Use of ropivacain and lidocaine for axillary plexus blockade

Michael Felfernig, Peter Marhofer[1], Marion Weintraud[1], Gudrun Huber[1], Andreas Duma[1], Aihie Nosa, Stephan Kapral[1]

ABSTRACT

Objective: The use of certain peripheral nerve blocks in paediatric patients is gaining increasing popularity, although distinctive characteristics of the juvenile anatomy, psychological barriers, time constraints on block placement, and risks of neurotoxic and cardio toxic side effects are still mentioned. However, newer agents like Ropivacaine and Levobupivacaine seem to offer excellent alternatives to Bupivacaine and Lidocaine, especially for use in paediatric patients. **Materials and Methods:** We evaluated Ropivacaine 0.5% and Lidocaine 1.0% using axillary plexus blockade as a single-shot technique in 50 children in the age group of 2 to 10 years and undergoing short upper limb surgery. The primary objectives were to compare onset time, duration and quality of block and the incidence of breakthrough pain. **Results:** Onset time was longer in the Ropivacaine group (15.4 minutes) than in the Lidocaine group (8.2 minutes). The duration of the effect was greater in patients in the Ropivacaine group (337 minutes) than in the Lidocaine group (137 minutes). Duration appeared to vary with patient's age but this effect was not statistically significant. **Conclusion:** Axillary plexus anaesthesia provides satisfactory perioperative pain relief in infants undergoing short-trauma surgery. Apart from its safety, these results underline that Ropivacaine 0.5% can be recommended for axillary brachial plexus block in children.

Key words: Drug safety, infants, local anaesthetics, plexus anaesthesia, trauma

DOI: 10.4103/0189-6725.62860

INTRODUCTION

Children with fractured arms, lacerated tendons, or amputated fingers are common in trauma units but they rarely arrive at hospital with an empty stomach. Thus, paediatric patients in particular can benefit from regional anaesthesia techniques.[1] In addition to relief from prolonged postoperative pain, brachial plexus block offers many advantages including prevention of aspiration and earlier discharge from hospital following treatment. Nevertheless, the axillary route should be used only if the patient is able to abduct the arm. Brachial plexus block originated in the early 19th century; its use in infants and children was described in 1951 by Small.[2] However, it remains less frequent in paediatric patients than adults. The main reasons could include psychological barriers, the fear of toxic reaction, lack of experience, distinctive features of juvenile anatomy and the fact that surgeons dislike the method.[1] In addition, it is commonly seen that parents are scared of the technique.

Several techniques may be used to block the brachial plexus in children. Some techniques, such as the perivascular or the transarterial axillary block, can be performed without technical support.[3] Ultrasound guidance facilitates the identification of nerves and plexus in paediatric patients.[4,5] Our study aims to compare the efficacy of Ropivacaine 0.5% with Lidocaine 1.0% in children undergoing axillary blocks using the single shot technique.

MATERIALS AND METHODS

A total of 50 children (ASA physical status I and II, age 2-10 years) who were scheduled for hand and forearm trauma surgery procedures were included in this study, which took place in the Medical University Vienna. The Local Research Ethics Committee approved the study and written, informed parental consent was obtained for each child. Children were excluded from the study if they had coagulopathies, neurological, cardiac or renal disease, known allergies or additional traumas that induced pain or required additional surgery. Each patient was premedicated rectally with Midazolam (Dormicum®, Roche, Germany) at a dose of 1 mg / kg up to a maximum dose of 15 mg. After insertion of a venous access, intravenous Midazolam 0.05-0.1 ml / kg and additional boluses of Propofol were administered if necessary. Routine monitoring included pulse

Medical Department, SMI Clinic, Port Harcourt, Nigeria, [1]Department of Anaesthesia and General Intensive Care, Medical University, Vienna, Austria

Address for correspondence:
Dr. Michael Felfernig,
Medical Department,
SMI Clinic Intels Camp, KM 12 Aba Road/ Expressway,
Port Harcourt, Nigeria.
E-mail: felfernigMD@doctors.org.uk

oxymetrie, electrocardiogram (ECG), and non-invasive blood pressure.

This study was designed as a randomised, double-blind, parallel-group, clinical trial. Each patient underwent acute upper forearm and hand surgery using a single shot axillary plexus blockade and the anaesthetic dose was calculated safely on a body weight basis. Twenty-five patients were assigned randomly to two experimental groups. In Group R, patients received 0.5 ml / kg Ropivacaine 0.5% (Ropivacaine®, Astra Zeneca, Bristol, UK). In Group L, patients received 0.5 ml / kg Lidocaine 1.0% (Xylocaine®, Astra Zeneca, Bristol UK).

