THE SAFETY AND FEASIBILITY OF SEGMENTAL THORACIC SPINAL ANESTHESIA ABOVE UMBILICUS AND BREAST SURGERY

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ABSTRACT

This study was conducted on 30 patients aged 16 to 70 years with American Society of Anesthesiology (ASA) physical status I, II, and III. Though general anesthesia (GA) is a universally accepted technique for most abdominal surgeries but not free from drawbacks including poly medicine side effects, prolonged recovery time, and unnoticed inadequate pain control, as well as risk to elderly patients with cardiopulmonary conditions, and safety issue limits the usefulness of general anesthesia. Thus, the new technique adopted attracts the attention of anesthesiologists, as thoracic segmental spinal anesthesia (TSSA) for several common surgeries where local anesthetic agents injected intrathecally above the termination of the spinal cord show value in patients with high risk for general anesthesia who need deep analgesia. The types of surgery were periumbilical hernia 7 (23.33%) in both age groups followed by epigastric hernia 8 (26.66%), neoplastic diseases of breast 6 (20%), laparoscopy cholecystectomy 4 (13.33%), open cholecystectomy 5 (16.66%). The analysis of intraoperative and postoperative mean systolic and diastolic arterial pressures (MAP) of patients up to 24 hours was found insignificant (P>0.05). Regarding the intraoperative hemodynamic changes, hypotension occurred in 3 patients and resolved with a single bolus of ephedrine, no tachycardia occurred, while bradycardia in 3 patients (15%). No patients need to be converted to general anesthesia due to inadequate block. On analysis complications, peri-operative or post-operative period showed that shoulder pain was experienced by 2 patients (6.66%) in the younger age group whereas in the older age group, two patients (6.66%) have hypotension and bradycardia was seen in 3 patients (13.33%). No respiratory complications, such as postoperative pneumonia or atelectasis were noted during the hospital stay with TSSA as well and no nausea/vomiting was noted. This study provides only preliminary evidence to support the feasibility and efficacy of segmental thoracic spinal anesthesia to be used effectively for safe anesthetic technique during routine laparoscopic surgery in normal patients as well as co-morbidity patients with stable intraoperative and post-operative hemodynamic and also avoidance of complications of general anesthesia with these benefits, decrease in length of stay in hospital, reduction of postoperative pain, and increased patients satisfaction. Thus, in future the segmental spinal anesthesia may become a good alternative to general anesthesia in normal patients as well as comorbid patients.

KEYWORDS

Thoracic spinal anesthesia, lap surgery, ASA, VAS, complications

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INTRODUCTION

A revolution in the techniques of regional anesthesia for several common surgeries has taken place in the twenty-first century, though anesthesiologists have been hesitant to perform spinal anesthesia above the termination of the spinal cord due to fear of injury to the spinal cord with a spinal needle, respiratory compromise, and total spinal block or the higher block with complications.[1] Though general anesthesia (GA) is a universally accepted technique for most abdominal surgeries but not free from drawbacks including polymedicine side effects, prolonged recovery time, and unnoticed inadequate pain control[2], as well as risk to elderly patients with cardiopulmonary conditions, and safety issue limits the usefulness of general anesthesia.[3-5] Thus, new technique adopted attracts the attention of anesthesiologists, as thoracic segmental spinal anesthesia (TSSA) for several common surgeries where local anesthetic agents injected intrathecally above the termination of the spinal cord show value in patients with high risk for general anesthesia needs for deep analgesia.[6] Despite the feasibility and safety reports in various literatures, TSSA has not become popular among the anesthesiologists in the clinical practice because of concerns regarding spinal cord injury on a higher level approach, above the termination of the spinal cord hence lumbar spinal anesthesia became more popular and dominant in clinical practice with increasing drugs volume,[7] because of this reason acceptance of TSSA as an alternate regional anesthesia technique in the clinical practice is hindering.[8] In the TSSA a low dose of anesthetic agent is less likely to cause cephalic spread of drugs, and the chances of the high or total spinal block are very low, thus small effective dose of local anesthetic is sufficient to block the required dermatomes for the proposed surgical procedure than the conventional spinal anesthesia below L1 to produce a true segmental block with sympathetic and motor blockade.[9]

