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ORIGINAL ARTICLE

Neuropathic complications after 157 procedures of continuous popliteal nerve block for hallux valgus surgery. A retrospective study

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KEYWORDS
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Summary
Background: Continuous peripheral nerve block (CPNB), in particular at the popliteal fossa, is widely used in orthopedic surgery, allowing good postoperative analgesia. Possible neuropathic complications, however, remain poorly known.
Objective: To review the characteristics of peripheral neuropathy (PN) after sciatic CPNB at the popliteal fossa, estimating prevalence, severity, evolution and possible risk factors, especially those relating to the procedure.
Methods: Retrospective study of PN associated with popliteal fossa CPNB for hallux valgus surgery, between November 1st, 2005 and November 1st, 2009. All procedures were analyzed (type of anesthesia, approach, nerve location technique, number of procedures by operator) with, for each case of PN, analysis of clinical and electromyographic data.
Results: One hundred and fifty seven sciatic CPNBs were performed (92% women; mean age, 55 years). The approach was lateral ($n = 62$), posterior ($n = 74$) or unknown ($n = 21$). Ultrasound guidance was combined to neurostimulation for 69 patients (44%). Three women (prevalence = 1.91%), aged 19, 24 and 65 years respectively, developed associated common superficial peroneal and sural nerve injury (2), axonal on electromyography, with motor ($n = 1$) and/or sensory ($n = 3$) residual dysfunction.
Discussion: The higher prevalence found in the present study than in the literature (0 to 0.5%) raises questions of methodological bias or technical problems. The common peroneal and sural nerves seem to be exposed, unlike the tibial. Several mechanisms can be suggested: anesthetic

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neurotoxicity, direct mechanical lesion, or tourniquet-related ischemia and conduction block. Further studies are necessary to determine the ideal anesthetic procedure.
Conclusion: Patients should be informed of the potential risk, however rare, even during mild surgery. The best possible technique should be implemented, with reinforced surveillance.
Level of evidence: Level IV retrospective study.

Introduction

Continuous peripheral nerve block (CPNB) of the sciatic nerve at the popliteal fossa is increasingly used in often painful foot surgery [1] to reduce postoperative pain and resort to opioids and to improve functional recovery [2,3]. The sciatic nerve divides in (or sometimes upstream of) the popliteal fossa, into the tibial and common peroneal nerve. First described by Labat in 1921 [4], PNB consists in anesthetizing both branches of the sciatic nerve, with a perineural catheter providing several days' analgesia (CPNB). Classically, it associates neurostimulation to superficial landmarking, to minimize the impact of variations in sciatic nerve division [3—8]; ultrasound guidance has provided further precision. There are two major types of complication, infection and neuropathy, with respective frequencies of 0.25—2.8% and 0—0.5%, although the latter has been little studied [9—14]. From our personal experience, we estimated the prevalence and initial and long-term severity of neuropathy and risk factors, looking for possible underestimation or oversight of sequelae and whether procedural modalities or initial health status might play a role in onset or severity. The final objective was to formulate practical advice enabling prevention.

Materials and method

Type of study and population

The design was a retrospective descriptive transverse epidemiological study. Inclusion criteria were: popliteal fossa PNB for hallux valgus performed between November 1st, 2005 and November 1st, 2009 in the Desgenettes military teaching hospital (Lyon, France), with truncal neuropathy persisting more than 48 hours after removal of the perineural catheter. The computer (FileMaker Pro software) and paper files of patients operated on during the study period were analyzed.

Study variables

For each included patient, paper and computerized (Amadeus II software) file data were examined by a single investigator. The study variables were: age, gender, comorbidity, type of procedure, interval between anesthesia and onset of early clinical signs, and preoperative and follow-up examination data. The surgical approach, sciatic nerve location technique, anesthetic substance and dose, block duration and number of procedures per operator were also noted, as were preoperative and follow-up data on electromyogram and popliteal fossa and fibular neck MRI.

Anesthesia technique

Anesthesia begins with midazolam injection (1 to 2 mg) for mild sedation and reduced neurostimulation discomfort.

In posterior approaches, the patient is positioned in ventral decubitus while the superficial landmarks are drawn: laterally, femoral biceps tendon; medially, semitendinosus tendon. The puncture point is located midway between the two, perpendicular to the skin, 7 cm above the popliteal fossa. Neurostimulation via a 10 cm needle begins at 1 Hz with a 0.1 ms stimulus duration and 2 mA intensity, gradually lowered to 0.5 mA until an appropriate motor response is obtained in either branch of the sciatic nerve. The tibial nerve is identified by plantar flexion or flexion of the toes, and the common peroneal nerve by dorsiflexion or eversion. This motor response should disappear below 0.2 mA, in which case the needle is slightly withdrawn. After aspiration test and checking absence of blood reflows, a slow fractionated injection of 10 mL ropivacaine 0.5% associated to clonidine is made in each trunk. The injection is stopped if the patient expresses violent pain.

