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Anatomical study of the dorsal cutaneous branch of the ulnar nerve using ultrasound

T. Le Corroller · S. Bauones · S. Acid · P. Champsaur

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Abstract

Objectives To determine whether ultrasound allows precise assessment of the course and relations of the dorsal cutaneous branch of the ulnar nerve (DCBUN).

Methods This work, initially undertaken in cadavers, was followed by high-resolution ultrasound study in 20 healthy adult volunteers (40 nerves) by two musculoskeletal radiologists in consensus. Location and course of the DCBUN and its relations to adjacent anatomical structures were analysed.

Results The DCBUN was consistently identified along its entire course by ultrasound. Mean cross-sectional area of the nerve was 1.6 mm² (range 1.1–2.2). The level at which the DCBUN branches from the ulnar nerve was located a mean of 57 mm (range 40–80) proximal to the ulnar styloid process and 11 mm (range 7–15) radial to the medial border of the ulna. The DCBUN then crossed the medial border of the ulna a mean of 14 mm (range 6–25) proximal to the ulnar styloid process.

Conclusion The DCBUN is clearly depicted by ultrasound. Precise mapping of its anatomical course could have significant clinical applications, such as preventing injury during surgery of the ulnar side of the wrist or helping in the diagnosis of chronic pain of the ulnar side of the hand.

Key Points

- The dorsal cutaneous branch of the ulnar nerve (DCBUN) is often injured.
- The DCBUN originates from the ulnar nerve in the distal third of the forearm.

- It can be clearly depicted by ultrasound.
- The level at which the DCBUN crosses the ulna is variable.
- Precise mapping of its anatomical course could have significant clinical applications.

Keywords Ultrasound · Nerve · Anatomy · Wrist · Hand

Abbreviation

DCUBN dorsal cutaneous branch of the ulnar nerve

Introduction

The dorsal cutaneous branch of the ulnar nerve (DCBUN) is a terminal rami of the ulnar nerve [1, 2]. It originates from the medial side of the ulnar nerve at the distal third of the forearm. The DCBUN then pierces the antebrachial fascia volar to the ulna and dorsal to the flexor carpi ulnaris tendon to become subcutaneous and runs superficially at the dorsal ulnar aspect of the hand. It is a purely sensory nerve that supplies sensation to the dorso-ulnar aspect of the hand, dorsum of the fifth finger and dorso-ulnar aspect of the fourth finger [2].

Lesions of the DCBUN may result from traumatic injuries or have iatrogenic causes [3, 4]. The DCBUN is at risk when performing a direct approach to the subcutaneous border of the ulna, which is commonly used for many operations including open reduction and internal fixation of ulnar fractures, treatment of delayed union or non-union of ulnar fractures, osteotomy of the ulna, treatment of chronic osteomyelitis, and ulnar lengthening and shortening procedures [5, 6]. Iatrogenic injuries to the DCBUN have also been described in arthroscopic surgery, with recommendations on safe zones for wrist portal positioning [4, 7–9]. Clinically, lesions of the DCBUN present with numbness,

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dysaesthesia and pain of the dorso-ulnar aspect of the hand. One potential complication of injury to the DCBUN is the formation of a painful neuroma which may be more disabling than an area of anaesthesia [3, 8].

Conditions that affect the peripheral nerves are generally evaluated through a combination of history, clinical examination and electrodiagnostic studies. Nevertheless, as electrodiagnostic studies neither allow visualisation of intrinsic abnormalities of peripheral nerves nor provide information about their relationship to adjacent anatomical structures, ultrasound has become an attractive complement for assessing the peripheral nervous system [10, 11]. Hence, ultrasound provides high-resolution images, characterises tissue movement in real time, displays blood flow with Doppler, is compatible with implanted metal devices and is portable, making it an ideal imaging technique [10].

Yet, to the best of our knowledge, no description of the DCBUN by means of ultrasound has been reported. Precise mapping of the course of this nerve may have significant clinical implications, such as avoiding injury to it during surgery, diagnosing iatrogenic injuries or guiding an elective neural blockade. Thus, the aim of our study was to determine whether ultrasound allows precise assessment of the course of the DCBUN and of its relations with adjacent anatomical structures.

