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A Comparative Study Evaluating the Effectiveness of Epidural Volume Expansion with Normal Saline in Combined Spinal Epidural Anesthesia for Infraumbilical Surgeries using Low-Dose Intrathecal Hyperbaric Bupivacaine

Running Title: *Epidural volume expansion in Combined spinal epidural anesthesia*

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Abstract: ***Background*: Combined spinal epidural anesthesia (CSEA) is frequently utilized for infraumbilical surgeries due to its rapid onset and prolonged postoperative pain relief, often enhanced by epidural volume expansion (EVE) with normal saline. Aim: To evaluate the effectiveness of epidural volume expansion with normal saline in combined spinal epidural anaesthesia for infra umbilical surgeries *Materials and Methods*: A prospective randomized comparative study involving 70 ASA grade I and II patients aged 18-59 undergoing elective infraumbilical surgeries, participants were divided into two groups: Group I (CSEA with EVE) and Group II (CSEA without EVE). Key parameters assessed included the onset and duration of sensory and motor blockade, hemodynamic stability, and adverse effects. *Result*: Group I experienced a significantly faster onset of sensory block at the T10 level and a quicker time to maximum motor blockade, along with a longer duration of sensory blockade and analgesia. Both groups maintained stable hemodynamic parameters with no significant differences or severe adverse effects reported. *Conclusion*: EVE with normal saline in CSEA enhances both the onset and duration of sensory and motor blockade while ensuring hemodynamic stability, making it a safe and effective technique for infraumbilical surgeries.***

Keywords: Combined spinal epidural anesthesia, Epidural volume expansion, Infraumbilical surgeries, Low-dose hyperbaric bupivacaine, Hemodynamic stability

1. Introduction

Combined spinal epidural anesthesia (CSEA) has revolutionized the landscape of anesthesia for infraumbilical surgeries, offering a blend of rapid onset, precise titration, and prolonged postoperative analgesia.[1,2] Within the spectrum of CSEA techniques, epidural volume expansion (EVE) stands out as a promising adjunct, augmenting sensory block levels through the controlled infusion of normal saline via the epidural catheter.[2] By integrating the reliability of subarachnoid blockade with the flexibility of continuous epidural anesthesia, EVE empowers clinicians to customize anesthesia depth, modulate block intensity, and extend analgesia duration, thereby enriching the perioperative experience.[3] At its core, EVE operates on the principle of a volume effect, exerting pressure within the intrathecal space to facilitate the cranial dispersion of spinal medications, a phenomenon elucidated by recent research endeavors.[4]

However, despite the promise of EVE, lingering uncertainties persist regarding its efficacy in conjunction with low-dose hyperbaric bupivacaine and its potential ramifications on hemodynamic stability in clinical settings.[3] Through meticulous evaluation of sensory and motor block characteristics, hemodynamic parameters, and potential adverse events, this research furnish valuable insights into the

practical application of EVE, further enriching the armamentarium of contemporary anesthesia practice.

The introduction of novel techniques in anesthesia, such as EVE, not only underscores the continuous evolution of medical practices but also raises critical questions regarding their efficacy and safety profiles in real-world scenarios.[5,1] As anesthesia providers navigate the complexities of patient care, optimizing perioperative outcomes remains paramount, necessitating a nuanced understanding of the intricacies associated with EVE. Moreover, with the burgeoning demand for minimally invasive surgical procedures and enhanced recovery pathways, the role of EVE in facilitating optimal intraoperative conditions and expediting postoperative rehabilitation warrants meticulous examination.[6] Against this backdrop, this study endeavors to bridge existing knowledge gaps surrounding EVE in the context of CSEA, shedding light on its efficacy, safety, and clinical implications in infraumbilical surgeries.

This study seeks to significantly advance the existing body of knowledge on anesthesia techniques by synthesizing a comprehensive review of the relevant literature with robust clinical evidence from empirical investigations. In doing so, it endeavors to inform evidence-based practices and optimize patient outcomes. Thus, this research aims to evaluate the effectiveness of epidural volume expansion with normal saline in combined spinal epidural anaesthesia for infra umbilical surgeries.

