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ORIGINAL ARTICLE

Morphometric study of the shoulder and subclavicular innervation by the intermediate and lateral branches of supraclavicular nerves

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Abstract
Background The supraclavicular (intermediate) and supra-acromial (lateral) branches of supraclavicular nerves contribute to the innervation of the thorax, shoulder, and neck. Despite their clinical and surgical interest, they are not often considered for descriptive anatomy. The goal of this work was to clarify the morphometric knowledge of these two branches and to discuss the clinical relevance of the anatomical features.
Methods Intermediate and lateral branches of supraclavicular nerves of 14 necks (8 embalmed cadavers) were dissected using magnifying glasses. Macroscopic parameters were measured and nerve relationships were recorded.
Results In 12 cases, the intermediate and lateral branches arose from a common trunk behind the posterior border of the sternocleidomastoideus muscle, at a mean distance of 96 mm (70–137) from the sternal angle. The intermediate branch divided into two or three secondary rami. Its most internal ramus crossed the middle third of the clavicle and its most external ramus crossed the second lateral quarter of the bone. The distance between the two farthest nerve endings of this branch was at mean of 98 mm (85–125). The mean distance of the most distal nerve ending from the clavicle was 46 mm (30–63). The lateral branch divided into two or three rami in eight cases and did not divide in six cases. Its most anterior rami crossed the trapezius muscle at a mean distance from the clavicular insertion of 17 mm (12–24). In 13 cases, these rami ended posteriorly or at the level of the anterior border of the acromion process and in 12 cases, they ended laterally or at the level of the acromion process with a mean distance 10.4 mm (0–24).
Conclusion In case of deficiency of these nerves, pain or sensitive deficit can occur without motor trouble. The factors of acute or chronic injury are direct compression, nerve stretching, repetitive stresses, and direct wound. Moreover, several neck or shoulder surgical approaches are dangerous for these nerves.

Keywords Superficial cervical plexus · Supraclavicular nerves · Innervation · Clavicle · Shoulder · Anatomy · Pectoral region

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Introduction

The superficial cervical plexus is described with four main branches: the lesser occipital nerve, originating from C2 spinal nerve, the great auricular nerve from C2 and C3 spinal nerves, the transverse cervical nerve from C2 and C3 spinal nerves and the supraclavicular nerves from C3 and C4 spinal nerves [4]. According to Hovelacque [5], the supraclavicular nerve divides into a medial or suprasternal ramus, an intermediate or supraclavicular ramus and a lateral or supra-acromial ramus.

The intermediate ramus emerges beneath the posterior border of the sternocleidomastoideus muscle (SCM), descends distally and anteriorly, and divides into numerous rami, which supply the skin over the anterior aspect of the chest. These rami, primitively placed under the platysma, pierce the muscle to reach the skin. It supplies the skin of the anterior upper part of the chest and can be injured during clavicular fracture or clavicular surgery.

The lateral branch passes directly towards the acromial process, crosses the anterior border of the trapezius muscle and divides into several rami, which supply the skin of the shoulder [11]. In orthopedic practice, several cases of pain located in the acromial region could be explained by an injury or an entrapment of this nerve.

The goal of this work was to study the morphometry and to clarify the bony and muscular relationships of these two cutaneous nerves to highlight the clinical and surgical relevance of these anatomical features, particularly in orthopedic surgery.

Materials and methods

Fourteen supraclavicular nerves were dissected on eight embalmed cadaver necks (five females and three males, aged 71–82), including six bilateral dissections.

Dissections were realized after raising a triangular cutaneous flap. The incision was performed along the SCM and its posterior border was preserved. It extended to the sternal manubrium and curved horizontally, around 6 cm below the inferior surface of the clavicle. The cutaneous flap was raised carefully to preserve the hypodermic tissue. The limits of this flap could be extended if needed.

The nerves were dissected first beneath the SCM after incision of the superficial cervical fascia above the crossing point of external jugular vein with the SCM. Their proximal diameters were measured using a digital caliper (Digimatic caliper IP 67, Mituyo Corporation®, Japan) and 4× magnifying glasses, as for all other measurements. Distances from this emergence to the sternal angle and to the most lateral point of the clavicular insertion of the sternocleidomastoideus muscle were measured (Fig. 1). The intermediate and the lateral branches were then dissected as far as possible using the magnifying glasses. The patterns of division of the two branches were studied.

