Original Article

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Feasibility, Safety, and Efficacy of Segmental Spinal Anesthesia with Predominantly Isobaric Levobupivacaine: A Tertiary Care Hospital Study

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Abstract

Objective: To assess feasibility, safety, and efficacy of segmental spinal anesthesia with isobaric levobupivacaine in patients undergoing various abdominal and lower limb surgeries.

Methods: This was a prospective cohort study conducted at the Department of Anesthesiology and Critical Care of Kota Heart Institute and group of hospitals in India. The study involved 100 patients undergoing various abdominal and lower limb surgeries under segmental spinal anesthesia (SSA). Isobaric levobupivacaine 0.5% with fentanyl 20–25 µg or dexmedetomidine 5–10 as adjuvant or hypobaric levobupivacaine 0.167% was injected in intervertebral space depending on the surgery. Hemodynamic parameters, postoperative pain level, and adverse effects were analyzed with a p-value less than 0.05 was considered statistically significant.

Results: An overall male predominance was observed with a 1:0.515 male-to-female ratio. The most affected age group was 41–50 years (37%), with a mean age of 44.51±11.72 years. ASA classification indicated 34% of patients in ASA I, 40% in ASA II, 24% ASA III and 2% in ASA IV . The primary surgery was laparoscopic cholecystectomy (26%) in normal risk group and orthopedic in high-risk group(20%). Postoperative pain assessment showed mean VAS scores ranging from 1.92 to 3.42 at different time intervals. Common adverse effects were hemodynamic instability (13%), shoulder tip pain (33%), PONV (3%), headache (6%), pruritis (2%) and urinary retention (1%). The hemodynamic instability showed less incidence in ASA III/IV category.

Conclusion: Segmental spinal anesthesia can be used successfully for abdominal and lower limb orthopedic surgeries in patients of ASA I to ASA IV.

Keywords: ASA grade, levobupivacaine, segmental spinal anesthesia, visual analogue scale

Introduction

Segmental spinal anesthesia (SSA) offers a precise anesthesia for a variety of surgical procedures. In contrast to the conventional spinal anesthesia, the SSA consists of selective administration of local anesthetic agents at a specific spinal level, achieving anesthesia limited only to that particular segment of the body.[1] SSA minimizes venous dilation over a significant portion of the body thereby reducing the intraoperative blood pressure fluctuations.[2] Moreover, the minimal doses of anesthetic drugs are required in SSA due to its targeted action on specific nerve roots, which reduces the risk of systemic side effects in patients undergoing various surgeries. SSA also allows for adequate muscle

relaxation without compromising respiratory or circulatory functions. Segmental spinal anesthesia provides effective anesthesia with minimal hemodynamic changes; therefore, SSA has a favorable safety profile compared to conventional spinal and general anesthesia.[3]

Segmental spinal anesthesia is commonly used in lower limb orthopedic surgeries, abdominal surgeries, various breast surgeries, laparoscopic cholecystectomy, nephrectomies, cystectomy, and lower segment Caesarean sections.[4] Surgeries where SSA can be particularly advantageous include, but are not limited to, inguinal hernia repair and urological surgeries such as transurethral resection of the prostate (TURP). By selectively blocking spinal nerves innervating the operative site while preserving sensation and motor function in other regions, SSA offers the potential for improved intraoperative conditions, reduced postoperative pain, and enhanced patient satisfaction.[5]

One important limitation of segmental spinal anesthesia is that it should not be used as the sole technique in cases where a prolongation of the surgical procedure is expected. Surgeries lasting an extended period require the combined use of spinal-epidural or continuous spinal anesthesia. Moreover, technically, SSA is more demanding, as factors such as the vertebral level for dural puncture, patient positioning, drug dosages, and volume, as well as the levels of sensory and motor blockade, need to be considered carefully. In SSA, the duration of the block is shorter than in conventional spinal anesthesia (the difference is even greater for motor effects than sensory), making it ideal for day-care procedures.[6]

In addition to the type of surgery, patient factors such as pulmonary functions, the risk of complications associated with general anesthesia, etc., are also major considerations for using segmental spinal anesthesia. In patients with chronic respiratory disease, segmental spinal anesthesia (SSA) is helpful because it avoids the use of medication causing impaired mucociliary clearance, avoids mechanical ventilation, and prevents complications that are linked to mechanical ventilation, including the ventilator-associated pneumonia and atelectasis. General anesthesia in these patients may be responsible for ventilator dependence, as well as respiratory complications in the postoperative period. All these complications can be minimized by using segmental spinal anesthesia.[7]