Recently, TSSA was practiced by Van Zundert *et al*[6] in a patient with severe obstructive lung disease using low thoracic puncture (T10) for laparoscopic cholecystectomy. Then, they study the feasibility of TSSA in healthy patients admitted for laparoscopic cholecystectomy.[10] Imbelloni *et al*[11] concluded that TSSA reduces the doses of hyperbaric bupivacaine in combination with fentanyl for laparoscopic cholecystectomy leading to better outcomes with less hemodynamic instability and shorter duration of a sensory and motor blockade than conventional lumbar spinal anesthesia and can be considered in laparoscopic cholecystectomy surgery and surgery of lower limb.[12-14]

On the other side, Mohammed and Sherif[15] in 2013 have shown that TSSA can be used as a sole anesthetic technique in breast cancer surgery with axillary lymph node clearance. In another study, many surgical procedures could be carried out in segmental spinal anesthesia including awake thoracic surgeries, laparoscopic cholecystectomy, breast surgeries etc.[11]

Delivering low-dose anesthetic agents directly to a level requiring surgery has several advantages. Firstly, no blockade of the lower extremities, i.e. very little caudal spread so that a larger portion of the body experiences no venous dilatation and may be beneficial to stabilizing blood pressure intra-operatively whereas in conventional spinal anesthesia hypotension is the most common adverse effect and major risks identified.[2] Secondly, in the thoracic spinal the dose of spinal anesthetic agent is low which helps to achieve specific nerve block along the cord.[16] Thirdly, muscle relaxation is superior to general anesthesia without cardiovascular or respiratory compromise, which lowers the danger of cardiac arrest. Fourthly, motor control in the legs is spare, which exhibits greater satisfaction and decreased anxiety.[3] Fifthly, extensive thoracic nerve blockade causes anterior abdominal wall muscle paralysis leading to some impedance in forceful expiration and coughing but this can be minimized with lower doses of drugs while achieving good surgical relaxation.[3]

While performing TSSA, the anatomical layers pierced by a spinal needle are the same as conventional spinal anesthesia at the lumbar region. When the midline approach is adopted, the needle passes through the skin, subcutaneous fat, supraspinous ligament, interspinous ligament, ligamentum flavum, dura mater, subdural space, arachnoid mater, and lastly subarachnoid space. Whereas in the paramedian approach, the needle passes through the skin, subcutaneous fat, paraspinous muscles, ligamentum flavum, dura mater, subdural space, arachnoid mater, and subarachnoid space.[5] On studying, the anatomy of the thoracic canal with magnetic resonance imaging (MRI) revealed that space between the dura mater and spinal cord at T2 measured 5.19 mm, 7.75 mm at T5, and 5.88 mm at T10 and the angle of needle entry between T5 and T6 is almost 50°. MRI also confirmed that at the lumbar level, the spinal cord and cauda equine touch the dura mater posteriorly and at the

thoracic level anteriorly.[17] This position of the spinal cord increases the safe distance allowing needle tip advancement without touching the cord. Practically, all abdominal surgeries (upper/lower, major/minor, daycare/or not, laparoscopic/open) are possible with segmental spinal alone or CSE (combined spinal-epidural). The purpose of this study was to determine the safety and feasibility of thoracic spinal anesthesia to perform surgeries above the umbilicus and up to the level of the breast in normal patients and comorbid patients as well as observe changes in blood pressure, peripheral oxygen saturation, and heart rate before and after the procedure, observe the recovery time, duration of anesthesia and analgesia, discharge from the post-operative ward and study the patient's satisfaction and recommendation.

