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Ultrasonography-guided rectus sheath block in paediatric anaesthesia—a new approach to an old technique[†]

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Background. The purpose of this study was an anatomical and clinical evaluation of ultrasonography-guided rectus sheath blocks in children.

Method. A total of 30 children were included in the sono-anatomical part of the study. The depth of the anterior and posterior rectus sheath was evaluated with a portable SonSite 180 plus ultrasound machine and a 5–10 MHz linear probe. In total, 20 consecutive children undergoing umbilical hernia repair were included in the clinical part of this study. After induction of general anaesthesia children received a rectus sheath block under real-time ultrasonographic guidance by placing 0.1 ml kg^{-1} bilaterally in the space between the posterior aspect of the sheath and the rectus abdominis muscle.

Results. Ultrasonographic visualization of the posterior rectus sheath was possible in all children. The correlation between the depth of the posterior rectus sheath and weight (adjusted r^2=0.175), height (adjusted r^2=0.314) and body surface area (adjusted r^2=0.241) was poor. The ultrasound-guided rectus sheath blockade provided sufficient analgesia in all children with no need for additional analgesia in the perioperative period.

Conclusion. The bilateral placement of levobupivacaine 0.25% 0.1 ml kg^{-1} in the space between the posterior aspect of the rectus sheath and the rectus abdominis muscle under real-time ultrasonographic guidance provides sufficient analgesia for umbilical hernia repair. The unpredictable depth of the posterior rectus sheath in children is a good argument for the use of ultrasonography in this regional anaesthetic technique in children.

Br J Anaesth 2006; **97**: 244–9

A rectus sheath block can provide effective pain relief for umbilical or other midline surgical incisions. This regional anaesthetic technique was first described by Schleich[1] in 1899 for use in adults to provide relaxation of the anterior abdominal wall. In 1996, Ferguson and colleagues[2] suggested a rectus sheath block to provide analgesia for umbilical hernia repair in children. Since then this regional anaesthetic technique has become increasingly popular and is used to provide analgesia for umbilical and epigastric hernia repair, laparoscopic surgery, pyloromyotomy and other small midline incisions.

Two methods have been described in children.[2 3] Both aim to block the terminal branches of 9th, 10th and 11th intercostal nerve within the rectus sheath in a different way. After injecting one quarter of a volume of 0.5 ml kg^{-1} of local anaesthetic as a s.c. fan shaped injection, Courreges and colleagues[3] injected the second quarter once a click was felt into the rectus sheath. Ferguson and colleagues[2] performed this block by placing local anaesthetic deep into the rectus abdominis muscle within a potential space between the rectus abdominis muscle and the posterior aspect of the

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sheath relying on tactile sensation ('scratching sensations' or 'palpable gives') to identify the correct needle position.

The use of ultrasound as an aid for accurate placement of local anaesthetic is gaining in popularity for regional anaesthesia.[4–15] Ultrasonography allows non-invasive real-time imaging of the relevant anatomical structures while the needle is placed under direct vision. The superiority of ultrasonography-guided block techniques to blind techniques relying on subtle sensations, which may be unreliable even in experienced hands, was shown in the past.[16–21]

The purpose of this study was to evaluate the sono-anatomy at the puncture site of a rectus sheath block and to determine the efficacy of levobupivacaine 0.25% 0.1 ml kg^{-1} injected bilaterally within the space between the rectus abdominis muscle and the posterior sheath using real-time imaging. Figure 1 illustrates the anatomical structures involved in a rectus sheath block and a corresponding ultrasonographic scan.

Materials and methods

This study was approved by the ethics committee at the University of Cape Town. Informed parental consent and, where applicable, the child's assent was obtained before recruitment to this prospective study. In both parts of the study, exclusion criteria included parental or patient refusal and the inability to see the posterior rectus sheath on ultrasound. In the clinical part any contraindication to a rectus

Fig 1 (A) Anatomy of the rectus sheath (cross-sectional). (B) Corresponding ultrasound scan of the rectus sheath (cross-sectional): white arrow indicates anterior aspect of the rectus sheath; grey arrow indicates posterior aspect of the rectus sheath.

sheath block (e.g. local infections) and allergy to amide local anaesthetics were also included.

