British Journal of Anaesthesia 98 (6): 797–801 (2007)
doi:10.1093/bja/aem092 Advance Access publication April 21, 2007

BJA

PAEDIATRICS

Ultrasonographic guidance for sciatic and femoral nerve blocks in children†

U. Oberndorfer[1], P. Marhofer[1], A. Bösenberg[2], H. Willschke[1], M. Felfernig[1], M. Weintraud[1], S. Kapral[1] and S. C. Kettner[1]*

[1]*Department of Anaesthesia and Intensive Care Medicine, Medical University Vienna, Währinger Gürtel 18–20, A-1090 Vienna, Austria.* [2]*Department of Anaesthesia and Intensive Care Medicine, University of Cape Town, Red Cross Children Hospital, Klipfontein Road, Rondebosch 7700, South Africa*

**Corresponding author. E-mail: stephan.kettner@meduniwien.ac.at*

Background. Recent studies have shown that ultrasound guidance for paediatric regional anaesthesia can improve the quality of upper extremity and neuraxial blocks. We therefore investigated whether ultrasound guidance for sciatic and femoral nerve blocks prolongs sensory blockade in comparison with nerve stimulator guidance in children.

Methods. Forty-six children scheduled for surgery of one lower extremity were randomized to receive a sciatic and femoral nerve block under either ultrasound or nerve stimulator guidance. After induction of general anaesthesia, the blocks were performed using an ultrasound-guided multiple injection technique until the nerves were surrounded by levobupivacaine, or by nerve stimulator guidance using a predefined dose of 0.3 ml kg^{-1} of levobupivacaine. An increase in heart rate of more than 15% of baseline during surgery defined a failed block. The duration of the block was determined from the injection of local anaesthetic to the time when the patient received the first postoperative analgesic.

Results. Two blocks in the nerve stimulator group failed. There were no failures in the ultrasound group. The duration of analgesia was longer in the ultrasound group mean (SD) 508 (178) *vs* 335 (169) min ($P<0.05$). The volume of local anaesthetic in sciatic and femoral nerve blocks was reduced with ultrasound compared with nerve stimulator guidance [0.2 (0.06) *vs* 0.3 ml kg^{-1} ($P<0.001$) and 0.15 (0.04) *vs* 0.3 ml kg^{-1} ($P<0.001$), respectively].

Conclusions. Ultrasound guidance for sciatic and femoral nerve blocks in children increased the duration of sensory blockade in comparison with nerve stimulator guidance. Prolonged sensory blockade was achieved with smaller volumes of local anaesthetic when using ultrasound guidance.

Br J Anaesth 2007; **98**: 797–801

Keywords: anaesthetic techniques regional, sciatic; children; measurement techniques, ultrasound

Accepted for publication: March 1, 2007

Ultrasound guidance for peripheral nerve blocks reduces the number of complications and improves the quality of regional blockade in adults, compared with blind techniques or nerve stimulator guidance.[1 2] Recently, we were able to demonstrate the value of ultrasonography for performing nerve blocks in children.[3 4] In infraclavicular brachial plexus block and ilioinguinal/iliohypogastric nerve block, we observed improved sensory and motor block, faster onset of block, and longer duration of sensory blockade with ultrasound guidance compared with conventional techniques.[3 4]

At present, nerve blocks of the lower extremities are used infrequently in children, perhaps, due to the alternative of the caudal block, which is a simple and reliable technique.[5] Furthermore, the failure rate of caudal blocks is lower than peripheral nerve blocks performed under nerve stimulator guidance.[6 7] Nevertheless, there are potential benefits of peripheral nerve blocks compared with caudal blocks in children, such as reduced risk of side-effects and a

†The study was performed at the Red Cross Children Hospital, Klipfontein Road, Rondebosch 7700, Cape Town, South Africa.

reduction in the dose of local anaesthetic.[8 9] Peripheral nerve blocks were not associated with any complications in the largest available study, whereas caudal blocks had a morbidity of approximately 0.7 per million.[5]

No studies are available investigating the use of ultrasound for lower extremity nerve blocks in children. We tested and compared ultrasound guidance with nerve stimulator guidance for sciatic and femoral nerve blocks in children.

