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Comparison of Mean Time to Regression of Sensory Block in Patients Treated with Sequential Combined Spinal Epidural Anesthesia Vs. Epidural Volume Extension in Patients Undergoing Lower Limb Surgeries

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ABSTRACT

Background: It is now well established that these lower limb surgeries often use techniques of regional anesthesia that include Sequential Combined Spinal Epidural Anesthesia (SCSE) and Epidural Volume Extension (EVE). Both techniques provide effective sensory blockade but there remains interest in the relative effect on sensory regression time, hemodynamic stability, analgesic duration. **Objective:** This study aims to compare SCSE and EVE in terms of mean time to sensory regression, hemodynamic stability, and postoperative analgesia in lower limb surgeries. **Results:** A randomized controlled trial was conducted at the Department of Anesthesiology, Shaheed Zulfiqar Ali Bhutto University of Medical Sciences (PIMS) Islamabad during a period of six months. Sixty patients (ASA I–ll), who were undergoing lower limb surgeries, were randomly allocated to the SCSE and EVE group. The variables included sensory regression time to T12, hemodynamic parameters and duration of analgesia, which were analyzed using SPSS version 26.0. **Conclusions:** EVE had a significantly longer sensory regression time (120 ± 17.39 min) versus SCSE (98 ± 15.35 min; p=0.000). The EVE group had greater hemodynamic stability with fewer patients experiencing significant fluctuations in heart rate and systolic blood pressure compared to the SCSE group. Analgesia was comparable between both the techniques with duration of analgesia (143 min in EVE vs 134 min in SCSE, p=0.104). EVE allows a prolonged sensory blockade with superior continued hemodynamic stability, which makes it the better option for patients with risk of hypotension. However, SCSE continues to provide a sensible option where a very rapid, profound anesthesia is necessary. These findings need further validation in multiple centers and wider application.

INTRODUCTION

Regional anesthesia has several advantages over the alternatives due to good pain control, avoidance of systemic complications and fast recovery (Kane, 2018; Mutahar et al., 2019) in case of lower limb surgeries. Because regional anesthesia techniques such as spinal anesthesia, epidural anesthesia, and combined spinal epidural anesthesia (CSE), provide sufficient sensory blockade and hemodynamic stability (Lim & Lee, 2020), they are popular. More recent modifications, such as Sequential Combined Spinal Epidural Anesthesia (SCSE) and Epidural Volume Extension (EVE) are used to improve patient's outcome and decrease complications (Azam et al., 2018).

Advantages of the SCSE are a prolonged anesthetic effect with reduced risk of hypotension and better patient hemodynamic stability (Hofhuizen et al., 2019). In patients with limited cardiopulmonary reserve or in geriatric patients this approach is advantageous (Alkonaiesy et al., 2023). The volume effect occurs when small volume of saline is deposited in the epidural space after the spinal anesthesia, thereby increasing the cephalad spread of local anesthetic (Tyagi et al., 2021). EVE is hypothesized as lasting longer than the sensory block and being hemodynamically stable (Aboulseoud, 2020).

The anesthesiologist's choice in technique represents critically for patient safety, surgical efficacy and postoperative recovery (Michel-Levy, 2020). The choice of anesthesia is dependent on several factors including

the patient age, comorbidities and surgical duration (Grant and Raju, 2016). SCSE and EVE (Fettes et al., 2009) modify the technique to remove the hypotension of spinal anesthesia alone, which provides rapid and deep block, but has a short duration of effect.

SCSE and EVE have both been found to be both effective and ineffective, but neither by previous literature. Similarly, other studies have shown that EVE provides better haemodynamic stability–have a similar sensory block duration (Choi et al, 2018), or a significantly longer sensory block regression time compared to SCSE (Hakim et al, 2020). It shows that there is still need for figuring out a better technique for surgeries of the lower limbs.

