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Original Research Article

A Comparative Evaluation between Thoracic Segmental Spinal Anaesthesia and General Anaesthesia for Laparoscopic Cholecystectomy

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Abstract

Background: Thoracic segmental spinal anaesthesia is a technique which may offer more targeted blockade, spontaneous ventilation and better postoperative analgesia, when compared with general anaesthesia, which is the standard anaesthetic technique used for laparoscopic cholecystectomy. To compare the haemodynamics of the perioperative period, postoperative pain, recovery profile and complications between thoracic segmental spinal anaesthesia and general anaesthesia in adults undergoing elective laparoscopic cholecystectomy.

Method: Prospective comparative study involving 80 ASA I-II patients who were allocated randomly to either thoracic segmental spinal anaesthesia (TSSA; n=40) or general anaesthesia (GA; n=40) group. TSSA was done at T8-T10 with low dose levobupivacaine with fentanyl, and GA with propofol, fentanyl, rocuronium, endotracheal intubation and sevoflurane. The primary outcomes were postoperative visual analogue scale (VAS) pain score and 24-hours of rescue opioid use. Secondary outcomes included hemodynamics at the time of the procedure, recovery time, nausea and/or vomiting, pain at the shoulder tip, conversion and satisfaction.

Results: There were no differences in baseline age, sex, BMI, ASA grade, or operative duration ($p>0.05$). Mean VAS at 2 hours was lower with TSSA than GA (2.1 ± 0.8 vs 4.0 ± 1.0; $p<0.001$), and 24-hour tramadol requirement was significantly reduced (56.3 ± 24.8 mg vs 112.5 ± 38.6 mg; $p<0.001$). PACU discharge time was shorter in TSSA (58.4 ± 12.6 min vs 78.9 ± 17.5 min; $p<0.001$). PONV was less frequent with TSSA (10.0% vs 32.5%; $p=0.014$), whereas shoulder-tip discomfort was more frequent (20.0% vs 5.0%; $p=0.043$).

Conclusions: There was no change to GA and no neurological complication. Every laparoscopic cholecystectomy patient is not suitable for thoracic segmental spinal anaesthesia as this could be a feasible and effective alternative with better analgesia, lesser requirement of opioids and quick recovery with acceptable safety in selected patients.

Keywords: Thoracic Spinal Anaesthesia; Segmental Spinal Anaesthesia; General Anaesthesia; Laparoscopic Cholecystectomy; Postoperative Analgesia; Pneumoperitoneum.

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Introduction

Laparoscopic cholecystectomy is the optimal surgical management of symptomatic cholelithiasis since it lowers wound morbidity, postoperative pain and hospital stay as compared to open surgery [1]. Although minimally invasive, creation of carbon dioxide pneumoperitoneum and reverse Trendelenburg position can induce clinically significant cardiovascular and respiratory changes particularly in patients with reduced cardiopulmonary reserve [2].

Tracheal intubation under general anaesthetic is the preferred method of anaesthetic for laparoscopic cholecystectomy as it helps to maintain control of ventilation and to protect the airway [3]. The increased interest in regional anaesthesia for laparoscopy is due to the attractive benefits of avoiding airway instrumentation, decreased systemic anaesthetic exposure and early analgesia for carefully selected patients. Laparoscopic cholecystectomy under regional blockade was achieved in the early experience with epidural and lumbar spinal techniques, but the problems of shoulder pain, anxiety and hemodynamic instability were important issues [4, 5].

It was then attempted to obtain a denser and more restricted block at the dermatomes necessary for upper abdominal laparoscopy by using the segmental thoracic spinal anaesthetic technique in order to obtain a smaller intrathecal dose compared to lumbar spinal anaesthetic [6]. Thoracic

segmental spinal anaesthesia is based on the anatomical premise that it involves depositing a small quantity of local anaesthetic in proximity to the thoracic dermatomes that innervate the upper abdominal wall and peritoneum. MRIs and clinical feasibility studies have indicated that it is possible to perform a thoracic puncture safely without neurological sequelae if it is done carefully by experienced anaesthesiologists with careful patient selection, either in the midline or paramedian approach [7].