In lateral approaches, the technique differs in that the patient is positioned in dorsal decubitus with the leg half bent; the puncture point is at the intersection of two lines through the superior edge of the patella and the superior edge of the femoral biceps tendon.

Since 2007, we have associated ultrasound guidance to neurostimulation. The common peroneal and tibial nerves are located as two well-contoured rounded hypoechogenic structures, in contrast to the anechogenic rounded structures of the popliteal artery and vein, identified by their Doppler flow. The probe is then moved toward the head until the sciatic nerve bifurcation is located. The needle is introduced toward the nerve, parallel to the probe, under 0.7 mA sentry stimulation and ultrasound guidance; the target motor response is plantar or dorsal flexion of the foot. Ropivacaine is injected around the nerve, under visual control, and is immediately stopped in case of ''ballooning'' of the nerve, which indicates intraneural damage. Optimal diffusion is assessed by local diffusion of the anesthetic around the nerve (''doughnut'' sign).

The neural catheter is left for 72 hours, with analgesia maintained by continuous feed and possible boli of ropivacaine.

Study methods

Possible motor deficit was assessed on the Medical Research Council motor testing classification, from 0 to 5 (0: no contraction; five: normal muscle resistance). Electromyography used a Micromed System 98 apparatus.

Descriptive statistical analyses were used to present the study population and describe the subgroups.

Results

Epidemiological data

Between November 1st, 2005 and November 1st, 2009, 210 patients were operated on for hallux valgus: 189 female (90%), 19 male (9%), two without recorded gender. Mean age was 55 years (range, 18—80 yrs).

During the same period, 239 popliteal fossa PNBs were performed (185 women [77%], 54 men [23%]), including 190 (79%) CPNBs with popliteal perineural catheterization. The main indications for surgery were hallux valgus ($n = 157$, 66%), arthrodesis (21.9%) or amputation (11.5%).

In 45 cases of hallux valgus surgery, the type of anesthesia was not recorded. Popliteal fossa sciatic nerve block was performed in 157 hallux valgus patients (95%): 92% female ($n = 144$); mean age 55 years (range, 18—80 yrs). Approaches were lateral ($n = 62$) or posterior ($n = 74$), and not recorded in 21 patients. In 69 patients operated on by a posterior approach (44%), ultrasound guidance was associated to neurostimulation, with neurostimulation alone in the other cases. 96% of blocks were CPNBs with popliteal catheterization ($n = 150$). There was complete popliteal block failure in seven patients (4%) and partial failure in 15 (10%), with crossover to general anesthesia or morphine supplementation, and success in 135 (86%). Difficulties were recorded for ten patients (6%): anxiety ($n = 7$), iterative puncture ($n = 3$) or vasovagal syncope ($n = 1$).

Other forms of anesthesia in hallux valgus surgery were spinal ($n = 6$), multiple-injection ankle block ($n = 1$) or tibial block at the ankle ($n = 1$). In 15 patients, a peroneal block supplemented the popliteal block.

For hallux valgus surgery, a pneumatic tourniquet was placed at the ankle for a mean 51 min (maximum, 99 min). Tourniquet time data were missing in 24 cases. Seven surgeons in all performed hallux valgus operations during the study period, with a single surgeon performing 81%.

All popliteal blocks were performed in presence of a senior anesthetist, sometimes supervising an intern or assistant. Over the study period, 30 physicians, including 14 senior anesthetists, were involved in the popliteal blocks. The number of blocks per operator/supervisor ranged from 1 to 40, for a mean 3.3 procedures per physician per year.

Persistent postoperative peripheral neuropathy, without cause unrelated to the procedure, was found in three female patients, aged 19, 24 and 65 years: i.e., a complications rate of 1.26% associated to sciatic nerve block at the popliteal fossa and of 1.91% associated to popliteal block for hallux valgus surgery. These three cases of neuropathic complications were non-consecutive.

