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Two Cases of Doppler Sonography for Intraneural Vascularity of Ulnar Neuropathy at the Elbow: Before and After Surgery

Yuka KURIHARA[*1], Kozo HANAYAMA[*2], Mitsuhiko KODAMA[*1], Toshiaki FURUKAWA[*1] and Yoshihisa MASAKADO[*1]

[*1]*Department of Rehabilitation Medicine, Tokai University School of Medicine*
[*2]*Department of Rehabilitation Medicine, Kawasaki Medical School*

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The finding of an intraneural blood flow (IBF) signal on Doppler sonography (DS) in non-surgical cases is interpreted in several ways and usually represents a pathologic condition with entrapment neuropathy. There have been no reports of the IBF signal on DS after surgery for ulnar neuropathy at the elbow (UNE). IBF was investigated before and after surgery in two cases diagnosed with UNE before surgery and confirmed after surgery. Both underwent electrodiagnostic (EDX) studies, grey scale sonography (GS), and DS before and after surgery and were diagnosed as having UNE by EDX study and GS. On DS, an IBF signal was not detected in both cases before surgery. After surgery, both cases improved their clinical and EDX findings, and an IBF signal and pulsatility were detected on DS. With respect to vascular problems, recovering venous and arterial blood supplies and dilated vessels would show much more blood flow during recovery of the affected ulnar nerve site following decompression surgery. The IBF signal would not always implicate pathology. When assessing recovery from UNE after surgery, it may be useful to evaluate intraneural vascularity at the affected site with DS.

Key words: Doppler sonography, intraneural vascularity, electrodiagnosis, ulnar neuropathy at the elbow, surgery

INTRODUCTION

Peripheral nerves depend on their blood supply through a rich anastomotic system of epineural, perineural, and endoneural blood vessels. The blood–nerve barrier action of endoneurium capillaries and perineurium barrier action maintain intrafascicular homeostasis [1].

The pathophysiology of entrapment neuropathy varies according to each neuropathy, but it is thought to be roughly as follows. First, due to pressure of various degrees, the mobility of the nerve decreases. As a result, due to traction and frictional forces, ischemia of the nerve is exacerbated by joint movement. The nerve swells, and further pressure and decreased flexibility occur. For ulnar neuropathy at the elbow (UNE), there are many cases in which dynamic factors such as traction and friction participate, as well as the pressure in the semi-closed cavity [1]. Both direct mechanical problems and vascular problems may occur in UNE. Impairment of the blood supply causes intraneural ischemia, which induces increasing permeability of endoneural vessel walls [2, 3].

The finding of an intraneural blood flow (IBF) signal on Doppler sonography (DS) has been interpreted in several ways and usually represents a pathologic condition with entrapment neuropathy. According to previous reports about UNE, an IBF signal was frequently found in association with axonal injury detected on electrodiagnostic (EDX) studies, severe atrophy of the first dorsal interosseous (FDI) or abductor digiti minimi (ADM) muscle, and severe muscle weakness [4, 5]. There have been no reports of IBF signals on DS after surgery for UNE. Thus, the present study investigated the IBF signal on DS in UNE before and after surgery. The pathophysiology of IBF after surgery and the usefulness of detecting the IBF signal on DS in UNE were also considered.

PATIENTS AND METHODS

Two cases were diagnosed as having UNE before surgery and confirmed to have UNE after surgery. EDX studies, grey-scale sonography (GS), and DS were performed for both cases before and after surgery. Before presenting the cases, how the EDX studies and sonography were performed and how muscular power is evaluated are described.

Electrodiagnostic study

An ulnar nerve (UN) conduction study and, if necessary, another nerve conduction study and needle electromyography study were performed with an electromyograph (MEB-2208®; Nihon Kohden, Tokyo, Japan).

A standardized UN conduction study was completed. The diagnosis of UNE was based on absolute

Yuka KURIHARA, Department of Rehabilitation Medicine, Tokai University School of Medicine, 143 Shimokasuya, Isehara, Kanagawa 259-1193, Japan
Tel: +81-463-93-1121 Fax: +81-463-95-8248 E-mail: ykuri@is.icc.u-tokai.ac.jp

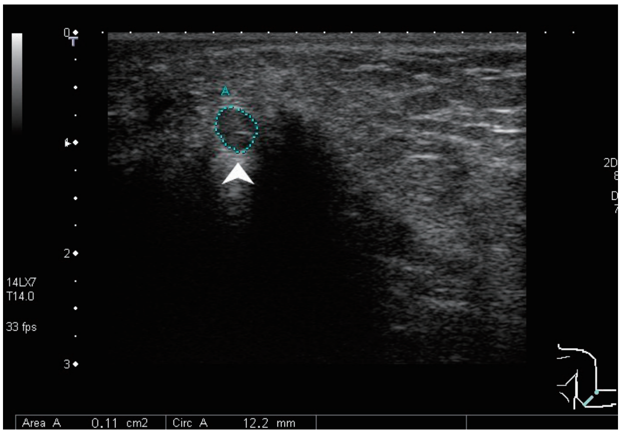

Fig. 1 Grey-scale sonography: UN (arrowhead). Largest point from 2 cm distal to the ME in the transverse view (largest CSA). CSA is 11 mm^2.