MATERIALS AND METHODS

After ethical clearance from the Nepal Medical College Institutional Review Committee, the cross-sectional observational study was carried out between September 2022 and April 2023 in 30 patients after getting signed informed consent. Patients were explained about the procedure in detail to alleviate anxiety and discomfort or pain during surgery were dealt with intravenous medications and also informed about the possibility of conversion to general anesthesia.

The inclusion criteria for the study were American Society of Anesthesiology (ASA) physical status I-III, surgery above the umbilicus to the level of breast, i.e breast cancer with or without axillary lymph node involvement, scheduled for radical mastectomy with or without axillary clearance of any age with comorbidity and exclusion criteria were inflammatory breast condition, diagnostic lumpectomy, body mass index above 35 kg/m^2 and conditions that contraindicate spinal anesthesia. Preoperative evaluation and preparation were standardized according to the anesthesia department on arrival in the operation theater, an intravenous line was secured with an 18-gauge cannula on the contralateral side to be operated and ringer lactated solution was started. All monitors were attached e.g. electrocardiogram (ECG), non-invasive blood pressure (BP), and pulse oximeter (SPO_2). After obtaining baseline vital signs positioning was done and isobaric ropivacaine was administered depending on the level of block required. As mentioned in different journals below T10 level 3 ml, at T10 level 2ml and at T5-6 level 1.5 ml with 25mcg fentanyl as an adjuvant to prolong the duration of anesthesia and analgesia and oxygen at 2 L/min was given through a face mask or nasal cannula. On average 7.5 to 10 mg (1.5 to 2 ml) of drug was required which was exactly half of the conventional spinal at lumber level 0.5% ropivacaine.[18] Then all patients were sedated with midazolam hydrochloride 5 mcg/kg to alleviate the anxiety associated with disease and surgery.

This gradual decrease in the dose of anesthetic agent from lumber to the thoracic spinal vertebra level is because of a diminished amount of CSF at thoracic levels compared to lumbar.[19] Thus, less anesthetic dilution of drug per segmental nerve fibers, and roots are easily blocked due to their small size, both these factors predicting effective segments blockade. During the surgery, the quality of anesthesia was evaluated, the need for supplementary sedation, hemodynamic changes (tachycardia i.e. heart rate greater than 100 bpm; bradycardia, heart rate below 60 bpm; hypotension, defined as a 20% drop in baseline blood pressure and hypertension increase in 20% from baseline blood pressure) and complications such as pruritus, nausea, vomiting were recorded as well as the length of the surgery, duration of analgesia and demand of first analgesia was evaluated using a verbal analogue scale. If the sensory block was inadequate after 10 minutes the patient underwent general anesthesia.

RESULTS

This study was conducted on 30 patients aged 16 to 70 years with ASA physical status I, II, and III. The study included patients who underwent breast surgery, laparoscopic surgery, and upper abdominal surgery, based on predefined inclusion and exclusion criteria. Among the participants, 13 (43.33%) were females, and 17 (56.66%) were males, with a M:F ratio of 1:1.33. The mean age was 69.37±1.88 years. The height, weight, body mass index, and ASA grades were comparable in both age groups, with no significant difference observed between them ($P>0.05$). Tables 2, 3, and 4 provide further details on the duration of surgery complications and types of surgery.

Intraoperative period mean systolic pressure in 5-minute intervals was a minimum of 109.60 mmHg to a maximum of 110.87 mm Hg whereas in the postoperative mean systolic pressure was a minimum of 109 mm Hg. The analysis of intraoperative and postoperative mean diastolic pressures minimum of 67.47 and maximum of 71.73 mm Hg was found insignificant ($P>0.05$).