Part 1: sono-anatomical study of the rectus sheath

A total of 30 ASA I children aged between 1 month and 10 yr, undergoing minor surgery were included in this study to evaluate the sono-anatomy of the rectus sheath. None of these children had an umbilical hernia but were of a similar age group as those presenting for umbilical hernia repair. Following induction of general anaesthesia an ultrasound examination of the rectus sheath was performed using a portable SonoSite 180+ (SonoSite™, Bothell, WA, USA) ultrasound unit and a 5–10 MHz linear 'hockey stick' probe. Adjustments (depth, probe frequency, low and far gain) were made to obtain optimal images to identify the rectus sheath and relevant surrounding anatomical structures. The distance from the skin to the anterior and to the posterior aspect of the rectus sheath was measured. The thickness of the rectus abdominis muscle was also calculated.

Part 2: prospective evaluation of the ultrasonography-guided rectus sheath block

A total of 20 consecutive ASA I children aged between 4 months and 10 yr undergoing elective umbilical hernia repair were enrolled in this study. Informed consent was obtained from the parents of all children and where appropriate, assent was obtained from the child.

Children were premedicated with oral midazolam 0.5 mg kg^{-1} at the discretion of the anaesthetist. General anaesthesia was induced with sevoflurane via a face mask. After establishing venous access, a laryngeal mask was placed and anaesthesia was maintained with 1 minimal alveolar concentration (MAC) halothane in oxygen/nitrous oxide 40:60. Intraoperative monitoring included ECG, heart rate, pulse oximetry, automatic non-invasive blood pressure, end-tidal carbon dioxide concentration and end-expiratory measurement of the halothane concentration.