Methods

After local ethics committee approval and written informed consent from the parents of all children, 46 children up to 8 yr of age who were undergoing surgery of one lower extremity were enrolled into this study. Exclusion criteria were history of seizures or neurological, neuromuscular, psychiatric, or blood clotting disorders. Before randomization, patients were stratified into two groups based on the planned surgical procedure and the need for either sciatic nerve block or sciatic nerve block plus femoral nerve block. Children were then randomized to receive the nerve blocks, using either nerve stimulator guidance (nerve stimulator group) or ultrasound guidance (ultrasound group). Randomization was based on computer-generated codes that were kept in sequentially numbered opaque envelopes until just before use.

As a premedication, patients received oral midazolam (0.5 mg kg^{-1}) at least 15 min before induction of anaesthesia. General anaesthesia was induced with sevoflurane 8% via a face mask and a laryngeal mask was inserted after establishing venous access. Anaesthesia was maintained with 1 MAC halothane in nitrous oxide and oxygen. All blocks were performed under general anaesthesia by the same anaesthetist who was experienced in both nerve stimulator and ultrasound-guided regional anaesthesia in children. Sciatic nerve blocks were performed in all children, either in the subgluteal or in the popliteal area as indicated by the surgical procedure. Femoral nerve blocks were performed when indicated by the planned operation.

Group A: ultrasound group

A SonoSite 180plus portable ultrasound unit (SonoSite™, Bothell, WA, USA) with a 5–10 MHz linear hockey stick probe was used to visualize the targeted nerves, the needle, and the distribution of the local anaesthetic. After aseptic preparation of the puncture site and ultrasound probe, the nerve blocks were performed using an insulated 22-gauge 40 mm needle with facette tip and injection line (Pajunk™, Geisingen, Germany). All blocks were performed with the cross-section technique,[10] and Figures 1 and 2 show the positions of the probe and of the needle for the different approaches. Figures 3 and 4 show typical ultrasound images of the sciatic and the femoral nerve. The needle was positioned close to the target nerves under ultrasound visualization. In order to optimize the distribution of the local anaesthetic around the target nerves, a multi-injection technique was performed. The local anaesthetic (levobupivacaine 0.5%) was injected under real-time ultrasound control until the nerve was surrounded. An observer injected the local anaesthetic and recorded the injected amount. The anaesthetist who performed the blocks was blinded to the amount of local anaesthetic injected.

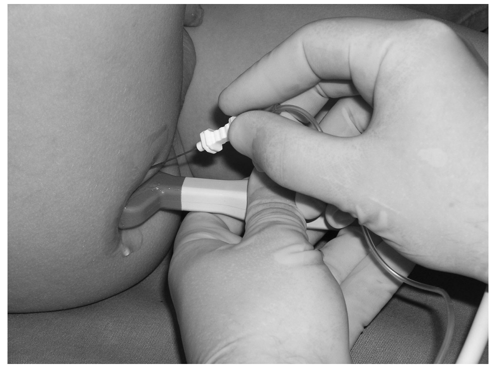

Fig 1 Position of the ultrasound probe and of the cannula for a subgluteal approach to the sciatic nerve.

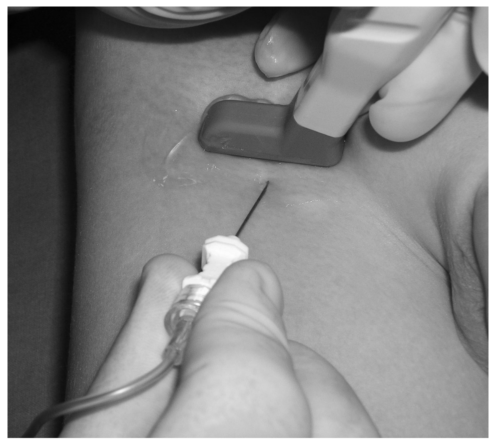

Fig 2 Position of the ultrasound probe and of the cannula for the approach to the femoral nerve.

