

The "critical zones" of entrapment of the nerves of the lower limb

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Summary. The author has studied, in a group of 40 dissections on cadavers of individuals of different ages, the main "critical zones" of entrapment of some terminal branches of the lumbo-sacral plexus, which include canals (fibrous, osteo-fibrous, fibro-muscular), intervals (intermuscular, fibro-muscular, musculo-ligamentous), rings (fibrous or fibro-muscular) and foramina. They provide the topographical anatomical basis for possible compressive phenomena of the nerves of the lower limb.

Les "zones critiques" d'étranglement des nerfs du membre inférieur

Résumé. L'auteur a étudié sur 40 dissections cadavériques d'individus d'âges différents, les principales "zones critiques" d'étranglement de certaines branches terminales du plexus lombo-sacré, constituées de canaux (fibreux, ostéo-fibreux, fibro-musculaires) d'interstices (musculaires, fibro-musculaires, ligamento-musculaires), d'anneaux (fibreux, fibro-musculaires) et de trous. Elles représentent les bases anatomo-topographiques d'éventuels phénomènes de compression des nerfs du membre inférieur.

Key words: Nerves — Lower limb — Critical zones — Entrapment

The present study is part of a research project designed to examine the "critical zones" of entrapment of the nerves of the limbs. Its purpose is to reveal, by a topographical anatomical study on preparations obtained by macro- and micro-dissection, the "critical zones" of entrapment of the nerves of the lumbo-sacral plexus branching in the lower limb [7, 9, 10, 17, 19]. These "zones" include: canals (fibrous, osteo-fibrous, fibro-muscular), intervals (intermuscular, fibro-muscular, musculo-ligamentous), rings (fibrous or fibro-muscular) and foramina. A proper knowledge of the main "critical zones" should be indispensable for the diagnosis of peripheral neuropathies and of great help to the surgeon.

Materials and methods

The study was carried out on the cadavers of 40 subjects of both sexes and of different ages, mostly fixed by slow perfusion (with a mixture of alcohol, glycerin, formalin, phenol, potassium acetate, potassium nitrate, sodium chloride and water) and others recently

deceased.

The techniques used for the preparation were traditional anatomical dissection and microdissection by stereo-photo-microscope [1, 2, 3, 4, 6, 8, 11, 13, 14, 16, 18, 20].

Results

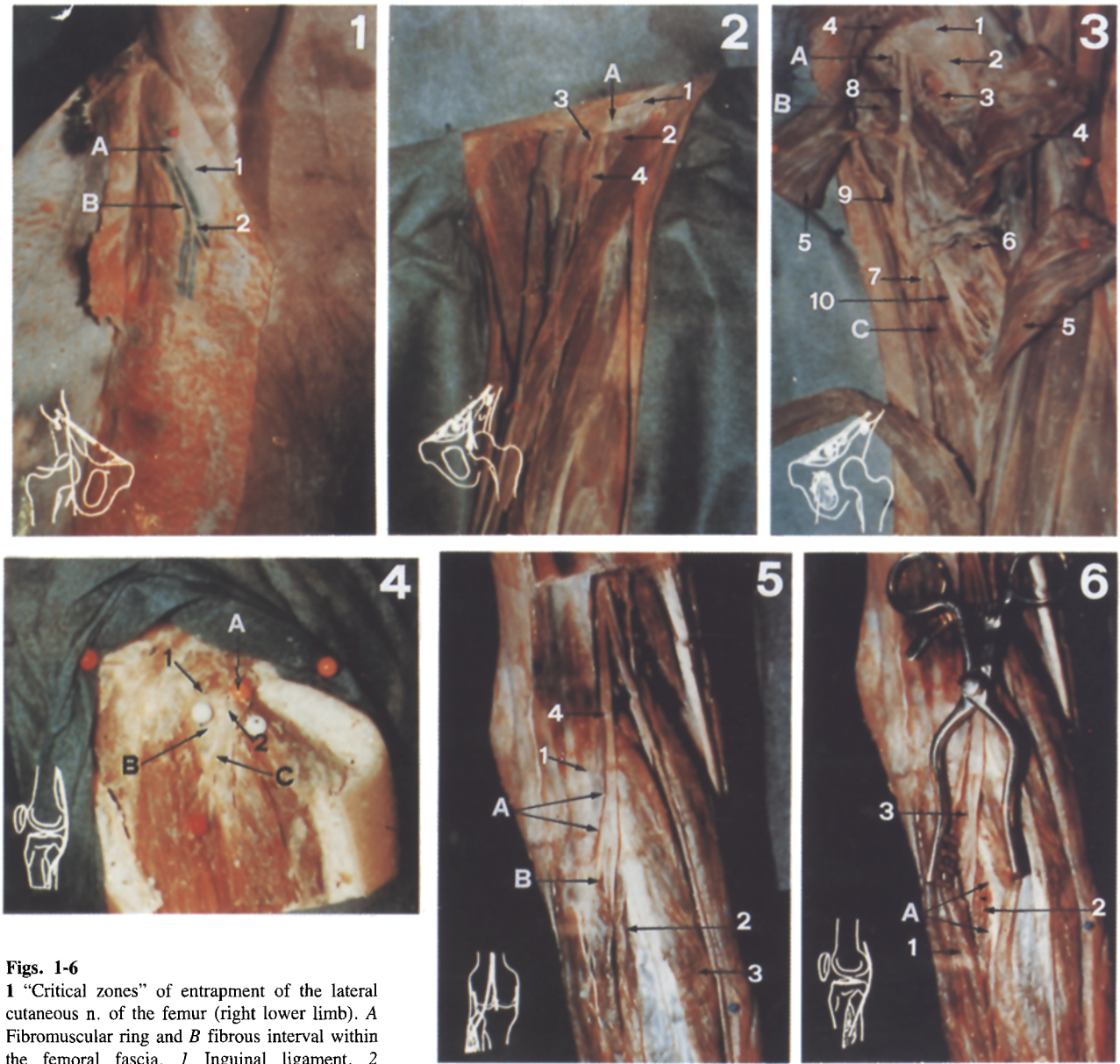
During dissections for the study of the pathway of the nerves of the lower limb, particular relations were observed which, if affected by pathological alteration or anatomical-functional adaptation, may constitute "critical zones" of entrapment of the above mentioned nerves.