The places of crossing between the intermediate branch and the clavicle and between the lateral branch and the anterior part of the trapezius muscle were recorded. For the intermediate branch, the distances (*D*) between the rami that crossed the clavicle and the acromioclavicular joint were measured. The length of the clavicle (LC) was also measured. A lateral ratio (Fig. 2) was calculated with the formula *D*/LC. The cutaneous paddles supplied by each branches were studied. We measured the length as the distance between the two farthest nerve endings in a horizontal plane, and the height by the distance between the most distal nerve ending and the clavicle or the acromion process. The ratio of length and height indexed to the length of clavicle was calculated. Only one observer performed all the measurements, and the data were expressed with a risk error 0.1 mm for diameters and 1 mm for distances.

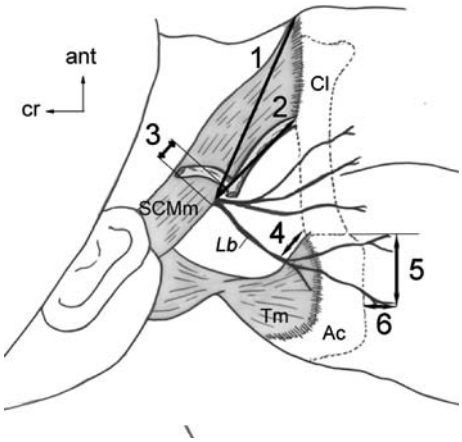

Fig. 1 Drawing of a lateral view and measurements performed for the emergence of the nerves behind the sternocleidomastoid muscle (*SCMm*) and for the lateral branch (*Lb*). *Tm* trapezius muscle, *Ac* acromion process, *Cl* clavicle. *1* distance between the emergence and the sternal angle, *2* distance between the emergence and the most lateral point of SCM insertion, *3* distance between the emergence and the external jugular vein crossing, *4* distance between the lateral branch (where its cross the trapezius muscle) and the most internal point of muscle insertion, *5* length of the cutaneous paddle supplied by the lateral branch, *6* height of the cutaneous paddle supplied by the lateral branch

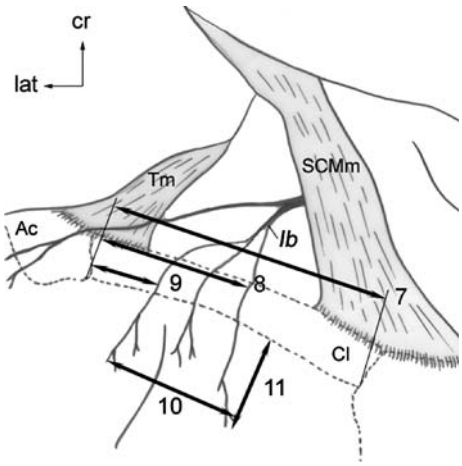

Fig. 2 Drawing of an anterior view and measurements performed for the intermediate branch (*Ib*). *SCMm* sternocleidomastoideus muscle, *Tm* trapezius muscle, *Ac* acromion process, *Cl* clavicle, *7* total length of clavicle, *8* distance between the acromioclavicular joint and the most internal ramus of intermediate branch, *9* distance between the acromioclavicular joint and the most external ramus of intermediate branch, *10* length of the cutaneous paddle supplied by the intermediate branch, *11* height of the cutaneous paddle supplied by the intermediate branch

Results

The results of all measurements are summarized in Table 1 and Fig. 3.

