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New insights on anatomical study of the accessory deep peroneal nerve

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ABSTRACT

The purpose of this study is to establish the incidence, course, relations and distribution of the accessory deep peroneal nerve. Thirty-two legs of different adult's cadavers of both sexes were dissected. The analysis of the incidence, course, relations and distribution was performed. The frequency obtained was 87,5% (28 legs). The course was constant in 82% (23 cases), with five variations. The relations with the lateral malleolus and the sural nerve were found in all limbs. The accessory deep peroneal nerve gave off branches to the peroneus brevis muscle in all legs, to the peroneus longus muscle in 21,4% and to the extensor digitorum brevis in 25%. The accessory peroneal muscles were always innervated by this branch. Articular branches were observed in all legs. The frequency observed in the study was high (87,5%) and the course and relations were constant. The distribution includes to the lateral compartment, accessory peroneal muscles and to the ankle and tarsal joints and frequently for the extensor digitorum brevis muscle (25%).

Keywords: Innervation; peroneal muscles; dissection; accessory deep peroneal nerve.

INTRODUCTION

The accessory deep peroneal nerve (ADPN) was first seen in humans by Bryce (1891, 1901) after Ruge´s describing (1878) in lower mammals and primates (1). Subsequently, the description of this nerve was enriched by Winckler (1934) that besides human dissections performed a comparative study with small mammals, insects and primates.

The ADPN is described as a branch issued by superficial peroneal nerve (SPN) at its posterior edge. The ADPN can provide sensory innervation to the ankle and foot joints, and motor fibers to muscles of the lateral compartment like peroneous longus muscle (PLM) and peroneal brevis muscle (PBM), and to accessory muscles like peroneous quartus muscle (PQ) and peroneous digiti quinti muscle (PQM) (1, 2). The extensor digitorum brevis (EDB) normally innervates by deep peroneal nerve (DPN) can receive partial or fully innervation from ADPN (1-4).

The shortage of anatomical descriptions, and the prevalence of electrophysiological studies, minimize the possible participation in the sensory innervation of the ankle and foot joints, and make it confusing to study the frequency of ADPN, ranging from 18 to 100%. This leads several

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authors to classify the ADPN as an anomalous branch, and others as a standard variant of normality (1-15).

No description was found in classical textbooks of Human Anatomy about the ADPN, even in descriptions of surgical approaches to the ankle and foot (16-19). Its importance lies in the possible distribution patterns, related to surgical approaches and procedures performed in the peroneal store and ankle. Knowing the anatomy of this variation is key to establishing standards of electromyographic neurological injuries in lower limb. This work aims to study the incidence, course, relations and distribution of the ADPN.

MATERIALS AND METHODS

This work complies with the provisions of the declaration of Helsinki in 1995 (as revised in Edinburgh, 2000). The protocol for the present work has been approved by Department of Morphology, Biomedical Institute from the Fluminense Federal University. This is a descriptive study, observational and quantitative. The study population is finite, comprising human corpses, this is an extracted simple random sample of 32 adult human cadavers of Brazilians. Dissections were performed in 32 lower limbs from different adult human cadavers, 28 of which were male.

The ADPN was addressed in peroneal compartment, on the side of the leg muscles through the dissection by planes in the region between the peroneal head and the dorsal-lateral of the foot (metatarsal). In dissection we folded the PLM (cut at the groove of the cuboid) and PBM (away earlier on the lateral malleolus). Thus, we obtained a full view and approach of the lateral retromalleolar space.

ADPN has been identified, issued at the back of the SPN, placing himself in posterior relation to the PBM in the distal leg, between this and the posterior intermuscular septum. This nerve was individualized in its entire path, taking care to avoid any damage to epineural tissue or compromise their relationships. Were cataloged its path, relationships, distribution and incidence, in schematic form of lateral compartment itself. Magnifying glass was used as an aid in this dissection, when necessary.

The results were analyzed statistically with the incidence of nerve, through analysis of percentage. With respect to branches issued by the ADPN, the statistical analysis was obtained through the minimum, maximum, percentage and MODA, for each muscle separately.