The nerves examined were the following [5]:

1. lateral cutaneous n. of the thigh
2. femoral n.
3. obturator n.
4. common peroneal n.
5. tibial n.
6. lateral and medial plantar nn.

1. Lateral cutaneous nerve of the thigh

The lateral cutaneous nerve of the thigh, which most frequently arises from the ventral branch of the second lumbar n., travels from the psoas across the quadratus lumborum in the lumbar region. It reaches the iliac fossa, first crosses the inner lip of the iliac crest, then the iliacus m., continuing 1/2 cm medially



Figs. 1-6

1 "Critical zones" of entrapment of the lateral cutaneous n. of the femur (right lower limb). *A* Fibromuscular ring and *B* fibrous interval within the femoral fascia. *1* Inguinal ligament, *2* anterior branch of the nerve **2** "Critical zones" of entrapment of the femoral n. (left lower limb). *A* Fibro-muscular ring. *1* Inguinal ligament, *2* ilio-psoas m., *3* ileopectineal band, *4* femoral n. **3** "Critical zones" of entrapment of the obturator n. (left lower limb). *A* Obturator canal, *B* intermuscular interval, *C* intermuscular interval, *1* superior ramus of the pubis, *2* obturator membrane, *3* obturator externus, *4* pectinus m., *5* adductor brevis, *6* adductor longus, *7* adductor magnus, *8* obturator n., *9* anterior branch of the obturator n., *10* posterior branch **4** "Critical zones" of entrapment of the common peroneal n. (newborn, left lower limb). *A* Foramen of the lateral intermuscular septum, *B* osteo-fibrous tract, *C* fibro-muscular interval. *1* head of the fibula, *2* common peroneal n. **5** "Critical zones" of entrapment of the common peroneal n. (left lower limb). *A* Osteo-fibrous tract, *B* fibro-muscular interval. *1* head of the fibula, *2* peroneus longus, *3* lateral head of the gastrocnemius, *4* common peroneal n. **6** "Critical zones" of entrapment of the common peroneal n. (left lower limb). *A* intermuscular interval. *1* peroneus longus, *2* peroneus brevis, *3* superficial peroneal n.