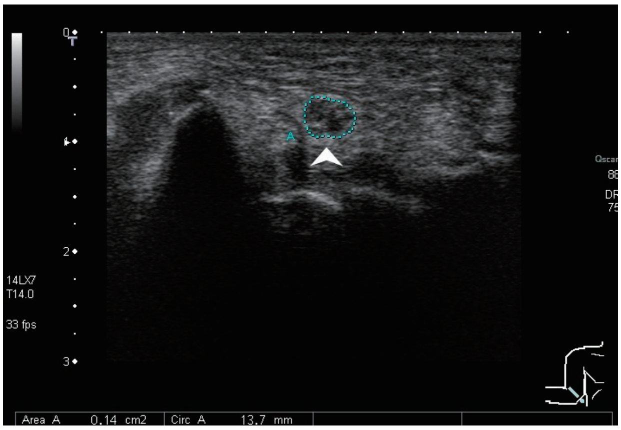

Fig. 2 Grey-scale sonography: UN (arrowhead). Largest point from 2 cm distal to the ME in the transverse view (largest CSA). CSA is 14 mm^2.

motor conduction velocity (MCV) from above the elbow to below the elbow of less than 50 m/s, and 1) differential slowing (10 m/s across the elbow) and/or 2) conduction block across the elbow based on the American Academy of Neurology Summary Statement (1999) [6]. A needle EMG study of the ulnar muscles, e.g. FDI, ADM, flexor digitorum profundus (FDP), and flexor carpi ulnaris (FCU), was performed.

Sonography

Sonography was performed using an AprioXV® (Canon Medical Systems, Ootawara, Japan) with a 12-MHz linear-array transducer to investigate the ulnar nerve.

Grey-scale sonography (GS)

The UN was examined from the wrist to the axilla by GS to check for any structures compressing the UN. The cross-sectional area (CSA) was measured at several sites, and the swelling ratio (SR) was calculated. The diagnosis of UNE was based on a cut-off value from our previous investigation. One of the criteria was the CSA at the largest point from 2 cm distal to the medial epicondyle (ME) in the transverse view (largest CSA) (Fig. 1 and Fig. 2), and the cut-off value for male subjects was >11 mm^2. One of the other criteria was SR of the largest CSA to CSA at the middle upper arm (MUA) in the transverse view (largest/MUA SR) for male subjects >1.7.

Doppler sonography (DS)

The color Doppler setting and the pulse Doppler setting (color Doppler velocity range) were chosen to optimize identification of weak signals from vessels with slow velocities, using a low transmission frequency and low pulse-repetition frequency (PRF) [5]. The UN was investigated from 2 cm distal to 2 cm proximal to the ME. At first, we attempted to detect an IBF signal by color DS. When an IBF signal was observed, we adjusted the color gain and PRF to optimize the image of the IBF (Fig. 3a and Fig. 4a). We checked the pulsatility and measured the blood flow velocity by pulse DS (Fig. 3b and Fig. 4b).

Muscular power

Manual muscle testing was performed using the British Medical Research Council scale (MRC scale) to evaluate muscular power [7]. The MRC scale uses numerical grades of 0 to 5: 0, no contraction; 1, flicker or trace contraction; 2, active movement, with gravity eliminated; 3, active movement against gravity; 4, active movement against gravity and resistance; and 5, normal power.

Case 1: A 27-year-old man

The patient had a two-month history of numbness of his left hand. Because of difficulty pulling the parking brake, he went to the hospital. He had sensory disturbances of both the dorsal and palmar parts of the medial side of the fourth finger and the whole of the fifth finger, palmar ulnar area and dorsal ulnar area, on clinical examination. Tinel's sign was present at the left elbow. Bending of his fourth and fifth fingers was slightly weak (MRC scale grade 4). The UN-innervated muscles were not atrophic. On EDX study, the UN conduction study showed that the MCV between the wrist and below the elbow was 48.4 m/s, and the MCV between below the elbow and above the elbow was 24.0 m/s. The MCV from above the elbow to below the elbow was 24.4 m/s, which was less than the 50 m/s cut-off value, with differential slowing of 24 m/s across the elbow, which was greater than the 10 m/s cut-off value. The CMAP amplitude was 9.6 mV below the elbow and 4.1 mV above the elbow, with a 57% decrease in CMAP amplitude across the elbow, which was conduction block. In the short segmental study, there was remarkable differential slowing of the MCV (7.8 m/s) and decreasing of the CMAP amplitude of 40% between 1-cm distal from the ME to the ME. The distal UN sensory nerve action potential (SNAP) was 3.4 μV, which was low. On needle EMG study, there were spontaneous activities in the left FDP and no spontaneous activities in the left FCU and FDI. On US, the largest CSA (Fig. 1) was 11 mm^2, which did not meet the cut-off value, but the largest/MUA SR was 2.2, which was greater than the cut-off value.