Table 1: Intraoperative and post-operative vital parameter

Parameter		Time	5 min mean	5 min P	10 min mean	10 min P	15 min mean	15 min P	20 min mean	20 min P	25 min mean	25 min P	30 min mean	30 min P
BP mmHg	Systolic	Intra	109.87	.007	110.43	.081	109.60	.300	109.90	.001	109.90	.221	109.67	.588
		Post	109		109		109		109		109		109	
	Diastolic	Intra	70.47	.499	69.30	.744	69.93	1.00	67.47	.324	67.47	.441	71.63	.065
		Post	69.93		69.93		69.93		69.93		69.93		69.93	
HR(MIN)		Intra	99.50	.819	99.07	.969	100.43	.381	99.67	.722	100.07	.507	98.70	.762
		Post	99.13		99.13		99.13		98.73		99.13		99.13	
SPO_2 %		Intra	98.40	.001	99.23	.007	98.37	.001	99.13	.573	98.47	.023	98.30	.033
		Post	98.80		98.80		98.80		98.80		98.80		98.80	

Table 2: Post-operative complications

Hypertension	0 (30)
Hypotension	2 (30)
Tachycardia	0 (30)
Bradycardia	3 (30)
Paresthesia	2 (30)
Pruritis	1 (30)
Nausea/Vomiting	0 (30)
Shoulder pain	2 (30)
Total	**10**

Table 3: Types of surgery

Surgery done	Patients (n)
Epigastric hernia	8
Periumblicus hernia	7
Lap cholecystectomy	4
Open cholecystectomy	5
Breast surgery	6

Table 4: Duration of Surgery and Surgical Anesthesia

Duration of surgery (mean±SD) (min)	101.77±21 mins
Duration of surgical anesthesia	291.67±97.73 mins

Regarding the intraoperative hemodynamic changes, hypotension occurred in 3 patients and resolved with a single bolus of ephedrine, no tachycardia occurred, while bradycardia in 3 patients (15.0%). The analysis of heart rates showed that the mean heart rate in the intraoperative period was 100.43 per minute whereas in the post-operative period mean heart rate was 99.13 per minute with P >0.05.

Two patients developed paresthesia during spinal puncture which disappeared on withdrawal of the needle without any neurological sequel. Two patients developed postoperative purities not requiring treatment. No postoperative nausea or vomiting in any patient in either age group. Two patients complained of shoulder pain intraoperative or discomfort at the end of the procedure and responded to fentanyl, there was no evidence of respiratory compromise and oxygen saturation dropped below 98.0% throughout surgery. No patients need to be converted to general anesthesia due to inadequate block.

On analysis complications, peri-operative or post-operative period showed that shoulder pain was experienced by 2 patients (6.66 %) in the younger age group whereas in the older age group, two patients (6.66%) had hypotension and bradycardia was seen in 3 patients (13.33%). No respiratory complications, such as postoperative pneumonia or atelectasis were noted during the hospital stay with TSSA as well no nausea/vomiting was noted postoperatively.

The types of surgery were periumbilical hernia 7 (23.33%) in both age groups followed by epigastric hernia 8 (26.66%), neoplastic diseases of breast 6 (20%), laparoscopy cholecystectomy 4 (13.33%), open cholecystectomy 5 (16.66%).

Analysis of cases based on co-morbid conditions showed that common co-morbid conditions were hypertension 8 (26.66%), diabetes mellitus 7 (23.33%), and pulmonary conditions 5 (16.66%) with ASA II-III and the remaining 10 patients were ASA I (33.33%) with normal physical status.

The duration of surgery was 101.77±21mins for almost all surgeries carried out in segmental

thoracic anesthesia, and the surgical anesthesia time, patients were comfortable.

After completion of the surgery, VAS (Visual analogue score) was significantly less at 2, 4, 8, and 12 hours and postoperatively, and the intensity of pain was lower, and consumption of supplementary analgesics was lower. The pain was satisfactorily controlled by non-steroidal anti-inflammatory drugs within the first 12 hours in 2 patients (6.66%) then after 12 hours rescue analgesia was received with tramadol in 6 patients (20%). This shows that the intensity of pain and consumption of supplementary analgesics were lower in patients in the TSSA block. The length of stay in the recovery room and hospitalization were shorter in TSSA. Regarding patient and surgeon satisfaction an encouraging result was observed.