1 « Zones critiques » d'étranglement du n. cutané latéral de la cuisse (membre inférieur droit). *A* anneau fibro-musculaire et *B* interstice fibreux délimité par le dédoublement du fascia lata. *1* Ligament inguinal, *2* branche antérieure du nerf **2** « Zone critique » d'étranglement du n. fémoral (membre inférieur gauche). *A* anneau fibro-musculaire. *1* Ligament inguinal, *2* m. ilio-psoas, *3* ligament ilio-pectiné, *4* n. fémoral **3** "Zones critiques" d'étranglement du n. obturateur (membre inférieur gauche). *A* canal obturateur, *B* interstice musculaire I, *C* interstice musculaire II. *1* Branche craniale du pubis, *2* membrane obturatrice, *3* m. obturateur externe, *4* m. pectiné, *5* m. court adducteur, *6* muscle long adducteur, *7* m. grand adducteur, *8* n. obturateur, *9* branche antérieure du n. obturateur, *10* branche postérieure **4** « Zones critiques » d'étranglement du n. fibulaire commun (nouveau-né, membre inférieur gauche): *A* traversée du septum intermusculaire latéral, *B* tractus ostéo-fibreux, *C* interstice fibro-musculaire. *1* tête de la fibula, *2* n. fibulaire commun **5** « Zones critiques » d'étranglement du n. fibulaire commun (membre inférieur gauche). *A* tractus ostéo-fibreux, *B* interstice fibro-musculaire. *1* tête de la fibula, *2* m. long fibulaire, *3* chef latéral du m. gastrocnémien, *4* n. fibulaire commun **6** « Zones critiques » d'étranglement du n. fibulaire commun (membre inférieur gauche). *A* interstice. *1* m. long fibulaire, *2* m. court fibulaire, *3* n. fibulaire superficiel

from the anterior superior iliac spine. At this point it runs beneath the inguinal ligament and, at about 2 cm from it, enters the femoral fascia where it divides into two terminal branches: the gluteal branch and the femoral branch. Therefore in the latter part of its course, the nerve takes on the shape of an S.

There are two "critical zones" where a compression of the nerve is likely to occur (Fig. 1): a) the fibro-muscular ring outlined by the inguinal ligament and the ilio-psoas muscle; b) the fibrous interstices within the femoral fascia.

2. Femoral nerve

The femoral nerve, arising from the convergence of the roots L2, L3 and L4 passes the psoas m., enters a groove outlined by the psoas m. itself and the iliacus and then crosses beneath the inguinal ligament in a muscular groove where it divides into its collateral and terminal branches. At this point the close relation between the nerve, the femoral vein and the femoral artery (the latter separated from the nerve only by the iliopectineal band) as well as the proximity of the femoral lymph-nodes can be observed. Furthermore, the musculo-fascial groove where the nerve is located, formed by the medial arch of the extra-pelvic part of the ilio-psoas muscle and the lateral arch of the pectineus, must be considered.

The "critical zone" of entrapment is the fibro-muscular ring outlined superficially by the inguinal ligament, deeply by the ilio-psoas muscle and medially by the iliopectineal band (Fig. 2).

3. Obturator nerve

The obturator nerve, arising from the convergence of the roots L2, L3 and L4 passes the psoas muscle and crosses the brim of the pelvis in its posterolateral portion, then enters the obturator canal, inside which, or

immediately on emergence, it divides into two terminal branches: the anterior branch and the posterior branch. Inside the canal, within the cellulo-adipose tissue, the close relation between the nerve and the obturator artery, which is located immediately below it, can be observed.

It can also be noted that the vasculo-nervous bundle and the cellulo-adipose tissue do not completely occupy the canal.

There are three "critical zones" where a compression of the obturator n. is likely to occur (Fig. 3): a) the obturator canal, an osteo-fibro-muscular structure, outlined, above, by the obturator groove of the superior ramus of the pubis and, below, by the upper margin of the obturator membrane, the free margin of the subpubic band and the upper margin of the obturator internus and the obturator externus mm.;

b) the intermuscular interval between the pectineus and the obturator externus muscles and between the adductor longus and adductor brevis, where the anterior branch of division of the nerve is involved; c) the intervals between the obturator externus and adductor magnus and the adductor brevis where the posterior branch is involved.

4. Common peroneal nerve

This nerve represents the lateral terminal branch of the sciatic nerve usually at the superior angle of the popliteal fossa. It passes the popliteal fossa and runs first behind the fibula, then around the neck of the fibula, forming a half spiral, then entering a fibro-muscular interval where it divides into two terminal branches: the superficial and the deep peroneal nerves [12]. In the course between the lateral intermuscular septum and the fibro-muscular interval the position of the nerve is superficial, as it is placed

between the crural fascia and the bone.