The choice of local anesthetic agent plays a crucial role in the success and safety of SSA. Agents commonly used in SSA are bupivacaine, levobupivacaine, and ropivacaine. Each of these agents have its distinct pharmacokinetic and pharmacodynamic properties.[8] Among them, Levobupivacaine has gained popularity due to its lower cardiotoxicity and similar efficacy compared to racemic bupivacaine. When administered in an isobaric formulation, levobupivacaine offers predictable spread and duration of anesthesia, making it an attractive option for SSA.[9]

Safety can be further enhanced by using a hypobaric formulation or by diluting the drug to reduce its concentration. In patients who are debilitated, have poor muscle mass, or are at high risk due to comorbidities, or in surgeries where motor relaxation is not required and only sensory effects are needed.[10] The safety of SSA in ASA I & II is already established in former studies for routine open and lap surgeries. This study establishes the same safety, efficacy and feasibility for ASA III and IV also.

Methods

This was a prospective cohort study conducted in the Department of Anesthesiology at a Tertiary Care Medical Institute, India. The study duration was from July 2023 to December 2023. A total of 100 patients undergoing various laparoscopic and open abdominal and lower limb surgeries were included based on predefined inclusion and exclusion criteria. The sample size was calculated based on a pilot study on segmental spinal anesthesia, which assumed 90% power and a 95% confidence interval; thus, the required sample size was 90 patients. Consequently, 100 patients who underwent various surgeries under segmental spinal anesthesia during the study period were included. The study participants were patients aged 18 years and older who underwent elective or semi-emergency abdominal and lower limb orthopedic surgeries, provided they gave informed and written consent. Eligible participants were classified under ASA I to IV. Patients under 18 years of age, those who refused consent, and those with contraindications to spinal anesthesia—such as severe thrombocytopenia, bleeding disorders, or local infections at the injection site—were excluded.

A detailed pre-anesthetic evaluation was conducted for all cases. Special attention was given to the cardiac, respiratory, renal, nervous, and endocrine status of patients. Previous anesthetic exposure and drug

sensitivities were documented. A thorough general and systemic examination was performed, and baseline parameters were recorded. An airway assessment was also conducted. Written informed consent was obtained from all patients. Complete blood counts, pre-operative bleeding time, clotting time, blood urea, serum creatinine, blood sugar, TSH, serum electrolytes, ECG, and serological tests for HIV and HBsAg were performed for all cases. Additional investigations were conducted based on patients' history and age. Needed investigations were repeated after the second dose of analgesic postoperatively.

Throughout the surgery, all patients received oxygen via Venturi mask, with an FiO2 ranging from 28% to 40%. An additional 500 mL of colloid solution was administered to patients with good cardiac reserve. Standard monitoring procedures were implemented for both hemodynamic and clinical parameters, as well as the extent of sensory numbness. In cases where a drop in mean arterial blood pressure of over 20% from the initial pre-anesthetic value was observed (hypotension), mephenteramine boluses at a dosage of 6 mg were used, whereas atropine 0.6 mg was administered for a significant drop in heart rate.

For laparoscopic surgeries in this study, pneumoperitoneum was established through either open umbilical access or a Veress needle. The intraperitoneal pressure was maintained within the range of 10 to 12 mmHg. After the surgical procedure was completed, patients were transferred to the recovery area, where they underwent monitoring for a minimum of 30 minutes before being moved to the Surgical Unit.

Patients undergoing various surgeries, including laparoscopic cholecystectomy, total laparoscopic hysterectomy, diagnostic laparoscopic hysteroscopy, laparoscopic hernia repair, laparotomy, and lower limb orthopedic surgery, were included in this study. SSA at the thoracic or lumbar area was administered depending on whether the patient was undergoing abdominal or orthopedic surgery. Isobaric levobupivacaine 0.5% with fentanyl (20–25 µg) or dexmedetomidine (5–10 µg) as an adjuvant was injected. The volume of the drug and the intervertebral space were determined based on the type of surgery (Table 2). In cases of laparoscopic cholecystectomy, the T9-T10 or T10-T11 intervertebral spaces were used; for total laparoscopic hysterectomy, the T10-T11 or T11-T12 spaces were utilized; for laparoscopic hernia, the T9-T10 space was used; for laparotomy, T10-T11; and for lower limb orthopedic surgeries, the L2-L3 intervertebral space was selected. The dose of isobaric levobupivacaine was titrated according to the type and duration of surgery. Hypobaric levobupivacaine was also used in some high-risk (ASA III/IV) orthopedic cases, prepared by adding distilled water to isobaric levobupivacaine.