The aim of this study is to compare mean time to sensory regression of SCSE vs EVE, in patients that undergo lower limb surgery. The techniques are then compared based on sensory block duration, hemodynamic responses and postoperative analgesia in terms of potential advantages and disadvantages (Gan, 2017). The findings may help anesthesiologists in choosing the appropriate anesthetic for lower limb surgeries of patients at risk of hemodynamic instability (Fischer & Bosch, 2015).

Following a randomized controlled trial design, the plot of the analysis ensures that we have robust data and that bias is eliminated. This research extends previous findings by using a defined patient population and standardized outcome measures, and it fills some of the gaps present in current literature (Navarro et al., 2013). The results will contribute to the spectrum of knowledge of regional anesthesia techniques and their impact on surgical practice (Birnbach & Ojea, 2002).

METHODOLOGY

Study Design and Setting

This research was carried out as a randomized controlled trial at the Department of Anesthesiology Shaheed Zulfiqar Ali Bhutto University (PIMS) Islamabad. An institutional ethical review committee approved the study that spanned for six months from May 6, 2024 to November 5, 2024.

Study Population and Sampling

60 patients, ASA I or II, aged 21–60 years, scheduled for lower limb surgery were enrolled. Thirty patients each were enrolled and were randomly assigned into two groups: Sequential Combined Spinal Epidural Anesthesia (SCSE) and Epidural Volume Extension (EVE). A non-probability consecutive sampling technique was used for selection.

Inclusion and Exclusion Criteria

Both male and female patients of the targeted age range who consented to participate were included and excluded according to criteria. Patients with ASA III or higher, BMI ≥ 35 kg/m², diabetes (fasting blood sugar ≥110 mg/dl), hypertension (systolic blood pressure ≥140 mmHg), cardiovascular disease (ejection fraction <50 %), coagulation disorders (INR ≥2.5), allergy to local anesthetics, pregnancy or lactation, were excluded.

Intervention

Intervention was done by Randomizing and Intervening Participants. The standard monitoring, including non-invasive blood pressure measurement and an ECG and a pulse oximetry were carried out. An 18 gauge intravenous line was placed and a 500mL infusion of Ringer's solution was infused.

Epidural space identification in the SCSE group was done by Tuohy, using a 17-G needle, with loss of resistance. A subarachnoid dose of 0.5% isobaric bupivacaine in 2 ml (10 mg) was given immediately after catheter placement. An incremental epidural top-up was applied of 2 ml 0.5% isobaric bupivacaine per unblocked segment, if the T10 sensory level was not achieved at 10 minutes.

Similar technique was used in the EVE group to identify the epidural space and 10 mg of 0.5% isobaric bupivacaine was injected intrathecally. An epidural injection of 10 ml saline was then performed to promote cephalad spread of the anesthetic. Rescue dose through the epidural was reserved in case of early regression.

Outcome Measures

The mean time to sensory regression to T12 was the primary outcome. Secondary outcome measures included the duration of analgesia and hemodynamic stability (heart rate and blood pressure fluctuations).

Data Analysis

Data analysis included patient demographics, procedural details, sensory block regression times, and comparison of sensory block. Intraoperatively, heart rate and blood pressure were observed. SPSS 26.0 was used to analyze data. Age, height, weight, BMI, duration of surgery, duration of analgesia, and time to sensory regression were expressed as mean±standard deviation of numerical variables. Mean sensory regression times were compared using independent sample t test, and a p-value of less than 0.05 was considered statistically significant. Frequency and percentage distributions were used to look at categorical variables such as gender, ASA status and hemodynamic changes.

Ethical Consideration

Ethical approval was obtained prior to the study commencement. All data was collected with written informed consent in place, leading to the confidentiality and respect for the Declaration of Helsinki principles. Patients had the right to withdraw at any time from study without this being detrimental to their medical care.

Limitations

These limitations included a single center setting and enrollment only included ASA I and II patients. Results

may not be applicable to higher risk populations or alternate surgery settings. Future research should include multi center trials, and inquiry of the applicability of SCSE and EVE to other surgical procedures.