Materials and methods

Anatomical study in cadavers

In compliance with institutional safety and ethics regulations, this study was initially undertaken on four formalin-embalmed cadaveric upper limbs amputated at the elbow level (2 women, mean age at death 80 years) to preliminarily assess the ultrasound depiction of the DCBUN and gain a better understanding of its anatomical course. The specimens were placed in full supination and were examined using an iU22 (Philips Medical Systems, Bothell, WA, USA) and a linear 17.5-MHz probe. A staff radiologist with 7 years of experience and a fellow in musculoskeletal radiology performed all the examinations in consensus. The visibility of the DCBUN was scored according to a four-level scale: 0—not visible; 1—identified with difficulty; 2—clearly identified without internal nerve structure visibility; and 3—clearly identified with internal nerve structure visibility. The cross-sectional area and course of the DCBUN and its relationship to the flexor carpi ulnaris muscle were recorded. We set out to define the point where the DCBUN originates from the ulnar nerve in relation to the ulnar styloid process and medial border of the ulna, and also to define where the nerve crosses the medial border of the ulna in relation to the ulnar styloid process. The distances between the nerve origin and the ulnar styloid process and

between the nerve origin and the medial border of the ulna were measured using ultrasound (Fig. 1a). The distance between the point where the DCBUN crosses the medial border of the ulna and the ulnar styloid process was noted (Fig. 1b). Blue stain was then injected under ultrasound guidance in contact with the presumed DCBUN at its point of branching from the ulnar nerve. Finally, a cadaver dissection was performed to validate the ultrasound data. A skin and subcutaneous flap was reflected from the distal half of the anteromedial forearm to a point 5 cm distal to the ulnar styloid process and raised medially. The ulnar nerve was identified on the palmar aspect of the forearm beneath the fascia of the flexor carpi ulnaris and palmar to the flexor digitorum profundus. The course of the DCBUN was then identified and the three previously defined distances were again measured. After the nerve was dissected fully, we changed the position of the forearm from full supination to full pronation to evaluate whether this had an effect on the course of the nerve.

Ultrasound study in volunteers

Following informed consent, 20 healthy adult volunteers, 10 men and 10 women (mean age 43 years, age range 25–61 years) with a mean body mass index (BMI) of 23.7 (range 20–28) participated in this study. The volunteers had no traumatic or surgical history, and no symptoms referable to the peripheral nervous system. They were examined in full supination using an iU22 (Philips Medical Systems, Bothell, WA, USA) and a linear 17.5-MHz probe. Initially, the probe was placed in a transverse direction at a mid-ulnar level. At this location, the ulnar nerve was identified beneath the flexor carpi ulnaris muscle and then followed distally until the division of the DCBUN. The DCBUN could then be seen as a distinctive nerve that was separated from the ulnar nerve. The visibility of the DCBUN was scored according to a four-level

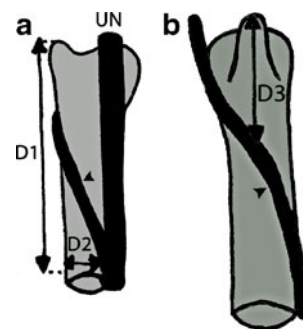


Fig. 1 Anterior (a) and medial (b) schematic anatomical views of the distal ulna demonstrating the dorsal cutaneous branch of the ulnar nerve (DCBUN; arrowhead) originating from the ulnar nerve (UN) and the mean distances between the nerve origin and the ulnar styloid process ($D1$), between the nerve origin and the medial border of the ulna ($D2$) and between the point where the DCBUN crosses the medial border of the ulna and the ulnar styloid process ($D3$)

scale: 0—not visible; 1—identified with difficulty; 2—clearly identified without internal nerve structure visibility; and 3—clearly identified with internal nerve structure visibility. Power Doppler was used in all examinations to differentiate the nerve from the adjacent vessels. The morphology, cross-sectional area and course of the DCBUN and its relations to the surrounding structures were then analysed in real time while imaging. The previously defined visibility score of the DCBUN and the distances between the nerve origin and the ulnar styloid process, between the nerve origin and the medial border of the ulna and between the point where the DCBUN crosses the medial border of the ulna and the ulnar styloid process were recorded bilaterally.

