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# Low amplitude dorsal ulnar cutaneous nerve sensory nerve action potential from cross over innervation. Can nerve ultrasound help?

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### *Abstract*

The ulnar dorsal aspect of the hand is predominantly innervated by the dorsal ulnar cutaneous nerve with variable input from the superficial radial cutaneous nerve. This cross innervation can cause difficulty in interpreting low amplitude sensory nerve action potential for the dorsal ulnar cutaneous nerve particularly when facing suspected ulnar neuropathyat the elbow. In three subjects with low dorsal ulnar cutaneous sensory nerve action potential amplitude due to cross over with the superficial radial nerve, we compared amplitude with nerve circumference and fascicular count as measured by ultrasound. Dorsal ulnar cutaneous nerve circumference was significantly smaller where there was low sensory nerve action potential amplitude and showed fewer fascicles. Nerve ultrasonography may be a useful additional test modality to determine if low dorsal ulnar cutaneous nerve amplitude is physiological.

*Key words:* Dorsal Ulnar Cutaneous Nerve, Nerve conduction study, sensory nerve action potential, nerve ultrasound, nerve fascicle

## INTRODUCTION

Significant variability in the cutaneous innervation of the ulnar dorsal aspect of the hand has been widely recognized in both anatomical and electrophysiological studies. Cross innervation between the radial and ulnar nerves occurs in 16-60% of hands.[1,2] Since the dorsal ulnar cutaneous nerve (DUCN) is useful in the neurophysiological identification of suspected ulnar neuropathy at the elbow[3], it is important to discern pathological from physiological causes of low amplitude sensory nerve action potential (SNAP). The most important physiological cause of low DUCN SNAP is cross innervation by the superficial radial cutaneous nerve (SRCN).[4]

Currently, the identification of physiological low DUCN SNAP is achieved using electrophysiological techniques.[4] These demonstrate cross innervation by means of electrical nerve stimulation resulting in a SNAP of the cutaneous territory being territorially investigated. Since nerve ultrasound is able to record the morphological features of peripheral nerves accurately and reproducibly, we wondered whether it could be applied as an additional method for the detection of physiological low DUCN SNAP. This consideration is fueled by the anatomical presupposition that the greater the surface area innervated by a cutaneous nerve, the larger the nerve will be.

## CASE REPORTS

We encountered three subjects, examined in the Neurology Diagnostic Laboratory at the National University Hospital in Singapore for non-specific limb numbness, with unilateral low DUCN SNAP due to cross over innervation with the SRCN. Cross innervation was determined by stimulating the SRCN and recording the SNAP over the dorsal ulnar region as previously described.[2] We compared DUCN SNAP amplitude with the cross sectional area (CSA) of the DUCN, at the site where the DUCN exits the main ulnar nerve trunk proximal to the wrist (Figure 1). The DUCN was traced back and forth from its point of origin from the ulnar nerve until the point where it clearly separates from main branch and continues into the hand. This was done until all authors were satisfied that the DUCN had been corrected identified and encircled, hence guarding against errors where

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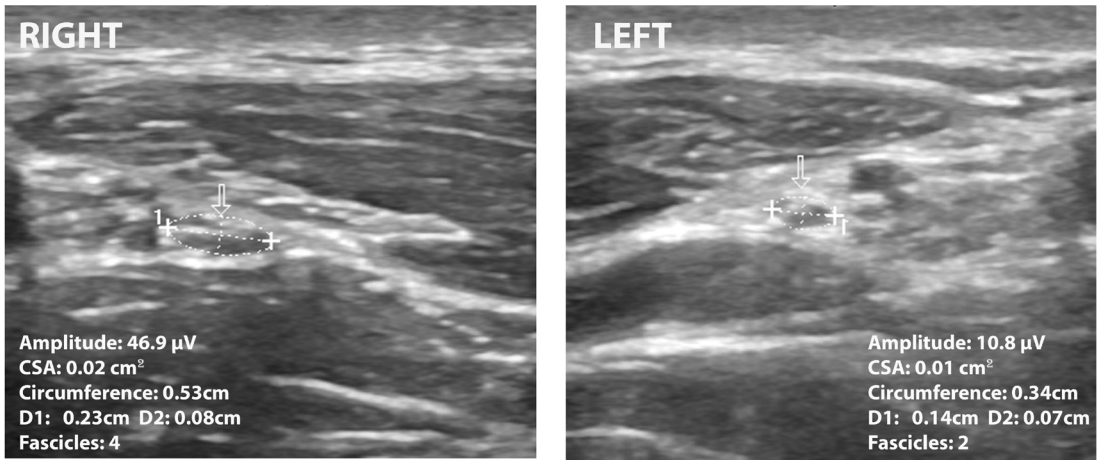


