The novel use of spinal anesthesia at the mid-thoracic level: a feasibility study

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Background
Breast surgery is commonly performed in geriatric patients. In this age group, patients commonly suffer from comorbidities, making regional anesthesia the preferred option during surgery. Recently, segmental thoracic spinal anesthesia for laparoscopic cholecystectomy was tried successfully. Anatomical studies showed that the posterior dural–spinal cord distance is wider at the mid-thoracic region. This encouraged us to test the feasibility of performing spinal anesthesia at the mid-thoracic level for surgeries in the thoracic region, namely breast surgery.
Materials and methods
We performed a prospective feasibility trial including 25 patients, American Society of Anesthesiologists-I (ASA-I), undergoing minor breast surgery (lumpectomy or simple mastectomy) under segmental thoracic spinal anesthesia at T5 level with 1 ml plain bupivacaine (5 mg/ml) and 0.3 ml fentanyl (50 μg/ml). We assessed the number of attempts required, paresthesia during needle insertion, sensory block level, need for supplemental analgesics or general anesthesia, and block-related complications. Hemodynamics as well as patient satisfaction were also recorded.
Results
The block was successful in all patients. A single insertion attempt was needed in 22 (88%) patients. No paresthesia was recorded during needle insertion. The upper sensory level was at T1 (T1–T2) and the lower sensory level at T11 (T11–T12). No additional analgesics or general anesthesia were needed during procedure. Four patients required ephedrine to correct hypotension. Two of these patients developed nausea during hypotension. No other complications were recorded. Total satisfaction was reported by 23 (92%) patients.
Conclusion
Segmental thoracic spinal anesthesia at T5 level in healthy patients undergoing breast surgery can be used successfully with minimal hemodynamic instability. The safety of this technique needs to be confirmed by further studies involving larger number of patients, with comorbid conditions, before it can be advised for routine use.

Keywords:
breast surgery, segmental thoracic spinal anesthesia, thoracic surgery

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Introduction

Epidemiological studies have shown that the incidence of breast cancer increases with age, with more than 65% of patients diagnosed above the age of 65 years [1]. In this geriatric age group, the possibility of coexisting major medical problems is high, which makes regional anesthesia a preferable option.

Different regional techniques have been attempted during breast surgery, including thoracic epidural [2] and thoracic paravertebral block [3–5]. However, the delayed onset of block, patchy sensory block, and large volume of local anesthetic used with potential risk for local anesthetic toxicity are still issues of concern when applying these techniques during breast surgery.

In two previous anatomical studies [6,7], MRI of the thoracic spine demonstrated that the posterior dural–spinal cord distance is significantly greater at the mid-thoracic region than at the upper and lower thoracic levels. This suggests the possibility of safe introduction of a spinal needle into the subarachnoid space at that level, but still with strict precautions and highly experienced hands. Van Zundert *et al.* [8] tested the feasibility of segmental spinal anesthesia for laparoscopic cholecystectomy concluding that the technique can be used effectively, but that further studies are required to confirm the safety of this novel technique.

Encouraged by the results of these previous studies, we decided to examine the feasibility of using segmental thoracic spinal anesthesia as a sole regional anesthetic technique for minor breast surgery to assess success, effectiveness, and potential complications.

Materials and methods

The study was carried out at Beni Suef University Hospital from October 2012 to May 2013 after approval by the local research and ethics committee and after obtaining written informed consent from the enrolled patients. The study included 25 female patients aged 21–60 years with American Society of Anesthesiologists (ASA) physical status I scheduled for minor breast surgery in the form of lumpectomy or simple mastectomy. Exclusion criteria included more extensive breast surgery other than lumpectomy or simple mastectomy, patients with a BMI of more than 35 kg/m^2 or height less than 160 cm, and patients with contraindication to regional anesthesia, such as local infection, spine deformity, or coagulopathy.

