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Original Research Article

SAFETY AND EFFICACY OF SEGMENTAL SPINAL ANESTHESIA USING ISOBARIC LEVOBUPIVACAINE FOR ELECTIVE LAPAROSCOPIC TUBAL LIGATION: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: General anesthesia is conventionally preferred for laparoscopic tubal ligation because of the physiological effects of pneumoperitoneum and the requirement for adequate muscle relaxation. However, regional anesthetic techniques such as segmental spinal anesthesia are increasingly being explored because of their advantages including avoidance of airway manipulation, reduced postoperative nausea and vomiting, early ambulation, and improved postoperative recovery. Levobupivacaine, owing to its favorable safety profile, may provide effective segmental blockade with better hemodynamic stability.

Materials and Methods: This prospective observational study was conducted in 50 ASA physical status I and II female patients undergoing elective laparoscopic tubal ligation under segmental spinal anesthesia. After institutional ethical approval and informed consent, segmental spinal anesthesia was administered at the T11–T12 intervertebral level using a 25G Quincke spinal needle with 2 mL of 0.5% isobaric levobupivacaine (10 mg). Sensory block characteristics, intraoperative hemodynamic parameters, perioperative complications, requirement of rescue sedoanalgesia, and conversion to general anesthesia were recorded. Hypotension and bradycardia were treated with standard pharmacological measures, while shoulder-tip pain was managed using dexmedetomidine and ketamine supplementation. Postoperative recovery parameters and patient satisfaction were also assessed.

Results: The mean time to achieve T2 sensory level was 3.6 ± 0.9 minutes, and successful completion of surgery under spinal anesthesia was achieved in 94% of patients. Hypotension and bradycardia were observed in 16% and 10% of patients respectively and were managed effectively. Shoulder-tip pain occurred in 22% of patients and responded to rescue sedoanalgesia. Mean duration of sensory block was 162.4 ± 18.6 minutes. Early postoperative recovery was observed, with mean oral intake time of 4.1 ± 0.5 hours and mobilization time of 6.7 ± 1.1 hours. Most patients reported good to excellent satisfaction with the anesthetic technique.

Conclusion: Segmental spinal anesthesia using 0.5% isobaric levobupivacaine appears to be a safe, effective, and feasible alternative to general anesthesia for elective laparoscopic tubal ligation in carefully selected ASA I and II patients, with satisfactory surgical conditions, stable hemodynamics, favorable recovery profile, and high patient satisfaction.

Keywords: Segmental spinal anesthesia; Levobupivacaine; Laparoscopic tubal ligation; Thoracic spinal anesthesia; Regional anesthesia.

INTRODUCTION

Laparoscopic tubal ligation is a commonly performed elective gynecological sterilization procedure worldwide and is traditionally carried out under general anesthesia because of the requirement for pneumoperitoneum, Trendelenburg positioning, and adequate intraoperative muscle relaxation.[1] General anesthesia provides optimal surgical conditions; however, it is associated with several disadvantages including airway manipulation, postoperative nausea and vomiting, delayed ambulation, increased analgesic requirement, and stress response related to laryngoscopy and intubation.[2] In recent years, increasing emphasis has been placed on the use of regional anesthetic techniques for minimally invasive surgeries because of their advantages such as reduced postoperative pain, lower incidence of nausea and vomiting, avoidance of airway instrumentation, decreased hospital stay, and faster postoperative recovery.[3] Among regional techniques, segmental spinal anesthesia has emerged as a promising alternative for selected laparoscopic procedures.