After aseptic preparation and a small infiltration of the subcutaneous tissue with 0.5-1.0 ml of lidocaine 1%, the perivascular axillary approach was used to block the brachial plexus. In this technique, the patient's arm is abducted 90° from the body and the elbow is flexed so that the hand is over the head or behind it. A 24-gauge, 40-mm Sprotte needle (Pajunk™, Geisingen, Germany) is inserted high in the axilla at an angle of 45° to the skin just above the arterial pulsation. As the fascia is pierced, a loss of resistance can be noticed. If the position is correct, the needle pulsates. The injection of a single-shot, of local anaesthetic into the neurovascular sheath results in a successful block. All blocks were done by the same anaesthesiologist (S. Ka) with experience in this technique.

Observation method

We used Vester-Andersens criteria, which are met when a block of at least two of the four nerves is effective, to select patients for the study. Motor function was evaluated 10 and 30 minutes after the puncture and then at intervals of one hour up to eight hours (except for the duration of the operation).The quality of the sensory block was evaluated using the paediatric visual analogue scale (VAS) in which values on the adult visual analogue pain scale are transformed to symbols (Smiley scale) ranging from 1 (no pain) to 5 (maximum pain). Sensory block onset was defined as the time from injection of the tested agents to the first recording of the VAS equivalent value of 1. Values were recorded every five minutes, intraoperatively and every 15 minutes, postoperatively. Paracetamol 30 mg / kg was given rectally as soon as VAS score was 3 or if a child showed any other signs of pain. Sensory block duration was defined as the time between brachial block plexus and first dosage of Paracetamol. Further, a simplified pinprick test was used to assure the successful distribution of sensory blockade.

Statistics

For the analysis of continuous variables such as onset and duration of analgesia, anaesthesia, paresis, and paralysis, the T-test was used. Binary variables such as the presence or absence of sensory or motor block were analysed using a Chi-square test or Fischer's exact test.

RESULTS

Of the 50 subjects initially selected for this study, 44 (20 in group L and 24 in Group R) were included in the analysis [Table 1]. Each subject met the Vester-Andersen's criteria 30 minutes after the brachial plexus block. Six children in each group were less than four years old. Another six patients, who failed to meet this criteria or showed signs of pain on manipulation, were given general anaesthesia and excluded from this study.

The duration of the sensory effect was significantly greater in the Ropivacaine group than in the lidocaine group [Table 1]. Onset time was shorter in the Lidocaine group. In each group, the duration of the effect was greater in younger children (less than four years of age) than in older children. Breakthrough pain was observed in six patients in the Lidocaine group, whereas there was only one patient in the Ropivacaine group, who suffered from the same experience. No adverse effects were observed in any patients.

DISCUSSION

In this study we compared effects of Lidocaine, the most common local anaesthetic, with Ropivacaine, a newer drug, for minor surgery treatment of hand and forearm traumas in children. Patients in the Ropivacaine group had significant longer analgesia. Only one of 24 patients

Table 1: Summary of effects on selected variables of Lidocaine (Group L) and Ropivacain (Group R) used for axillary plexus blockade in children

Variable	Group L	Group R	Level of significance
Initial sample size	25	25	
Final sample size	20	24	
Mean age (years)	5.8 (2-10)	6.6 (2-10)	n.s.
Mean height (cm)	116	122	n.s.
Mean weight (kg)	24.7	28.7	n.s.
Sex ratio (M:F)	10:10	13:11	
Time of onset (min.)	8.2	15.4	<0.05
Duration (min)	137	336	<0.01
Duration <4a	142	356	n.s.
Duration >4a	115	309	n.s.
Duration of procedure (min)	36	29	n.s.
Breakthrough pain score	6	1	<0.05

in the Ropivacaine group of patients suffered from breakthrough pain. Further, the duration of the period of effectiveness appeared to vary with age of children.

