Abstract: Thoracic epidural anaesthesia in anaesthetized children requires a meticulous technique and may have an increased success rate when the distance between skin and epidural space is known. The objective of this observational study was to measure the skin to epidural distance (SED) during thoracic epidural puncture in 61 children. The epidural puncture was performed using the loss of resistance technique with saline 0.9%. The distance from the needle tip to the point where the needle emerged from the skin was measured. The postoperative analgesia parameters were also measured. Skin to epidural distance correlated significantly with the age and weight of the children. The equation for the relation between SED (cm) and age was \[ 2.15 + \left(0.01 \times \frac{\text{months}}{100}\right) \] and for SED vs weight was \[ 1.95 + \left(0.045 \times \frac{\text{kg}}{100}\right) \]. Despite considerable variability among individuals, the observed correlation of SED with both age and weight shows that this parameter may be helpful to guide thoracic epidural puncture in anaesthetized children.

Key words: Anaesthetic techniques : regional : epidural ; anaesthesia : paediatric ; anatomy : epidural space.

Paediatric epidural anaesthesia/analgesia has increased in popularity in the last 20 years, but its success rate and the frequency of complications have not been fully elucidated (1, 2). The smaller size of the vertebral canal and epidural space, and the catheter insertion under general anaesthesia may make epidural cannulation in children more hazardous than in awake adults.

Although newer techniques (ultrasound guidance, stimulation) may be helpful in assisting epidural puncture and catheter insertion, they are not routinely available. The loss of resistance technique still remains the basic technique for recognition of the epidural space. Knowledge of the depth of the epidural space or the skin epidural distance (SED) might increase the success rate and the safety of epidural puncture. However, in children this has only been described for the lumbar epidural space (3, 4).

The main objective of this study was to describe insertion details and to measure the SED during thoracic epidural puncture in anaesthetized children up to 14 years of age. Furthermore, postoperative analgesic efficacy was evaluated.

Patients and methods

Sixty-one patients were included in this prospective observational study for which institutional research committee approval and informed consent from the children and/or parents were obtained. The children were scheduled for major thoracic or abdominal surgery where postoperative thoracic epidural analgesia was selected. Abnormal coagulation and local infection at the epidural puncture site were contra-indications.

Epidural puncture was always performed by an experienced paediatric anaesthesiologist after induction of general volatile anaesthesia with tracheal intubation performed without neuromuscular blocking drugs. All children were monitored with ECG, SpO₂, non-invasive blood pressure and capnography.

The epidural puncture was performed in the right lateral position with the hips flexed. An aseptic technique was used. A paediatric Tuohy needle 20G (for a 24G catheter) was used for children < 10 kg and a 18G needle (for a 20G catheter) for those ≥ 10 kg (Perifix Paed, B Braun, Germany). The needle was introduced 1-2 mm from the midline between two processi spinosi with an angulation of 40-60 degree upward to the long axis of the spine. The intervertebral space of needle insertion...
was either one or two segments below the dermatomal level of the intercostal incision (for thoracotomies) or at a low to mid-thoracic level for laparotomies. The loss of resistance technique was performed using saline 0.9%. The needle was advanced with the left index finger and thumb while continuous pressure was exerted on the syringe with the right thumb until loss of resistance was felt. The distance from the needle tip to the point where the needle emerged from the skin after loss of resistance was measured. The epidural catheter (soft Perifix catheter with central opening) was threaded 3 cm cranially in the epidural space. A test dose of 0.25 mg.kg⁻¹ bupivacaine with epinephrine 1/200 000 was given followed after 5-10 min by a slow bolus dose up to 1 mg.kg⁻¹ bupivacaine. The number of attempts for siting was limited to three. When blood appeared in the needle or syringe further attempts were stopped. Anaesthesia was further maintained with a volatile anaesthetic and rocuronium as non-depolarizing muscle relaxant.

At the end of surgery a continuous epidural infusion of plain bupivacaine was started at 0.4-0.5 mg.kg⁻¹.hr⁻¹ for children older than six months and at 0.25 mg.kg⁻¹.hr⁻¹ when younger than six months of age. Paracetamol 60-90 mg.kg⁻¹ daily was given to all patients in four divided doses. The CHIPPS pain scale was used at frequent intervals in children up to five years of age (5). In older children a numerical analogue pain scale (0-10) was used. When the pain score in either scale was > 3, escape medication was given with an i.v. morphine infusion at 3-20 µg.kg⁻¹.hr⁻¹. When children were distressed for reasons other than surgical pain (nasogastric tube, urinary catheter etc.) an infusion of morphine was given, but at a lower dose of 3-5 µg.kg⁻¹.hr⁻¹.