Average duration of surgery was noted in all cases. The need for additional blocks, such as the Transversus abdominis plane (TAP) block or the fascia iliaca compartment block (FICB), was determined based on the patient's build, the duration of surgery, and the concentration of drug used in SSA respectively. Heart rate, respiratory rate, systolic and diastolic blood pressures, mean arterial pressure, and oxygen saturation (SPO_2) were recorded for all cases. Postoperative pain was assessed at 2, 4, 6, 12, and 24 hours after surgery using the Visual Analog scale. Any adverse effects, including nausea, vomiting, headache, urinary retention, pruritus, post-dural puncture headache, and shoulder tip pain, were noted. The need for conversion to general anesthesia was also recorded. Additionally, mean anesthesia time, duration of surgery, and postoperative pain were documented.

Table 1 Patient Characteristics

	Age Group	No of Cases	Percentage
Age Distribution (Mean Age 44.51+/- 11.72)	18–30 years	15	15.0
	31–40 years	17	17.0
	41–50 years	37	37.0
	51–60 years	12	12.0
	Above 60	19	19.0
	Total	100	100.0
ASA Grade	ASA I	34	34.0
	ASA II	40	40.0
	ASA III	24	24.0
	ASA IV	2	2.0

Table 2 Types of Surgeries, Doses of Anesthetic Drugs, Intervertebral Space Used, Additional Blocks and Duration of Surgery

Variable	Number of Cases	Anesthetic Drug and Dose	Intervertebral Space Used	Average Duration of Surgery (Minutes)	Additional Block Given
Laparoscopic cholecystectomy	26	TV*:1.8–2.2 mL Iso Levobupivacaine (1.4–1.8 mL) + fentanyl 20µg	T9-T10 / T10-T11	90.34	No
Hysterectomy/ hysteroscopy	16	TV:2.1–2.3 mL bupivacaine(H) 0.5mL + Iso Levobupivacaine 1.2 mL + fentanyl (20–25 µg) + dexmedetomidine 10µg	T10-T11 / T11-T12	122.48	No
Laparoscopic hernia repair	22	TV:2-2.6 mL Bupivacaine(H)0.5 mL+ (1–1.5 mL + fentanyl 25 µg + dexmedetomidine 10µg	T9-T10	88.12	Transversus abdominis plane (TAP)
Laparotomy	16	TV:2–2.5 mL Iso LVB 1.5–2 mL+fentanyl 25µg	T10-T11	96.68	No
Orthopedic surgeries	20	TV:1.2–1.6 mL Iso/hypo Levobupivacaine (1.2–1.6) mL	L2-L 3	102.28	Fascia iliaca compartment block (FICB)

Notes: Tv: total drug volume

Results

Out of the 100 cases studied, there were 66 (66%) males and 34 (34%) females, indicating a male preponderance with an M:F ratio of 1:0.515. The most commonly affected age group was 41-50 years (37%), followed by those above 60 years (19%) and 31–40 years (17%). The mean age of affected cases was found to be 44.51±11.72 years. An analysis of the patients based on American Society of Anesthesiologists (ASA) classification showed