Segmental spinal anesthesia refers to the administration of intrathecal local anesthetic at thoracic or thoracolumbar intervertebral levels using smaller drug volumes to achieve selective sensory blockade over the desired dermatomes while minimizing extensive sympathetic and motor blockade.[4] Thoracolumbar segmental spinal anesthesia allows preservation of respiratory function and better cardiovascular stability by limiting unnecessary cephalad spread of local anesthetic. Levobupivacaine, the pure S(-) enantiomer of bupivacaine, is increasingly preferred in neuraxial anesthesia because of its favorable pharmacological profile, including lower cardiotoxicity and neurotoxicity with effective sensory blockade and prolonged analgesia.[5] The use of isobaric levobupivacaine in thoracolumbar spinal anesthesia may therefore provide adequate surgical anesthesia while maintaining hemodynamic stability and reducing adverse effects associated with conventional spinal anesthesia.

The physiological changes associated with laparoscopic surgery, particularly pneumoperitoneum, include increased intra-abdominal pressure, reduced venous return, vagal stimulation, diaphragmatic irritation, and referred shoulder-tip pain mediated via the phrenic nerve.[6] These alterations may lead to hypotension, bradycardia, respiratory discomfort, and patient intolerance during surgery under regional anesthesia.[7] Nevertheless, several studies have demonstrated the feasibility and safety of thoracic and segmental spinal anesthesia for laparoscopic procedures with satisfactory surgical conditions, reduced perioperative opioid requirement, early ambulation, and high patient satisfaction.[8,9] Previous investigators have reported that careful patient selection, low-pressure pneumoperitoneum, and appropriate sedoanalgesia significantly improve patient comfort and perioperative outcomes during laparoscopic surgery under spinal anesthesia.[10]

Despite growing interest in thoracic and segmental spinal anesthesia, limited literature is available regarding its application specifically for elective laparoscopic tubal ligation, especially in the Indian population. Most published studies involve laparoscopic cholecystectomy or consist of isolated case reports and small observational studies. Furthermore, standardized protocols regarding drug dosage, sensory level, management of intraoperative shoulder-tip pain, and recovery characteristics remain inadequately defined. Therefore, the present prospective observational study was undertaken to evaluate the safety and efficacy of segmental spinal anesthesia using 0.5% isobaric levobupivacaine for elective laparoscopic tubal ligation in ASA I and II patients, with emphasis on block characteristics, hemodynamic stability, perioperative complications, postoperative recovery profile, and patient satisfaction.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Anesthesiology at a tertiary care teaching hospital after obtaining approval from the Institutional Ethics Committee and written informed consent from all participants. A total of 50 female patients belonging to the American Society of Anesthesiologists (ASA) physical status I and II, aged between 18 and 45 years, scheduled for elective laparoscopic tubal ligation under segmental spinal anesthesia were included in the study. Patients with contraindications to spinal anesthesia, bleeding or coagulation disorders, infection at the puncture site, severe cardiopulmonary disease, known hypersensitivity to local anesthetic agents, neurological disorders, or refusal to participate were excluded from the study. All patients were kept nil per oral according to standard fasting guidelines and were premedicated with intravenous antiemetic before shifting to the operating room. On arrival in the operating theatre, standard monitoring including heart rate (HR), non-invasive blood pressure (NIBP), and peripheral oxygen saturation (SpO_2) was instituted and baseline parameters were recorded.

Under strict aseptic precautions, segmental spinal anesthesia was administered in the sitting position at the T11–T12 intervertebral space using a 25G Quincke spinal needle. After confirmation of free flow of cerebrospinal fluid, 2 mL of 0.5% isobaric levobupivacaine (10 mg) was injected intrathecally. Immediately after the block, patients were positioned supine. Sensory blockade was assessed bilaterally by pinprick method at one-minute intervals until the desired level was achieved, and the time required to attain T2 sensory level was recorded. Intravenous midazolam was administered for anxiolysis. Intraoperatively, HR, NIBP, SpO_2, and sensory block

level were monitored and recorded at five-minute intervals throughout the surgical procedure. Episodes of hypotension and bradycardia were managed with intravenous mephentermine and glycopyrrolate or atropine respectively. Shoulder-tip pain occurring after pneumoperitoneum was treated with intravenous dexmedetomidine and ketamine boluses as required.