Nerve stimulator group

A nerve stimulator (MultiStim Vario™, Pajunk, Geisingen, Germany) and the same needle as in the ultrasound group were used to perform sciatic and femoral nerve blocks (Fig. 3). For the subgluteal and popliteal approaches to the sciatic nerve, the child was placed in the semiprone position with the side to be blocked uppermost. For the subgluteal approach, the needle was inserted perpendicular to the skin at mid-distance between the coccyx and the greater trochanter of the femur. For the popliteal

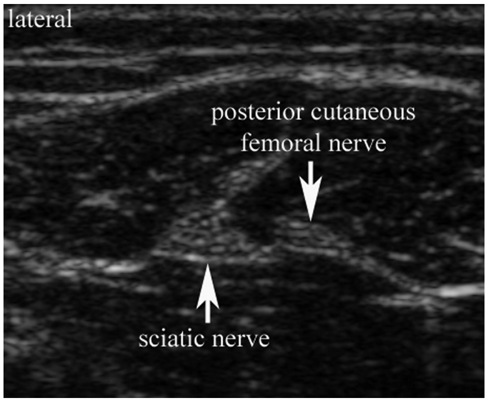

Fig 3 Transverse view of the sciatic nerve and the posterior cutaneous femoral nerve of a 6-yr-old child.

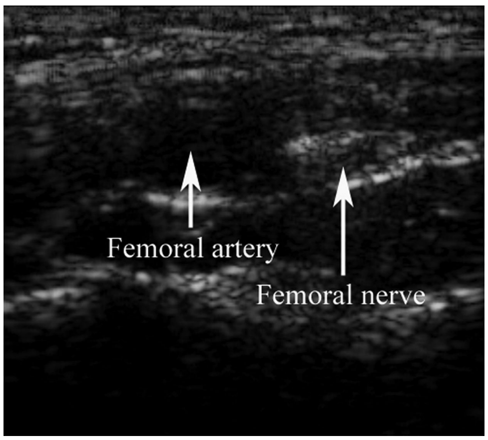

Fig 4 Transverse view of the femoral nerve lateral to the femoral artery of a 6-yr-old child.

approach, the needle was inserted at a 45° angle to the skin lateral to the midline and proximal to the popliteal fold in a cephalad direction as previously described by Konrad and Johr.[11] The distance from the popliteal fold to the point of insertion of the needle was defined in relation to weight as follows: weight of the patient <10 kg: distance from popliteal fold to point of insertion 1 cm; 10–20 kg: 2 cm, and so forth. For subgluteal and popliteal blocks, levobupivacaine 0.5% (0.3 ml kg^{-1}) was injected slowly, when a current of 0.3 mA over 0.3 ms at 2 Hz elicited appropriate plantar flexion and aspiration was negative. For femoral nerve blocks, the needle was inserted lateral to the femoral artery and distal to the inguinal ligament and was advanced cephalad at an angle of 45° to the skin (Fig. 4). When a current of 0.3 mA over 0.3 ms at 2 Hz elicited contractions of the quadriceps femoris muscle with clearly visible impulse synchronous cephalic movement of the patella and after negative aspiration, levobupivacaine 0.5% (0.3 ml kg^{-1}) was injected slowly.

Evaluation of perioperative analgesia and rescue medication

In both groups, skin incision was performed at least 20 min after the block. If the heart rate increased more than 15% of baseline value at skin incision or during surgery, analgesia was considered insufficient, and the patient received i.v. morphine (0.1 mg kg^{-1}). Patients who received morphine were excluded from further investigation. On the first postoperative day, all puncture sites were checked for haematoma or signs of infection, and a sensorial examination of the blocked nerves was performed.

Evaluation of the duration of the block

The duration of postoperative analgesia was measured, using the OPS score, in which five behavioural variables are assessed (crying, facial expression, position of torso and legs, and motor restless). Each pain variable is scored on a three-point scale (1=none, 2=moderate, and 3=severe), and accordingly, the maximum cumulative score is 15. If two consecutive OPS-scores were >11, the child received additional analgesia. The OPS-scores were evaluated at removal of the laryngeal mask which was defined as the end of anaesthesia. Afterwards OPS-scores were evaluated at 15, 30, 45, 60, 90, 120, 180 min, and then every 60 min until first administration of analgesic. The duration of the block was determined from the injection of local anaesthetic to the time when the patient received the first postoperative analgesic. OPS scores were evaluated by an anaesthetist who was blinded to the randomization.

The sample size calculation was based on the assumption that the duration of sensory blockade could be prolonged from 300 min (nerve stimulator guidance) to 450 min (ultrasound guidance). Assuming a power of 80%, a level of significance of 5%, and an SD of 160 min, it was estimated that 18 patients would be required in each group. We decided to include 23 children in each group, as children who required intraoperative analgesia were excluded from further analysis, and we assumed a success rate of 80% at most in the nerve stimulator group.