The "critical zones" where a compression of the common peroneal nerve is likely to occur are: a) the foramen of the lateral intermuscular septum separating the muscles of the posterior compartment from those of the lateral compartment of the leg (Fig. 4);

b) the osteo-fibrous tract corresponding to the head and neck of the fibula (Figs. 4, 5);

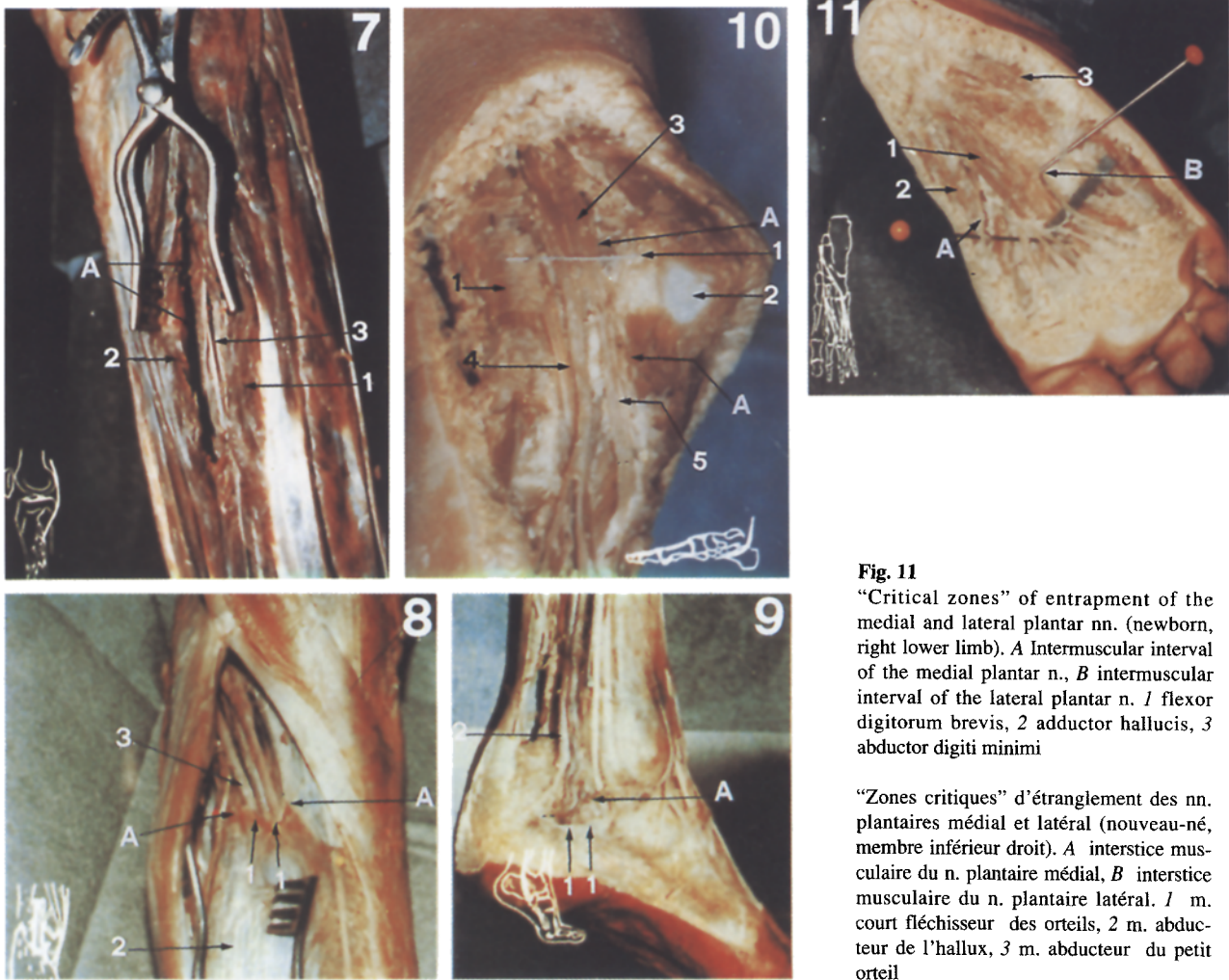
c) the fibro-muscular interval between the fibers originating from the peroneus longus muscle (Figs. 4, 5); d) the intermuscular interval between peroneus longus and peroneus brevis where the superficial peroneal nerve is involved (Fig. 6); e) the fibro-muscular interval between peroneus longus and extensor digitorum muscles, where the deep peroneal nerve is involved (Fig. 7).

5. Tibial nerve

Like the common peroneal nerve, the tibial nerve is a terminal branch of the sciatic nerve at the superior angle of popliteal fossa. It runs down, vertically, below the lateral and medial heads of the gastrocnemius; it crosses the arch of the soleus together with the tibial vessels, anterior to it, and then continues its oblique path downwards, medially to the tarsal canal, where it divides into two terminal branches: the lateral and the medial plantar nerves.