Clinical observations

Case n° 1

A 65 year-old woman with obesity and hypertension had history of right breast cancer in remission following surgical excision and radiation therapy, right meniscectomy, colposuspension and appendectomy; on November 25, 2005, she was operated on for left hallux valgus with 2nd ray claw toe. Surgery consisted in Scarf osteotomy of the 1st metatarsal (M1), varization osteotomy of the 1st phalanx (P1) and Weil osteotomy of the second metatarsal (M2). A pneumatic tourniquet was applied at the ankle at 230 mmHg for 62 minutes. In the immediate postoperative course, the patient experienced hypoesthesia of the anterolateral side of the leg and dorsal side of the foot. At 5 days, she complained of motor impairment. At 12 days, left foot and toe levator deficit was total, with evertor function graded 3/5. At the sensory level, there was hypoesthesia of the lateral and dorsal sides of the foot in the superficial and deep peroneal nerve territory. The lateral sural cutaneous branch of the common peroneal nerve was conserved, as was the tibial and sural territory. EMG found isolated severe left common peroneal nerve damage, with predominantly motor response in the fibers running to the deep branch, and no sensory response in the superficial peroneal nerve. The other nerve trunks were conserved. MRI of the popliteal fossa and fibular neck was normal, without hematoma, edema, popliteal cyst or expansive process. Motor function began to improve at 5 months; in September 2009, however, deficits were still found in the foot (3/5) and toe (0/5) levators and, to a lesser degree, evertors (4/5), with little change in the area of hypoesthesia. A private counter-examination was undertaken, although we are not aware of the result.

Case n° 2

A 24 year-old woman with history of appendectomy underwent surgery for disabling congenital left hallux valgus on October 8, 2009. Surgery comprised Scarf M1 and P1 varization osteotomy. A pneumatic tourniquet was applied at the left ankle at 230 mmHg. On release, examination following the patient's complaint found total deficit in the toe levators and partial (3/5) deficit in the left foot levators and evertors. At the sensory level, there was anesthesia in the common peroneal nerve territory with lateral sural cutaneous and sural nerve involvement. EMG confirmed these findings, showing severe but incomplete sensory-motor common peroneal nerve damage; the tibial nerve was conserved and the sural nerve involved. MRI found non-compressive edema of the soft tissue in contact with the common peroneal nerve just after the bifurcation. The patient received NSAID treatment and physiotherapy. Eleven months later, motor function had improved; hypoesthesia, however, remained severe, although slightly less in the sural territory.

Case n° 3

A 19 year-old woman without previous history underwent right hallux valgus surgery on June 26, 2008, by Scarf osteotomy with P1 varization. Catheterization induced no neuralgia. A pneumatic tourniquet was applied at the right ankle at 220 mmHg for 51 minutes. On release, the patient complained of weakness of the right foot with numbness and paresthesia of the anterolateral side of the leg and superior and lateral sides of the foot. Clinical examination found deficits in eversion (4/5), foot and toe dorsiflexion (3/5) and hypoesthesia of the lateral sural cutaneous, superficial and deep peroneal and sural nerve territories. EMG found severe sensory-motor axonal damage to the common

Table 1 Analysis of the anesthetic procedure in the three cases of neuropathy.

	Case n° 1	Case n° 2	Case n° 3
Approach	Lateral	Lateral	Lateral
Peroperative anesthetic substance	Ropivacaine	Ropivacaine	Bupivacaine
Postoperative anesthetic substance	Ropivacaine + adrenalinated lidocaine	Ropivacaine	Ropivacaine
Perineural catheterization time	72 hrs	72 hrs	72 hrs
Operator	Assistant anesthetist	Anesthesia intern	Anesthesia intern
Reported problems	Partial failure (supplementary opioids)	None	None

peroneal and sural nerves. MRI found no hematoma in the area of the block. At 11 months, the patient complained of impaired resistance to effort in the truncal territory, without abnormality on segmentary examination, very occasional transient neuralgia in the lateral side of the right leg and hypoesthesia in the sural territory. She underwent osteotomy for contralateral hallux valgus 8 months later, under general anesthesia.

Analysis of the procedure

These 3 CPNBs were performed by trainee staff, but under senior supervision. During the study period, the senior anesthetists in question accumulated 48 popliteal blocks (9, 9 and 30, respectively). Operators reported no peroperative issues; in one case, however, the block was a partial failure, with resort to elevated opioid doses. Approaches were systematically lateral, without ultrasound guidance. In the three cases of neuropathic complication, the operator was the surgeon who performed 81% of the hallux valgus procedures during the study period (Table 1).

Electromyographic data

Each case consisted in more or less severe axonal, length-dependent common peroneal nerve involvement, with no signs of fibular neck damage (no reduction in conduction speed or conduction block), and concomitant sensory (superficial peroneal) deficit (Table 2). The tibial nerve was systematically conserved, although the sural nerve was involved in two of the cases. There was more or less full motor response recovery, except for distal response in two of the cases, at between 11 months' and 4 years' follow-up, whereas sensory response failed to improve.

