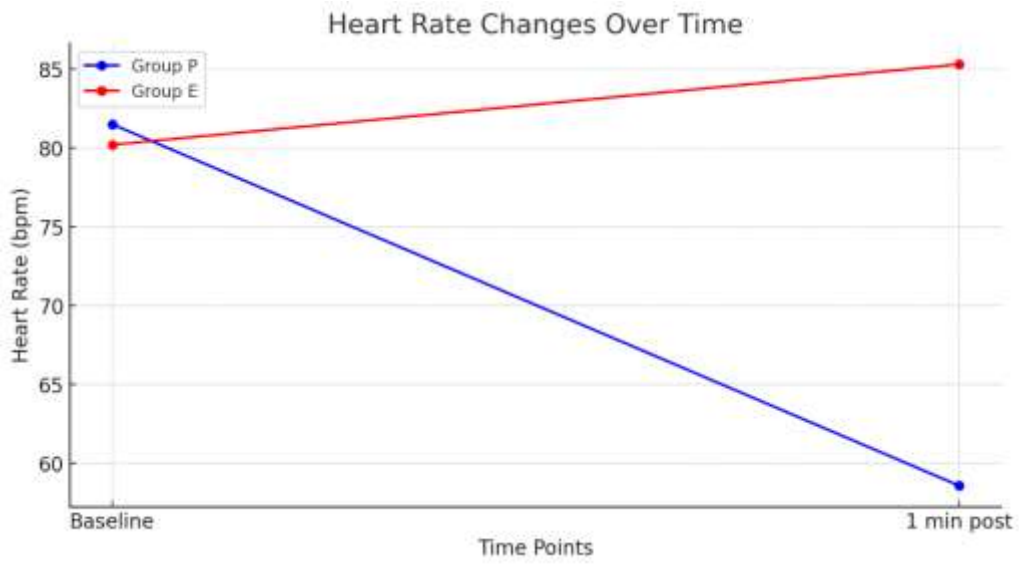
Time Interval	Group P HR (bpm)	Group E HR (bpm)	p-value
Baseline	81.5 ± 3.3	80.2 ± 3.3	0.082
1 min post	**58.6 ± 7.5**	**85.3 ± 10.1**	**<0.001**

Phenylephrine caused significant bradycardia compared to ephedrine.

- **Throughout Intraoperative Period:**

Heart rate remained significantly lower in Group P at all intraoperative time points ($p<0.001$).

FIGURE 1: HEART RATE CHANGES OVER TIME



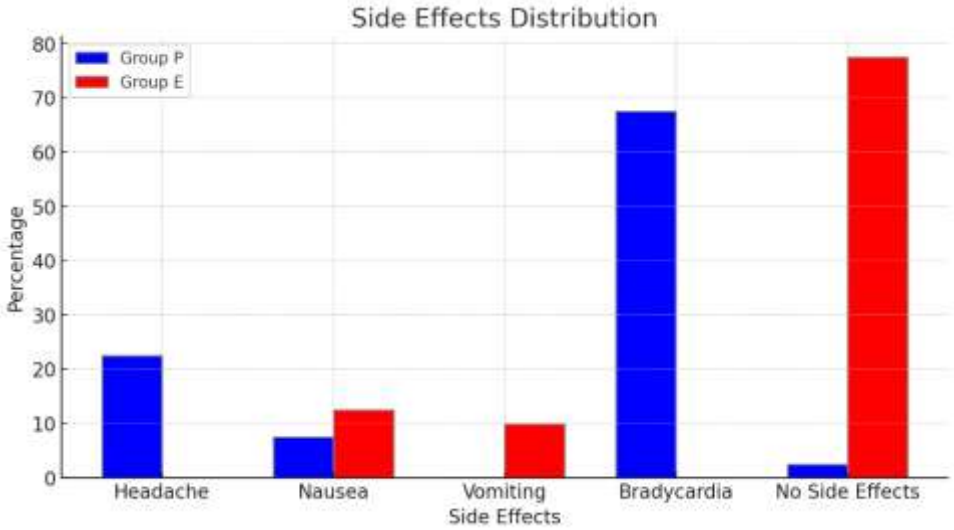
Side Effects

TABLE 6: INCIDENCE OF SIDE EFFECTS

Side Effect	Group P (n=40)	Group E (n=40)	p-value
Headache	9 (22.5%)	0 (0%)	0.002
Nausea	3 (7.5%)	5 (12.5%)	0.46
Vomiting	0 (0%)	4 (10%)	0.04
Bradycardia	27 (67.5%)	0 (0%)	<0.001
No Side Effects	1 (2.5%)	31 (77.5%)	<0.001

- Phenylephrine group had a higher incidence of headache and bradycardia.
- Ephedrine group experienced more nausea and vomiting.