The diagnosis of UNE was made on both EDX and US. No IBF signal was detected on DS. The surgical procedure was simple decompression and interfascicular neurolysis in the part that was slightly firm on palpation. At surgery, the only finding was nerve indentation, with no pseudoneuroma. Follow-

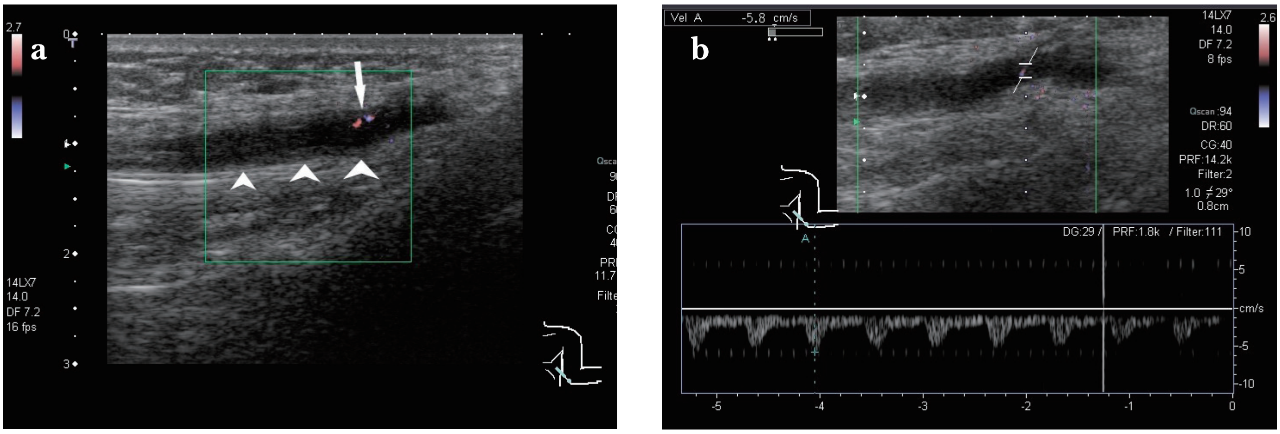

Fig. 3a: Color Doppler image of the affected site of the UN after surgery. UN (arrowhead). IBF signals (arrow) in a longitudinal view at the elbow.
b: Pulse Doppler image of the affected site of the UN after surgery. Pulsatility in a longitudinal image at the elbow. Maximum blood flow velocity is 5.8 cm/s.

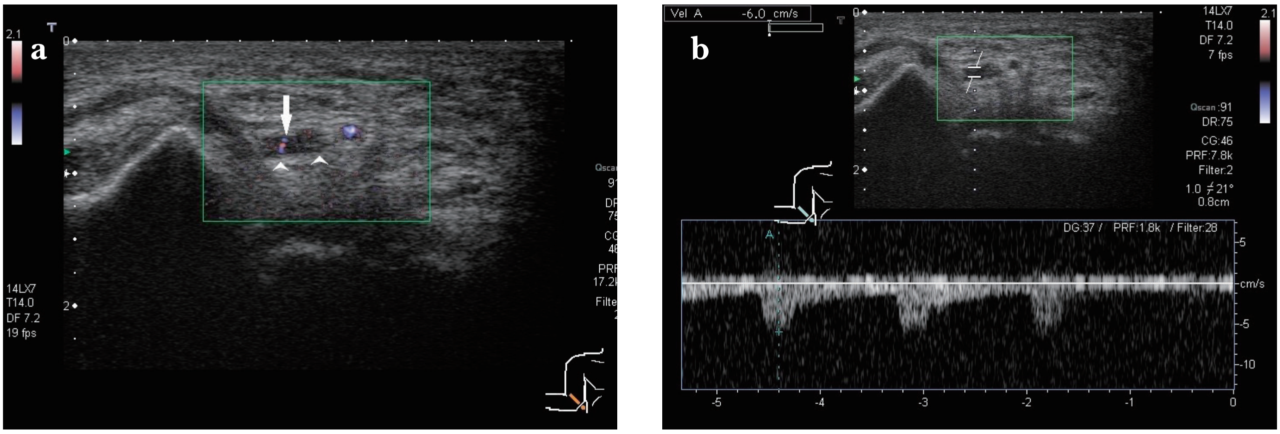

Fig. 4a: Color Doppler image of the affected site of the UN after surgery. UN (arrowhead). IBF signals (arrow) in a transverse view at the elbow.
b: Pulse Doppler image of the affected site of the UN after surgery. Pulsatility in a transverse view at the elbow. Maximum blood flow velocity is 6.0 cm/s.