Discussion

Peripheral sciatic nerve block at the popliteal fossa, whether continuous (CPNB) with perineural catheterization providing continuous anesthesia via a pump with the possibility of supplementary boli, or not (NCPNB), may induce several complications (hematoma, paresthesia or pain during nerve location, systemic and/or allergic toxic reaction, difficulty of catheter insertion or accidental ablation, or infection) [11,14,15], including peripheral nerve deficit [9—13]. Prevalence ranges from 0 to 0.50% in the literature (Table 3), but seems lower in NCPNB (0.34% or 0.32%) [9,12] than CPNB (0.5% or 0.45%) [11,13], except in Capdevila et al.'s series [15] where it was zero for CPNB. These figures are close to those for CPNB in other nerve trunks, where prevalence ranges from 0 to 0.21% [9,10,15,16]. Several reasons may be suggested for the much higher prevalence of 1.26% in the present series. Missing data (type of anesthesia in 45 cases and approach in 21) may have induced methodological bias. The tourniquet cannot be implicated, as it was at the ankle and never unduly maintained. Health status and age were not predisposing factors, as two of the three patients were young and free of comorbidity. On the other hand, certain technical factors (too few anesthesia procedures per physician, and choice of approach and means of landmarking) or surveillance issues (the difficulty of assessing absence of paralysis under a cast) may be implicated. Borgeat et al. [17] correlated the number of procedures per physician and risk of neuropathic complications. A search of the literature failed to show neuropathy risk to vary with type of landmarking (Table 3) or approach, but all three of the present cases were associated with a lateral approach (prevalence, 4.84% for 62 procedures) and exclusive neurostimulation (3.41% for 88 procedures), and none with a posterior approach or ultrasound guidance.

Another notable point was that only the common peroneal and sometimes sural nerve and sciatic fibers running toward them were involved in the present cases, as previously reported for the common peroneal nerve in the few reports in the literature (Table 4) [11,13]. This raises the question of greater common peroneal nerve vulnerability to lesion factors and a consequent need to revise procedure.

Direct toxicity implicating the anesthetic substance has been suggested as an explanation, with cytotoxicity proportional to concentration or duration, inducing axon lesions [18]. Reduced neural vascularization by vasoconstriction induced by the anesthetic substance has also been hypothesized, based on animal studies showing reduced neuronal blood flow on Doppler after lidocaine or bupivacaine injection [19]. Bonner et al. [20] suggested that, in certain patients, adrenalinated local anesthetics could induce neural ischemia by intense nutrient-vessel vasoconstriction caused by alpha-adrenergic stimulation. The perineurium clearly appears as a crucial barrier: intraneural and intrafascicle injection induces more neural lesions than does extraneural and extrafascicle injection [21], the only consequence of the latter seeming to be extended block time [22—24]. Other studies suggested direct nerve trauma, by accidental contact with the needle, especially in case of difficulty in introducing the catheter or when the operator lacks experience. This phenomenon may be more frequent in PNB under general anesthesia, where the patient cannot

Table 2 First and final motor and sensory conduction findings.

		Case n° 1	Case n° 1	Case n° 2	Case n° 2	Case n° 3	Case n° 3
Date		Dec. 7, 2005	Sept. 16, 2009	Oct 14, 2009	Sept. 27, 2010	July 7, 2008	May 26, 2009
DLM	N	L	L	L	L	R	R
Common peroneal (EDB)	< 6	0.0	0.0	8.1	9.9	3.8	4.9
Common peroneal (TA)		2.3	4.8	4.1	3.0	3.3	4.4
Common peroneal (PL)		3.2	2.4	3.2	3.8	4.2	3.9
Tibial	< 6.5	4.7	4.7	5.2	5.0	4.0	6.0
MCV							
Common peroneal (EDB)	> 40	0	0	34.4	41.3	46.6	48.3
Common peroneal (TA)	> 40	44	55	41.7	52.9	66.6	45.2
Common peroneal (PL)	> 40	50	57	44.4	60.0	61.5	59.4
Tibial	> 40	44	42	40.4	41.0	46.7	45.7
CMAP							
Common peroneal (EDB)	> 2	0.0	0.0	0.2	0.3	0.6	2.7
Common peroneal (TA)	> 2	0.2	2.2	0.9	3.3	0.8	2.2
Common peroneal (PL)	> 2	1.8	2.1	1.6	4.1	0.8	2.3
Tibial	> 3	6.6	6.0	5.9	10.2	5.8	6.0
F wave							
Common peroneal	< 56	0.0	0.0	0.0	0.0	42.5	41.1
Tibial	< 57	48.8	48.5	49.0	48.8	41.9	41.5
SNAP							
Sural	> 10	11.8	11.7	2.2	3.3	7.0	7.3
Superficial peroneal	> 8	0.0	0.0	0.0	0.0	6.2	7.0
SCV							
Sural	> 40	45	44	34.6	32.8	55.6	43.8
Superficial peroneal	> 40	0	0	0	0	40.0	44.3

