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Femoral Nerve Blockade in Children Using Bupivacaine

L. Ronchi, M.D., D. Rosenbaum, M.D.,* A. Athouel, Pharm.D.,† J. L. Lemaitre, M.D.,* F. Bermon, Pharm.D.,‡ C. de Villepoix, Sc.D.,† Y. Le Normand, Pharm.D.§*

The authors evaluated the efficacy and incidence of side effects from blockade of the femoral nerve with 0.5% bupivacaine in 14 children with fracture of the middle third of the femoral shaft. In nine of these children, a pharmacokinetic analysis was also performed. The onset of analgesia occurred in 8.0 ± 3.5 minutes after blockade of the femoral nerve. One block failed, resulting in iv narcotics being administered to alleviate the pain. In the remaining 13 children, pain decreased to nonexistent in 11 of the children and only mild pain with movement in the remaining two children. The level of analgesia did not change when the children underwent radiographic examination (60 ± 18 min after the femoral nerve block) and application of traction (124 ± 19 min after femoral nerve block). The maximum bupivacaine plasma concentration was 0.89 ± 0.37 μg/ml, obtained 24.4 ± 12.6 min after the end of the injection. The femoral nerve blockade with bupivacaine provides prompt, effective, and prolonged analgesia in children suffering from fractures of the femoral shaft, allowing transport, radiographic examination, and application of traction in optimal conditions. Although the sample size was small, the side effects appeared to be rare. (Key words: Anesthesia: pediatric. Anesthetic techniques: femoral nerve block. Pharmacokinetics: bupivacaine.)

FRACTURES of the femoral shaft in children occur frequently and are painful.[1] Providing adequate analgesia for transportation, radiographic analysis, and application of traction is a problem. Femoral nerve block (FNB) can be performed in supine position, without moving patient's lower limbs (as epidural or caudal block needs), and provides profound analgesia. We evaluated in children the efficacy, occurrence of side effects, and pharmacokinetics of FNB with plain 0.5% bupivacaine.

Methods

We studied 14 children, aged 6.4 ± 3.4 yr (mean ± SD) (range, 2–10 yr), weighing 24.1 ± 9.5 kg (range, 14–36 kg). Informed consent from relatives was obtained in all cases, and the investigation was approved by the Human Investigation Committee. All the children showed a fracture of the middle third of the femoral shaft. Associated injuries were head trauma (three children) and chest wall trauma (one child). Comatose children and those with neurologic perturbations preventing clinical evaluation of pain were excluded, as well as those requiring emergency laparotomy or thoracotomy for hemostasis. None had received analgesics or narcotics before FNB was performed. All children were subjected only to traction and long-term casting. None underwent initial surgical reduction of the fracture.

All children had physical examinations by one of the clinical investigators (L.R., D.R., or J.L.L.). After evaluating the extent of trauma, we inserted a short catheter into a forearm vein and began fluid resuscitation with 20 ml/kg of lactated Ringer's solution over a 20-min period. A cardiotachometer, ECG, and noninvasive arterial blood pressure device were applied. Results of clinical examination, with special attention to neurologic abnormalities such as femoral nerve deficit, were recorded.

After local anesthesia of the skin (1% lidocaine: 10 mg), a 23-G needle was inserted one finger breadth lateral to the femoral artery at the level of the inguinal ligament passing through the deep fascia. Injection was performed after verification of the extra vascular placing of the needle by an aspiration test. When blood was aspirated, a second attempt was performed after a local compression of 10 min. We then injected 2 mg/kg of 0.5% bupivacaine without epinephrine. We observed and recorded the onset, quality, and duration of analgesia (table 1) and the occurrence of side effects or complications, such as major ECG changes or seizures. The pharmacokinetics of bupivacaine following FNB were studied in nine of the children weighing 25.3 ± 10.6 kg. All were ASA 1 status and free of cardiac, renal or hepatic disease. There was no evidence of hypovolemia at the time of the study.

Venous blood samples were collected (on the forearm opposite the iv line) before and 5, 10, 15, 20, 30, 40, 50, 60, 90, 120, 150, and 180 min after FNB was performed. Plasma was separated by centrifugation and stored at −18° C. Bupivacaine plasma levels were performed by a gas-liquid chromatography method using fused-silica capillary column and nitrogen-specific detection.¶ Pharmacokinetics were calculated, assuming complete availability,

* Staff Anesthesiologist, Hopital de St Nazaire.