2. Materials and Methods

This prospective, randomized, comparative study was carried out at Bapuji Hospital and Chigateri Government Hospital, affiliated with J.J.M. Medical College, Davangere. The study comprised 70 patients (ASA grades I and II) scheduled for elective surgeries under combined spinal-epidural anesthesia between August 2022 and July 2024. Participants included male and female patients aged 18 to 59 years, with a BMI ranging from 18 to 30 kg/m², and heights between 150 and 160 cm. All eligible patients provided informed consent and were classified as ASA physical status I or II. Exclusion criteria encompasses patients with ASA physical status III and IV, those with absolute contraindications to spinal anesthesia such as severe hypovolemia, elevated intracranial pressure, bleeding disorders, local infections, or significant comorbidities like diabetes, hypertension, cerebrovascular, psychiatric, or neurological conditions. Patients with spinal deformities or those who declined to participate were also excluded from the study.

Sample size was calculated utilizing the formula: Sample size $= \frac{2*S^{2*}(Z_{1-\frac{\alpha}{2}}+Z_{1-\beta})^2}{(M_1-M_2)^2}$, Where, S is pooled standard deviation of duration of surgery valued 0.828; $Z_{(1-\alpha/2)}$ is Z value associated at 95% confidence interval valued 1.64; $Z_{(1-\beta)}$ is power of the study (95%) valued 0.84; M1 and M2 are the mean times required to achieve maximum sensory blockade in Groups A and B, which are 4.26 and 4.76, respectively. Consequently, the required sample size was calculated to be 34 participants per group, which was rounded to 35 for each group.

Seventy eligible patients, meeting the selection criteria and providing informed consent, were enrolled and randomly divided into two groups (35 each) for elective surgeries under combined spinal epidural anesthesia. Group I received epidural volume expansion, while Group II did not. The data collection process was meticulously designed for accuracy and reliability. Preoperatively, patients were instructed to fast for 8 hours for solids and 2 hours for clear fluids, and were given standard premedication of Ranitidine (150 mg) and Alprazolam (0.5 mg) the night before surgery to enhance comfort and reduce anxiety. In the operating theater, intravenous (IV) access was established with an 18G cannula, and a preload of 10 ml/kg of Ringer's lactate solution was administered over 20 minutes. Continuous monitoring was conducted using non-invasive blood pressure monitors, pulse oximeters, and 3-lead ECGs. Following strict aseptic protocols, patients were positioned on their left side, with key anatomical landmarks identified to locate the L3-L4 or L4-L5 intervertebral spaces accurately. An epidural catheter was placed at the L2-L3 level using a loss-of-resistance technique, followed by a spinal block at L3-L4 with a 25G Quincke needle, confirmed by the free flow of cerebrospinal fluid (CSF). Subsequently, 2 ml of 0.5% hyperbaric bupivacaine was injected. After securing the epidural catheter, patients were repositioned supine, with Group I receiving a 10 ml saline injection for volume expansion, while Group II did not receive this volume expansion.

The study observed several critical parameters. The onset of the sensory block at the T10 level and motor blockade onset (modified Bromage score of 1) were recorded, alongside the time to attain maximum motor blockade (Bromage score of 3) and time to recover from motor block. The highest sensory block level and its regression by two segments were documented, as well as the total duration of sensory blockade (until sensation at S1 dermatome). Sensory blockade quality was assessed using a pinprick test with a blunt needle, and motor blockade was evaluated with the modified Bromage scale. (Modified Bromage Scale: 0 = no paralysis; 1 = unable to raise an extended leg; 2 = unable to flex the knee;3 = unable to flex the ankle)

Hemodynamic parameters, including Heart Rate (HR), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Mean Arterial Pressure (MAP), and Oxygen Saturation (SpO2), were monitored at 5-minute intervals for the first 30 minutes and then every 15 minutes. Hypotension (SBP drop >30% or below 90 mmHg) was managed with IV fluids and mephentermine, while bradycardia (HR <60 bpm) was treated with 0.6 mg IV atropine. Postoperatively, patients were monitored for analgesia duration and side effects, including hypotension and bradycardia, with any adverse events being treated as necessary. Upon completion of the procedures, data were entered into Microsoft Excel and subsequently analyzed using SPSS version 22. Continuous variables were presented as Mean and Standard Deviation. To assess differences in means between the two groups, an independent samples t-test was employed. A p-value of <0.05 was considered statistically significant.