DLM: distal motor latency (ms); MCV: motor conduction velocity (m/s); CMAP: compound muscle action potential (mV); F: F wave minimal latency (ms); R: right; L: left; EDB: response on extensor digitorum brevis; TA: response on tibialis anterior; PL: response on peroneus longus; SNAP: sensory nerve action potential (μV); SCV: sensory conduction velocity (m/s).

Table 3 Prevalence of neuropathic complications after sciatic nerve block at the popliteal fossa, literature data.

Authors	Auroy et al. [9] 2002	Capdevila et al. [15] 2005	Swenson et al. [13] 2006	Compère et al. [11] 2009	Orebaugh et al. [12] 2009
Number of popliteal blocks	952	167	224	400	876
Landmarking	NS and other	NS	US	NS	NS (n = 475) vs. US (n = 401)
Anesthetic substances	Non-specified	Induction: ropivacaine 0.5% or bupivacaine 0.375% or mepivacaine 1.5% Maintenance: ropivacaine 0.2% or bupivacaine 0.25%	Induction: bupivacaine 0.5% Maintenance: bupivacaine 0.25%	Induction: ropivacaine 0.475% Maintenance: ropivacaine 0.2%	Ropivacaine 0.5% and mepivacaine 0.75%
Type	NCPNB	CPNB	CPNB	CPNB	NCPNB
% neuropathic complications	0.32% (n = 3)	0%	0.45% (n = 1)	0.50% (n = 2)	0.34% (n = 3)

NS: neurostimulation; US: Ultrasound; CPNB: continuous peripheral nerve block, NCPNB: non-continuous peripheral nerve block.

Table 4 Characteristics of neuropathic complications after sciatic nerve block at the popliteal fossa, literature data.

Authors	Auroy et al. [9] 2002	Swenson et al. [13] 2006	Compère et al. [11] 2009	Orebaugh et al. [12] 2009
Number of neuropathic complications	3	1	2	3
Landmarking	Non-specified	US (1)	NS (2)	NS (3)
Territory	Non-specified	Common peroneal nerve (1)	Common peroneal nerve (2)	Non-specified
Approach	Non-specified	Non-specified	Non-specified	Posterior (3)

NS: neurostimulation; US: Ultrasound.

report paresthesia. Recent studies, however, showed that direct contact between nerve and needle seen on ultrasound did not systematically induce paresthesia or motor response [23,25]. Rather, it seems to cause neural edema, which does not itself induce clinical manifestations without the associated local anesthetic injection [18]. Another source of mechanical nerve lesion may lie in the tourniquet, inducing ischemia and conduction block with irreversible neural lesions appearing after only 2 to 4 hours of use [18]. Compression may also be related to patient positioning on the table.

To improve the reliability of popliteal block and reduce incidence of adverse events, several studies compared analgesia time and PNB success rates according to local anesthetic concentration, dose and substance. To our knowledge, none focused on prevalence of complications according to substance or mode of administration: a short-action, short half-life substance such as lidocaine or mepivacaine as initial bolus might enable early detection of neuropathic complications, with impact on prognosis. The interest of a posterior approach and especially of ultrasound-guided landmarking in reducing complications is not clear [12], but the latter has the advantage of reducing operation time and quantity of anesthetic, providing a better success rate than neurostimulation [26,27]. Ultrasound also avoids certain failures related to anatomic variants. Finally, there does not seem to be any difference in terms of complications between single and double (at peroneal then at tibial nerve response) injection block [28]. An adequate number of procedures per anesthetist and careful examination during continuous block are a matter of common sense.

Conclusion

Although rare, neuropathic complications following sciatic CPNB at the popliteal fossa may leave definitive sequelae, which raises the question of the risk/benefit ratio in a procedure implemented for benign pathology. At all events, the patient should be fully informed during the anesthesia consultation; the optimal technique should be proposed and reinforced surveillance implemented for continuous block.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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