RESULTS

In the 32 cases surveyed, the issue by the SPN of a branch from its posterior edge was unanimous. In four cases, this branch was distributed to the musculature of the lateral compartment, not extending to the ankle and foot, or by issuing articular branches to the peroneal muscles accessories and short extensor of the fingers. Using the criteria described above, these cases do not represent the ADPN. The prevalence of the ADPN was 87.5% (28 cases).

Figure 1. The ADPN is shown.

In 32 lower limbs, the ADPN has issued a posterior branch, which heads back and sideways, putting themselves in direct relationship to the PBM, between it and the

posterior intermuscular septum, sending branches to the PLM and short. In four cases, this branch has finished 2 to 4 cm before the lateral malleolus, and this wasn´t named ADPN for not following the original concept. In the remaining cases (28 cases), the nerve continued between the PLM and PBM, all running deep in relation to the peroneal retinaculum. In three cases, a part the path of the ADPN became on the depth of the PBM, emerging distally, near the ankle. In two cases, there was a bifurcation of this nerve, with one arm following his usual path and another in the depth of the peroneus PBM. In both cases, the branches are gathered near the ankle. In two cases, there was only one branch piercing the posterior intermuscular septum. In one case, the ADPN issued a communicating branch to the sural nerve. In one case, we observed the early division of SPN (medial dorsal cutaneous branches and intermediate) the ADPN in this case represents a branch of the intermediate dorsal cutaneous nerve.

The accessory peroneal muscles, peroneus digiti quinti muscle and peroneus quartus muscle, were found respectively in 10 and 1 cases. All of them had their origin of the belly of the PBM. The sensory branches to the ankle joint were issued during its route, through the lateral collateral ligament. The articular branches originated in tarsal joint on the dorsal side of the foot. The data relating to branches issued by the NFPA are displayed in Table 1.

Table 1: Results - Frequency and branches of the NFPA

	(n)	Freq. %	Min.	Max.	Mean	MODA
PLM	28	21,4	1	1	1	1
PBM	28	100	1	8	3,6	3
EDB	28	25,0	-	-	-	-
PQM	28	41,6	1	4	2	1
PQD	28	3,5	-	-	-	-
PA						
Ankle	28	100	-	-	-	-
Tarsus	28	50	-	-	-	-

DISCUSSION

In the literature, diverse data were found regarding the incidence of ADPN. This diversity is justified by contrasting studies of dissection to those using the electroneuromyographic analysis, which minimize the participation of the sensory component (1-15).

The frequency, relative to the number of limbs considered by the electroneuromyographic analysis, based on the EDB was uniform (Table 1). All these studies used similar methodology. As described previously, these figures express only the motor innervation of the ADPN. Analyzing the incidence of motor innervation to the EDB in the

work of dissection, Bryce (1897, 1901 - *apud* Winckler (1934)), found 2.7%, Winckler (1934), 21% and Kudoh *et al* (1999), 66.6%. In this study, 25% of the cases. The results varied in electromyographic studies of 9.5% - 25% with an average of 18.9% (± 5.72) and median of 20.35%. In anatomical studies, ranged from 2.7% - 66.6%, with an average of 28.8% (± 26.99) and a median of 19.63%. Looking at the median found similar values (20.35% versus 19.63%), suggesting some uniformity in most studies.

In anatomical studies, when it was used gross dissection, considering the involvement sensitive, Winckler (1934) found a frequency of 36.8%, Kudoh *et al*. (1999) found in 100% and Bryce (1897, 1901 - *apud* Winckler (1934)) found a frequency of 8.2% in their series of 110 limbs dissected. In this study, the frequency found was 87.5%. Therefore, there is great divergence in reports regarding the frequency of this nerve, even when the methodology was similar. The reason for this difference could not be established, it was not suggested by any of the above authors.

Bilateral involvement was found in the literature with a frequency of 5.7%, according to Mapelli *et al* (1978), 43.85%, according to Stamboul (1987), and 74%, according Budak and Gönenç (1999). This research was not addressed to bilateral, it did not correspond with the proposed goal of this work. Rarely EDB was innervated exclusively by the ADPN and only Neundorf and Seiberth (1975) and Murad *et al* (1999) reported a case about this.