Randomised and prospective trials have shown that patients undergoing laparoscopic cholecystectomy under spinal anaesthesia had better early postoperative pain control and required less pain medication such as opioids as compared to those under general anaesthesia; however, some trials have also revealed discomfort at the shoulder-tip and low blood pressure.

Some randomised and prospective trials have found that patients undergoing laparoscopic cholecystectomy under spinal anaesthesia experienced better early postoperative pain control and a reduced requirement for pain medication, including opiates, compared with those receiving general anaesthesia, and some had a discomfort at the shoulder-tip and hypotension during the surgery [8, 9].

This technique is once again gaining traction given recent reports of thoracic spinal anaesthesia, and has been used for day-case surgery and patients for whom general anaesthesiamight be contraindicated [10]. Many studies are, however, feasibility reports or small case series or comparisons of various solutions for thoracic local anaesthetic techniques, but not comparisons of these techniques with general anaesthesia using standardised outcomes measures.

The benefits (pain and nausea control) have to be balanced with potential risks (hypotension, bradycardia, anxiety, general anaesthetic) and this is dependent on the degree of protocol standardization at the institution.

The aim of the present prospective comparative study was thus to compare the effectiveness of thoracic segmental spinal anaesthesia with conventional general anaesthesia in elective laparoscopic cholecystectomy in adult patients. The purpose was to evaluate the postoperative pain, need for rescue analgesic, hemodynamic stability, recovery time, adverse events, and satisfaction of patient between the two techniques.

Materials and Methods

Study design and setting: It was a prospective comparative study carried out in the Department of Anaesthesiology of a tertiary care teaching hospital during 12 months period. Patients were screened in the pre-anaesthetic clinic visit for elective laparoscopic cholecystectomy for uncomplicated symptomatic cholelithiasis. Institutional ethical clearance was obtained.

Sample size:

The sample size was determined based on the primary measurable outcome (mean 24 hour opioid consumption). The sample size was calculated to be 35 per group, with a clinically meaningful difference of 25 mg tramadol equivalent between the groups, a standard deviation of 35 mg, 80% power, and a two-sided alpha of 0.05. If you take into account possible exclusions or deviations from the protocol, 40 patients were enrolled in each group, totalling 80 patients.

Patients with ASA physical status class I or II, BMI 18-30 kg/m2, who were scheduled for elective laparoscopic cholecystectomy were included. The exclusion criteria were acute cholecystitis, difficult anticipated airway requiring awake intubation, contraindications to spinal anaesthesia, coagulopathy, infection at puncture site, severe cardiopulmonary disease, pregnancy, neurological disease, chronic opioid use, allergy to study drugs, psychiatric illness that would interfere with cooperation, and refusal to participate.

Anaesthetic technique: Electrography, non-invasive blood pressure, pulse oximetry, capnography (if), temperature were used as standard monitors. Patients were preloaded with 8 - 10 mL/kg of crystalloid intravenously. For the TSSA group, the spinal puncture was done at T8-T10 in sitting position with a 26G Quincke needle under the supervision of a highly experienced consultant. Slow intrathecal injection of 1.4-1.6 mL of 0.5% Isobaric Levobupivacaine along with Fentanyl 15 micrograms was made after free flow of CSF.

The sensory level was evaluated through pinprick, and the surgery was started once bilateral block (T4-T12) was obtained.

Face mask oxygen was used and light sedation was provided with infusion of midazolam (0.5-1 mg) or dexmedetomidine as needed. For the GA group, propofol 2 mg/kg, fentanyl 2 micrograms/kg and rocuronium 0.6 mg/kg were used, followed by endotracheal intubation, and sevoflurane in oxygen-air mixture was used for maintenance. In both groups, the pressure of the pneumoperitoneum was maintained at between 10 and 12 mmHg.

Primary outcome: Pain level at 1, 2, 6, 12 and 24 hours after surgery on a 10-cm visual analogue scale. If VAS was over 3, rescue analgesia of paracetamol 1 g intravenous and tramadol 50 mg was administered. Secondary outcomes were

intraoperative hypotension, intraoperative bradycardia, and pain at shoulder tip, nausea /vomiting, conversion to GA, operative duration, PACU discharge time, total 24-hour tramadol use and satisfaction on a 5-point scale at 24 hours.