In the preoperative visit, the procedure and intended anesthetic technique were explained to all the patients, and written informed consent was obtained. Patients were exposed to routine preoperative evaluation, including history taking, general examination, and laboratory investigations. An 18-G intravenous cannula was inserted in the contralateral upper limb to the side of surgery, through which a volume preload of 10 ml/kg lactated Ringer's solution was administered. Sedation with midazolam (2–3 mg intravenously) was given 15 min before the block was performed.

On arrival to the operating room, routine monitors were attached (ECG, noninvasive blood pressure, and pulse oximeter). The patient was placed in the sitting position with the head flexed to perform the block. The desired insertion level was determined by ultrasound guidance using a 2–5 MHz curved array probe (Sonosite M-Turbo; Sonosite Inc., Bothell, Washington, USA). The T5–T6 intervertebral level was determined on the basis of the 'counting-up' method from the last rib [9]. The probe was oriented in a sagittal direction and placed at the level of the 12th rib in a parasagittal plane 2 cm from the midline. The probe was moved in cephalad direction and the ribs were counted up until the fifth rib was reached. The probe was then moved medially to identify the ligamentum flavum at the T5–T6 intervertebral space, and a skin mark was placed to identify the correct level of the block. The block was performed under complete aseptic conditions and after sterilization of the back. Using a paramedian approach, an 18-G epidural needle of a combined spinal epidural needle set (BD Durasafe Plus; BD Medical, Franklin Lakes, New Jersey, USA) was used to identify the epidural space by the 'loss of resistance to air' technique. The distance from the skin to the epidural space was recorded according to the length of needle still protruding from the skin. A 27-G Whitacre spinal needle was advanced through the epidural needle. When the resistance of the dura mater was felt, the distance from the tip of the epidural needle to the dura was recorded. The needle was then advanced very slowly until the dura was pierced. Once free flow of cerebrospinal fluid confirmed dural puncture, the two needles were locked together by a locking device to prevent the spinal needle from moving any further forward, and 1 ml of plain bupivacaine 0.5% (5 mg bupivacaine) and 0.3 ml of fentanyl 50 μg/ml (15 μg fentanyl) were injected. Then, the spinal needle and epidural needle were removed, and the patient was then returned to the supine position. Supplemental oxygen was administered (2–3 l/min) with the aid of nasal prongs. The number of needle insertion attempts required and the occurrence of paresthesia during either needle insertion or drug injection were both recorded.

Vital signs [heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure, respiratory rate, and oxygen saturation (SpO_2)] were recorded every minute for 15 min and then every 5 min until the end of the procedure. The upper and lower levels of sensory block were assessed by the pin-prick method 5 min after performing the block, and reassessed every 5 min for 15 min. Surgery was initiated only when an adequate sensory block was achieved (at least from T2–T6). The time required to achieve this level was recorded. The maximum upper and lower sensory levels reached after 15 min were recorded. The degree of motor block in the upper and lower limbs was assessed at the same time points. The motor block in the upper limbs was assessed by the epidural scoring scale for arm movements (ESSAM) score: hand grip (T1/C8), wrist flexion (C8/C7), and elbow flexion (C6/C5); four grades (0–3) based on the number of absent movements [10]. The motor block in the lower limbs was assessed by the modified Bromage scale: 0, free movement of legs and feet; 1, just able to flex knees with free movement of feet; 2, unable to flex knees but with free movement of feet; and 3, unable to move legs or feet. General anesthesia was not used unless a satisfactory block level was not achieved by the spinal injection after 15 min or if systemic analgesics did not control any intraoperative pain. Patients were advised about the possibility to convert to general anesthesia if they were dissatisfied with the block they received.