3. Results

Table 1 presents a comparison of systolic and diastolic blood pressures between Group I and Group II at various time intervals, from baseline to 2 hours post-procedure. At baseline, Group I showed a slightly higher systolic pressure (125.91 mmHg) compared to Group II (125.66 mmHg), with both groups experiencing fluctuations over time. However, Group II generally maintained higher systolic pressures, particularly immediately after the procedure. Diastolic pressure followed a similar pattern, with Group II showing marginally higher values than Group I at baseline (79.71 mmHg vs. 78.71 mmHg) and during several post-procedure intervals. These results indicate that Group I (CSEA with EVE) did not compromise hemodynamic stability, as fluctuations remained within clinically acceptable limits.

Table 1: Comparison of Mean Systolic and Diastolic Blood Pressure between the groups at various time intervals

Timeline	Group	Systolic Blood Pressure			Diastolic Blood Pressure		
		Mean	Std. Error	P value	Mean	Std. Error	P value
Baseline	I	125.91±4.71	0.80	0.78	78.71±5.90	1.00	0.52
	II	125.66±2.68	0.45		79.71±7.03	1.19	
0 mins	I	120.91±4.10	0.69	0.61	77.31±5.66	0.96	0.62
	II	120.51±2.13	0.36		76.69±5.18	0.88	
5 mins	I	121.94±3.90	0.66	0.48	77.89±4.55	0.77	0.38
	II	121.37±2.73	0.46		76.86±5.21	0.88	
10 mins	I	123.71±3.07	0.52	064	76.74±5.84	0.99	0.86
	II	124.00±1.88	0.32		76.51±5.34	0.90	
15 mins	I	125.03±3.54	0.60	0.29	75.77±7.01	1.18	0.86
	II	125.83±2.67	0.45		76.06±7.22	1.22	
20 mins	I	126.74±4.71	0.80	0.17	81.41±7.81	1.34	0.51
	II	127.94±2.09	0.35		80.17±7.92	1.34	
25 mins	I	125.37±6.43	1.09	0.13	83.71±6.90	1.17	0.75
	II	127.37±3.59	0.61		84.23±7.03	1.19	
30 mins	I	122.00±6.06	1.02	0.085	78.57±6.30	1.06	0.60
	II	124.11±3.82	0.65		79.37±6.70	1.13	
45 mins	I	121.71±6.25	1.06	0.13	75.66±5.28	0.89	0.85
	II	123.60±3.81	0.64		75.89±4.92	0.83	
60 mins	I	120.34±5.67	0.96	0.22	72.80±5.34	0.90	0.96
	II	121.83±4.35	0.74		72.74±4.60	0.78	
75 mins	I	118.29±4.15	0.70	0.18	72.51±4.07	0.69	0.24
	II	119.43±2.93	0.50		71.43±3.68	0.62	
90 mins	I	118.40±4.75	0.80	0.15	75.26±6.79	1.15	0.86
	II	119.83±3.34	0.56		75.54±6.69	1.13	
105 mins	I	119.89±5.76	0.97	0.09	76.86±7.86	1.33	0.85
	II	122.00±4.47	0.76		77.20±8.09	1.37	
120 mins	I	120.80±5.34	0.90	0.31	77.20±4.40	0.74	0.34
	II	121.89±3.53	0.60		76.23±4.11	0.69	
> 2 hours	I	122.00±4.83	0.82	0.95	76.91±4.07	0.69	0.19
	II	122.06±3.05	0.52		75.71±3.50	0.59	

Table 2 presents the heart rate and mean arterial pressure (MAP) between the groups at various intervals. At baseline, Group II had a slightly higher heart rate (86.69 bpm) than Group I (85.31 bpm), with both groups showing fluctuations throughout the study. Group I displayed a decreasing heart rate trend, while Group II remained relatively stable. Similarly, MAP at baseline was slightly higher in Group I (72.46 mmHg) compared to Group II (71.54 mmHg), with fluctuations in both groups during the study. No significant differences were observed between the groups for either parameter ($p > 0.05$). Both interventions maintained stable heart rates and MAP within clinically acceptable ranges, suggesting that epidural volume expansion with normal saline does not adversely impact hemodynamic stability compared to standard intrathecal hyperbaric bupivacaine alone.