Statistical analysis

Differences among the groups for dose of local anaesthetic and duration of the nerve blocks were assessed with a two-sided *t*-test for independent samples. Statistical significance was considered for $P<0.05$. Results are expressed as mean (SD) or median (range) as indicated.

Results

Demographic and operative characteristics were similar in both groups and are shown in Table 1. Ultrasound visualization of the sciatic and the femoral nerve was possible in all cases. All anaesthetic procedures were uneventful,

Table 1 Demographic and operative data. Values are presented as median (range) or mean (SD)

	Ultrasound group (*n*=23)	**Nerve stimulator group (*n*=23)**
Age (yr)	5 (1–8)	5 (1–8)
Weight (kg)	19.4 (8)	18.3 (7.4)
Sex (male/female)	11/12	14/9
Time for surgery (min)	56 (15–130)	47 (15–180)
Foot surgery (*n*)	9	9
Knee and lower leg surgery (*n*)	8	9
Upper leg surgery (*n*)	5	4

Table 2 Number of performed blocks in groups

	Ultrasound group (*n*)	**Nerve stimulator group (*n*)**
Sciatic/subgluteal approach	11	12
Sciatic/popliteal approach	12	11
Femoral nerve block	14	14

Table 3 Amount of local anaesthetic. Values are presented as mean (SD)

	Ultrasound	**Nerve stimulation**
Sciatic nerve block (ml of local anaesthetic kg^{-1} body weight)	0.2 (0.06)	0.3
Femoral nerve block (ml of local anaesthetic kg^{-1} body weight)	0.15 (0.04)	0.3
Patients who required intraoperative additional analgesia	0	2

involving no clinical signs of nerve damage, inadvertent puncture of major vessels, infection, or haematoma.

All children received a sciatic nerve block and 14 children of each group received an additional femoral nerve block (Table 2). No child in the ultrasound group received additional analgesia, whereas two patients in the nerve stimulator group required intraoperative analgesia and were excluded from further evaluation.

The amount of local anaesthetic was lower in the ultrasound group compared with the nerve stimulator group; mean (SD) 0.2 (0.06) *vs* 0.3 ml kg^{-1} ($P<0.001$) in sciatic nerve blocks and 0.15 (0.04) *vs* 0.3 ml kg^{-1} ($P<0.001$) in femoral nerve blocks (Table 3).

Although children in the ultrasound group received less local anaesthetics, the duration of analgesia was longer in the ultrasound group compared with the nerve stimulator group; mean 508 (178) *vs* 335 (169) min ($P<0.001$).

For sciatic nerve blocks using the subgluteal approach, the needle had to be repositioned in 45% of the cases in order to surround both the sciatic and the posterior cutaneous femoral nerve with local anaesthetic.

Discussion

This is the first study investigating the use of ultrasound guidance for lower extremity nerve blocks in children. In this study, the use of ultrasound guidance was associated with longer duration of sensory blockade and the use of less local anaesthetics compared with nerve stimulator guidance. Our data also support the hypothesis that ultrasound guidance may increase the success rate of lower extremity blocks, although the study is underpowered to prove this.

The prolonged duration of sensory blockade in the ultrasound group is an indicator for the improved quality of nerve blocks in comparison with nerve stimulator guidance. Direct visualization of the spread of local anaesthetic with ultrasound allows the anaesthetist to use a multiple injection technique to surround the targeted nerve with local anaesthetic. This seems to result in more profound blockade with lower volumes of local anaesthetics. With nerve stimulator guidance, it is not reliably possible to surround major nerves, such as the sciatic nerve, with local anaesthetic.

The reduction in the dose of local anaesthetics necessary to achieve neural blockade is another advantage of ultrasound guidance in regional anaesthesia. In a recently published study of ultrasound guidance for ilioinguinal/iliohypogastric nerve blocks, we were able to achieve adequate blockade with 0.075 ml kg^{-1} of local anaesthetic, compared with the recommended doses from 0.3 to 0.4 ml kg^{-1}.[12] Local anaesthetic toxicity is an important concern in paediatric anaesthesia, as children have lower plasma concentration of the binding protein alpha-1 acid glycoprotein and therefore higher free plasma concentrations of local anaesthetics.

In our present study, the injection of local anaesthetic was stopped when the target nerves were surrounded by local anaesthetic. The study was not designed to minimize the volume of local anaesthetics. Nevertheless, we were able to show a reduction in the necessary volume of local anaesthetics by one-third for sciatic nerve blocks and by one-half for femoral nerve blocks. Despite this reduction in local anaesthetic volume, the duration of analgesia was still longer in the ultrasound group.