up studies were performed 13 months later. There was neither weakness of the UN-innervated muscles nor clumsiness. Only the fifth finger, palmar side showed a sensory disturbance. On the EDX study, the UN conduction study showed that MCV between the wrist and below the elbow was 55.2 m/s and MCV between below the elbow and above the elbow was 58.8 m/s. The CMAP amplitude was 16.3 mV below the elbow and 15.9 mV above the elbow. The conduction block had disappeared. The distal UN SNAP was 4.1μV, which was still low. On the needle EMG study, spontaneous activity of the FCU had disappeared. On US, the largest CSA was 14 mm^2, which was higher than before surgery. On DS, an IBF signal and pulsatility were detected (Fig. 3a, b).

Case 2: An 82-year-old man

The patient had a 5-month history of right elbow pain and numbness of his right hand and a 1-month history of not being able to use chopsticks. He had a sensory disturbance of both the dorsal and palmar parts of the medial side of the fourth finger and the whole of the fifth finger. Second finger and fifth finger abduction were MRC scale grade 3. Right hand grip power was 14 kg. Right FDI and ADM muscles were atrophic. X-rays showed right elbow osteoarthritis. On the EDX study, the UN conduction study showed that the MCV from above the elbow to below the elbow was 19.5 m/s (less than 50 m/s), differential slowing was 31.9 m/s across the elbow (more than 10 m/s), and there was no evoked distal UN SNAP. On the needle EMG study, there were spontaneous activities in the right FCU, FDP, and FDI. On US, the largest CSA was 14 mm^2 (Fig. 2), and the SR of 1.8 was greater than the cut-off value.

The diagnosis of UNE was made on both EDX and US. No IBF signal was detected on DS. The surgical procedure was simple decompression. The sole surgical finding was nerve indentation, with no pseudoneuroma. Follow-up studies were performed 6 months later. At that time, the patient could use chopsticks, and movement of the fourth finger was improved. Right hand grip power was 19.3 kg (higher). On the EDX study, the distal UN SNAP was evoked (4.3μV), and the SCV was 32 m/s. Spontaneous activity of the FCU and FDI had disappeared on the needle EMG study. On US, the largest CSA was 10 mm^2 (smaller than before surgery). An IBF signal and pulsatility were detected on DS (Fig. 4a, b).

DISCUSSION

The mechanism of the pathogenesis of intraneural vascular impairment in UNE has not been reported, while it has been described in median neuropathy at the wrist (carpal tunnel syndrome). Vascular disturbances caused by elevated pressure in the carpal tunnel syndrome are explained in three stages: 1) venous congestion; 2) nerve edema; and 3) impairment of venous and arterial blood supplies [8]. Some investigators have found that the intraneural microvasculature was dilated due to inflammation and ischemia within the median nerve at the wrist [2].

The procedure of simple decompression surgery removes not only pressure and friction, but also traction affecting a nerve by removing the external obstacle [9].

A pseudoneuroma due to a thickening of the epineurium or axon swelling occurs proximal to the obstruction, and the nerve cell body is disturbed because retrograde axon flow is affected. These two cases showed no pseudoneuromas, and clinical findings and EDX findings improved after decompression surgery. Impairment of the affected nerve was reversible, and because both IBF and axonal flow recovered, UN function recovered.

With respect to vascular problems, recovering venous and arterial blood supplies and dilated vessels result in much more blood flow during recovery of the affected site of the UN following decompression surgery. The IBF signal was detected easily compared to before surgery on DS. In this situation, the increasing IBF was not compensating for the ischemia but recovering the impairment of the blood supplies. The meaning of increased IBF after surgery would be different from that before surgery or non-surgery in UNE.

LIMITATIONS

This was a retrospective report of two cases. Before surgery, the part of the UN that would undergo surgery could not be known, and because of the surgery, the location of the UN would be changed. Thus, exactly the same sites could not be investigated before and after surgery. In addition, quantitative assessment of IBF signals was different.

Finally, with a higher frequency linear-array transducer than was used in the present study (e.g. 22 MHz), IBF signals in UNE would be depicted more clearly.

CONCLUSION

An IBF signal does not always imply pathology. One cannot judge the condition of a patient from only the increase in the IBF signal. With respect to recovery from UNE after surgery, it may be useful to evaluate intraneural vascularity at the affected site by DS.

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