BJA

SHORT COMMUNICATIONS

Prediction of the distance from skin to epidural space for low-thoracic epidural catheter insertion by computed tomography

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Background. It may be clinically useful to predict the depth of the epidural space.

Methods. To investigate the accuracy of preoperative abdominal computed tomography (CT) in prediction of the distance for low-thoracic epidural insertion, a single group observational study was conducted in 30 male patients undergoing elective major abdominal surgery requiring epidural analgesia for postoperative pain relief. Using the paramedian approach, low-thoracic epidural insertion at T10–11 interspace was performed with a standardized procedure to obtain an actual insertion length (AIL). According to the principles of trigonometry, an estimated insertion length (EIL) was calculated as 1.26 times the distance from skin to epidural space measured from the preoperative abdominal CT.

Results. The mean (SD) EIL and AIL were 5.5 (0.7) and 5.1 (0.6) cm, respectively, with a significant correlation ($r=0.899$, $P<0.01$). The EIL tended to have a higher value than the AIL (0.4 (0.3) cm). There were significant correlations of both EIL and AIL with weight ($P<0.01$), BMI ($P<0.01$), and body fat percentage ($P<0.01$), but not with height ($P>0.05$).

Conclusions. We conclude that the preoperative abdominal CT is helpful in prediction of the distance for low-thoracic epidural insertion using the paramedian approach.

Thoracic epidural analgesia provides effective post-operative pain relief for major abdominal or thoracic surgery. However, insertion of the epidural catheter at the thoracic spine is technically more difficult and can cause neurological complications.[1][2] Having prior knowledge of the distance for thoracic epidural insertion may be helpful during this procedure in the prevention of complications.

Magnetic resonance imaging and computed tomography (CT) had been used to measure the distance from skin to epidural space (Sk-Ep) without clinical application in epidural insertion.[3][4] It is technically difficult to estimate the thoracic or lumbar Sk-Ep by ultrasonography.[5–7] Carnie and colleagues reported the use of preoperative chest CT to predict the distance for mid-thoracic epidural insertion using the midline approach.[8] However, the paramedian approach is favoured for thoracic epidural insertion by many practitioners because of the acute angle of thoracic spinous processes and possible calcified supraspinous ligaments.[9]

The objective of this study was to evaluate the accuracy of preoperative abdominal CT in prediction of the distance for low-thoracic epidural insertion using the paramedian approach. The estimated insertion length (EIL) predicted from CT was compared with the actual insertion length (AIL).

Methods and results

The study was approved by our Institutional Review Board and we obtained informed consent from each patient in this observational study. Data were collected from 30 adult male patients of ASA class I–III, who were to undergo elective major abdominal surgery requiring low-thoracic epidural

Table 1 The mean (SD), range, and 95% CI of the EIL, the AIL, and the difference between the EIL and AIL (E – A), *n*=30. ^{a}EIL=1.26×Sk-Ep on CT

	EIL (cm)^a	AIL (cm)	E – A (cm)
Mean (SD)	5.5 (0.7)	5.1 (0.6)	0.4 (0.3)
Range	4.4–7.6	4.0–6.7	–0.4–1.1
95% CI	5.3–5.8	4.9–5.3	0.3–0.6

analgesia for postoperative pain relief. All patients had preoperative upper abdominal CT performed for diagnosis of their disease. Patients with coagulopathy, sepsis, and pre-existing neurological disease were excluded.

One anaesthestist performed all the low-thoracic epidural insertions before surgery using a standardized paramedian approach as described by Cousins and Veering.[10] The patient was placed in the lateral decubitus position and the levels of T10 and T11 spinous processes were identified. Using an aseptic technique and after skin infiltration with lidocaine 2% 5 ml, a 17-gauge Tuohy needle (Arrow, Reading, PA) aiming at T10–11 interspace was inserted at 1–1.5 cm lateral to the caudad edge of the inferior spinous process of T11 vertebra. The insertion angle of the needle was measured by a sterile protractor as slightly inward at 15° to the sagittal plane and upward 55° to the long axis of the spine. Entry of the needle into the epidural space was identified by the loss of resistance technique and the final upward angle reaching the epidural space was measured with the protractor. The AIL was marked and then measured with a ruler. The proper placement of the epidural catheter was confirmed by segmental sensory block after injecting lidocaine 2% 2 ml.