Data analysis: Data was analysed using Statistical Package for Social Science (SPSS) version 26.0.

Continuous variables were expressed as mean ± standard deviation and compared using independent-samples t test, following normality tests. The categorical variables were presented as number and percentage and compared using chi-square test or Fisher exact test. A p-value of < 0.05 was deemed statistically significant.

Results

A total of 92 patients were assessed for eligibility; 12 were excluded because of refusal, acute inflammation, BMI above 30 kg/m2, or contraindication to neuraxial block. Eighty patients completed the study protocol and were analyzed equally in the TSSA and GA groups.

Baseline demographic and clinical characteristics were comparable between groups.

Table 1: Baseline demographic and surgical characteristics

Variable	TSSA (n=40)	GA (n=40)	p-value
Age (years)	42.6 ± 10.8	43.9 ± 11.4	0.602
Female sex, n (%)	27 (67.5)	29 (72.5)	0.626
BMI (kg/m2)	24.8 ± 2.7	25.1 ± 2.8	0.625
ASA I/II, n	24/16	22/18	0.651
Duration of symptoms (months)	9.4 ± 5.7	10.1 ± 6.2	0.599
Operative duration (min)	46.8 ± 9.6	48.5 ± 10.2	0.445
Pneumoperitoneum pressure (mmHg)	10.7 ± 0.8	10.9 ± 0.7	0.237

Intraoperative hemodynamics remained clinically manageable in both groups.

Mean heart rate and mean arterial pressure during pneumoperitoneum were lower in the TSSA group, but vasopressor-treated hypotension did not differ significantly. No patient in the TSSA group required conversion to GA.

Two patients required additional fentanyl for shoulder-tip pain and six required small-dose midazolam for anxiety.

Table 2: Intraoperative and recovery outcomes

Outcome	TSSA (n=40)	GA (n=40)	p-value
Mean HR during pneumoperitoneum (beats/min)	72.4 ± 8.9	82.6 ± 10.1	<0.001
Mean MAP during pneumoperitoneum (mmHg)	78.5 ± 8.6	86.7 ± 9.4	<0.001
Hypotension requiring vasopressor, n (%)	7 (17.5)	3 (7.5)	0.176
Bradycardia requiring atropine, n (%)	4 (10.0)	1 (2.5)	0.359
Conversion to GA, n (%)	0 (0.0)	NA	-
PACU discharge time (min)	58.4 ± 12.6	78.9 ± 17.5	<0.001
Time to oral fluids (hours)	4.1 ± 0.8	5.2 ± 1.1	<0.001

Postoperative pain scores were consistently lower in the TSSA group during the early postoperative period.

The difference remained significant at 6 hours but narrowed by 24 hours. Overall rescue tramadol consumption was approximately 50% lower in the TSSA group.

PONV was significantly lower in the TSSA group, whereas shoulder-tip pain was more common. Patient satisfaction was higher in the TSSA group.

Table 3: Postoperative analgesia, complications, and satisfaction

Outcome	TSSA (n=40)	GA (n=40)	p-value
VAS pain at 1 hour	1.6 ± 0.7	3.6 ± 1.1	<0.001
VAS pain at 2 hours	2.1 ± 0.8	4.0 ± 1.0	<0.001
VAS pain at 6 hours	2.5 ± 0.9	3.3 ± 1.0	<0.001
VAS pain at 24 hours	2.0 ± 0.7	2.2 ± 0.8	0.238
24-hour tramadol use (mg)	56.3 ± 24.8	112.5 ± 38.6	<0.001
PONV, n (%)	4 (10.0)	13 (32.5)	0.014
Shoulder-tip pain, n (%)	8 (20.0)	2 (5.0)	0.043
Satisfaction score (1-5)	4.5 ± 0.6	4.0 ± 0.8	0.003
Neurological complication, n (%)	0 (0.0)	0 (0.0)	1.000

Discussion

The present study demonstrated that patients undergoing elective laparoscopic cholecystectomy under thoracic segmental spinal anaesthetic experienced superior early postoperative pain relief, lower 24 h opioid consumption, shorter/post anaesthetic care unit stay and less post-op nausea and vomiting as compared to general anaesthetic. These benefits were seen without the use of general anaesthetic or any neurological complications. The results confirm the concept of a well-placed thoracic segmental block that can be performed to achieve adequate surgical anaesthesia during laparoscopy of the upper abdomen without the loss of spontaneous breathing.