RESULTS

The study participants' demographic data is given in Table 1. The SCSE group was 42.1 ± 12.4 years of age at the study end, which was 2.6 years older than the EVE group (39.5 ± 11.8 years, $p < 0.001$). In gender distribution there were 15 males and 15 females in the SCSE group and 20 males and 10 females in the EVE group. Most patients were in the normal BMI range and the BMI categories in the two groups were similar.

Table 1

Demographic and Baseline Characteristics

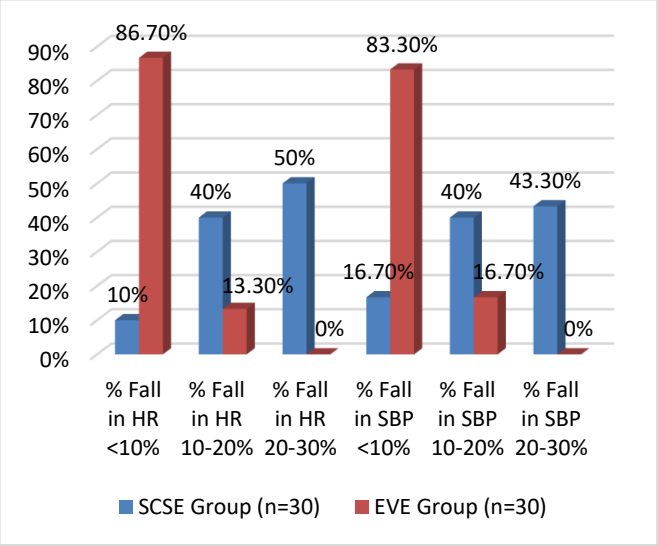
Characteristic	SCSE Group (n=30)	EVE Group (n=30)
Age (years)	42.1 ± 12.4	39.5 ± 11.8
Male (%)	50%	66.7%
Female (%)	50%	33.3%
Normal BMI (%)	50%	76.7%

Table 2

Hemodynamic Changes

Parameter	SCSE Group (n=30)	EVE Group (n=30)
% Fall in HR <10%	10%	86.7%
% Fall in HR 10-20%	40%	13.3%
% Fall in HR 20-30%	50%	0%
% Fall in SBP <10%	16.7%	83.3%
% Fall in SBP 10-20%	40%	16.7%
% Fall in SBP 20-30%	43.3%	0%

Figure 1



Sensory Block Regression and Analgesia Duration

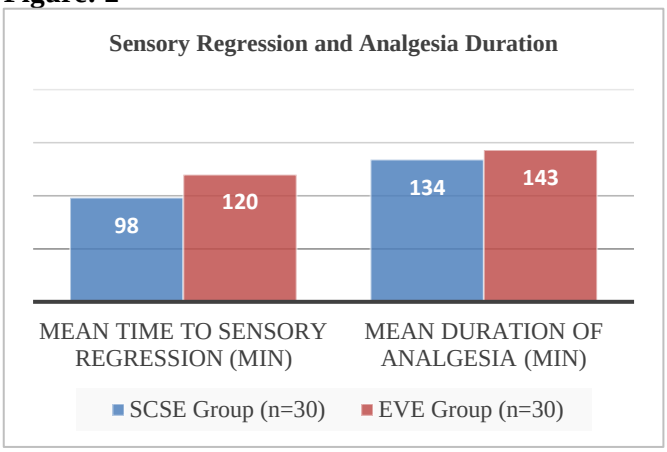
EVE group had significantly longer mean time to sensory regression to T12 (120 ± 17.39 minutes) vs. SCSE group (98 ± 15.35 minutes, p=0.000). Additionally, analgesia was longer in the EVE group (143 minutes compared to 134 minutes in the SCSE, p=0.104).