All surgical procedures were performed by the same surgeon. An anaesthetist experienced in ultrasound-guided regional anaesthesia in children performed the blocks. A SonoSite 180+ portable ultrasound unit (SonoSite™, Bothell, WA, USA) and a 5–10 MHz linear hockey stick probe were used to identify the relevant structures within the rectus sheath. Adjustments (depth, probe frequency, low and far gain) were made to achieve optimal images of the target area and the surrounding anatomy (Fig. 2A). Following aseptic preparation of the puncture site and the ultrasound probe, the rectus sheath block was performed under continuous ultrasound imaging using an insulated 22 gauge 40 mm needle with a facette tip and an injection line (Pajunk™, Geisingen, Germany) on both sides of the umbilicus (Fig. 2B). The injection site was defined where the optimal ultrasonographic visualization of the posterior rectus sheath was achieved. Once the tip of the needle was correctly positioned within the rectus sheath using a
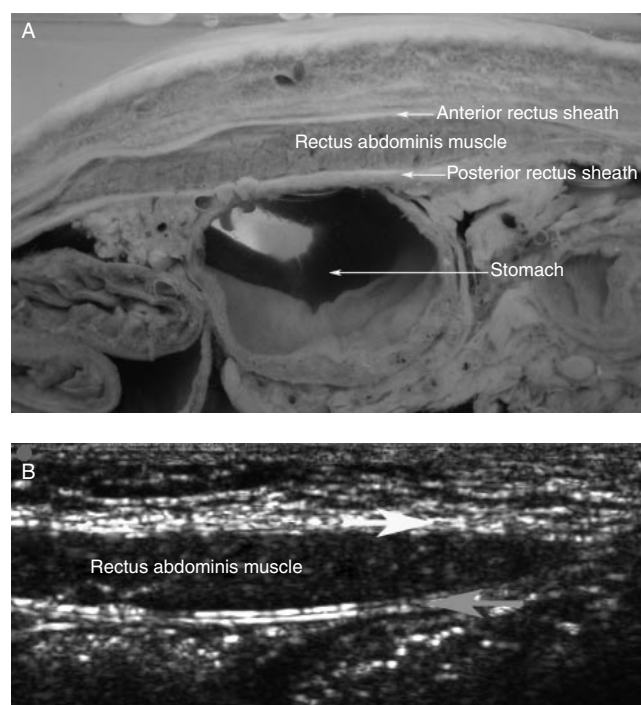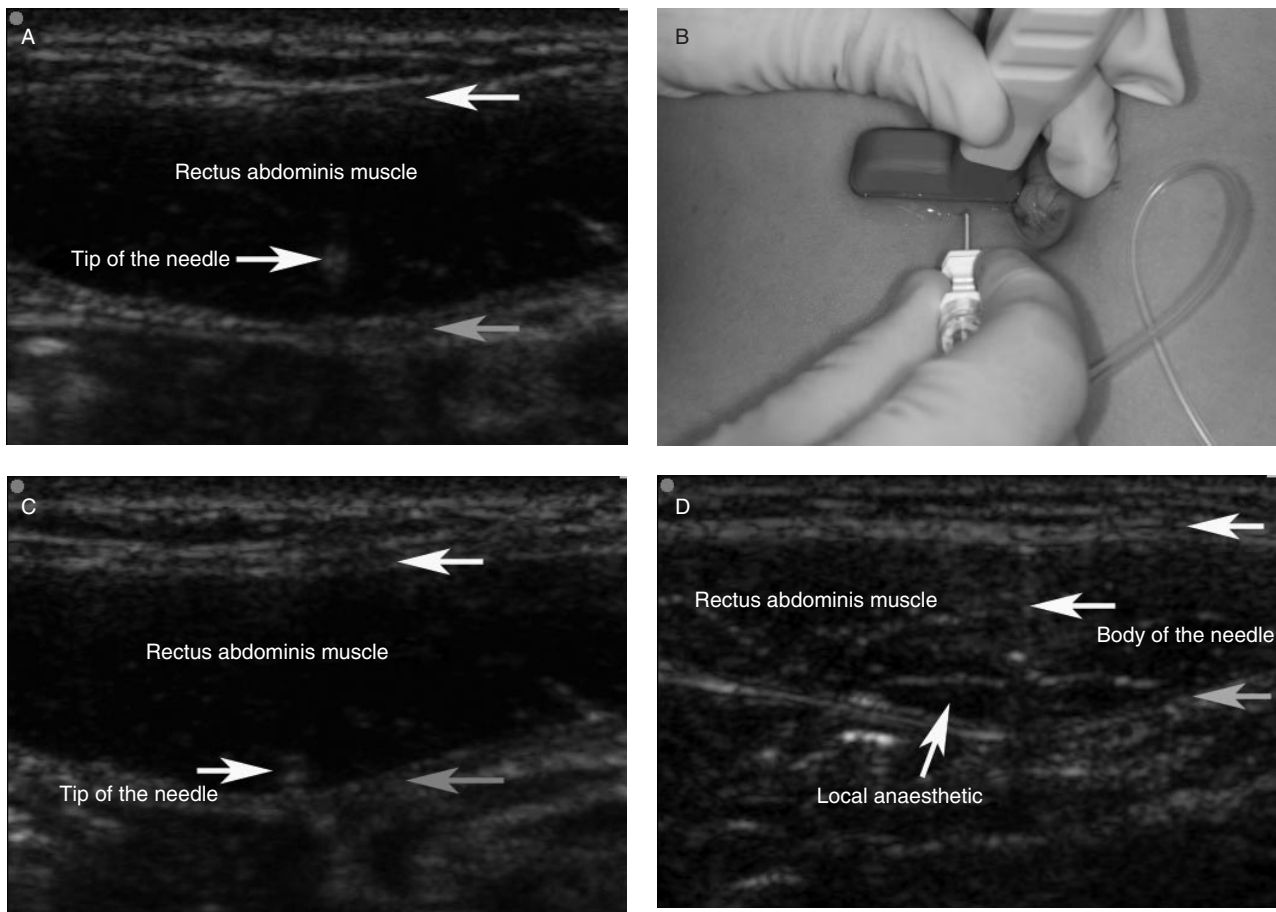
Fig 2 (A) Cross-sectional scan at the puncture site during puncture: needle within the muscle; white arrow indicates anterior aspect of the rectus sheath, grey arrow indicates posterior aspect of the rectus sheath. (B) Position of the ultrasound probe relative to the cannula for an optimal view of the posterior aspect of the rectus sheath. (C) Cross-sectional scan at the puncture site during puncture; needle in the correct position directly above the posterior aspect of the rectus sheath; white arrow indicates anterior aspect of the rectus sheath, grey arrow indicates posterior aspect of the rectus sheath. (D) Cross-sectional scan at the puncture site during injection; white arrow indicates anterior aspect of the rectus sheath, grey arrow indicates posterior aspect of the rectus sheath.

cross-sectional ultrasonographic puncture technique (Fig. 2C), a predetermined volume of levobupivacaine 0.25% 0.1 ml kg^{-1} (Chirocaine™, Abbott, Roscrea, Ireland) was injected after a negative aspiration test. The distribution of local anaesthetic was monitored under real-time imaging (Fig. 2D) and in the event of misplacement the needle was repositioned so that the local anaesthetic was injected between the rectus abdominis muscle and the posterior sheath. The puncture was performed in the same manner on the opposite side of the umbilicus.

