

Depth of the thoracic epidural space in children

F. MASIR (*), J. J. DRIESSEN (**), K. C. THIES (***), M. H. WIJNEN (****) and J. VAN EGMOND (*****)

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 post-operative 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 $2.15 + (0.01 \times \text{months})$ and for SED vs weight was $1.95 + (0.045 \times \text{kg})$. 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 mid-line 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

F. MASIR ; J. J. DRIESSEN ; K. C. THIES ; M. H. WIJNEN ; J. VAN EGMOND.

(*) Resident, Department of Anesthesiology 550, UMCN Radboud, PO Box 9101, 6500 HB Nijmegen, The Netherlands.

(**) Paediatric Anesthesiologist PhD, Department of Anaesthesiology 550, UMCN Radboud, PO Box 9101, 6500 HB Nijmegen, The Netherlands.

(***) Paediatric Anesthesiologist, Birmingham Children's Hospital, Steelhouse Lane, Birmingham B4 6NH, United Kingdom.

(****) Paediatric Surgeon, UMCN Radboud, PO Box 9101, 6500 HB Nijmegen, The Netherlands.

(*****) Physicist PhD, Department of Anaesthesiology 550, UMCN Radboud, PO Box 9101, 6500 HB Nijmegen, The Netherlands.

Correspondence address : Dr J. J. Driessen, Department of Anesthesiology, Geert Groteplein, 10, PO Box 9101, 6500 HB Nijmegen, The Netherlands.
Tel. : 31-24-3614553.
E-mail : JJ.Driessen@anes.umcn.nl.

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.

Table 1

Demographic patient data. Data represent numbers or mean (and SD)

Age (months)	61.6 (56.2)
Gender (n)	
male	34
female	27
Weight (kg)	19.7 (14.1)
ASA class (n)	
I-II	38
III-IV	23
Type of surgery	
Thoracotomy	
Lobectomy	13
Thoracoplasty	4
Other	3
Laparotomy	
Tumour resection	16
Diaphragmatic hernia	3
Nissen Funduplication	13
Miscellaneous	7
Jejunum interposition	2
Duration of anesthesia (hrs) :	174.3 (94.6)

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 :

$$\text{SED} = 2.15 + (0.01 \times \text{months}).$$

The formula for SED vs weight was :

$$\text{SED} = 1.95 + (0.045 \times \text{kg}).$$

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.

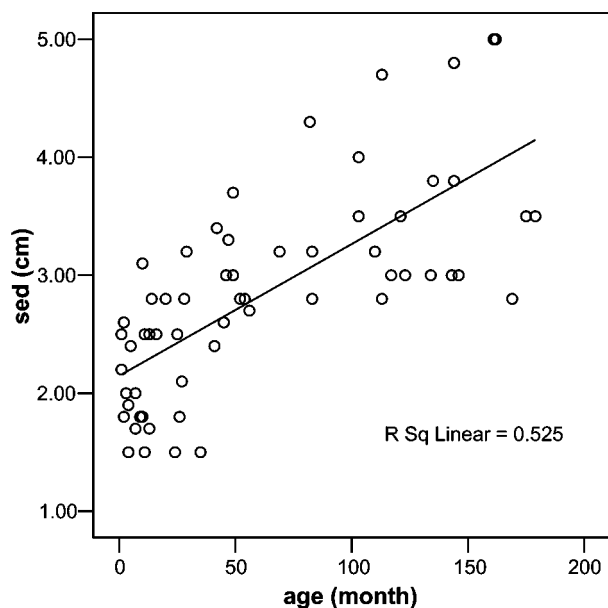


Fig. 1. — The relation between skin-epidural distance (SED) and age (in months).

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 septicæmia 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

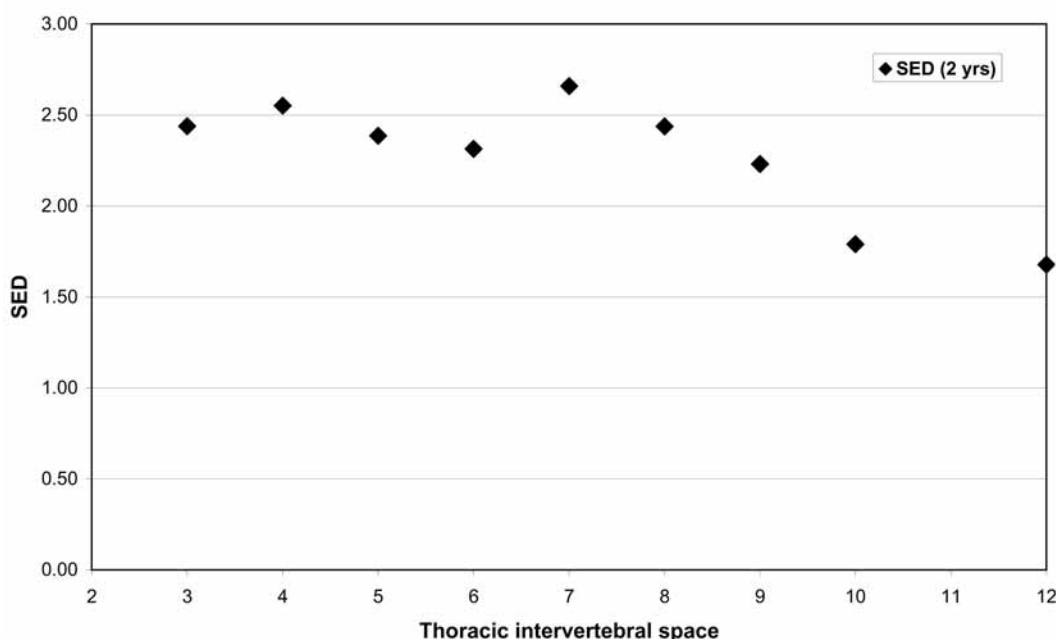


Fig. 2. — The relation between SED in cm (extrapolated to 2 yrs) and thoracic intervertebral space