Table 3

Sensory Regression and Analgesia Duration

Parameter	SCSE Group (n=30)	EVE Group (n=30)
Mean Time to Sensory Regression (min)	98 ± 15.35	120 ± 17.39
Mean Duration of Analgesia (min)	134 ± 10.8	143 ± 12.5

Figure: 2



The results showed that EVE has a longer sensory block regression time than SCSE but with better hemodynamic stability. Nevertheless, both techniques exhibited similar success in terms of analgesia duration and surgical time.

DISCUSSION

Due to the comparative advantages and limitations of Sequential Combined Spinal Epidural Anesthesia (SCSE) and Epidural Volume Extension (EVE), the findings of this study provide insight on which technique is preferable in lower limb surgeries. Both techniques allow effective sensory blockade but their hemodynamic stability and sensory regression time are markedly different.

This study also found that the sensory regression time was significantly longer in the EVE group (120±17.39 minutes) compared to the SCSE group (98±15.35 minutes). The epidural saline injection in the EVE group allows for better cephalad spread of local anesthetic to extend sensory blockade duration, independent of loss of varying duration of the sympathetic blockade. This is consistent with previous studies that have shown improved sensory block duration with EVE based on volume effect within the epidural space.

Anesthetic technique safety depends on hemodynamic stability. In contrast to the SCSE group, the EVE group showed fewer hypotension episodes and significantly less variability in heart rate. On the other hand, the percentage fall in heart rate and systolic blood pressure were greater in the SCSE group, which is indicative of a higher incidence of hemodynamic instability. This is consistent with previous research that has demonstrated that SCSE can result in a more abrupt sympathetic blockade that also enhances the risk of hypotension.

An important observation during the study was that the mean duration of analgesia was similar between groups. Although analgesia durations tended to be longer in the EVE group (143 minutes) than in the SCSE group (134 minutes), there was no statistical difference between the two groups. This suggests that both of these techniques are as effective at postoperative pain relief as it can be for lower limb surgeries.

Although the advantages seen with EVE, there are a few limitations. Observations in EVE may lead to delayed early mobilization and rehabilitation that is an important aspect of postoperative recovery. In addition, while EVE achieves superior hemodynamic stability, it can succeed only with meticulous technique and a high degree of patient monitoring to ensure that local anesthetic is adequately applied, while minimizing the risk for an inadequate block.

Some of the limitations of the study should also be considered. The results of this study may not be generalizable to other populations or clinical settings as it is a single center study. Despite the small sample size, the results should be further validated with larger, multi center studies. The hemodynamic parameters were monitored closely throughout but further work is needed to determine long term survival outcomes such as patient satisfaction and recovery times.

In conclusion, both SCSE and EVE offer effective anesthetic solutions for lower limb surgeries, with distinct advantages. Rapid onset and profound sensory blockade are offered by SCSE, which allows for faster patient preparation time. On the other hand, EVE provides better sensory regression and prolonged hemodynamic stability, making it an ideal candidate for patients that are at risk for hypotension. Because these techniques show promise, future studies should consider how to optimize these techniques for the best benefits without as many potential costs.

CONCLUSION

The study compares Sequential Combined Spinal Epidural Anesthesia (SCSE) and Epidural Volume Extension (EVE) in lower limb surgeries. Results are presented showing that EVE can offer longer sensory regression time with better hemodynamic stability and should thus be used for patients with a tendency for hypotension. However, for procedure that require denser block, SCSE provides rapid onset of anesthesia and a deep sensory block. Both techniques were similar in duration of analgesia and therefore viable in a surgical setting.

The findings advance the ongoing discussion of how to optimize regional anesthesia techniques by emphasizing a patient-specific approach to anesthesia. These results should be further validated by larger multi center trials to better understand broader clinical applications. In general, this study grounds the need for individualized selection of anesthesia according to the specific needs of the patient and requirements of the surgery, while maintaining both safety and efficacy in lower limb surgeries.

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