At the level of the arch of the soleus muscle it is possible to observe the close relation between the nerve and the tibial a. and between the nerve and the tendinous arch.

At the level of the tarsal canal, within cellulo-adipose tissue, the superficial position of the nerve and the relation between the nerve itself and its terminal branches with the tendons of the flexor muscles enveloped in synovial sheaths may be observed.



Figs. 7-10

7 "Critical zone" of entrapment of the commun peroneal n. (left lower limb). A Interval. 1 peroneux longus, 2 extensor digitorum, 3 deep peroneal n. 8 "Critical zone" of entrapment of the tibial n. (left lower limb). A Fibro-muscular ring. 1 tendinous arch of the soleus, 2 soleus, 3 tibial n. 9 "Critical zone" of entrapment of the tibial n. (left lower limb). A Tarsal canal. 1 retinaculum of the flexor digitorum longus tendon, 2 tibial n. 10 "Critical zone" of entrapment of the tibial n. (newborn, right lower limb). A Tarsal canal. 1 retinaculum of the flexor digitorum longus tendon, 2 calcaneal tuberosity, 3 tibial n., 4 medial plantar n., 5 lateral plantar n.

7 « Zone critique » d'étranglement du n. fibulaire commun (membre inférieur gauche). A interstice. 1 m. long fibulaire, 2 m. long extenseur des orteils, 3 n. fibulaire profond 8 « Zone critique » d'étranglement du n. tibial (membre inférieur gauche). A anneau fibro-musculaire. 1 arc tendineux du m. soléaire, 2 m. soléaire, 3 n. tibial 9 « Zone critique » d'étranglement du n. tibial (membre inférieur gauche). A canal calcanéen. 1 rétinaculum des fléchisseurs, 2 n. tibial 10 « Zone critique » d'étranglement du n. tibial (nouveau-né, membre inférieur droit). A canal calcanéen. 1 rétinaculum des fléchisseurs, 2 tubérosité du calcanéum, 3 n. tibial, 4 n. plantaire médial, 5 n. plantaire latéral

Fig. 11

"Critical zones" of entrapment of the medial and lateral plantar nn. (newborn, right lower limb). A Intermuscular interval of the medial plantar n., B intermuscular interval of the lateral plantar n. 1 flexor digitorum brevis, 2 adductor hallucis, 3 abductor digiti minimi

"Zones critiques" d'étranglement des nn. plantaires médial et latéral (nouveau-né, membre inférieur droit). A interstice musculaire du n. plantaire médial, B interstice musculaire du n. plantaire latéral. 1 m. court fléchisseur des orteils, 2 m. abducteur de l'hallux, 3 m. abducteur du petit orteil

The two "critical zones" where a compression of the tibial nerve is likely to occur are:

a) the fibro-muscular arch of the soleus outlined by the tendinous arch extending between the tibia

and the fibula and flexor hallucis longus, flexor digitorum longus and tibialis posterior (Fig. 8); b) the tarsal canal, an osteofibrous structure, outlined by the grooved medial surface of the calcaneus and the superficial and deep sheaths of

the retinaculum of the flexor digitorum longus tendon (Fig. 9).

6. Medial and lateral plantar nerves

The medial plantar nerve runs deeply into the intermuscular intervals

between adductor hallucis and flexor digitorum brevis; the lateral plantar n. runs into the interval between flexor digiti minimi brevis and flexor accessorius (Figs. 10, 11).

Therefore a compression of the plantar n. is likely to occur in the tarsal canal and the above mentioned intervals [15].

Conclusions

The morphological nature of the "critical zones" of entrapment of the nerves of the lower limb represents the principal topographical anatomical premise for a compression of the nerves. These "zones" include canals (fibrous, osteo-fibrous, fibro-muscular), intervals (intermuscular, fibro-muscular, musculo-ligamentous), rings (fibrous or fibro-muscular) and foramina.

The anatomical structure of the constituent elements of the "critical zones" (bones, muscles, fasciae, tendons, ligaments, synovial sheaths) can also be altered by different pathological processes and can also be a major cause of compression or entrapment.

The cellulo-adipose tissue, abundant in some "critical zones",

which often cushion the nerve, may also become an element of compression when overabundant or when the consistency of its structure becomes thick.

When the arteries, which often accompany the nerves in the "critical zones", are subjected to aneurysms, these may also cause compression.

Besides, the lymph-nodes, adjacent to some "critical zones" of entrapment when affected by inflammatory processes, become a compressive element of the nerve.

The hernias, which often spread through some "critical zones" (obturator and femoral), may also cause compression.

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