† Research Assistant, Department of Pharmacology, Faculté de Médecine de Nantes.

‡ Head, Department of Biology, Hopital de St Nazaire.

§ Assistant Professor of Pharmacology, Faculté de Médecine de Nantes.

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Address reprint requests to Dr. Ronchi: Anesthésiologie, Centre Hospitalier, BP 414, F44606, Saint-Nazaire, Cedex, France.

¶ Le Normand Y, Athouel A, Blanloeil Y, de Villepoix C, Melchior JC, Kergueris MF, Bourin M, Larousse C: Rapid gas chromatographic assay of bupivacaine in plasma. Fundam Clin Pharmacol 6:471–478, 1987.

with G-Pharm computer program using a nonlinear regression model (exponential decay). Triexponential equations were fit to the total serum concentration *versus* time data. The area under the plasma concentration curve (AUC) was calculated by the trapezoidal rule and extrapolated to infinity. Plasma clearance (Cl) was then calculated. All values are expressed as mean ± SD.

Results

Upon arrival at the emergency department, nine children had grade 4 pain, and five grade 3 pain (table 1). The onset of analgesia occurred 8.0 ± 3.5 min after FNB. One block failed, and the child required iv narcotics to tolerate movement. In the remaining 13 children, pain dramatically decreased to level 0 (11 children) or level 1 (two children). No supplemental analgesia was then needed in this subgroup. Analgesia level did not change when the children underwent radiographic examination (60 ± 18 min after FNB) and traction installation (124 ± 19 min after FNB). In all 13 children, traction had a definitive analgesic effect, so that the exact duration of analgesia due to FNB could not be determined.

On one occasion, the femoral artery was punctured. After 10 min of local compression the second attempt at FNB was successful. No patient had ECG changes, seizures, or abnormalities in respiratory rate, nor did any adverse sequelae occur. Upon hospital discharge, all children were found free of any neurologic abnormality. In six children physical examination could be repeated 1 yr after the femoral fracture had occurred and was found to be normal.

Figure 1 shows the time course of the mean venous bupivacaine concentrations: there is an apparent first-order elimination, with an average terminal half-life of 2.76 ± 1.18 h (range, 0.86–3.98 h). Other pharmacokinetic parameters are listed in table 2. Maximal bupivacaine plasma concentration was 0.89 ± 0.37 μg/ml, obtained 24.4 ± 12.6 min after the end of the injection.

TABLE 1. Evaluation of Analgesia

Pain
Grade 0: calm, no spontaneous pain or during handling, radiographs, or traction installation
Grade 1: calm, no spontaneous pain, pain during handling
Grade 2: calm, pain expressed spontaneously, handling impossible
Grade 3: child is crying, pain expressed spontaneously, handling impossible
Grade 4: child is crying, major tachycardia (>60% normal rate in consideration to age) and high blood pressure, handling impossible
Onset of analgesia
Time from FNB completion to pain = 1 or 0
Duration of analgesia
Time from onset to pain grade 2

Discussion

This technique provides rapid and prolonged analgesia, with comfort, in children suffering from fracture of the femoral shaft. It appears easy to perform (successful in 13 of 14 children). The major advantages of this method are the absence of attenuation of abdominal tenderness and a consequent alteration of the abdominal examination, and the ability to perform this block in the supine position without moving the child's lower extremeties. Onset of analgesia was similar to that previously reported in adult patients, as well as failure rate.[2] No side effects were observed despite a probable partial intravascular injection. Bupivacaine was preferred to lidocaine, despite higher potential toxicity, to ensure optimal analgesia during the whole, time-consuming procedure, ranging from initial examination to application of traction. As reported by Tondare and Nadkarni,[3] analgesic action wears off after 2 h when lidocaine is used. All fractures in our series of patients were located on the middle third of the femoral