Table 2: Comparison of Mean arterial Pressure and Heart rate between the groups at various time intervals

Timeline	Group	Mean Arterial Pressure			Heart Rate		
		Mean	Std. Error	P value	Mean	Std. Error	P value
0 mins	I	72.45±4.03	.681	0.25	84.11±4.23	0.71	0.53
	II	71.54±2.33	.393		84.69±3.29	0.56	
5 mins	I	71.54±4.42	.747	0.42	79.77±3.06	0.52	0.50
	II	70.80±3.47	.586		80.17±1.77	0.30	
10 mins	I	70.68±1.99	.337	0.83	75.89±5.84	0.99	0.64
	II	70.57±2.40	.406		76.57±6.52	1.10	
15 mins	I	73.77±2.81	.476	0.86	79.60±4.17	0.70	0.86
	II	73.65±2.58	.437		79.77±4.11	0.69	
20 mins	I	73.77±3.20	.542	0.93	79.89±5.84	0.99	0.96
	II	73.71±2.99	.506		79.83±6.09	1.03	
25 mins	I	76.40±3.59	.606	0.89	80.17±7.68	1.30	0.97

	II	76.51±3.33	.564		80.11±7.85	1.33	
30 mins	I	75.14±3.15	.533	0.73	76.80±4.32	0.73	0.78
	II	75.42±3.77	.638		76.51±4.56	0.77	
45 mins	I	72.00±2.99	.505	0.61	77.49±4.13	0.70	0.50
	II	71.65±2.58	.437		78.17±4.51	0.76	
60 mins	I	72.28±3.60	.608	0.46	79.94±4.01	0.68	0.95
	II	71.71±2.79	.472		80.00±4.00	0.68	
75 mins	I	74.00±3.36	.568	0.30	81.66±4.38	0.74	0.82
	II	73.31±2.05	.347		81.89±4.17	0.71	
90 mins	I	73.91±4.29	.725	0.41	81.71±3.40	0.57	0.93
	II	73.14±3.47	.587		81.66±2.81	0.47	
105 mins	I	74.22±2.26	.382	0.61	75.03±3.19	0.54	0.52
	II	74.57±3.27	.553		75.54±3.60	0.61	
120 mins	I	76.68±3.49	.590	0.36	79.94±1.85	0.31	0.59
	II	77.48±3.79	.642		80.17±1.77	0.30	
> 2 hours	I	71.82±2.96	.501	0.88	80.97±1.77	0.30	0.74
	II	71.94±3.51	.594		81.14±2.49	0.42	

Table 3 represents the oxygen saturation (SpO2) between the groups at various time intervals. At baseline, Group I had a slightly higher mean SpO2 (99.77%) than Group II (99.51%). Both groups exhibited fluctuations in SpO2 levels, but no statistically significant differences were found at any time point ($p > 0.05$). SpO2 levels remained above 95% in both groups, indicating adequate oxygenation throughout the procedure. This suggests that epidural volume expansion with normal saline did not compromise oxygen saturation, making it a viable approach in this context.

Table 3: Comparison of mean SpO2 between the groups at various time intervals

Timeline	Group I Mean ± SD	Group II Mean ± SD	P value
0 mins	99.77±0.42	99.51±0.50	0.16
5 mins	99.60±0.81	99.05±0.99	0.15
10 mins	99.68±0.47	99.51±0.50	0.14
20 mins	99.60±0.60	99.40±0.49	0.13
25 mins	99.42±0.81	99.71±0.62	0.10
30 mins	98.54±0.61	98.80±0.58	0.076
45 mins	99.02±0.16	99.02±0.45	1.0
60 mins	98.94±0.59	98.77±0.73	0.285
75 mins	98.71±1.01	98.25±0.98	0.060
90 mins	98.08±0.78	97.82±0.74	0.16
105 mins	99.11±0.40	98.85±0.42	0.12
120 mins	99.60±0.49	99.62±0.87	0.86
> 2 hours	99.85±0.35	99.85±0.60	1.0

Anesthetic effects between Group I and Group II are represented in Table 4. Group I reached maximum sensory block faster (9.66 vs. 13.80 minutes, $p = 0.0001$) and had longer two-segment regression (73.14 vs. 53.06 minutes, $p = 0.0001$) and sensory level wear-off times (261.34 vs. 128.29 minutes, $p = 0.0001$) compared to Group II. There was no significant difference in motor block onset ($p = 0.081$), but Group I achieved maximum motor block earlier (3.63 vs. 6.26 minutes, $p = 0.0001$). These results suggest that epidural volume expansion with normal saline may impact the onset and duration of anesthetic effects compared to standard intrathecal hyperbaric bupivacaine.