Hydration was maintained during surgery with lactated Ringer's solution (10 ml/kg/h). Any episodes of hypotension or bradycardia were recorded. Hypotension (defined as SBP <90 mmHg) was treated initially with ephedrine 5 mg intravenously followed by fluid bolus of 250 ml lactated Ringer's solution if needed. Bradycardia (defined as HR <50 beats/min) was treated with atropine 0.5 mg intravenously. Intraoperative anxiety

was treated with midazolam 1–2 mg intravenously. Pain during the procedure was treated by fentanyl 1 mcg/kg intravenous boluses. Intraoperative nausea and vomiting was treated by ondansetron 4 mg intravenously. The need for supplemental analgesics or antiemetics was recorded.

In the postanesthetic care unit (PACU), the sensory level of the block was assessed every 15 min and the time until complete regression of the block was recorded. The degree of motor block was assessed at the same time points. Patients were discharged from PACU after total regression of block, provided that postoperative pain was well controlled by systemic analgesics. Patient satisfaction was evaluated after discharge from PACU and classified as totally satisfied, average satisfaction, or not satisfied. The incidence of postdural puncture headache and postoperative urine retention was recorded. Discharge from hospital was after patients passed urine and when cleared by the surgeon as complication free.

Results

Twenty-five female patients undergoing minor breast surgery (lumpectomy or simple mastectomy) were recruited in this feasibility study. Patient characteristics (age, weight, height, and BMI) are shown in Table 1.

All blocks were performed at T5–T6 intervertebral level using a paramedian approach, and segmental spinal anesthesia was successful in all patients, with no epidural injections required in any patient. Of the 25 blocks performed, 22 blocks (88%) were performed using a single attempt of needle insertion and three patients (12%) required a second attempt to identify the epidural space (Table 2). In all patients, a single attempt was needed for introduction of spinal needle into the subarachnoid space. No paresthesia during introduction of the epidural or spinal needle or injection of the local anesthetic occurred in any patient. An adequate sensory level was achieved in all patients within 15 min after injection of local anesthetic. Sensory levels recorded at 15 min and before commencement of surgery were: upper level at T1 (T1–T2) and lower level at T11 (T11–T12). There was no significant lower limb motor block in any of the patients, and a Bromage scale of 0 was recorded in all patients whether before or after surgery. An ESSAM score of 1 was recorded in only four patients (16%) before surgery and in three (12%) patients after surgery. All the remaining patients had an ESSAM score of 0 whether before or after surgery.

Hemodynamic parameters (SBP, diastolic blood pressure, and HR) are shown in Fig. 1. Four patients required ephedrine to treat hypotension before the initiation of surgery. All four patients showed an adequate response to the vasopressor (ephedrine 5 mg intravenous single dose) and maintained hemodynamic stability after that. Two of the four patients complained of nausea during the event of hypotension that resolved after the correction of hypotension with no need for an antiemetic. Bradycardia did not occur in any of the patients. Arterial oxygen saturation was maintained above 97% with supplemental oxygen through nasal prong at 3 l/min, with none of the patients showing signs of respiratory compromise. None of the patients required intraoperative analgesics or conversion to general anesthesia. Twenty-three patients were totally satisfied, whereas the two patients who developed nausea with hypotension event reported average satisfaction. No patients developed postdural puncture headache, postoperative nausea or vomiting, postoperative

Table 1 Patient characteristics

Age (years)	50 (39–60)
Weight (kg)	82.5 ± 8.6
Height (cm)	164.6 ± 6.7
BMI (kg/m^2)	30.4 ± 2.7

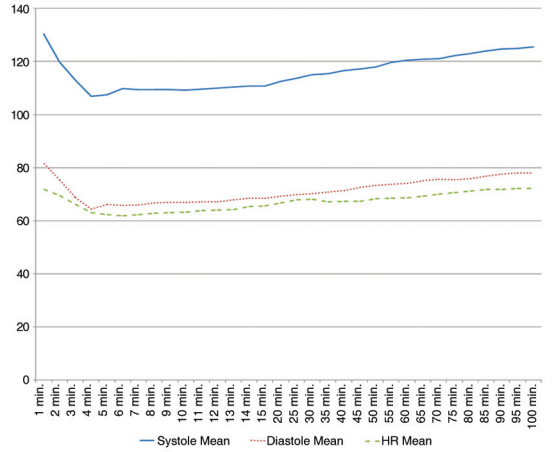
Data are expressed as mean (range) or mean ± SD.