The use of plexus anaesthesia goes back to Halsted in 1884, while it was documented in children much later.[2] Performing peripheral nerve blocks on children is easy because of minimal subcutaneous tissue overlying bony and vascular landmarks. Because of the ease and accuracy of placement of the needle as well as minimal incidence of complication, the axillary approach to the plexus is the most common access. The safety of regional techniques in children has been improved.[4,5] Peripheral nerve blocks have several advantages in the paediatric population, including decreased requirements for general anaesthesia and improved blood flow to the surgical site.[5,6] Nevertheless, some authors claim that evidence is lacking for an improved outcome using an axillary block for forearm-injured paediatric patients.[7]

We used the technique described by Clayton and Turner, which can be applied specifically when sonography is unavailable or when nerve stimulator-induced muscle contractions are unwanted, as in arm fractures.[3] Nevertheless the incomplete blockade in six children (eight per cent) underlines the usefulness of imaging techniques. Various techniques for brachial plexus blocks have been described in the last decades. Marhofer demonstrated better effects using ultrasound-guided methods compared to conventional nerve stimulation techniques with respect to onset time as well as sensory and motor block quality.[4] Continuing developments in this field will almost certainly improve the safety of plexus anaesthesia.

Local anaesthetics are commonly amphipathic and have an affinity for both lipid and water. Consequently, local anaesthetics cross the plasma membrane and intracellular membranes quickly and interact with charged targets such as structural or catalytic proteins and even signalling systems. Therefore, local anaesthetics can induce a variety of toxic effects in several types of tissue particularly in the brain, heart, and skeletal muscle.[8] In adults, toxic effects on the CNS are common but in children, effects on the heart are common.[8] While the main site of both the clinically desirable and toxic effects of local anaesthetics are thought to be exerted at the voltage-gated sodium channel, many alternative sites, such as a disruption of components of oxidative phosphorylation, have also been considered. In children, especially neonates and infants, the risk of reaching toxic levels might be greater due to an altered pharmacokinetic of local anaesthetics.[9] Risk of toxicity can be increased by changes in absorption, for example when acidosis occurs in sick children, or by an alteration of the level of binding to components of blood, such as albumin, a1-acid Glycoprotein and red blood cells.[8-10] Additionally, rates of liver metabolism are reduced in children due to a deficiency of enzymes belonging to the Cytochrome P450 family, especially during the first 36 months of life. Toxicity of anaesthetics also depend on the hepatic extraction ratio which itself depends on liver perfusion.[11] Interestingly, the duration of action in each group of our study declined in children more than four years of age although the size of our sample was not sufficient to draw strong conclusions. Loennquist described an age-related increase of Ropivacaine clearance measured after caudal administration in children one to eight years of age.[9]

The major Lidocaine metabolite, MEGX, can alter microsomal clearance activity.[12] Consequently, Lidocaine is not recommended for continuous administration. Lidocaine, which is the first amide local anaesthetic, was introduced clinically in 1948.[13] It has a fast onset, which is one of its main advantages, but it is limited to short procedures because of its intermediate duration of action and its strong neurotoxicity. Peripheral nerve blocks can mask symptoms of a compartment syndrome. Consequently, Lidocaine, which has a short duration, remains popular. Additionally it must be stated, that new methods, such as the near infrared spectroscopy, a non-invasive transcutaneous monitoring technique, can be used to avoid delayed or unnecessary fasciotomies even in children.[14]

Ropivacaine is a long-lasting local anaesthetic and the first single-enantiomeric anaesthetic to be introduced clinically.[15] The introduction of Ropivacaine in the medical field became necessary due to the toxic profile of Bupivacaine. Ropivacaine has a high threshold for systematic toxicity.[16,17] At low concentrations, it has been demonstrated to allow distinct separation between sensory and motor blockade. However, rare cases of toxic reaction have been reported in connection with brachial plexus blocks and even cases with cardiac arrest following epidural application of Ropivacaine have been noted.[18] Dalens reported that Ropivacaine concentration did not reach threshold in paediatric patients although large doses (3mg/kg) of the 0.5% solution had been administered for illio-inguinal blocks.[19] Cardio-toxicity is lower for Ropivacaine than Bupivacaine or Levobupivacaine.[16] The use of Ropivacaine for brachial plexus anaesthesia has

already been described in adults[20] and children using different approaches,[5,21] mainly with good results. The onset time and duration of action in the studies with a concentration of Ropivacaine of 0.5% are similar, regardless of the route of administration. Although regional anaesthesia is seen mostly sceptic initially, adult patients undergoing plexus anaesthesia would be in 78-93% agreeable to a redo of the same anaesthetic technique.[22] Further, excellent postoperative pain relief could increase acceptance of plexus anaesthesia by parents Based on our results, as a local anaesthetic for paediatric forearm surgery, Ropivacaine 0.5% has a greater duration of effectiveness than Lidocaine and should be considered to be a safe and effective alternative.