Table 4: Comparison of various anaesthetic effects between the groups

Variable	Group	Mean±SD	Std. Error	P value
Time for Maximum Sensory Block	I	9.65±1.16	.196	0.0001*
	II	13.80±0.86	.146	
Two Segment Regression Time	I	73.14±7.64	1.291	0.0001*
	II	53.05±2.33	.395	
Time for Sensory level wear of till S1	I	261.34±57.87	9.782	0.0001*
	II	128.28±5.46	.924	
Time of onset of Motor Block	I	2.00±0.72	.122	0.081
	II	2.31±0.75	.128	
Time of Maximum Motor Block	I	3.62±0.77	.130	0.0001*
	II	6.25±0.44	.074	
Time to recover from motor block	I	191.86±6.69	1.131	0.0001*
	II	126.69±5.42	1.012	

4. Discussion

This study evaluated the effectiveness of epidural volume expansion (EVE) with normal saline in combined spinal epidural anesthesia for infraumbilical surgeries using low-dose intrathecal hyperbaric bupivacaine. The primary objective was to assess whether this approach could maintain hemodynamic stability and provide effective anesthesia with minimal side effects. Key parameters such as systolic blood pressure, diastolic blood pressure, mean arterial pressure (MAP), heart rate, and oxygen saturation (SpO2) were closely monitored and compared between Group I and Group II.

The findings of this study revealed that Group II exhibited marginally higher SBP values compared to Group I throughout the observation period, though the differences did not reach statistical significance ($P > 0.05$). This observed SBP stability is consistent with previous studies done by Bhandari et al.[7] and Shobhit Singh et al.[8], who demonstrated that EVE with 10 ml of normal saline significantly enhanced hemodynamic stability in infraumbilical surgeries, offering superior SBP maintenance compared to both EVE with 15 ml and the control group. Consequently, these results, in conjunction with prior findings, suggest that EVE with normal saline effectively sustains stable SBP during infraumbilical procedures, thereby mitigating the risk of hypotension and its associated complications.

With regard to heart rate, both groups displayed fluctuations within clinically acceptable parameters though statistically not significant. This heart rate stability is corroborated by Shobhit Singh et al.,[8] who reported that EVE with 10 ml of normal saline had no significant effect on heart rate, maintaining hemodynamic consistency. Similarly, Doganci et al.[9] observed that EVE with normal saline preserved stable hemodynamic parameters, including heart rate, across various surgical settings. The stable heart rate observed in our study underscores the efficacy of EVE with normal saline in maintaining hemodynamic equilibrium without inducing significant bradycardia or tachycardia, critical for ensuring both patient safety and comfort during surgery. Thus, our findings, in alignment with prior studies, indicate that EVE with normal saline is a reliable method for maintaining heart rate stability during infraumbilical procedures without adverse effects.

Also, the present study revealed that both Groups sustained stable MAP readings within clinically acceptable ranges throughout the study, with no statistically significant differences between the groups ($P > 0.05$). This MAP stability aligns with the Shobhit Singh et al.,[8] who demonstrated that EVE with 10 ml of normal saline effectively maintained hemodynamic equilibrium, including MAP, during infraumbilical surgeries. Similarly, Salman et al.[10] highlighted that EVE with normal saline in combined spinal-epidural anesthesia preserved stable MAP levels and mitigated the incidence of significant hypotension. The consistent MAP in our study suggests that EVE with normal saline supports hemodynamic stability by preventing notable blood pressure declines, likely through intravascular volume maintenance and vascular tone regulation.

Regarding SpO2, both groups maintain SpO2 levels above 95%, indicating adequate oxygenation and respiratory stability. While Shobhit Singh et al. [8] did not specifically address SpO2 levels, their broader findings on hemodynamic stability suggest that EVE with normal saline does not impair respiratory function, reinforcing our results. Similarly, Tyagi et al.[11] concluded that EVE with normal saline preserved adequate oxygenation throughout surgical procedures. The maintained SpO2 levels in our study affirm that EVE with normal saline does not compromise respiratory function, a critical factor in ensuring patient safety during anesthesia.

Furthermore, Group I achieved maximum sensory block significantly faster than Group II, suggesting that EVE with normal saline accelerates the onset of sensory block. Additionally, Group I demonstrated a significantly extended duration of sensory block, with prolonged times for two-segment regression and complete sensory regression, indicating an enhanced anesthetic effect. These results align with those reported by Shobhit Singh et al.,[8] who found that EVE with 10 ml of normal saline resulted in both a faster onset and longer duration of sensory block compared to larger volumes of saline and the control group. Similarly, Salman et al.[10] observed that EVE with normal saline during combined spinal-epidural anesthesia resulted in a quicker onset and prolonged duration of sensory block. The improved onset and duration of sensory block in our study may be attributed to the compression of the thecal sac by EVE, facilitating a cephalad spread of the local anesthetic and enhancing its efficacy.