Lambert (1969) described the participation of the ADPN on the innervation of the muscle belly specific for each finger from EDB. Of the 22 cases studied with EMG in which there was innervation EDB, in 14 cases the ADPN was responsible only for the length of the IV finger, four fingers of the III and IV, one for the IV and V, one for the III finger, and one for the V finger. There was not found analysis of statistical nature like that in literature. Gutmann (1973) described two cases of injury in the DPN with extension maintenance IV and V fingers. Such *et al* described three cases with a lesion of the DPN, with another injury to the ADPN, and others with damage to the SPN, but does not specifically mention which fingers have been achieved. This analysis was not proposed in this work, because the difficulty of macroscopic analysis of specific lines for the portions of the EDB. Winckler reported finding a higher frequency of branches directed to the abdomen corresponding to the IV finger in the macroscopical study.

In the comparative study carried out by Winckler (1934), correlation was found with lower mammals, which showed a constant muscle called the extensor peroneal for fourth finger. According to him, echoing the findings of Ruge (1878 - *apud* Winckler (1934)). Lambert (1969), in discussing his article, says this relationship, which suggests the formation of part of the EDB in the side of the leg, with subsequent distal migration during development. The theory is confronted with the description described by embryological Ribbing (*apud* Lambert (1969)), under which, in humans the EDB originates embryologically from the anterior compartment, then migrate to this compartment of the dorsal foot.

In the three studies dissection found above, in all cases the ADPN issued from the posterior edge of the SPN, with posterior-lateral direction, positioning itself between the PBM and posterior intermuscular septum. Winkler (1934) describes a case in which part of the trajectory is in the depth of the PBM, emerging distally. The same occurred in four cases, according to Kudoh *et al.* (1999), and three in the present study. Kudoh *et al.* (1999) and Winckler (1934) described a case in which the nerve bifurcates, one part following its usual path, and another deep to the PBM, gathering distally. This pattern

on the path was found here in three cases. Found in four cases the nerve ending between 2 and 4 cm before of the lateral malleolus. Kudoh *et al.* (1999) presented five cases. In this study, was found in an early case of bifurcation of the SPN and has been issued in this time the ADPN like the intermediate dorsal cutaneous nerve of the foot.

Communication with the sural nerve was found in this study, a case indeed only found in the literature on the book called "Toldt's Textbook of Anatomy" (*apud* Lambert (1969)). All authors are unanimous on the relationship of the ADPN with the sural nerve and small saphenous vein, superficial, important in surgical approaches to the lateral ankle and hindfoot.

Infante and Kennedy (1970) emphasized the importance of its relationship with the tibial nerve through the space pre-achilles, in the evaluation Electroneuromyographic, especially in young children, the possibility of creating false positives for the presence of nerve. The tibial nerve stimulated determines a plantar flexion of the fingers, and the passive extension often seen as a false signal the presence of the ADPN. To avoid this false result, the authors suggest a fourth point of stimulation, immediately before the apex of the lateral malleolus. In this study, the point immediately prior to the lateral malleolus was a constant relationship with the ADPN.

Kudoh *et al.* (1999) reported that in all cases the ADPN crossed both the peroneal retinaculum deep inside. This has been found in all cases in this study (28 cases). The PQM was present in this study in 10 opportunities, according to Kudoh *et al.* (1999), in three cases and in Winckler (1934) study, into an opportunity. The PDQ, according to this study, was present in one case, according to Kudoh *et al.* (1999) in four, and in accord with Winckler (1934) in one case. However, none of the above authors give statistics on the peroneal muscle enhancement, described in the Book of Anatomy "Traité d'Anatomie Élémentaire L'Homme" (20), which also cites other accessory peroneal muscles, as described. This sample presented a case.

Like the current work, Winckler (1934) and Kudoh *et al*.(1999) found branches for the PBM in all cases. The PLM was innervated by ADPN in six cases (21,4%), while Winckler (1934) in five (71,34%) and Kudoh *et al* (1999) in eight of the cases (33,3%). In this work and other macroscopic studies, the accessory muscles (PDQ and PQM) when present, showed up in all cases, innervations by the ADPN. The EDB received, in 25% of cases, branches from the ADPN. Was not rated number of branches, because the technical difficulty of distinguishing between the tarsal articular branches that pierce the EDB, those who have this termination. Winckler (1934), likewise, does not present this result. Kudoh *et al.* (1999) presents average of 1.3 branches.