REFERENCES

1. Bonica JJ. Regional anesthesis in private practice. Anesthesiology 1960;21:554-6.
2. Small GA. Brachial plexus block anesthesia in children. J Am Med Assoc 1951;147:1648-51.
3. Clayton ML, Turner DA. Upper arm block anesthesia in children with fracture. J Am Med Assoc 1959;169:327-9.
4. Marhofer P, Sitzwohl C, Greher M, Kapral S. Ultrasound guidance for infraclavicular brachial plexus anaesthesia in children. Anaesthesia 2004;59:642-6.
5. Weintraud M, Lundblad M, Kettner SC, Willschke H, Kapral S, Lönnqvist PA, *et al*.Ultrasound versus landmark-based technique for ilioinguinal-iliohypogastric nerve blockade in children: The implications on plasma levels of ropivacaine. Anesth Analg 2009;108:1488-92.
6. Larsen VH, Treschow M. Venous blood gas analysis for evaluation of blood circulation of the hand during continuous axillary block. Acta Anaesthesiol Scand 1995;39:554-6.
7. Wissler M, Tomaske M, Stutz K, Schmitz A, Gerber A, Weiss M. Intravenous midazolam-ketamine anaesthesia for closed reduction of forearm fractures in children: Impact of additional axillary plexus anaesthesia. Anaesthesist 2006;55:944-9.
8. Eyres RL, Kidd J, Oppenheim R, Brown TC. Local anaesthetic plasma levels in children. Anaesth Intensive Care 1978;6:243-7.
9. Lonnqvist PA, Herngren L. Effects of pronounced haemodilution on the plasma protein binding of lidocaine. Perfusion 1995;10:17-20.
10. Booker PD, Taylor C, Saba G. Perioperative changes in alpha 1-acid glycoprotein concentrations in infants undergoing major surgery. Br J Anaesth 1996;76:365-8.
11. Bax ND, Tucker GT, Lennard MS, Woods HF. The impairment of lignocaine clearance by propanolol: Major contribution from enzyme inhibition. Br J Clin Pharmacol 1985;9:597-603.
12. Gordh T. Xylocain-a new local anaesthetic. Anaesthesia 1949;4:4-9.
13. Feldman HS, Covino BG. Comparative motor-blocking effects of bupivacaine and ropivacaine: A new amino amide local anaesthetic, in the rat and dog. Anaesthesia and Analgesia 1991;73:373-84.
14. Tobias JD, Hoernschemeyer DG. Near-infrared spectroscopy identifies compartment syndrome in an infant. J Pediatr Orthop 2007;27:311-3.
15. McClure JH. Ropivacaine. Br J Anaesth 1996;76:300-7.
16. Knudsen K, Beckman-Suurkula M, Blomberg S, Sjövall J, Edvardsson N. Central nervous and cardiovascular effects of i.v. infusions of ropivacaine, bupivacaine and placebo in volunteers. Br J Anaesth 1997;78:507-14.
17. Scott DB, Lee A, Fagan D, Bowler GM, Bloomfield P, Lundh R. Acute toxicity of ropivacaine compared with that of bupivacaine. Anesth Analg 1989;69:563-9.
18. Kimura Y, Kamada Y, Kimura A, Orimo K. Ropivacaine-induced toxicity with overdose suspected after axillary brachial plexus block. J Anesth 2007;21:413-6.
19. Dalens B, Ecoffey C, Joly A, Giaufré E, Gustafsson U, Huledal G, *et al*.Pharmakokinetics and analgetic effect of ropivacaine following ilioinguinal/iliohypogastric nerve block in children. Paediatr Anaesth 2001;11:415-20.
20. Casati A, Fanelli G, Albertin A, Deni F, Anelati D, Antonino FA, *et al*.Interscalene brachial plexus anesthesia with either 0.5% ropivacaine or 0.5% bupivacaine. Minerva Anestesiol 2000;66:39-44.
21. Fleischmann E, Marhofer P, Greher M, Waltl B, Sitzwohl C, Kapral S. Brachial plexus anaesthesia in children: Lateral infraclavicular vs axillary approach. Paediatr Anaesth 2003;13:103-8.
22. Waters JH, Leivers D, Maher D, Scanlon T, DeGuzman GM. Patients and surgeon satisfaction with extremity blockade for surgery in remote locations. Anesth Analg 1997;84:773-6.

Source of Support: Nil, **Conflict of Interest:** None.