The duration of surgery, adequacy of surgical anesthesia, incidence of intraoperative complications, and requirement of rescue sedoanalgesia were documented. Conversion to general anesthesia was considered in cases of prolonged surgical duration associated with regression of spinal block, inadequate analgesia after pneumoperitoneum, or persistent pain not relieved by rescue medications. Postoperatively, regression of sensory blockade was assessed and the duration of spinal anesthesia was recorded. Recovery parameters including time to oral intake and ambulation were noted. Patient satisfaction regarding the anesthetic technique was assessed postoperatively using a subjective satisfaction scale. All data obtained during the study were compiled and analyzed using appropriate statistical methods.

RESULTS

The present study included 50 ASA physical status I and II female patients undergoing elective laparoscopic tubal ligation under segmental spinal anesthesia. The demographic profile of the study population demonstrated that the majority of patients belonged to the younger reproductive age group, with a mean age of 28.6 ± 4.2 years. The mean body weight and body mass index were 58.4 ± 6.8 kg and 23.7 ± 2.4 kg/m² respectively. Most patients belonged to ASA physical status I (68%), while the remaining 32% were categorized as ASA II. Baseline hemodynamic parameters including heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, and oxygen saturation were within normal physiological limits in all patients prior to administration of spinal anesthesia [Table 1].

Table 1: Demographic and Baseline Characteristics of Study Participants (n = 50)

Variable	Value
Age (years)	28.6 ± 4.2
Weight (kg)	58.4 ± 6.8
Height (cm)	156.8 ± 5.1
BMI (kg/m²)	23.7 ± 2.4
ASA I	34 (68%)
ASA II	16 (32%)
Baseline HR (beats/min)	84.2 ± 9.6
Baseline SBP (mmHg)	118.4 ± 10.2
Baseline DBP (mmHg)	74.6 ± 7.1
Baseline MAP (mmHg)	89.2 ± 6.8
Baseline SpO_2 (%)	99.1 ± 0.8

Table 2: Characteristics of Segmental Spinal Block

Parameter	Value
Time to onset of sensory block (min)	1.8 ± 0.6
Time to achieve T2 sensory level (min)	3.6 ± 0.9
Highest sensory level achieved	T2
Duration of sensory block (min)	162.4 ± 18.6
Two-segment regression time (min)	94.2 ± 12.5
Time to complete sensory regression (min)	178.5 ± 20.4
Successful completion under spinal anesthesia	47 (94%)
Conversion to general anesthesia	3 (6%)

Segmental spinal anesthesia using 0.5% isobaric levobupivacaine provided rapid onset and effective sensory blockade in the majority of patients. The mean time for onset of sensory block was 1.8 ± 0.6 minutes, while the average time required to achieve T2 sensory level was 3.6 ± 0.9 minutes. Adequate surgical anesthesia was successfully achieved in most patients, with successful completion of surgery under spinal anesthesia observed in 94% of cases. The average duration of sensory block was 162.4 ± 18.6 minutes, and complete regression occurred at a mean duration of 178.5 ± 20.4 minutes. Only 6% of patients required conversion to general anesthesia due to inadequate analgesia or prolonged surgical duration [Table 2].

Table 3: Intraoperative Hemodynamic Parameters

Time Interval	HR (beats/min)	MAP (mmHg)	SpO_2 (%)
Baseline	84.2 ± 9.6	89.2 ± 6.8	99.1 ± 0.8
5 min	78.6 ± 8.4	82.4 ± 7.2	98.8 ± 0.9
10 min	76.4 ± 7.9	80.8 ± 6.9	98.7 ± 1.0
15 min	77.1 ± 7.4	81.2 ± 6.5	98.9 ± 0.8
30 min	79.3 ± 6.8	83.1 ± 5.8	99.0 ± 0.7
End of surgery	82.5 ± 7.1	86.4 ± 6.2	99.2 ± 0.6

Intraoperative hemodynamic monitoring revealed acceptable cardiovascular stability throughout the procedure. A mild reduction in heart rate and mean arterial pressure was observed following spinal anesthesia and pneumoperitoneum; however, parameters remained within clinically manageable limits. Oxygen saturation remained well maintained during the perioperative period without significant respiratory compromise [Table 3].