In 12 cases, the intermediate and lateral branches arose as a common trunk behind the posterior border of the SCM (Fig. 4). In these cases, the mean diameter of the trunk was

Table 1 Results of measurements (mm)

		Number of cases	Mean	Min	Max
	Length of clavicle	14	134.4	124	144
Common trunk	Distance emergence/sternal angle	14	96.2	70	137
	Distance emergence/lateral SCM insertion	14	54.8	42	67
	Distance emergence/external jugular vein	14	8.9	2	18
	Distance division/posterior border of SCM	12	16.7	6	37
Intermediate branch	Distance acromioclavicular joint/internal ramus	14	68.8	44	95
	Lateral ratio for the internal ramus	14	0.51	0.36	0.70
	Distance acromioclavicular joint/external ramus	14	41.4	28	62
	Lateral ratio for the lateral ramus	14	0.31	0.21	0.47
	Ratio of length of skin paddle/clavicle	14	0.72	0.64	0.88
	Ratio of height of skin paddle/clavicle	14	0.34	0.20	0.50
Lateral branch	Distance Tm-ramus crossing point/Tm insertion	12	17.9	12	24
	Ratio of length of skin paddle/clavicle	14	0.22	0.10	0.34
	Ratio of height of skin paddle/clavicle	12	0.08	0	0.18

SCM sternocleidomastoideus muscle, *Tm* trapezius muscle

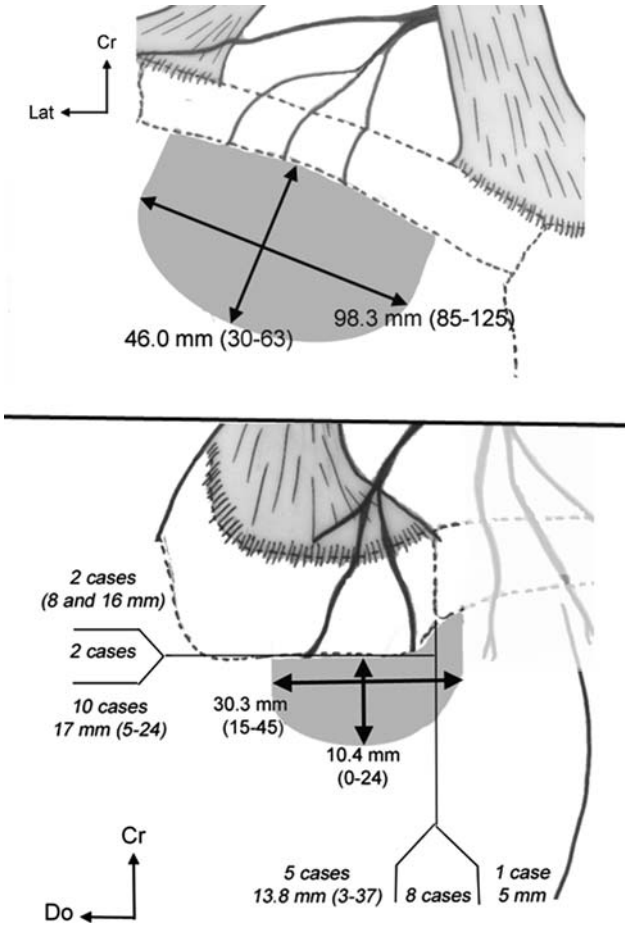

Fig. 3 Drawing summarizing the results. *Above* mean (range) of length and height of the skin paddle supplied by the intermediate branch. *Below* mean (range) of length and height of the skin paddle supplied by the lateral branch; number and measurements of skin paddles related to the anterior and lateral borders of the acromial process are also noted

4.1 mm (2.8–5.6). In one of these cases, the trunk included the medial (or supra-sternal) branch. In two cases, the intermediate and lateral branches were separated (Fig. 5). In six cases, direct rami of the trunk or branches pierced the deep surface of the platysma close to the SCM. After the division, the mean diameter of the intermediate branch was 2.5 mm (2.1–2.9) and the mean diameter of the lateral branch was 2.7 mm (2.2–3.2).

The intermediate branch passed antero-laterally while it stayed under the platysma. It divided into two secondary rami (internal and external) in seven cases and into three rami (internal, intermediate and external) in seven other cases (Fig. 6). These secondary rami did not divide above the clavicle. The internal ramus crossed the middle third of the bone and the lateral ramus crossed the second lateral quarter of the bone. Below the clavicle, the secondary rami divided into 4–12 (average 7) nerve endings.