Another anaesthesist, who was not involved in the procedures, reviewed the abdominal CT films using the Picture Archiving and Communication System. Using internal measurement device, Sk-Ep on the transverse CT plane was measured from the skin to the ligamentum flavum at the corresponding T10–11 interspace. Because the angle for the needle entry into the epidural space using the paramedian approach was close to 15° inward and 55° upward, the EIL was calculated using the principle of trigonometry as 1.26 times the Sk-Ep measured from CT (EIL=Sk-Ep/(cos15°×cos35°)=1.26×Sk-Ep).

Data collected included the AIL, EIL, body height, weight, and BMI for statistical analysis. In addition, body fat percentage was measured by bioelectrical impedance method using a hand-to-hand analyser (OMRON BF 300). The distribution of residuals was tested for normality using Durbin-Watson statistic. We used descriptive statistics and simple linear regression to analyse the correlation between the EIL and AIL. The correlation between the EIL or AIL with height, weight, BMI, and body fat percentage was analysed using Pearson correlation coefficient. A value of $P<0.05$ was considered statistically significant.

Mean (SD) age, height, weight, BMI, and body fat percentage were 66.3 (10.6) (range 41–80) yr, 165.4 (5.4) cm, 65.7 (11.7) kg, 24.0 (3.9) kg m^{-2} and 27.1 (5.1)%, respectively. The EIL and AIL were 5.5 (0.7) and 5.1 (0.6) cm, respectively. The EIL tended to have a higher value than the AIL by 0.4 (0.3) cm and the difference was significant by paired *T*-test ($P<0.01$). The final upward angle of needle insertion was 55.8 (5.3)° with a 95% CI 53.9–57.8°. The mean (SD), range and 95% confidence intervals (CI) of the EIL, the AIL and the difference between the EIL and AIL are shown in Table 1. There was a high correlation between the EIL and AIL ($r=0.899$, $P<0.01$). There were significant correlations of both the EIL and AIL with weight ($r=0.832$ and 0.721, $P<0.01$), BMI ($r=0.830$ and 0.767, $P<0.01$), and body fat percentage ($r=0.711$ and 0.636, $P<0.01$) but not height ($r=0.146$ and 0.029, $P>0.05$).

All patients had adequate pain relief with no complications.

Comment

Our data indicate that the EIL can be a helpful predictor of the length for low-thoracic epidural insertion using the paramedian approach. There was a mean difference of 0.4 cm with 95% CI 0.3–0.6 cm between the EIL and AIL induced. The difference between the values may arise from skin tightening and consequent s.c. tissue compression as a result of positioning of the patient in spine flexion, which differs from positioning during supine CT. In addition, the compressed skin during needle insertion may cause an underestimation of the AIL. The epidural space should be reached before the EIL in most cases. Therefore, advancing the needle closer to or over the EIL should be done with caution. The significant correlations of both the EIL and AIL with weight, BMI, and body fat percentage in the low-thoracic region confirm experience in clinical practice.

The final insertion angle reaching the epidural space among individuals could vary significantly with different practitioners. This would affect the accuracy of the prediction. More caution should be exercised when the upward angle is increased, because the AIL could be much shorter than the EIL. For needle insertion using the paramedian approach, an angulation close to 15° inward and 55° upward is generally applicable in our daily practice.

In conclusion, the Sk-Ep varies among individuals and is generally obesity related. The EIL derived from abdominal CT is helpful as a guide for low-thoracic epidural insertion using the paramedian approach. Thus, the potential risks for this procedure may be minimized.

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