FIGURE 2: SIDE EFFECTS DISTRIBUTION



Cost Analysis

TABLE 7: COST COMPARISON

Medication	Cost per Ampoule (INR)
Phenylephrine (100 µg)	325
Ephedrine (6 mg)	33

Phenylephrine is significantly more expensive than ephedrine.

4. DISCUSSION

This study compared the efficacy of phenylephrine and ephedrine in managing post-spinal hypotension among patients undergoing lower abdominal surgeries. Our findings suggest that phenylephrine demonstrated a more rapid restoration of systolic blood pressure (SBP) compared to ephedrine, aligning with the observations of previous investigations [9]. The immediate elevation in SBP with phenylephrine can be attributed to its pharmacodynamic profile as a pure alpha-1 adrenergic agonist. By selectively targeting alpha-1 receptors in the vascular smooth muscle, phenylephrine induces potent vasoconstriction, thereby increasing peripheral vascular resistance and ensuring a swift elevation in blood pressure [10]. This characteristic makes it a reliable first-line choice in scenarios requiring prompt correction of hypotension.

Despite the clear hemodynamic advantage observed with phenylephrine, our study also noted a significant incidence of bradycardia among patients receiving this agent. The development of bradycardia is likely a consequence of baroreceptor-mediated reflexes responding to the sudden increase in blood pressure [11]. As the systemic vascular resistance rises and blood pressure climbs, the baroreceptors in the carotid sinus and aortic arch trigger a reflex slowing of the heart rate to maintain homeostasis. While this reflex is physiologically adaptive, it can be clinically undesirable, particularly if the patient's heart rate becomes uncomfortably low, reducing cardiac output. In clinical practice, vigilance is warranted when administering phenylephrine, and anesthesiologists may consider co-administration of anticholinergic agents to counteract reflex bradycardia [12]. This approach ensures that the therapeutic benefits of phenylephrine are retained without compromising hemodynamic stability.

Ephedrine, on the other hand, provides a more balanced hemodynamic profile. As a mixed alpha and beta agonist, it not only increases vascular resistance but also enhances cardiac contractility and, to some extent, heart rate. This beta-mediated effect can help maintain a relatively stable heart rate, making ephedrine a suitable choice for patients who are more susceptible to bradycardia. However, our analysis showed that ephedrine was less effective in rapidly increasing SBP. This may be due to its indirect mechanisms of action, as ephedrine primarily works by releasing endogenous norepinephrine, which may be less predictable and slower in onset compared to the direct receptor stimulation achieved by phenylephrine.

Moreover, ephedrine's mode of action can have additional drawbacks. The increased incidence of nausea and vomiting observed in our study's ephedrine group may be attributed to its central nervous system stimulant effects [13]. While this side effect profile may not be severe in all patients, it can compromise patient comfort and satisfaction, as well as potentially lead to secondary complications such as aspiration in vulnerable individuals.

Another practical consideration is cost. Our cost analysis indicated that phenylephrine is approximately ten times more expensive than ephedrine, a finding that may have implications in settings where financial resources are constrained [14]. Thus, while phenylephrine offers rapid correction of hypotension and predictable hemodynamic effects, its high cost and propensity to cause bradycardia necessitate judicious use. In contrast, while ephedrine is more affordable and less likely to cause severe bradycardia, its slower onset and higher incidence of nausea may limit its appeal.

5. LIMITATIONS

Several limitations should be acknowledged. First, the sample size in this study was relatively modest, which may affect the generalizability of our findings. Additionally, we did not investigate the long-term outcomes of patients administered these vasopressors or assess the impact of coexisting comorbidities on drug efficacy and side-effect profiles. Future research could focus on larger, more diverse patient populations and investigate potential strategies to mitigate the adverse effects of both phenylephrine and ephedrine.

6. CONCLUSION

Phenylephrine hydrochloride is more effective than ephedrine hydrochloride in rapidly restoring blood pressure in post-spinal hypotension during lower abdominal surgeries but is associated with a higher incidence of bradycardia. Ephedrine maintains heart rate better but is less effective in increasing blood pressure promptly. Clinicians should consider the hemodynamic profiles, side effect profiles, and cost when choosing between these agents.

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