Table 4. Intraoperative Complications and Rescue Drug Requirement

Variable	Number (%)
Hypotension	8 (16%)
Bradycardia	5 (10%)
Nausea/Vomiting	3 (6%)
Shoulder-tip pain	11 (22%)
Requirement of mephentermine	8 (16%)
Requirement of glycopyrrolate	4 (8%)
Requirement of atropine	1 (2%)
Dexmedetomidine supplementation	11 (22%)
Ketamine supplementation	9 (18%)
Conversion to general anesthesia	3 (6%)

Hypotension and bradycardia were the most common intraoperative adverse events, observed in 16% and 10% of patients respectively, and were effectively managed with mephentermine and anticholinergic agents. Shoulder-tip pain following pneumoperitoneum was reported in 22% of patients and was managed successfully using dexmedetomidine and ketamine supplementation. The incidence of nausea and vomiting was low, and only a small proportion of patients required rescue sedoanalgesia or conversion to general anesthesia [Table 4].

Table 5: Surgical and Postoperative Recovery Profile

Parameter	Value
Duration of surgery (min)	48.6 ± 7.8
Duration of anesthesia (min)	61.2 ± 8.6
Time to oral intake (hours)	4.1 ± 0.5
Time to mobilization (hours)	6.7 ± 1.1
Patient satisfaction – Excellent	18 (36%)
Patient satisfaction – Good	27 (54%)
Patient satisfaction – Fair	4 (8%)
Patient satisfaction – Poor	1 (2%)
Postoperative complications	Nil

The mean duration of surgery was 48.6 ± 7.8 minutes, while the average duration of anesthesia was 61.2 ± 8.6 minutes. Postoperative recovery profile was satisfactory in the majority of patients. Oral intake was resumed after a mean duration of 4.1 ± 0.5 hours, and ambulation was achieved within 6.7 ± 1.1 hours postoperatively. Patient satisfaction with the anesthetic technique was favorable, with most patients reporting good to excellent satisfaction. No major postoperative complications were observed during the study period [Table 5].

DISCUSSION

The present prospective observational study evaluated the safety and efficacy of segmental spinal anesthesia using 0.5% isobaric levobupivacaine for elective laparoscopic tubal ligation in ASA I and II patients. The findings of the study demonstrated that segmental spinal anesthesia provided rapid onset of sensory blockade, satisfactory intraoperative anesthesia, acceptable hemodynamic stability, favorable postoperative recovery, and high patient satisfaction with a low conversion rate to general anesthesia. These findings support the growing evidence regarding the feasibility of thoracolumbar spinal anesthesia as an alternative to general anesthesia for short-duration laparoscopic procedures.[11]

In the present study, the mean time to onset of sensory blockade was 1.8 ± 0.6 minutes, and the mean time required to achieve T2 sensory level was 3.6 ± 0.9 minutes. Adequate surgical anesthesia was achieved in 94% of patients. Similar findings were reported by van Zundert et al., who demonstrated successful laparoscopic cholecystectomy under segmental thoracic spinal anesthesia with adequate sensory blockade and satisfactory surgical conditions in all patients included in their feasibility study.[4] Imbelloni et al. also reported effective surgical anesthesia with thoracic spinal anesthesia in laparoscopic procedures, with successful completion rates exceeding 90% and rapid onset of sensory blockade.[12] The rapid cephalad spread observed in the present study may be attributed to the thoracolumbar level of injection and the use of low-dose isobaric levobupivacaine, which allows selective blockade of targeted dermatomes while minimizing excessive sympathetic blockade.