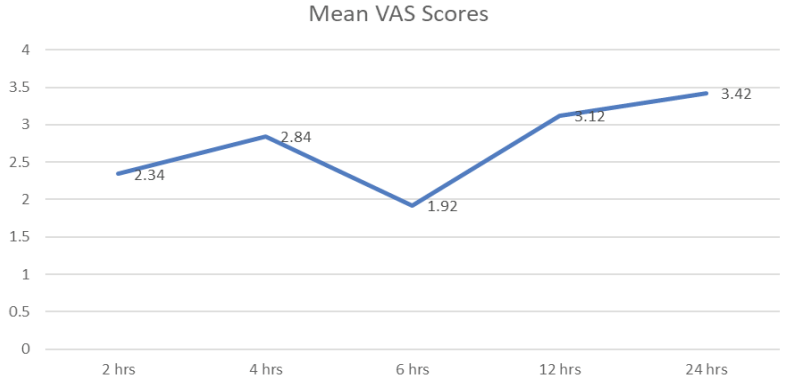

Fig. 1 Mean VAS Scores

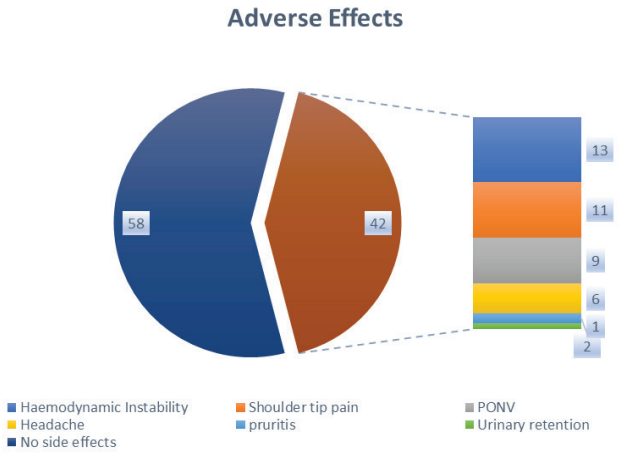

Fig. 2 Adverse Effects

Table 3 Relationship of ASA Grading with Hemodynamic Instability and Conversion into GA

	Number of Patients (%)	Conversion to GA (%)	Hemodynamic Instability (%)
ASA I/II	74	73	77
ASA III/IV	26	27	23

Notes: ASA: American Society of Anesthesiologists; GA: general anesthesia

that 40 (40%) belonged to ASA II, while 34 (34%) belonged to ASA I and 24 (24%) to ASA III. Two (2%) patients belonged to ASA IV (Table 1).

Laparoscopic cholecystectomy was the most common surgery performed, occurring in 26 cases (26%). The remaining surgeries included laparoscopic hernia repair (22%), orthopedic surgeries (20%), total laparoscopic hysterectomy or diagnostic laparoscopic hysteroscopy (16%), and laparotomy (16%). The determination of intervertebral space and dosage of anesthetic drugs were done based on the type and expected duration of surgery. In some cases of laparoscopic hernia repair, a TAP block was administered, while in certain lower limb orthopedic surgeries, FICB blocks was given in addition to segmental spinal anesthesia (Table 2).

Assessment of pain was conducted using Visual Analogue Scale (VAS). VAS scores were recorded at 2, 4, 6, 12, and 24 hours after surgery. The mean VAS score at 2 hours post-surgery was 2.34±0.82, while at 4, 6, 12, and 24 hours, the mean VAS scores were 2.84 ±0.92, 1.92±0.76, 3.12±0.90, and 3.42±1.12, respectively (Fig. 1).

Patients were analyzed for the incidence of adverse effects, which included shoulder tip pain (33%), hemodynamic instability (13%), post-dural puncture headache (PDPH) (6%), postoperative nausea and vomiting (PONV) (3%), pruritus (2%), and retention of urine (1%) (Fig. 2).

There were a total of 11 cases (11%) converted to general anesthesia (GA) for various reasons. It was observed that the incidence of conversion to GA or hemodynamic instability was independent of ASA grading (Table 3).

Discussion

Segmental spinal anesthesia has emerged as a novel technique within the domain of regional anesthesia. It is associated with a rapid onset of anesthesia, precise control over anesthesia levels, reduced systemic side effects, and enhanced safety. These factors are particularly important for patients with comorbidities or compromised respiratory function.[13]

In this study, laparoscopic cholecystectomy was the most common surgery performed on low-risk patients, while lower limb orthopedic procedures were prevalent among high-risk patients. Other surgeries included laparoscopic hernia repair, orthopedic surgeries, total laparoscopic hysterectomy,

diagnostic laparoscopic hysteroscopy, and laparotomy. Many studies have reported the effectiveness and safety of thoracic spinal anesthesia for upper abdominal surgeries, such as cholecystectomy. Singhal *et al*. conducted a study to assess the efficacy and safety of thoracic segmental spinal anesthesia in patients undergoing laparoscopic cholecystectomy.[14] For this purpose, the authors included 50 patients classified as ASA I, II, and III who underwent laparoscopic cholecystectomy under segmental spinal anesthesia. The study found that segmental spinal anesthesia provided complete surgical anesthesia in 48 patients; in two patients, there was a failure to achieve adequate sensory block, necessitating the administration of GA. The median time for full sensory regression was 90 minutes, and the median time for complete motor regression was 60 minutes. No major intraoperative or postoperative adverse events were noted. Based on these findings, the authors concluded that segmental spinal anesthesia offers safe and satisfactory operating conditions for elective laparoscopic cholecystectomy. Similar efficacy of segmental anesthesia for various surgeries has also been reported by other authors, such as Kejriwal *et al*.[15] and Wang *et al*.[16]