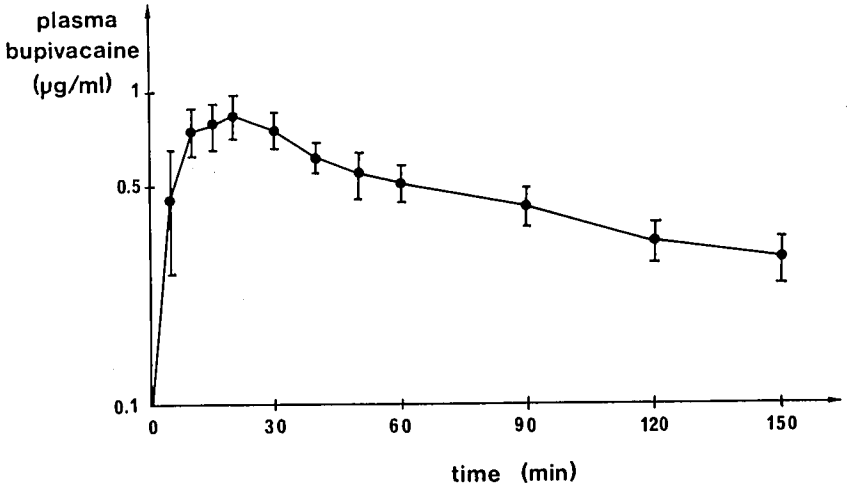

FIG. 1. Plasma bupivacaine concentrations (mean ± SEM) after FNB with a single injection of 2 mg/kg.

TABLE 2. Characteristics of the Patients and Pharmacokinetic Parameters

Patient	Weight (kg)	Cmax (μg/ml)	Tmax (min)	T1/2β (h)	Cl (ml·min^{-1}·kg^{-1})	VD_{ss} (l/kg)
1	14	1.19	20	3.98	9.3	2.84
2	15	0.85	30	2.14	18.7	3.54
3	16	1.12	10	1.10	20.0	2.73
4	18	1.52	5	0.86	20.6	1.42
5	20	0.82	40	3.85	7.0	2.36
6	34	0.46	15	2.57	42.6	7.64
7	35	1.12	30	3.85	8.0	2.38
8	36	0.52	40	3.30	15.0	4.08
9	40	0.44	30	3.21	16.5	4.60
Mean	25.3	0.89	24.4	2.76	17.5	3.51
SD	10.6	0.37	12.6	1.18	10.8	1.82

Cmax = maximum plasma concentration; Tmax = time to reach Cmax; T1/2β = slow elimination phase half-life; Cl = total plasma clearance; VD_{ss} = volume of distribution at steady state.

shaft. We believe that, as well as in adults,[4] for anatomic considerations, analgesia may be of lower quality for fractures of the lower or upper third of the femoral shaft.

Because low plasma levels were expected, we used a highly sensitive and specific gas chromatographic technique,¶ allowing accurate measurement of concentrations as low as 6 ng/ml, which is tenfold below the lowest values observed in this study. In all patients but one (patient 4), maximal plasma concentrations remained under 1.2 μg/ml, below assumed toxic values. In patient 4 Cmax reached 1.52 μg/ml at 5 min only, with a high Ka value (0.197/min). This was probably due to a partial accidental intravascular injection. In this case, as in all other cases, no side effects were observed. Addition of epinephrine to bupivacaine was not found to be useful. Tachycardia during injection could be due to spontaneous or fear-related variations of heart rate as well as intravascular injection of epinephrine. We believe there is no interest in reducing peak blood levels, assuming that they would remain under toxic values. Duration of action of plain bupivacaine was sufficient to provide pain-free transportation and application of traction.

The pharmacokinetic variables of bupivacaine in FNB were in agreement with the values previously reported in children.[5–7] Volume of distribution (VD_{ss}) and clearance are threefold higher than current values in adults if related to body weight.[8] These findings are in agreement with those published by Rothstein *et al.*[5] and might be explained by a lower proportion of adipose tissue or a higher hepatic blood flow than in adults. However, elimination half-life is comparable to values observed in adults.

In conclusion, FNB with bupivacaine provides prompt, effective, and prolonged analgesia in children suffering from fractures of the femoral shaft, allowing transport, radiographic examination, and traction installation in optimal conditions. Side effects appear to be rare in our limited sample size, although the aspiration test is mandatory to prevent intravascular injection.

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