Table 2 Anesthetic technique

Number of needle insertion attempts	
1	22 (88)
2	3 (12)
Distance from skin to epidural space (mm)	62.7 ± 4.4
Distance from Tuohy tip to dura mater (mm)	5.0 ± 0.7
Paresthesia from epidural needle	0 (0)
Paresthesia from spinal needle	0 (0)
Paresthesia during injection	0 (0)

Data are expressed as *n* (%) or mean ± SD.

Figure 1



Mean systolic and diastolic blood pressures and heart rate plotted against time.

urine retention, or problems with restoring activity postoperatively on the day of surgery (Table 3).

Discussion

In patients examined in this study, segmental thoracic spinal anesthesia was found to be successfully performed with an adequate level of sensory block during minor breast surgery. The technique was associated with a high degree of hemodynamic stability and a high patient satisfaction rate.

We were concerned about three issues: first, the risk for spinal cord injury; second, cephalad spread of local anesthetic causing high or total block; and third, hemodynamic or respiratory compromise due to block of cardioaccelerator fibers or intercostal nerves, respectively.

Concerning the first issue, we depended on the fact that the posterior subarachnoid space is wider at the mid-thoracic region compared with the upper and lower thoracic regions. This was shown in the study by Imbelloni *et al.* [6] who performed MRI of the thoracic spine in 50 patients. They found that the posterior dural–spinal cord distance was significantly greater at the mid-thoracic region (T5 = 5.8 ± 0.8 mm) compared with the upper (T2 = 3.9 ± 0.8 mm) and lower thoracic levels (T10 = 4.1 ± 1.0 mm). Another anatomical study performed by Lee *et al.* [7] showed very similar results. In their study, they performed MRI of the thoracic and lumbar spines in the supine, laterally recumbent, and sitting (head-down) positions. They found that the separation of the dura mater and spinal cord is greatest posterior in the middle thoracic region compared with the upper and lower thoracic levels for all three positions. These results encouraged us to perform the block at the T5 level to minimize the risk of injuring the spinal cord.

Table 3 Anesthetic outcome

Sensory block	
Adequate block level achieved (from T2 to T6)	25 (100)
Time to achieve adequate block level	
At 10 min	14 (56)
At 15 min	11 (44)
Upper level of block reached at 15 min	T1 (T1–T2)
Lower level of block reached at 15 min	T11 (T11–T12)
Motor block	
Number of patients with Bromage scale >0	
Before surgery	0 (0)
After surgery	0 (0)
Number of patients with ESSAM score >0	
Before surgery	4 (16)
After surgery	3 (12)
Duration of surgery (min)	61 (45–80)
Time to full block regression (min)	157 (140–190)
Need for intraoperative analgesia	0 (0)
Need for epidural injection	0 (0)
Need for general anesthesia	0 (0)
Complications	
Intraoperative	
Hypotension	4 (16)
Bradycardia	0 (0)
O2 saturation <90%	0 (0)
Nausea	2 (8)
Vomiting	0 (0)
Postoperative	
Nausea and vomiting	0 (0)
Itching	0 (0)
Urine retention	0 (0)
Postdural puncture headache	0 (0)
Patient satisfaction	
Totally satisfied	23 (92)
Average satisfaction	2 (8)
Not satisfied	0 (0)

Data are expressed as *n* (%) or mean (range); T, thoracic.

Concerning the second and third issues, we chose to exclude patients with a BMI more than 35 kg/m^2 and height less than 160 cm to minimize factors that may contribute to a higher spread of block. We limited our selection of patients to ASA physical status I, aged below 65 years to minimize the sequelae of a high spinal block or any hemodynamic or respiratory compromise, which may be worse in the presence of comorbidity or any limited functional capacity.