The lateral branch passed in a strictly frontal plane directed to the acromion process. It divided into three secondary rami (internal, intermediate and external) in four cases, into two rami (internal and external) in four cases, and did not divide in six cases. These rami stayed under the platysma. In 12 cases, the rami crossed the internal border of the clavicular part of the trapezius muscle (Fig. 7), and in two cases, the rami pierced the trapezius muscle (Fig. 8). The rami did not supply this muscle. In all cases, except one, the rami divided into two or three nerve endings. Therefore, the mean number of nerve endings was 3.4 (1–6). Besides, a communicating branch between the lateral branch and a posterior branch of the cervical plexus was noted which passed along the trapezius muscle without supplying the muscle. A long ramus communicans between the lateral ramus of the intermediate branch and the anterior ramus of the lateral branch was also observed.

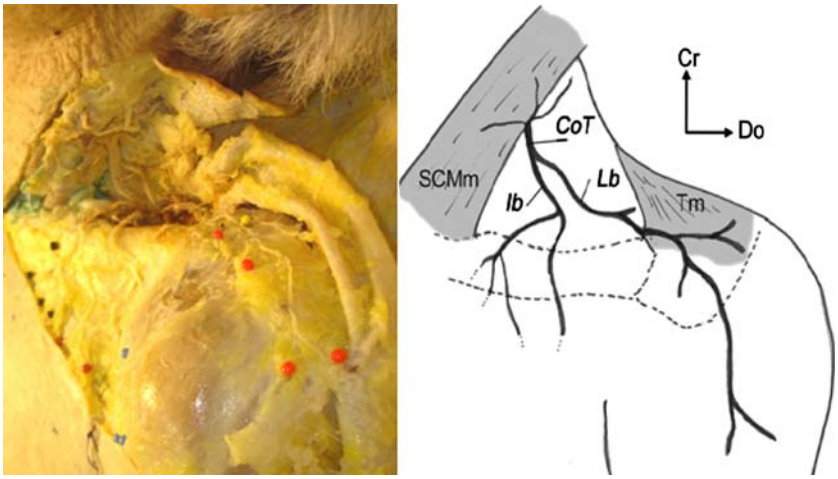

Fig. 4 Lateral view of a left neck showing the intermediate (*Ib*) and the lateral (*Lb*) branches, which arose with a common trunk (*CoT*) behind the posterior border of the sternocleidomastoideus muscle (*SCMm*), *Tm* trapezius muscle

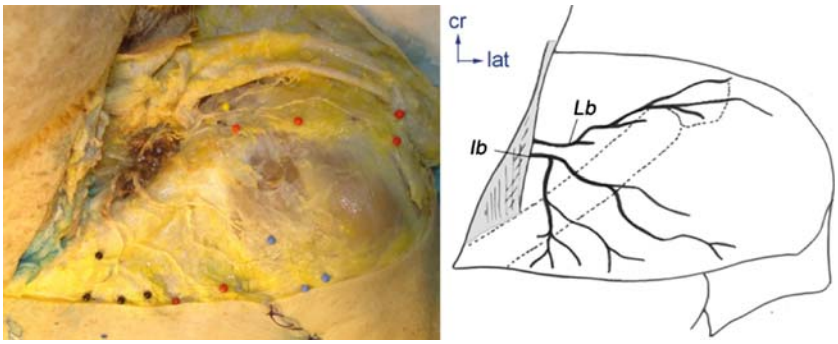

Fig. 5 Anterior view of a left neck showing the intermediate (*Ib*) and the lateral (*Lb*) branches which arose separately. The intermediate branch divides into two main secondary rami above the clavicle