Since early reports of using neuraxial anaesthesia for laparoscopic cholecystectomy in high-risk patients with respiratory illness [11] its use has been reported for this procedure. Hamad and El-Khattary showed that laparoscopic cholecystectomy could be performed under spinal anaesthesia with the use of nitrous oxide pneumoperitoneum, which was different from the current carbon dioxide laparoscopy [12]. Van Zundert et al. subsequently reported segmental thoracic spinal anaesthetic for laparoscopic cholecystectomy, noting its feasibility, but cautioning that the spinal puncture is made above the end of the spinal cord and thus would be a cause of concern [13].

Our lower VAS scores and opioid requirement in the postoperative period match the findings of other randomized studies which demonstrated that patients after spinal anaesthesia had better early postoperative pain control than those after GA for laparoscopic cholecystectomy [14]. These same analgesic benefits have been reported for other forms of anaesthetic, such as day-case spinal and combined spinal-epidural anaesthesias [15, 16]. It is believed to be a combination of several mechanisms: first, segmental blockade blocks afferent nociceptive transmission from the abdominal wall and peritoneum; second, it decreases intraoperative opioid use; and third, no instrumentation of the airways. These impacts can be a reason for the quicker discharge from PACU and earlier food consumption in TSSA group.

The hemodynamic profile in the current study was good, though hypotension and bradycardia were more frequently seen with TSSA. This observation is biologically plausible as thoracic sympathetic blockade could lead to a decrease in venous return and systemic vascular resistance. But, the events were mild and were controlled by the use of small doses of vasopressor or atropine. Low dose local anaesthetic, small pneumoperitoneum pressure, preloading of the system and constant communication with the patient probably helped to maintain stability. The lack of conversion and neurological sequelae is in keeping with the recent feasibility studies and case series carried out by more experienced anaesthesiologists [17]. Shoulder-tip pain was the main limitation of TSSA. It is due to the fact that the phrenic nerve is not completely blocked by the thoracic abdominal block, and irritation of the diaphragm from pneumoperitoneum can be transmitted through the phrenic nerve. Reassurance, low-pressure pneumoperitoneum and small-dose fentanyl were used in this study to treat shoulder discomfort. Attempts have been made to decrease shoulder pain by optimizing cephalad spread or changing intrathecal adjuvants with hypobaric and opioid-sparing thoracic techniques [18]. However, shoulder pain continues to be an important patient-selection and counseling question.

The different rates of PONV between the TSSA and control groups are clinically relevant. This may include avoidance of volatile anaesthetic and decreased post-operative opioid use and maintenance of gut function. Reduced nausea with opioid exposure may benefit Discharge Readiness and patient satisfaction for day-care laparoscopic cholecystectomy. TSSA should not be considered as a universal substitute for GA, however. It should be used with caution in patients with ASA I-II status, who are not obese and are scheduled for elective uncomplicated surgery in a centre where the surgeon has experience of thoracic neuraxial procedures, the patient has been made ready for conversion, and the surgeon is co-operative.

The current study has a few limitations. It was carried out in one centre, and included a medium number of participants. There was no blinding as the anaesthetic procedures were clearly different. Obese patients, acute cholecystitis, and severe cardiopulmonary disease patients were excluded from the study, which limits its generalizability. Early postoperative neurological follow-up was not carried out, and long-term follow-up was not performed. Sedation, low-pressure pneumoperitoneum, patient-reported recovery scores and a long-term safety follow-up should be standardized in future multicenter randomized trials.

Conclusion

Thoracic segmental spinal anaesthesia was a safe and an alternative option to general anaesthesia in carefully selected patients who underwent elective laparoscopic cholecystectomy. It was associated with excellent early postoperative analgesia, decreased opioid use, diminished incidence of PONV, rapid recovery and high satisfaction; without any complication of the neurologic system or significant hemodynamic changes in this population.

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