There are no data available on whether the amount of local anaesthetic has any influence on the duration of a nerve block. Direct visualization of the nerve or neuraxial structures, vessels, tendons, and bones allows optimal placement of the local anaesthetic and reduces the risk of intraneuronal or intravascular injection. For major nerves, such as the sciatic or the femoral nerve, surrounding the nerve with local anaesthetic with an ultrasound-guided multiple injection technique may prolong analgesia.

Ultrasonographic guidance also allowed us to ensure that the posterior cutaneous femoral nerve of the sacral plexus was blocked to prevent tourniquet pain. The posterior cutaneous femoral nerve is located close to the sciatic nerve in the subgluteal region. We observed the distribution of local anaesthetic during the sciatic nerve block. Redirection of the needle was necessary in 45% of the cases in order to block the posterior cutaneous femoral nerve separately.

Central blocks, including caudal anaesthesia, are not minor procedures, and their indications must be weighed against the severity of the surgery and potential complications. Peripheral nerve blocks have a lower incidence of side-effects compared with central blocks,[5] and should be preferred whenever possible. Ultrasound guidance can increase the efficacy of sciatic and femoral nerve blocks for the lower extremity in children and, therefore, might increase the use of these blocks in paediatric regional anaesthesia.

A limitation of our study is that it was not possible to blind the physician who performed the nerve blocks. Since we were not able to blind the anaesthetist, we decided to have a blinded observer, who investigated the success and the duration of analgesia, to minimize potential bias.

In conclusion, ultrasound guidance for lower extremity nerve blocks in children has not been investigated previously. In comparison with nerve stimulator guidance, the use of ultrasound was associated with prolonged duration of sensory blockade of the sciatic and femoral nerve with reduced amounts of local anaesthetics. Additionally, our data seem to support the hypothesis that ultrasound guidance may increase the success rate of lower extremity blocks.

References

1 Kapral S, Krafft P, Eibenberger K, *et al*. Ultrasound-guided supraclavicular approach for regional anesthesia of the brachial plexus. *Anesth Analg* 1994; **78**: 507–13

2 Marhofer P, Schrogendorfer K, Koinig H, *et al*. Ultrasonographic guidance improves sensory block and onset time of three-in-one blocks. *Anesth Analg* 1997; **85**: 854–7

3 Marhofer P, Sitzwohl C, Greher M, *et al*. Ultrasound guidance for infraclavicular brachial plexus anaesthesia in children. *Anaesthesia* 2004; **59**: 642–6

4 Willschke H, Marhofer P, Bosenberg A, *et al*. Ultrasonography for ilioinguinal/iliohypogastric nerve blocks in children. *Br J Anaesth* 2005; **95**: 226–30

5 Giaufre E, Dalens B, Gombert A. Epidemiology and morbidity of regional anesthesia in children: a one-year prospective survey of the French-Language Society of Pediatric Anesthesiologists. *Anesth Analg* 1996; **83**: 904–12

6 Schuepfer G, Konrad C, Schmeck J, *et al*. Generating a learning curve for pediatric caudal epidural blocks: an empirical evaluation of technical skills in novice and experienced anesthetists. *Reg Anesth Pain Med* 2000; **25**: 385–8

7 Vas L. Continuous sciatic block for leg and foot surgery in 160 children. *Paediatr Anaesth* 2005; **15**: 971–8

8 Ross AK, Eck JB, Tobias JD. Pediatric regional anesthesia: beyond the caudal. *Anesth Analg* 2000; **91**: 16–26

9 Ivani G, Tonetti F. Postoperative analgesia in infants and children: new developments. *Minerva Anestesiol* 2004; **70**: 399– 403

10 Marhofer P, Greher M, Kapral S. Ultrasound guidance in regional anaesthesia. *Br J Anaesth* 2005; **94**: 7–17

11 Konrad C, Johr M. Blockade of the sciatic nerve in the popliteal fossa: a system for standardization in children. *Anesth Analg* 1998; **87**: 1256–8

12 Willschke H, Bosenberg A, Marhofer P, *et al*. Ultrasonographic-guided ilioinguinal/iliohypogastric nerve block in pediatric anesthesia: what is the optimal volume? *Anesth Analg* 2006; **102**: 1680–4