Figure 1. Dorsal ulnar cutaneous nerve (DUCN) cross sectional area (CSA), circumference and fascicular count in subject B (D1: horizontal diameter, D2: vertical diameter)

fascicles from the ulnar nerve were included in the DUCN calculation or fascicles of the DUCN were excluded. Because of the small size of CSA of cutaneous nerves and subsequent inability of the US machine to calculate less than 0.01 $cm^2$, we primarily measured the circumferential distance as determined by the horizontal and vertical diameter. In addition, the numbers of nerve fascicules visualized were counted. In each subject, the contralateral unaffected limb was measured for comparison. All subjects had a normal neurological examination.

On NCS, the SNAP for the DUCN for subject A was 5.0 µV on the left and 32.2 µV on the right. For subject B (Figure 1), it was 10.8 µV on the left and 46.9 µV on the right and for subject C, it was 15.7 µV on the right and 28.8 µV on the left. The mean SNAP on the low side was 10.5 µV and 36.0 µV on the normal side.

Ultrasonography of the DUCN on the side with low SNAP amplitude from SRCN cross innervation showed smaller circumference (mean: 0.33 cm/ range: 0.26-0.39 cm) and fewer fascicles (mean: 2 / range: 1-3) than on the side with normal DUCN SNAP values (circumference mean: 0.53cm / range: 0.52-0.53 cm; fascicles mean: 4 range: 4-4). Although we are aware of the difficulty of using statistical significance in low numbers, circumference and SNAP amplitude was statistically highly significant (two-tailed paired t test P = 0.0050).[5] The correlation coefficient (r) between SNAP amplitude and nerve circumference was strong at 0.916.

Figure 1 contrasts CSA, circumference and fascicular count between cross innervated and non-cross innervated DUCN.

## DISCUSSION

In view of the variability in dorsal ulnar innervation of the hand, when we encounter low DUCN SNAP without slowing or conduction block across the elbow, we routinely perform SRCN stimulation to identify cross innervation.[4] This allows identifying whether low DUCN SNAP is pathological or physiological.

Our cases demonstrate the potential usefulness of nerve ultrasound as an additional method for the identification of physiological low amplitude DUCN due to SRCN cross over. In all subjects, on the side of low DUCN SNAP, the DUCN circumference was significantly smaller as compared to the contralateral side. Furthermore, the number of nerve fascicles was less on the side with SRCN cross innervation. Although nerve size and the number of conducting axons in the peripheral nerve has not been formally correlated using ultrasound and nerve conduction, data in the literature shows a firm correlation between the number of conducting axons and SNAP.[6] The data we present here strongly suggests that a smaller DUCN circumference relates to physiologically fewer conducting axons because of SRCN cross innervation. This is further strengthened by the excellent correlation coefficient (r=0.916) between SNAP amplitude and nerve circumference. In contrast, a decrease in SNAP, resulting from a pathological process, would be accompanied by an increase in nerve circumference as recently shown in studies on diabetic neuropathy.[7]

In conclusion, using ultrasound to compare the size of DUCN can provide a useful and simple additional parameter in detecting low DUCN SNAP due to SRCN cross over innervation. Further

studies will need to be performed in patients with ulnar neuropathy at the elbow to establish the value of this technique in differentiating pathological from physiological low DUCN amplitudes.

## DISCLOSURE

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Conflict of interest: None

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