Moreover, Group I exhibited a significantly longer time for sensory level wear-off until S1 compared to Group II, with mean times of 261.34 minutes and 128.29 minutes, respectively ($P = 0.0001$). This extended duration for sensory wear-off until S1 is corroborated by the findings of Shobhit Singh et al.,[8] who noted a significantly longer time for complete sensory regression (S1) with EVE using 10 ml of normal saline compared to larger volumes and the control group. Similarly, Salman et al.[10] found that EVE with normal saline during combined spinal-epidural anesthesia resulted in a prolonged sensory blockade until S1.

Besides, our findings indicated no significant difference in the onset time of motor block between Group I and Group II ($P > 0.05$). However, Group I achieved maximum motor block significantly earlier than Group II ($P = 0.0001$), and the duration of motor block was notably prolonged in Group I ($P = 0.0001$). These observations are consistent with the findings of Shobhit Singh et al.,[8] who reported no significant differences in the onset time of motor block across varying volumes of EVE, while noting that EVE with 10 ml of normal saline led to earlier maximum motor block achievement and an extended duration compared to larger volumes and the control group. Similarly, Doganci et al.[9] found that EVE with normal saline during combined spinal-epidural anesthesia resulted in prolonged motor block duration.

The extended sensory level wear-off and expedited achievement of maximum motor block observed in our study can be attributed to the enhanced spread and uptake of the anesthetic agent facilitated by EVE, resulting in a more extensive and prolonged sensory blockade, as well as a longer duration of motor block.

Furthermore, Group I experienced a significantly longer recovery time from motor block compared to Group II, with mean recovery times of 191.86 minutes and 126.69 minutes, respectively ($P = 0.0001$). This extended recovery time aligns with findings from Shobhit Singh et al.,[8] who reported that EVE with 10 ml of normal saline resulted in a significantly prolonged duration of motor block compared to larger volumes and the control group. Additionally, Goy et al.[12] found that EVE with normal saline during combined spinal-epidural anesthesia led to extended recovery times from motor block. Notably, no adverse side effects were observed in this study.

This study has several limitations. The small sample size may restrict the generalizability of the findings, and conducting the research in a single clinical setting limits applicability to other environments. Additionally, the focus on intraoperative and immediate postoperative outcomes, without long-term follow-up, hinders understanding of the technique's extended effects. Variability in patient demographics and health status may also influence results, and the study did not assess the impact of different fluids for volume expansion, which could provide deeper insights into optimal fluid management during anesthesia.

Despite these limitations, the study offers significant strengths. It provides valuable insights into a practical anesthetic technique that may enhance patient outcomes in infraumbilical surgeries. The detailed monitoring of

hemodynamic parameters improves our understanding of the physiological effects of EVE with normal saline. Furthermore, it highlights the technique's potential to maintain hemodynamic stability and prolong sensory and motor block duration, contributing to overall anesthesia safety and efficacy in this surgical context.

5. Future Scope

Clinicians are encouraged to adopt EVE with normal saline during infraumbilical surgeries to improve hemodynamic stability while prolonging the duration of both sensory and motor blockade. It is essential to pursue further research to investigate the long-term effects of this technique and its applicability across diverse clinical settings and patient demographics. Comparative studies examining various fluid types for volume expansion may yield valuable insights into optimizing fluid management strategies during anesthesia. Additionally, larger multicenter trials are warranted to validate these findings and enhance their generalizability.

6. Conclusion

Thus, the findings of the study elucidate the substantial benefits of utilizing epidural volume expansion with normal saline in promoting hemodynamic stability, notably in systolic blood pressure and mean arterial pressure, while exhibiting no detrimental effects on heart rate or oxygen saturation. Furthermore, this technique effectively extends the duration of both sensory and motor blockade, thereby augmenting the overall efficacy and safety of the anesthetic intervention. These findings strongly endorse the integration of EVE with normal saline as a robust approach to enhance patient outcomes in infraumbilical surgical procedures.

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Conflict of Interest: Nil

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