The analysis of VAS scores showed the results at 2, 4, 6, 12, and 24 hours after surgery. The mean VAS score at 2 hours after surgery was 2.34±0.82, while the mean VAS scores at 4, 6, 12, and 24 hours after surgery were 2.84±0.92, 1.92±0.76, 3.12±0.90, and 3.42±1.12, respectively. Segmental spinal anesthesia provided adequate analgesia for patients undergoing various abdominal and orthopedic surgeries. Vincenzi *et al*. conducted a study to analyze the benefits of segmental thoracic spinal anesthesia (STSA) with hypobaric ropivacaine for laparoscopic cholecystectomy.[17] Hypobaric segmental thoracic spinal anesthesia was performed on nine patients undergoing elective cholecystectomy. The study found that the mean VAS pain scores postoperatively within the first 12 hours after surgery were 3 (±2) and 4 (±2), respectively. The median length of hospital stay was 2 days (range=1–3 days). Similar effective analgesia in patients undergoing various surgeries under segmental spinal anesthesia was also reported by authors such as Paliwal *et al*.[18] and Haloi *et al*.[19]

Finally, an analysis of the adverse effect profile of patients in this study showed that shoulder tip pain was experienced by 33 (33%) patients and hemodynamic instability was observed in 13 (13%) cases. Other side effects included post-dural puncture headache (PDPH) in 6 (6%) patients, postoperative nausea and vomiting (PONV) in 3 (3%), pruritus in 2 (2%), and urinary retention in 1 (1%). Chandra R conducted a feasibility study of thoracic spinal anesthesia for laparoscopic cholecystectomy. The analysis of the side effect profile in that study indicated that the incidence of paresthesia during needle insertion was 5.8%. Hypotension was observed in 18% of patients, bradycardia in 13%, and nausea in 10%, with shoulder tip pain reported in only 6% of patients.[20] The hemodynamic effects noted in the above study were found to be similar to those in this study.

A total of 11 (11%) cases were converted to GA. Out of these 11 cases, 3 patients were converted due to a prolonged duration of surgery, while 7 patients were converted because of shoulder tip/neck pain that caused distress for both the patient and the surgeon. In 1 patient, conversion was necessitated by significant surgical emphysema that resulted in troubled breathing and hemodynamic instability. In this study, shoulder tip pain emerged as the most common reason for conversion to GA, an issue that needs to be addressed. Similar results were found in a study conducted by Vincenzi *et al*.,[17] which demonstrated that shoulder tip pain is an important factor determining the conversion of SSA to GA.

To address this issue, some pioneering researchers in SSA began using low-concentration hypobaric ropivacaine prior to isobaric ropivacaine with an adjuvant. They reported a significantly reduced incidence of shoulder tip pain. Such promising results have opened the door for researchers to explore this technique of using hypobaric ropivacaine to alleviate shoulder tip pain during surgeries under SSA.

The incidence of conversion to GA or hemodynamic instability was independent of ASA grading. There was no increase in incidence in the high-risk category (ASA III/IV); in fact, hemodynamic instability was borderline less in this group. This suggests that SSA is equally safe or potentially more promising for high-risk patients.

This study included 20 orthopedic procedures, with 12 (60%) of these cases classified as very high-risk (ASA III & ASA IV). Hypobaric levobupivacaine (0.167%) was administered at lumbar levels for these patients. No significant hemodynamic instability was observed. Patients were able

to tolerate oral intake two hours after the procedure, which eliminated the need for intravenous fluids in those with poor cardiac reserves. However, the absence of a control group for comparison was a major limitation of this study. A randomized controlled trial would be more appropriate for assessing the effectiveness of SSA.

Segmental spinal anesthesia can be successfully used for both abdominal and lower limb orthopedic surgeries in patients classified as ASA I to ASA IV. It is particularly effective for hemodynamically unstable patients and those with respiratory diseases, where general anesthesia may carry an unacceptably high risk of complications.

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