In all patients skin incision was performed at least 15 min after placement of the block. If an increase in heart rate and/or blood pressure of more than 15% occurred on skin incision, the block was considered a failure and fentanyl 1 µg kg^{-1} was given as rescue analgesia. The efficacy of postoperative analgesia was documented using the objective pain score (OPS), where objective behavioural variables (crying, facial expression, position of torso and legs, motor restlessness) are assessed. Each pain variable is scored on a three-point scale (1=none, 2=moderate,

3=severe) to give a maximum cumulative score of 15.[16 17 22 23] The children were monitored hourly for at least 4 h after operation before discharge from the outpatient surgical unit. An anaesthesiologist, who was not part of the study team, evaluated the need for rescue analgesia in the intraoperative and postoperative period and a research nurse collected the data. If the OPS score was ≥11, rescue analgesia of 30 mg kg^{-1} acetaminophen was administered. The children were discharged home after 4 h, when they were pain free with an oral acetaminophen suspension to be administered by their parents or care providers for subsequent analgesia (30 mg kg^{-1}). Parents or care providers were also asked to report difficulty in pain management or other medical concerns immediately to the hospital.

Biostatistical methods

Linear regression analysis was performed to determine the correlation of depth of the posterior rectus sheath with body weight, height and body surface area. Data are presented as mean (SD) or as median (range).

Table 1 Patient characteristic data

	Median age [months (range)]	Median weight [kg (range)]	Median height [cm (range)]	Median BSA [m²(range)]	Mean duration of surgery min (SD)
Sono-anatomical part	52.5 (1–120)	15.3 (3–40)	100.5 (50–135)	0.69 (0.21-1.18)	–
Clinical part	58 (4-105)	16.0 (5–40)	104.4 (58-135)	0.66 (0.28 – 1.15)	22.5 (5.2)

Table 2 Anatomy of the rectus sheath

	Depth of first fascia	Thickness of rectus abdominis muscle	Depth of second fascia
Median (range)	3.8 (1.6–5.5) mm	4.35 (2.4–7.8) mm	8. (0 5–13.8) mm

Results

In total, 30 children were included in the first part of the study. Patient characteristic data are presented in Table 1. In all these children ultrasonographic visualization of the anterior and posterior aspect of the rectus sheath was possible. The important anatomical characteristics are illustrated in Table 2. The correlation between the depth of the posterior rectus sheath and weight (adjusted r^2=0.175), height (adjusted r^2=0.314) and body surface area (adjusted r^2=0.241) was poor. Figure 3 illustrates the correlation and 95% confidence interval of the depth of the posterior aspect of the rectus sheath and body weight.

A total of 20 children were included in the second part of the study. Patient characteristic data and operative characteristics are presented in Table 1. Ultrasonographic visualization of the posterior aspect of the rectus sheath was possible in all children. The distribution of local anaesthetic within the potential space between the rectus abdominis muscle and the posterior aspect of the sheath was confirmed by ultrasound in all patients.

At skin incision the heart rate increased by 2 (4) beats min^{-1} and the blood pressure by 1 (3) mm Hg. All the blocks were thus considered successful and there was no need for rescue analgesia. The cumulative increase in heart rate at skin incision was 1.5% from baseline. There was no need for additional analgesia in postoperative period. OPS score did not exceed 11 in any of the patients at any time before discharge. Children were usually discharged home after 4 h as per hospital routine. None of the parent or care providers reported any pain management concerns after discharge.

There were no surgical complications. Despite the proximity of the peritoneum to the posterior rectus sheath there was no evidence of complications from the rectus sheath block such as small bowel or major vessel puncture either clinically or on ultrasound.

Discussion

This is believed to be the first study evaluating the impact of ultrasonography on rectus sheath blocks in children. Two
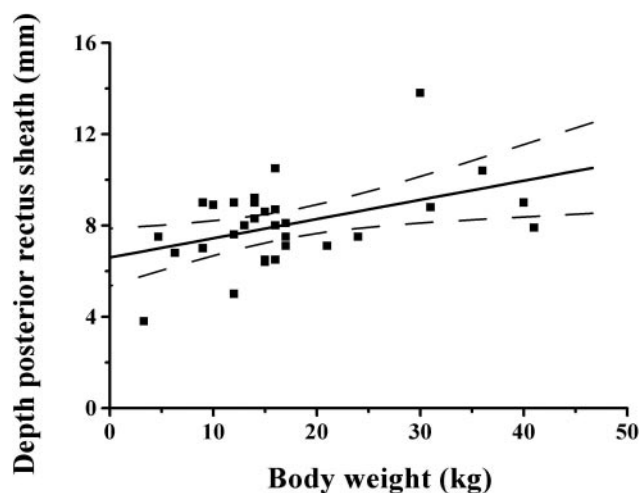

Fig 3 Correlation between body weight and depth of the posterior aspect of the rectus sheath; broken line demonstrates 95% confidence interval.

previous studies evaluating rectus sheath blocks used different blind techniques and were performed in small groups of children. Both intended to place at least part of the designated volume of local anaesthetic within the rectus sheath either superficial in the rectus abdominis muscle,[3] or deep into the posterior aspect of the rectus sheath.[2] The rest of the local anaesthetic was used to infiltrate s.c. to supplement the block. For correct needle placement for a rectus sheath block, both authors[2 3] relied on anatomic landmarks and tactile stimuli (scratching the posterior sheath or give a sensation on entering the sheath).

