Sonographic measurement of needle insertion depth in paravertebral blocks in women

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Single-injection paravertebral block offers adequate unilateral analgesia for thoracic and upper abdominal surgery. This technique is easy to learn but there is a risk, albeit low, of pleural puncture. The aim of the study was to determine whether sonographic measurements of the distances from the skin to the transverse process and to the parietal pleura are useful for calculating the required depth of needle insertion. Before puncture of the paravertebral space, the distances from the skin to the transverse process and to the parietal pleura were measured by sonography. The deviation of the needle from the horizontal plane was measured and an angle correction for the insertion depth was calculated. Twenty-two women undergoing elective unilateral breast surgery were studied. Sonographic visualization of the transverse process and the parietal pleura and measurement of their distances from the skin was successful in all women. Puncture of the paravertebral space failed in one obese woman. There was a very close correlation between needle insertion depth from the skin to the transverse process and the distance measured by ultrasound if angle correction was used (adjusted $r^2=0.95$). Similarly, there was excellent correlation between the angle-corrected ultrasound distance from the skin to the parietal pleura and the distance from the skin to the paravertebral space (adjusted $r^2=0.92$).

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Single-injection paravertebral block offers excellent intraoperative analgesia, reduces analgesia requirements after surgery and decreases discomfort after breast surgery.¹ To minimize the risk of pleural puncture, accurate placement of the needle in the paravertebral space, as recognized by the loss of resistance technique, is essential.² Accurate knowledge of the depth of the paravertebral block and the maximum needle insertion depth that would avoid pleural puncture would make it easier to perform paravertebral block. The purpose of the study was to determine whether ultrasound scanning of the transverse process and the parietal pleura can give an accurate reading of the depth to the paravertebral space.

Methods

After Institutional Review Board approval and written informed consent, 22 women (ASA I–II) undergoing unilateral elective breast surgery were included in the study. All women were scheduled for single-injection paravertebral block at the level of T4.¹ Patients were followed up for $\geq$12 h, in the PACU for the first 4 h and on the general ward later. Exclusion criteria were: age >70 yr, allergy to local anaesthetics, coagulation disorders and local infection at the injection site.

After application of standard monitoring, including ECG, non-invasive arterial pressure and pulse oximetry, all patients were sedated with midazolam 1–3 mg iv. Women were placed on their side, with the side to be blocked uppermost, and were scanned with a Hewlett-Packard scanner with a 7.5 MHz linear array probe. The transverse process was located and its distance from the skin and the distance of the parietal pleura from the skin were determined. The scanning head was placed at 90° to the skin in all planes, 3.5 cm from the anatomical midline at the level of the cephalad end of the spinous process of T4. The
transverse process and the parietal pleura were located by ultrasonography.

The skin was sterilized and then it and underlying structures were locally infiltrated with 3 ml of 2% lidocaine. The needle used for infiltration was inserted at 90° to the skin in all planes to strike the transverse process; the distance from the skin to the bony contact was marked on the needle and subsequently measured with a ruler. Angle corrections, if required to reach the bony contact, were recorded. Paravertebral block was performed 3.5 cm from the anatomical midline, as proposed by Eason and Wyatt. A 22 gauge spinal needle (Terumo spinal needle; Terumo Corporation, Tokyo, Japan) was inserted 3.5 cm from the anatomical midline at the level of the cephalad end of the spinous process of T4. The needle was advanced at 90° to the skin in all planes to strike the transverse process or the head of the rib. It was then directed over the top of the bony structure. The technique of loss of resistance to normal saline injection was used to identify the paravertebral space after the needle passed the costotransverse ligament. The depth was marked on the needle and the distance was measured with a ruler. After negative aspiration, a test dose of 5 ml of 0.5% bupivacaine with 1:200 000 epinephrine was administered incrementally. A single injection of 0.3 ml of 0.5% bupivacaine kg⁻¹ (maximum dose 150 mg) with 1:200 000 epinephrine was performed in all patients. The duration of injection of the local anaesthetic was ≥120 s. The puncture of the paravertebral space was performed in all cases by the same anaesthetist, who was blinded to the results of the ultrasonographic measurements. The patient’s body position was unchanged from the beginning of the ultrasonographic measurements until the block was finished. The angle deviation of the needle from the horizontal line was noted in order to calculate the angle correction of the sonographic distance: (i.e. needle distance=sonographic distance/cosine angle deviation). Angle deviation was measured with a protractor held on the patient’s skin.