The mean pain score was statistically insignificant at time intervals for the study up to 12 hours during the postoperative period.

VAS after surgery (mean±SD)	
2 hours postoperative	1.4±0.56
4 hours postoperatively	1.5±0.682
8 hours postoperatively	1.33±0.42
12 hours postoperatively	1.10±0.302
The time of the first analgesia within 12 hours by NSAID was 291.67± 97.7 minutes	
The time of rescue potent analgesic was 514.52±137.88 minutes	
Within 12 hours analgesic consumption (NSAID)	2 (6.66%)
Frist rescue analgesia given after 12hrs (Tramadol)	6 (20%)
The patients in TSSA had a shorter mean hospital stay of 2.535 ± 0.56 days	
Patient Satisfaction Score	Yes (80%)
	No (18%)
	No Conclusive (2%)

DISCUSSION

As reported by Olawin and Das,[20] the introduction of spinal anesthesia in 1898 by Bier, subarachnoid space (SAS) has been punctured below the termination of the spinal cord to avoid neural damage. But Jonessco[21] in 1909 proposed the term general spinal block to produce profound analgesia of the head, neck, and thorax by puncturing the SAS at thoracic levels T1 and T2. He also demonstrated thoracic and abdominal surgeries by puncturing the SAS at mid-thoracic and lower thoracic levels. In 2006 a new era of studies was started on segmental spinal anesthesia by Van Zundert *et al*[6] on puncturing SAS at T10 for laparoscopic cholecystectomy in patients with severe obstructive lung disease.

The demographic data of the study shows the male-female ratio was 1:1.33 the mean age was 70.83±11.01 years, and the mean weight was 69.37±140.88 kg. The onset of the mean sensory block within 4.3±1.6 min, and the duration of surgical time up to 101.77±21.0 mins in all cases. The laparoscopic surgery was carried out using carbon dioxide insufflation at low pressure of 10 –12 mmHg, and the anxiety was treated with midazolam 5 mcg/kg, and shoulder pain with 0.5 mg/kg ketamine intravenously. All patients were stable hemodynamically during the intraoperative and postoperative period except for 2 (8.33%) patients who had hypotension and bradycardia was seen in three (10%) patients. No neurological deficit and respiratory embarrassment were reported in postoperative wards.[22] Furthermore, SpO_2 was above 96% with the supplementation of oxygen through nasal prong to all patients during surgery.

Intraoperative parameters, postoperative recovery, analgesia, complications as well as patient and surgeon satisfaction were recorded, and concluded that TSSA provides better hemodynamic stability, lesser vasopressor requirement, and early ambulation and discharge with a higher degree of patient satisfaction making it excellent even for day care surgery compared with conventional lumbar spinal anesthesia.[23] A similar report was published by Imbelloni and Gouveia[24] with better hemodynamics stability during surgery in patients undergoing segmental spinal anesthesia.

In various studies, surgical site pain has been categorized into incisional, visceral, parietal, and referral shoulder pain. So, the pain management may be multifactorial and with a multimodal approach. The referral shoulder pain was noted in 2 patients out of 30 (6.66%) in our study whereas the study conducted by Van Zundert *et al*[10] in 2007 showed shoulder pain preoperatively in 25%, and postoperatively in 10%. Shoulder tip pain may be minimized by avoidance of extreme head-up or down position so that gases, blood, and fluids do not irritate

the diaphragm. In other studies, postoperative pain management is easier with the epidural technique with a catheter in situ. However, the postoperative pain in laparoscopic surgery can be managed with other analgesic modalities such as paracetamol, non-steroidal anti-inflammatory drugs, and opioids.[25]