Results

The anatomical data obtained from the cadavers are shown in Table 1. In every specimen, the axial ultrasound images identified a hypoechoic ovoid structure along the theoretical course of the DCBUN. The blue stain could be injected in the vicinity of the nerve under ultrasound guidance in every case at its point of branching from the ulnar nerve (Fig. 2). The mean visibility score of the DCBUN was 2.5 (range 2–3). The mean cross-sectional area of the nerve was 1.4 mm² (range 1.1–1.5). The mean distances measured using ultrasound between the nerve origin and the ulnar styloid process, between the nerve origin and the medial border of the ulna and between the point where the DCBUN crosses the medial border of the ulna and the ulnar styloid process were respectively 60 mm (range 57–64), 13 mm (12–15) and 17 mm (15–20) (Table 1). Subsequent cadaver dissection confirmed that the injected structure visualised on ultrasound in fact represented the DCBUN (Fig. 3). The same mean distances measured



Fig. 2 Horizontal ultrasound image obtained in a cadaver demonstrating a needle (*arrow*) injecting blue stain in contact with the presumed DCBUN (*arrowhead*) at the point where it branches from the ulnar nerve (*thick arrow*)

anatomically were 62 mm, 14 mm and 18 mm respectively (Table 1). In all cases, after dissecting the nerve, the DCBUN displaced a small amount in a palmar and radial direction on pronation. Contrary to previous reports, no communication between the DCBUN and the superficial sensory branch of the radial nerve was noted [12].

The ultrasound data obtained in 20 volunteers are shown in Table 2. The mean visibility score of the DCBUN was 2.7 (range 2–3), which indicates that the nerve was consistently clearly identified, with or without internal nerve structure visibility. The mean cross-sectional area of the nerve was 1.6 mm² (range 1.1–2.2). The mean depth of the nerve at its point of branching from the ulnar nerve was 8 mm (range 6–11). The mean distances measured using ultrasound between the nerve origin and the ulnar styloid process, between the nerve origin and the medial border of the ulna and between the point where the DCBUN crosses the medial border of the ulna and the ulnar styloid process were respectively 57 mm (range 40–80), 11 mm (7–15) and 14 mm (6–25).

Table 1 Anatomical results in four cadaveric specimens

	Ultrasound results	Anatomical dissection
Nerve visibility score (0–3)	2.5 (2–3)	Not available
Cross-sectional area (mm ²)	1.4 (1.1–1.5)	Not available
D1 (mm)	60 (57–64)	62 (58–66)
D2 (mm)	13 (12–15)	14 (13–16)
D3 (mm)	17 (15–20)	18 (15–22)

Data shown include: the dorsal cutaneous branch of the ulnar nerve (DCBUN) visibility score (0—not visible; 1—identified with difficulty; 2—clearly identified without internal nerve structure visibility; 3—clearly identified with internal nerve structure visibility); the DCBUN cross-sectional area; and the mean distances, respectively between the nerve origin and the ulnar styloid process (D1), between the nerve origin and the medial border of the ulna (D2) and between the point where the DCBUN crosses the medial border of the ulna and the ulnar styloid process (D3)

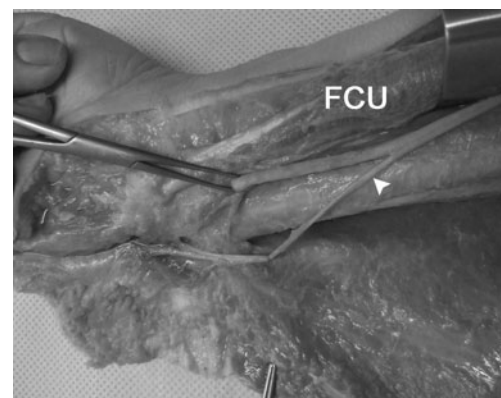


Fig. 3 Anterior view of a dissected right upper limb showing the DCBUN (*arrowhead*) originating from the ulnar nerve beneath the fascia of the flexor carpi ulnaris (FCU)