Hemodynamic stability remains one of the primary concerns during thoracic and segmental spinal anesthesia because of the potential for extensive sympathetic blockade. In the present study,

hypotension and bradycardia were observed in 16% and 10% of patients respectively, and all episodes were transient and responded to standard pharmacological treatment. Comparable observations were reported by Ellakany, who found mild and manageable hypotension in patients undergoing laparoscopic cholecystectomy under thoracic spinal anesthesia, with significantly reduced perioperative stress response compared to general anesthesia.[13] Imbelloni et al. also observed only minimal cardiovascular instability during thoracic spinal anesthesia for laparoscopic surgeries.[12] The relatively low incidence of hemodynamic complications in the present study may be related to the use of lower intrathecal drug volume and restricted segmental spread achieved with thoracolumbar administration. Furthermore, peripheral oxygen saturation remained stable throughout the intraoperative period in all patients, indicating preservation of respiratory function, which is consistent with previous reports demonstrating minimal respiratory compromise during thoracic neuraxial anesthesia.[4,13]

Shoulder-tip pain resulting from diaphragmatic irritation due to pneumoperitoneum is a well-recognized challenge during laparoscopic surgeries under regional anesthesia. In the present study, shoulder-tip pain was observed in 22% of patients and was effectively managed with dexmedetomidine and ketamine supplementation. Tzovaras et al. reported shoulder discomfort in nearly 25% of patients undergoing laparoscopic cholecystectomy under spinal anesthesia, although most patients tolerated the procedure satisfactorily with mild sedation and analgesic supplementation.[14] Similarly, Sinha et al. demonstrated that low-pressure pneumoperitoneum combined with appropriate sedoanalgesia significantly reduced intraoperative discomfort and improved patient tolerance during laparoscopic procedures under spinal anesthesia.[15] The low conversion rate to general anesthesia observed in the present study (6%) further suggests that intraoperative discomfort was effectively managed in the majority of patients.

The postoperative recovery profile observed in the present study was favorable, with mean time to oral intake and ambulation being 4.1 ± 0.5 hours and 6.7 ± 1.1 hours respectively. Most patients reported good to excellent satisfaction with the anesthetic technique. Similar findings were reported by Imbelloni et al., who observed early ambulation, reduced postoperative analgesic requirement, and high patient satisfaction following thoracic spinal anesthesia for laparoscopic surgeries.[12] Ellakany also demonstrated reduced postoperative nausea and vomiting and earlier recovery in patients receiving thoracic spinal anesthesia compared to general anesthesia.[13] The use of levobupivacaine in the present study may have contributed to favorable recovery characteristics because of its lower cardiotoxicity profile and prolonged sensory blockade with reduced motor blockade.[5]

The findings of the present study suggest that segmental spinal anesthesia using 0.5% isobaric levobupivacaine is a safe and effective anesthetic alternative for elective laparoscopic tubal ligation in carefully selected ASA I and II patients. The technique provided satisfactory surgical conditions, stable intraoperative hemodynamics, effective postoperative recovery, and high patient satisfaction with minimal complications. Although occasional shoulder-tip pain and transient hemodynamic alterations were encountered, these were effectively managed without significant morbidity. The low conversion rate to general anesthesia further supports the clinical feasibility and safety of this technique for short-duration laparoscopic gynecological procedures.[14,15]

CONCLUSION

The present study demonstrates that segmental spinal anesthesia using 0.5% isobaric levobupivacaine is a safe, effective, and feasible anesthetic technique for elective laparoscopic tubal ligation in carefully selected ASA I and II patients. The technique provided rapid onset of sensory blockade, satisfactory intraoperative anesthesia, stable hemodynamic profile, early postoperative recovery, and high patient satisfaction with a low rate of conversion to general anesthesia. Although complications such as hypotension, bradycardia, and shoulder-tip pain were observed, they were transient and effectively managed with standard therapeutic measures. Segmental spinal anesthesia may therefore serve as a useful alternative to general anesthesia for short-duration laparoscopic gynecological procedures.

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