The frequency of paresthesia during the insertion of a spinal needle into the subarachnoid space is 13.6%.[26] Whereas in another study 300 patients undergoing thoracic spinal puncture reported a 6.6% incidence of paresthesia.[27] In a study of 636 patients for different procedures under thoracic spinal puncture the incidence of paresthesia was 6.1%.[28] In our study, two patients (6.66%) developed paresthesia which disappeared after needle manipulation without any neurological sequel. The paresthesia in our study was comparable to other studies though we had less experience in thoracic spinal anesthesia. However, the study conducted by Van Zundert *et al*[10] 2007 found paresthesia in one patient and explained that it was due to the anatomical positioning of the spinal cord studied in MRI and some degree of 'tenting' of the dura during puncture.[6]

In our study no patient had dyspnea during abdominal insufflation or oxygen saturation below 96.0% even in patients with respiratory disease. This may be because of placing the patient in a horizontal position after spinal anesthesia, and low insufflation gas pressure and using nasal prong for oxygen which we agree with the study done by Van Zundert *et al*.[6] On the other hand, in patients without respiratory disease expiratory muscles of the anterior abdominal wall paralysis would have little consequences, or no issue regarding respiratory status. That's why no patient experienced dyspnea during abdominal insufflation.

The cardiovascular changes were minimal because of a lower dose of local anesthetic required to produce an effect on the segment of the spinal cord as well as liberal fluid therapy and conscious patients to avoid central depression of circulation. On the other hand, hypotension is a common adverse effect during conventional spinal anesthesia because of a decrease in systemic vascular resistance, and central venous pressure due to sympathetic block with vasodilatation and redistribution of blood volume to the extremities and splanchnic vascular bed.[29] However in segmental spinal anesthesia, the sympathetic block is rarely complete, with some preservation of the sympathetic reflex.[29] So, in segmental anesthesia, both blood pressure, heart rate, and oxygen saturation were within normal limits throughout the procedure.

The study done by Imbelloni[13] in 2014, compared low doses of isobaric, and hyperbaric bupivacaine and stated that the incidence of cardiovascular complications including hypotension was 14.2% in a low-dose isobaric group compared to conventional spinal anesthesia where it was 38.5%.[3] The incidence of hypotension was 12.5% and bradycardia was (4.5%) with no difference between the two local anesthetic solutions when the posture of the patients maintained horizontal.[11] The incidence of paresthesia was 4%. There was no neurological deficit in the study group. In our study, we noticed hypotension in 2 (6.66%) and bradycardia in 3 (10.0%) patients. This may be due to inadequate fluid supplementation, which was successfully dealt with liberal fluid supplements, vasopressin, and atropine respectively. The study conducted by Van Zundert *et al*[10] in 2007 also stated that anesthetic agents spread along the cord to affect most of the spinal cord segments responsible for sympathetic outflow block and deal with liberal fluid therapy. All patients gave an overall satisfaction score of 8 or above (out of 10), none of the patients developed a post-dural puncture headache, and all resumed normal activities within a few days.

In our study, postoperative discharge time from PACU was similar to all patients regardless of type of anesthesia as we have no facility to discharge after regaining activity. The quality of postoperative analgesia was superior and analgesic consumption was less in the segmental anesthesia. As the study done by Elakany and Abdelhamid[30] in 2018, VAS was significantly less in thoracic segmental anesthesia at the end of completion of the surgery, 4, 8, and 12 hours postoperatively, and the intensity of pain and consumption of supplementary analgesics were lower in TSSA which was comparable to our study. The study done by Elankany and Abdelhamid[30] showed that supplemental non-steroidal anti-inflammatory drugs easily controlled pain in the TSSA, which was comparable to our study, and the satisfaction with the anesthesia by the patients and surgeons was similar to our study.

This study provides only preliminary evidence to support the feasibility and efficacy of segmental thoracic spinal anesthesia to be used effectively for safe anesthetic technique

during routine laparoscopic surgery in normal patients as well as co-morbidity patients with stabile intraoperative and post-operative hemodynamic and also avoidance of complications of general anesthesia with these benefits, decrease in length of stay in hospital, reduction of postoperative pain, and increased patients satisfaction. Thus in future the segmental spinal anesthesia may become a good alternative to general anesthesia in normal patients as well as comorbid patients.

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