The key to success in regional anaesthesia is to place the correct dose of local anaesthetic in the right place. In this study successful rectus sheath blocks were achieved in all children using levobupivacaine 0.25% 0.1 ml kg^{-1} bilaterally—a much smaller dose than previously described.[2 3] Using real-time ultrasonographic imaging the tip of the needle and the spread of local anaesthetic can be seen within the potential space between the rectus abdominis muscle and posterior aspect of the rectus sheath. The fact that none of the children required any additional analgesia in the perioperative period suggests that the space between the rectus abdominis muscle and posterior aspect of the rectus sheath is the correct place and levobupivacaine 0.25% 0.1 ml kg^{-1} is an adequate dose of local anaesthetic to provide analgesia for umbilical hernia repair.

As regards the sono-anatomical findings of this study, the median depth of the posterior fascia was 8.0 (5–13.8) mm.
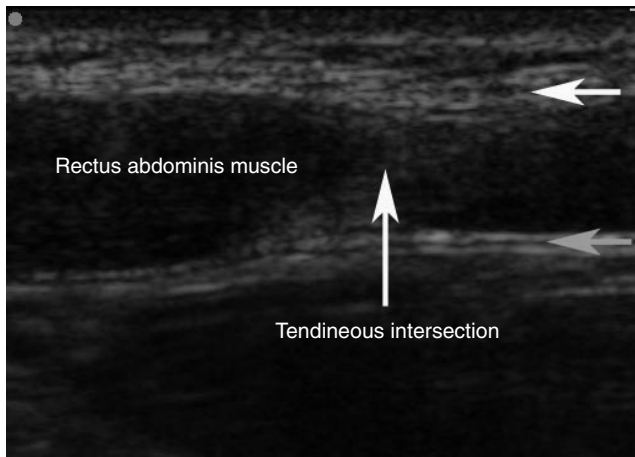
Fig 4 Transversal scan at the puncture site; white arrow indicates anterior aspect of the rectus sheath, grey arrow indicates posterior aspect of the rectus sheath.

Advancing the needle more than 1 cm in children younger than 10 yr is therefore potentially dangerous. The poor correlation between the depth of the posterior sheath and weight, height or body surface area (adjusted r^2=0.175; 0.314; and 0.241) indicates that neither weight nor height can be used to predict the depth of the rectus sheath in a growing child. The three tendinous intersections in the rectus muscle and sheath could be identified (Fig. 4). These were at the level of the xiphoid, at the level of the umbilicus and one in between. The free spread of local anaesthetic seen with real-time imaging confirms that these intersections do not extend through the whole rectus abdominis muscle to the posterior sheath. It is conceivable that with adequate volume this free communication will allow spread from the xiphoid to the pubis.

The proximity of the posterior sheath to the peritoneal cavity can easily lead to needle misplacement within the peritoneal cavity which carries the risk of intra-peritoneal injection and failure of the block, perforation of the bowel (stomach or colon) or puncture of a mesenteric vessel. Ferguson and colleagues[2] describe a missed block as a result of needle misplacement, a puncture of the inferior epigastric vessels and peritoneal injection as possible complication of this technique. Another author describes a retroperitoneal haematoma after a rectus sheath block.[24]

The limitation of this study was that the children were discharged home after 4 h. Pain assessment was therefore limited to the first 4 postoperative hours. It is conceivable that larger volumes or the use of epinephrine may have given the children a longer period of analgesia. Nonetheless a small accurately placed volume allowed the children to be discharged home without pain and no parent or care provider reported any difficulties with subsequent pain management after discharge.

In conclusion, the results of this study are similar to those obtained by our study group using ultrasound for ilioinguinal nerve blocks.[16 17] Accurate placement under direct real-time imaging allows a smaller volume of local anaesthesia to be used without compromising the efficacy or success of the block. Furthermore needle misplacement can be recognized and rectified immediately reducing the risk of failure or potential complications. Thus ultrasonography offers considerable advantages over conventional, landmark-based techniques for regional anaesthesia in children.

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