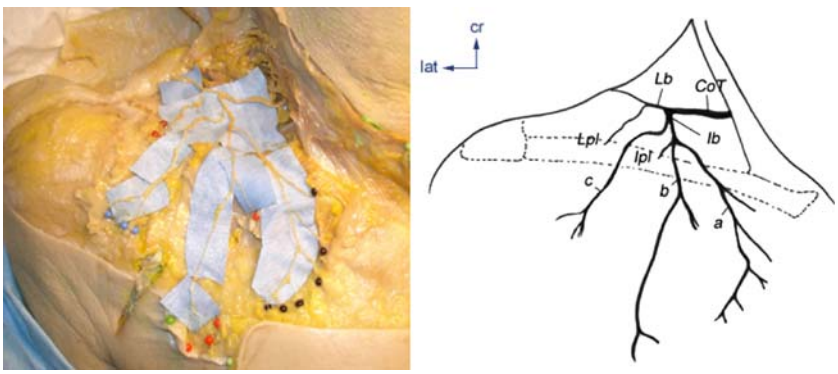

Fig. 6 Anterior view of a right neck showing the intermediate (*Ib*) which divides into three main rami, *a* interal ramus, *b* intermediate ramus, *c* lateral ramus, *Lb* lateral branch, *Lpl* muscular ramus from the lateral branch for the platysma, *Ipl* muscular ramus from the intermediate branch to the platysma

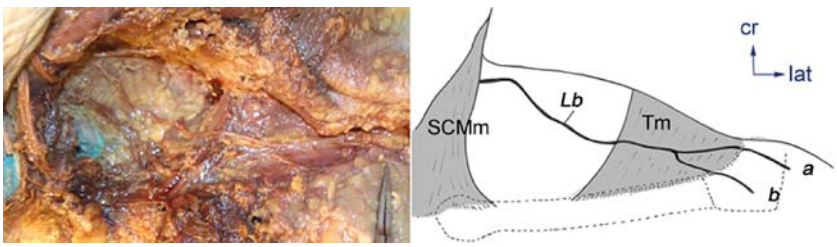

Fig. 7 Anterior view of a left neck showing the lateral branch (Lb) which crosses the trapezius muscle (Tm) and divides into two main rami, SCMm : sternocleidomastoideus muscle, *a* posterior ramus, *b* anterior ramus

Discussion

We have chosen to limit our study only to the lateral and intermediate branches in the goal to elucidate some clinical facts that could be met in shoulder surgery.

Even if the number of cases is limited, our results are completely in agreement with the description of Hovelacque [5] who has described the division of the superficial cervical plexus with three branches, internal or supra-sternal, intermediate or supra-clavicular, and lateral or

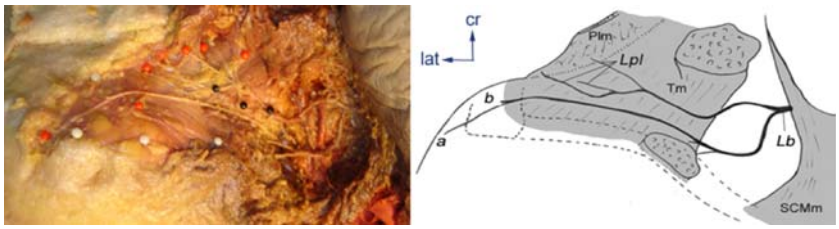

Fig. 8 Anterior view of a right neck showing the lateral branch (*Lb*) which passes through the trapezius muscle (*Tm*) and divides into two secondary rami, *a* anterior ramus, *b* posterior ramus, *Lpl* muscular rami for the platysma muscle (*Plm*), *SCMm* sternocleidomastoideus muscle

supra-acromial. Each branch divides itself into a various number of rami.

Paturet [10] has described the common trunk between the intermediate and lateral branches. According to him, the diameter of the intermediate branch was higher than the diameter of lateral branch. The lateral branch crossed almost perpendicularly the middle part of the anterior border of the clavicle, pierced the platysma and distributed in the quite superior part of the pectoral cutaneous area. For Paturet [10], some of the nerve endings were located at the level of the second rib. The lateral branch divided into several rami, which crossed the anterior belly of the trapezius muscle or course through its fibers and distributed in the most proximal part of the lateral face of shoulder below the acromial region.

More detailed knowledge of these two nerve branches is useful to understand their deficiency, and the mechanism of their disease. Few clinical applications were described in the literature even though these intermediate and lateral branches are located in the posterior triangle of the neck and can be entrapped or injured by traumatisms or surgical procedures.