gastro-intestinal function, and may even reduce mortality and morbidity (6). The segmental intervertebral approach to the thoracic epidural space has the advantage of reducing the total dose of local anaesthetic required for a certain number of dermatomes to be blocked, thereby improving the quality of analgesia. This approach, however, may be associated with greater risk of neurologic damage or dural puncture than thoracic epidural analgesia with a catheter inserted via the caudal or lumbar approach. However, advancing the epidural catheter from the lumbar intervertebral or the caudal epidural space is frequently unsuccessful (7, 8).

Recently newer techniques such as ultrasound guidance and stimulation techniques (9, 10) have been developed for epidural catheter placement. These are not, however, routinely available and can only assist in confirming the epidural localisation of the catheter. The most critical point in the technique of epidural puncture remains the exact appreciation of loss of resistance when piercing the ligamentum flavum. In the present study a good correlation between SED and age and weight was observed for the thoracic epidural puncture. However, there was a rather high interindividual variability. Despite this limitation, estimation of the SED will be helpful to guide thoracic epidural puncture and minimize the potential risks.

Previous studies have measured the SED using CT scans. When using thoracic epidural midline insertion a CT-scan derived distance can be calculated using the perpendicular distance obtained from preoperative chest CT films and the angle of the needle insertion (11). This information should also be used when a preoperative CT-scans of the thoracic vertebrae is available.

For lumbar epidurals performed in children using a midline approach in the L3-4 interspace with the patient in the lateral position, the one mm.kg⁻¹ body weight rule has been shown to be a useful guideline for children between six months and 10 years of age (4). For a 10 kg child this would give a SED at lumbar level of 1.0 cm. At the thoracic level we calculate a distance of 1.95 cm + (0.045 × 10) = 2.4 cm. The much larger distance at thoracic level is caused by the longer spinal processes but also the different angle to the long axis of the spine with overlap of the spinous processes. Our study also showed that at the lower intervertebral spaces the SED is smaller (as for the lumbar interspaces) than at the other thoracic interspaces.

Measurement of the extent and intensity of epidural blocks in small children is difficult.

Regular assessment of pain, motor block and respiratory parameters remain important. Sensory block testing was always used in children capable of responding. However, our primary objective was to maintain the pain score below 4/10. The number of children where additional escape medication was used may seem rather high, but this was mainly due to morphine being given to allow mechanical ventilation. The data in the pain auditing forms also showed that things other than surgical pain may cause subjective pain scoring e.g. hunger, bladder or gastric catheters etc.

In conclusion, a formula was presented for estimation of the SED using age or weight during thoracic epidural blocks in anaesthetized children. Despite considerable variability in SED 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.

Acknowledgements

The authors thank the paediatric surgeons, the pain team and the nurses on the paediatric ward for their assistance. We also thank Dr Eric Robertson for correcting the English language and Prof Dr G. J. Scheffer, chairman of the department, for his support.

References

1. Chalkiadis G., *The rise and fall of continuous epidural infusions in children*, PAEDIATRIC ANAESTHESIA, **13**, 91-3, 2003.
2. Williams D. G., Howard R. F., *Epidural analgesia in children. A survey of current opinions and practices amongst UK paediatric anaesthetists*, PAEDIATRIC ANAESTHESIA, **13**, 769-76, 2003.
3. Hasan M. A., Howard R. F., Lloyd-Thomas A. R., *Depth of epidural space in children*, ANAESTHESIA **49**, 1085-7, 1994.
4. Bosenberg A. T., Gouws E., *Skin-epidural distance in children*, ANAESTHESIA, **50**, 895-7, 1995.
5. Büttner W., Finke W., *Analysis of behavioural and physiological parameters for the assessment of postoperative analgesic demand in newborns, infants and young children : a comprehensive report on seven consecutive studies*, PAEDIATRIC ANAESTHESIA, **10**, 303-18, 2000.
6. Sielenkamper A., van Aken H., *Editorial : Thoracic epidural anesthesia : more than just anesthesia/analgesia*, ANESTHESIOLOGY, **99**, 523-5, 2003.
7. Blanco D., Llamazares J., Rincon R., Ortiz M., Vidal F., *Thoracic epidural anesthesia via the lumbar approach in infants and children*, ANESTHESIOLOGY, **84** (6), 1312-6, 1996.
8. Valairucha S., Seefelder C., Houck C. S., *Thoracic epidural catheters placed by the caudal route in infants : the importance of radiographic confirmation*, PAEDIATRIC ANAESTHESIA, **12**, 424-8, 2002.

9. Marhofer P., Bosenberg A., Sitzwohl C., Willschke H., Wanzel O., Kapral S., *Pilot study of neuroaxial imaging by ultrasound in infants and children*, PAEDIATRIC ANAESTHESIA, **15**, 671-6, 2005.
10. Tsui B. C. H., Wagner A. M., Cave D., Seal R., *Threshold current for an insulated epidural needle in pediatric patients*, ANESTHESIA ANALGESIA, **99**, 694-6, 2004.
11. Carnie J., Boden J., Gao Smith F., *Prediction by computerised tomography of distance from skin to epidural space during thoracic epidural insertion*, ANAESTHESIA, **57**, 690-5, 2002.