The postoperative follow-up of epidural analgesia and adjuvant and escape medication was done according to the hospital’s postoperative children’s pain protocol. This was audited in every case by the hospital acute pain service and recorded into a data base.

Data were introduced and analysed in an Excel spreadsheet. Statistical analysis was done using SPSS for Windows. The correlation between SED and weight and age was analysed using the Pearson correlation coefficient. A regression analysis was performed to describe the relation between SED and age or weight. To assess and visualize the effect of the thoracic intervertebral space level on SED, the individual SED’s were recalculated by extrapolation to an age of 24 months based on the linear regression analysis. A P value < 0.05 was considered statistically significant.

RESULTS

Table 1 summarizes the demographic patient data. The dermatomal level of epidural puncture was a high-thoracic (Th5-6 or above) in 14 children, mid-thoracic (Th6-7 to T8-9) in 40 and low-thoracic (Th9-10 to Th11-12) in seven children. The epidural needle size was 18-G in 41 children and 20-G in 20 children. The epidural space could be clearly identified with the loss of resistance technique in all children. In 50 children, the epidural space was identified after one puncture attempt. In eight patients, two attempts and in three patients three attempts were necessary. All 20-G catheters were threaded up successfully. In one child a 24-G catheter could not be threaded and in three children threading up the catheter was difficult despite clear loss of resistance.

There were no dural punctures or bloody taps. No signs of intravascular injection were seen after the loading dose of bupivacaine with epinephrine. There were no convulsive events during epidural analgesia and no neurological sequelae or deficits at discharge from the hospital.

The linear relation between SED (cm) and age was:

SED = 2.15 + (0.01 × months).

The formula for SED vs weight was:

SED = 1.95 + (0.045 × kg).

The Pearson correlation coefficient for SED vs age was 0.724 and for SED vs weight was 0.725 (both p < 0.01). Figure 1 shows the relation between SED and age in months. There was a wide interindividual variability.
Figure 2 shows the relation between SED extrapolated to an age of two years and the level of the intervertebral space. At the lower thoracic intervertebral spaces there was a smaller SED than at the other thoracic intervertebral spaces.

In most patients (n = 37) epidural administration of bupivacaine was continued for 48 hours. In 15 patients, undergoing very painful procedures, epidural analgesia was prolonged for one more day. In one patient a catheter could not be threaded and in eight patients epidural analgesia was stopped prematurely for various reasons: dislocation (n = 1), leakage (n = 1), difficulty in measuring the efficacy of block cq analgesia (n = 3), intercurrent septicaemia not catheter-related (n = 1), and morphine administration for mechanical ventilation (n = 2).

Thirty nine patients were discharged to the ward after postoperative recovery room observation. Twenty two patients were electively admitted to ICU postoperatively for either extended monitoring (14 children) or for postoperative mechanical ventilation (eight children).

In 31 children no morphine was required to maintain a pain score < 3/10. In 22 children a morphine dose between 0 and 5 μg.kg⁻¹.hr⁻¹ was given. In eight children an infusion rate between 5 and 20 μg.kg⁻¹.hr⁻¹ was given to facilitate elective (eg after jejunum interposition or cardiovascular instability) or secondary mechanical ventilation.

**DISCUSSION**

After major thoracic and abdominal surgery, thoracic epidural anaesthesia reduces postoperative respiratory depression and allows earlier return of
Racic level we calculate a distance of 1.95 cm +
give a SED at lumbar level of 1.0 cm. At the tho-
and 10 years of age (4). For a 10 kg child this would
useful guideline for children between six months
insertion a CT-scan derived distance can be calcu-
thetic vertebrae is available.
also be used when a preoperative CT-scans of the
of epidural puncture remains the exact apprecia-
ment of resistance when piercing the ligamentum
In the present study a good correlation
between SED and age and weight was observed for
the thoracic epidural puncture. However, there was
rather high interindividual variability. Despite this
limitation, estimation of the SED will be helpful to
guide thoracic epidural puncture in
acknowledged children.

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