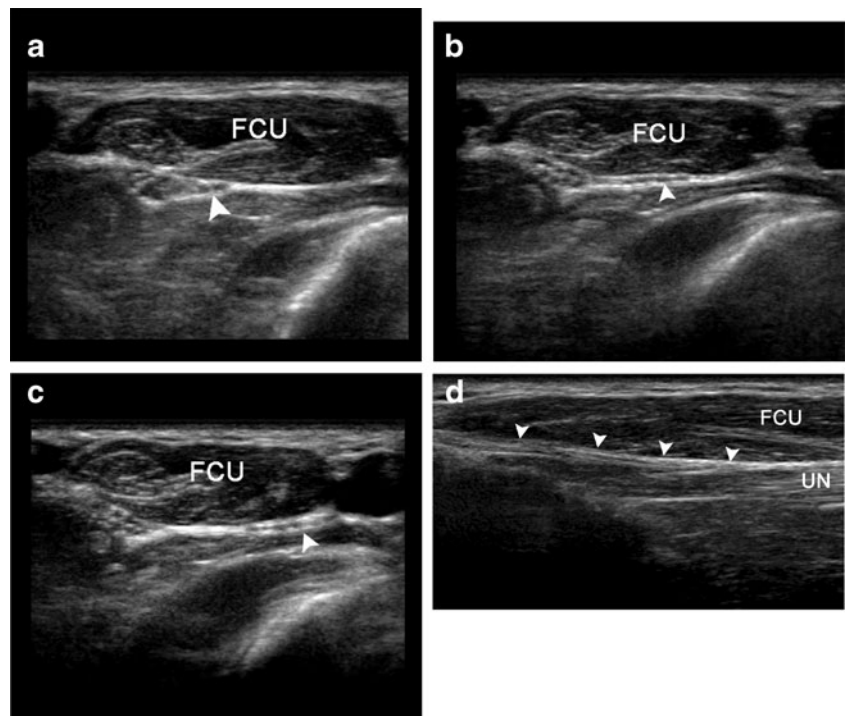
Table 2 Results for 20 volunteers

	Data (range)
Mean age	43 (25–61)
Mean BMI	23.7 (20–28)
Nerve visibility score (0–3)	2.7 (2–3)
Cross-sectional area (mm ²)	1.6 (1.1–2.2)
Depth (mm)	8 (6–11)
D1 (mm)	57 (40–80)
D2 (mm)	11 (7–15)
D3 (mm)	14 (6–25)

Data include demographics; the DCBUN visibility score (0—not visible; 1—identified with difficulty; 2—clearly identified without internal nerve structure visibility; 3—clearly identified with internal nerve structure visibility); the DCBUN cross-sectional area; the DCBUN depth; and the mean distances between the nerve origin and the ulnar styloid process (D1), between the nerve origin and the medial border of the ulna (D2) and between the point where the DCBUN crosses the medial border of the ulna and the ulnar styloid process (D3)

The DCBUN could be identified along the majority of its course, from its point of branching from the ulnar nerve at the distal third of the forearm to the point where it pierces the antebrachial fascia to become subcutaneous (Fig. 4). Naturally, the terminal branches of the DCBUN that supply sensation to the dorso-ulnar aspect of the hand, dorsum of the fifth finger and dorso-ulnar aspect of the fourth finger were more difficult to assess given their small size and the adjacent hyperechoic subcutaneous fat.

Fig. 4 Horizontal (a–c) and sagittal (d) ultrasound images obtained at the distal third of the forearm. The DCBUN (arrowhead) could be identified as a distinctive nerve that originated from the medial side of the ulnar nerve (UN) beneath the fascia of the flexor carpi ulnaris (FCU)



Discussion

The DCBUN is a terminal sensory branch of the ulnar nerve that supplies sensation to the dorso-ulnar aspect of the hand and fourth and fifth digits [2]. The remainder of the dorsum of the hand is innervated by the superficial branch of the radial nerve [8]. Although the DCBUN is a small branch of the ulnar nerve, its anatomical location is crucial as it arises proximal to the wrist joint and winds around the ulnar side of the forearm. Therefore, this nerve is prone to different kinds of traumatic or iatrogenic injuries [3, 4]. Such lesions may not be uncommon and can produce pain and sensory loss in its innervation area [3, 8]. In all of these disorders, involvement of the nerve must be differentiated from other causes of such symptoms by objective testing. High-resolution ultrasound can provide information about not only the peripheral nerve itself but also about its relationship to adjacent anatomical structures, and thus it could become an attractive complement to clinical examination and electrodiagnostic studies [11]. Precise mapping of the course of the nerve may have significant clinical implications, such as avoiding injury during surgery, diagnosing iatrogenic lesions or even guiding an elective neural blockade. Thus, the purpose of our study was to determine whether ultrasound would allow precise assessment of the course and anatomical relations of the DCBUN.