The pinprick method and thermographic spread were used to assess the extent of analgesia. Paravertebral blocks with a thermographic spread (sympathetic block) of <4 dermatomes or loss of pinprick sensation of <3 dermatomes were taken to indicate incorrect puncture. Ipsilateral warming was recorded using an infrared temperature scanner (Dermatemp, Exergen, Watertown, MA, USA). Patients with insufficient paravertebral block were excluded from study evaluation. A chest X-ray was performed in all patients after surgery to exclude pleural puncture.

Patients characteristics and all distances are presented as mean (range). Correlations were calculated by the Spearman rank test.

### Results

Twenty-two women undergoing elective unilateral breast surgery were studied and 21 finally evaluated. In one obese woman, puncture of the paravertebral space was abandoned because of inability to identify the paravertebral space, whilst sonographic measurements were successful. No other patient was excluded. The characteristics of the remaining 21 patients are presented in Table 1. Sonographic visualization of the key structures (parietal pleura and transverse process) and paravertebral block were successful in all women.

There was a very close correlation between the distance of the needle from the skin to the transverse process and the distance measured by ultrasound if angle correction was used (adjusted $r^2=0.95$). The distance measured by ultrasound difference was always less than the needle distance, the mean difference being 4 mm (range 1–7 mm). Similarly, the angle-corrected ultrasound distance from the skin to the parietal pleura showed excellent correlation with the needle distance from the skin to the paravertebral space (adjusted $r^2=0.92$). Again, the ultrasound distance always exceeded the needle distance, the mean difference being 4 mm (range 1–7 mm). In all women, the angle-corrected sonographic distance from the skin to the pleura was greater than the distance of the needle from the skin to the paravertebral space. No accidental pleural puncture occurred in our study.

### Discussion

Ultrasound scanning of the transverse process and the parietal pleura gave an accurate reading of the depth to the paravertebral space, helping to avoid accidental pleural puncture. Sonographic measurements correlated well with distances found during needle insertion when angle correction was used. The maximum insertion depth required to minimize the risk of pneumothorax could be predicted accurately.
Although accidental pleural puncture is rare,² paravertebral block is still considered potentially dangerous by many anaesthetists,⁴ so the technique is performed infrequently. However, some centres specialized in this block consider it the regional anaesthesia of choice for unilateral thoracic or abdominal surgery.⁴ Using ultrasound to visualize anatomical landmarks, it may be possible to improve the safety of the block.

The transverse process is an important landmark when one is performing paravertebral block. However, it can be difficult to locate in obese patients or in cases of vertebral abnormality, so the risk of pleural puncture may be higher in these patients. The finding that the apparent distances from the skin to the bony contact when measured using the needle method were greater than angle-corrected sonographic measurements may be explained by tangential contact of the transverse process or by skin compression with the scanning head. This compression might in part explain the relatively small differences between the distance to the paravertebral space and the angle-corrected ultrasound distance to the parietal pleura. Another explanation could be the quite lateral approach to the wedge-shaped paravertebral space of 3.5 cm laterally from the anatomical midline.

Ultrasound scanning of the transverse process and the parietal pleura provides accurate assessment of the maximum needle insertion depth to avoid pleural puncture and enables calculation of the depth to the paravertebral space. Prior knowledge of the depth to the paravertebral space should make paravertebral block easier to perform.

References