The entrapment of the supraclavicular branch within a tunnel through the clavicle has been reported as a cause of neuropathy by Gelberman et al. [3] who have reported a case of traumatic neuroma of the intermediate branch, which coursed through an osseous tunnel of the clavicle. De La Caffinière and Konsbruck [2] have also reported an 11-year-old patient with shoulder pain that was caused by entrapment of the nerve through a foramen in the clavicle. More recently, Omokawa et al. [8] have reported two symptomatic cases with nerve entrapment in an intra-osseous tunnel that relieved following decompression. One case complained about mid-clavicular pain, which spontaneously appeared and radiated in the high part of the pectoral area. The other case complained about cervical pain radiated in the shoulder, which appeared subsequently to a 3-m height fall. This intraosseous variation is well known and was first described by Bock [1]. Papadatos [9] on a study of 254 cases have found a 4% incidence. As recently published by Tubbs et al. [12], the supraclavicular nerve is enclosed within the bone during development, most likely during the 57 mm embryonic stage. In case of intraosseous tunnel nerve, it seems that symptomatic cases occurred following traction mechanism injury of these entrapped nerves.

For Jelev and Surchev [6], some other variations could be considered as potential entrapment sites. They have described an unusual course of the intermediate branch, which did not pierce the deep cervical fascia above the clavicle but was entrapped by an independent fibrous band near the periosteum.

The superficial position of the intermediate branch crossing the clavicle and that of the lateral branch crossing the trapezius muscle suggest possible compression injury, as by the safety belt during car accidents, and should be considered in post trauma painful sequellae.

The nerves injury can also occur after clavicular or acromial fracture by direct wound or entrapment between bone fragments, or during the healing phase. Mehta and Birch [7] have reported two cases of persistent supraclavicular pain that occurred 1 and 8 years after the initial fracture. Clinical examination showed severe tenderness and paresthesiae to the light touch of the neck with a positive Tinel's sign. Diagnosis was neuroma of an intermediate ramus.

These nerves can be injured during the surgical approaches. Mehta and Birch [7] have described three other similar cases of pain after iatrogenic injuries involved during surgery of the acromioclavicular joint during biopsy-removal of a cervical tumor, and during surgery of torticollis.

Neuropathy of the lateral branch can also occur. Jelev and Surchev [6] have described the specific conditions for entrapment of that branch through the variant structures of the trapezius muscle. We think that the relationship between the lateral branch and the anterior border of the trapezius muscle can explain some cases of paresthesiae or pain after violent muscular contraction or after repetitive stresses. The subsequent sensitive signs are located laterally to the acromion process. In these cases, a Tinel sign could be found along the border of the trapezius muscle. Highlighted by this work, we have diagnosed several cases of such a disease, which we have successfully treated with local anesthetic and corticoid injection.

We insist on the risks of the surgical incisions performed in shoulder surgery and of all incisions situated in

the posterior triangle of the neck laterally to the posterior edge of the SCM. One of the most concerned approaches is the anterior approach, drawn along the clavicle, crossing the intermediate branch, and used for the treatment of clavicular fracture or non-union. Others incisions are the anterolateral, superolateral or superior approaches of the shoulder, drawn superiorly or anteriorly to the acromioclavicular joint, sometimes extended laterally to the acromion process, which can cross the lateral branch or the external ramus of the intermediate branch. Approaches used for shoulder arthroscopy can be dangerous for the lateral nerve if they are performed too proximally. When such surgical procedures are necessary, the patient can be informed about the risks of sensitive deficiency, pain or neuroma.

Finally, the superficial place of the nerve emergence, located above the crossing of the external jugular vein and behind the SCM lets us suppose the possibility of an easy nerve block for analgesia after shoulder surgery. Modern ultrasound-guided techniques could be helpful to identify the origin of the nerves.

Conclusion

We explain some sensitive disorders of the lateral and intermediate branches of the supraclavicular nerves, which could be injured after shoulder surgery or traumatism, or which could be entrapped by trapezius muscle or clavicle. The knowledge of the nervous route and skin paddles supplied by these two branches is helpful for the diagnosis and treatment of their diseases.

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