Our results show that, despite the thinness of the nerve, the course of the DCBUN can be clearly depicted by ultrasound thanks to high-resolution real-time imaging. The

nerve was particularly well analysed from its point of branching from the ulnar nerve at the distal third of the forearm to the point where it pierces the antebrachial fascia to become subcutaneous. More distally, the terminal branches of the DCBUN were more difficult to assess as they are distributed to the skin at the dorso-ulnar aspect of the hand. In the part of our work performed on cadavers, the distances measured by ultrasound between the nerve origin and the ulnar styloid process, between the nerve origin and the medial border of the ulna and between the point where the DCBUN crosses the medial border of the ulna and the ulnar styloid process were quite similar to the same distances measured anatomically. In addition, both in anatomical specimens and in asymptomatic volunteers, these three distances measured using ultrasound fell within the range reported in the literature. Hence, previous anatomical studies have suggested that the DCBUN leaves the ulnar nerve, piercing the antebrachial fascia 4.8 to 10.0 cm above the ulnar styloid process taking a posterior direction [2, 3, 8, 12–15]. In our work, the DCBUN originated from the ulnar nerve an average of 5.7 cm proximal to the ulnar styloid process, reaching the dorsum of the hand after coursing palmar to the head of the ulna. We also found that the DCBUN originated an average of 1.1 cm palmar and radial from the medial border of the ulna, which is in complete agreement with the data obtained in three previous cadaveric studies [3, 8, 13]. The nerve then crossed from the palmar aspect to the dorsum an average of 1.4 cm proximal to the tip of the ulnar styloid. Overall, our data confirm that the DCBUN is at risk when performing a direct approach to the subcutaneous border of the ulna, which is commonly used for many operations including open reduction and internal fixation of ulnar fractures, treatment of delayed union or non-union of ulnar fractures, osteotomy of the ulna, treatment of chronic osteomyelitis, and ulnar lengthening and shortening procedures [5, 6]. Here, we noted that manoeuvres such as full pronation could assist in displacing the nerve in a palmar and radial direction, further away from the surgical field [8].

Some limitations may be considered inherent to the methodology used in this study. First, we only dissected four upper limbs, which is small for a study in cadavers. Second, we did not analyse the intra- and interobserver variation in the ultrasound study of the DCBUN. As we considered the preliminary assessment of the DCBUN undertaken in cadavers crucial to providing an exhaustive understanding of its anatomy on ultrasound, the ultrasound examinations in anatomical specimens or in healthy volunteers were all performed by the two same operators in consensus. All the ultrasound measurements were then performed in full supination both in cadavers and healthy volunteers. Yet, we observed in the cadaveric specimens that, after dissecting the nerve, the DCBUN displaced a small amount in a palmar

and radial direction on pronation. Finally, the results obtained in our volunteer population might have been influenced by a “healthy” BMI facilitating the ultrasound depiction of the nerve. It is important to note that, in patients with a higher BMI, the course of the DCBUN may be more difficult to assess with ultrasound especially given its relatively small size.

As the anatomy of the DCBUN varies between individuals and can vary from the right to left upper limb in the same individual, ultrasound mapping of the nerve may have useful clinical implications. Firstly, the DCBUN could be blocked successfully with the use of ultrasound guidance, which may be a useful complement to common postoperative analgesics. Secondly, as injury to the DCBUN may not be uncommon after both conventional and arthroscopic wrist surgery, later resulting in neuralgia and sensory loss in its innervation area, ultrasound could help in the differential diagnosis of postoperative wrist pain.

In conclusion, our study has demonstrated that, in healthy individuals, the course of the DCBUN can be depicted by using ultrasound. The potential applications of this technique must now be confirmed by further clinical studies.

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