Van Zundert *et al.* [8] proved the initial feasibility of segmental spinal anesthesia in laparoscopic cholecystectomy using T10 level for performing the block in 20 patients. The block was successful in all patients. The upper sensory block level obtained was T2–T4 with minimal hemodynamic changes and no respiratory complications, despite the abdominal insufflation. In comparison with the study by Van Zundert and colleagues, we performed the block at the T5 level. We chose this level on the basis of the anatomical studies stated above, and also because this level was nearer to the required level to be blocked (T2–T6) to perform breast surgery. The higher block level in our study may explain the higher levels of sensory block than those obtained in the Van Zundert study (upper level: T1–T2 vs. T2–T4 and lower level: T11–T12 vs. L1–L5, respectively). Our sensory block range was limited to the thoracic region (T1–T12), which can be explained using the midpoint of thoracic region to inject the isobaric bupivacaine, and also due to the normal concavity of the vertebral canal at the thoracic region. Both factors may have aided the equal distribution of local anesthetic above and below the injection level (T5).

Another difference in our study is that we performed the block with the patients in the sitting position

with head flexed compared with the left lateral position used by Van Zundert *et al.* [8]. We chose this position on the basis of the results published by Lee *et al.* [7] in their anatomical study. They found that, by placing the patient in a head-down sitting position, the posterior separation of the dura mater and spinal cord is increased compared with the supine and lateral positions. This again will decrease the potential risk for spinal cord injury during performing the block at the thoracic level. We also chose a paramedian approach during performing the spinal block and not the midline approach used in the Van Zundert study. The extreme caudal angulation of the thoracic spinous processes makes the midline approach to the thoracic epidural space more difficult [11].

We chose to use a combined spinal epidural set to perform the spinal block. We chose this technique to allow for safer localization of the subarachnoid space and to minimize the risk for cord injury. However, we chose not to thread a catheter into the epidural space after performing the spinal block. Our reason for that was that we performed the block with the patient in the sitting position, and the time taken to thread the epidural catheter might potentially lead to cephalad migration of the plain local anesthetic injected intrathecally, leading to a higher level of block than intended.

We used ultrasound guidance to identify the T5–T6 intervertebral level at which we performed the spinal block. Previous studies have shown that palpation of surface anatomical landmarks [inferior tip of scapula (T7) and spinous process of vertebra prominens (C7)] is inaccurate at identifying thoracic spinous processes and intervertebral levels [12–14]. That is why we chose to depend on ultrasound guidance to achieve a more accurate localization of the desired block level.

The level of sensory block we achieved (T1–T12) suggests that this technique can be successfully used in other surgical procedures that are carried out at the same dermatomal level. One of the potential applications of this block is during what is known as 'awake thoracic surgery' [15], in which certain thoracic surgical procedures are performed in fully conscious, spontaneously breathing patients under regional anesthesia. This technique has been successfully used in different thoracoscopic procedures, including bullectomy, thymectomy, lung volume reduction surgery, and wedge resections. The clear advantages of this technique are the avoidance of side effects associated with general anesthesia as well as a faster recovery. Both of these factors can result in reduced morbidity, especially in high risk patients.

The main limitations to this study are the small number of patients included as well as the absence of comparison with other anesthetic techniques for this type of surgery, whether general or regional. Further studies with larger sample sizes are required to detect any potential disadvantages or complications associated with this anesthetic technique, especially in patients with concurrent diseases. The comparison of this segmental spinal anesthesia technique with other regional blocks, such as thoracic epidural and thoracic paravertebral blocks, and with general anesthesia for breast surgery patients should also be looked at.

Conclusion

We have found that segmental spinal anesthesia for minor breast surgery performed at T5 level was effective and associated with minimal hemodynamic instability and a high patient satisfaction rate. However, it should not be advised for routine application until more studies with larger numbers of patients, including patients with comorbid conditions, can provide sufficient evidence of safety.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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