In the quantitative analysis of the branches issued for each muscle was found: for the PBM an average of 3.6 branches (Min.: 1 - Max: 8) with an MODA equal to 2 branches. Winckler (1934) found an average of 4.8 branches (Min.: 3 - Max: 8) with an MODA equal to 4 branches. Kudoh *et al.* (1999), showed an average of 5.8 branches (Min.: 2 - Max: 14), with no data to establish himself the MODA. The PLM has received a branch in all six cases (mean equal to 1 and MODA equals 1). Winckler (1934) observed an average of 2.2 branches (Min: 2 - Max: 3), MODA equal to 2. Kudoh *et al*. (1999) showed an average of 1.4 branches (Min.: 1 - max: 2). For the PDQ, the only case found in this study there was only one branch. Kudoh *et al.* (1999) showed an average of 1.3 branches (Min.: 1 - max: 2). For the accessory peroneal muscle was evident in the only case found in this research, a branch.

On Statistical analysis indicated above about the frequency of branches, we use the

average with the purpose of comparing with the data from two other papers that carried out this analysis, given that Kudoh *et al*. (1999) had only this statistical analysis. The analysis of MODA was considered statistically more relevant because it represents the most frequent pattern of distribution of this nerve, and the difficulty of analyzing for the average number of branches, an indivisible unit.

Casagrande *et al*. (1951) and Freemann and Wike (1967), reported an anatomical study of the sensory innervation of the ankle joint, and did not mention the participation of the ADPN. Champetier (1970) cites the uneven participation of SPN in the innervation of the ankle joint through its branch called accessory deep Casagrande *et al.* (1951) described in his article in procedure satisfactory results of denervation procedure of the ankle in osteoarthritis, although not taking the articular branches of the ADPN for this joint.

The sensory branches were found in all cases in this study, like the two other studies conducted by the dissection. In the present work, likewise in Winckler (1934) and Kudoh *et al* (1999) papers, the tarsal joints receive branches from ADPN. The current work found 14 cases (50%), Winckler (1934) in five (71.4%) and Kudoh *et al.* (1999) showed up five cases too (20.8%). Kudoh *et al*. (1999) showed, in nine cases, the ADPN sending sensitive branches to the fibula, performing a quantitative analysis of these branches. Found for the ankle average of 3.9 branches (Min.: 1 - Max: 8) and for the tarsal joints, an average of 1.4 branches (Min.: 1 - Max: 3). In the present work this analysis has been removed due to technical difficulties exposed to the branches issued to the EDB.

CONCLUSIONS

The ADPN is a frequent variation in the pattern of innervation of the lower limb (87.5%). It was present in humans as a character of mixed nerve (sensory and motor) or just sensitive. In the analysis of their frequency, participation in the ADPN sensory innervation of the ankle and foot should not be overlooked.

Its course and anatomical relationships have been shown steady, with few variations (5 cases).

The branches issued from the ADPN regarding a uniform standard in the nerve supply to the muscles of the peroneal compartment. Very often participated in the innervation of the EDB (25%). Its articular branches, likewise, shown to be constant (100%).

CONFLICTS OF INTEREST

There are no conflicts of interest in this study.

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RESUMO

Novos insights sobre o estudo anatômico do nervo peroneal profundo acessório

O objetivo deste estudo é estabelecer a incidência, curso, relações e distribuição do nervo fibular profundo acessório. Foram dissecadas trinta e duas pernas de diferentes cadáveres de adultos de ambos os sexos. Foi realizada a análise da incidência, curso, relações e distribuição. A frequência obtida foi de 87,5% (28 pernas). O curso foi constante em 82% (23 casos), com cinco variações. As relações com o maléolo lateral e o nervo sural foram encontradas em todos os membros. O nervo fibular profundo acessório emitia ramos para o músculo fibular curto em todas as pernas, para o músculo fibular longo em 21,4% e para o extensor curto dos dedos em 25%. Os músculos fibulares acessórios sempre foram inervados por esse ramo. Ramos articulares foram observados em todas as pernas. A frequência observada no estudo foi alta (87,5%) e o percurso e as relações foram constantes. A distribuição inclui o compartimento lateral, músculos fibulares acessórios e articulações do tornozelo e tarso e frequentemente para o músculo extensor curto dos dedos (25%).

Palavras-chave: inervação; músculos fibulares; dissecção; nervo fibular profundo acessório.