

# Role of high resolution ultrasound in ulnar nerve neuropathy

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## SUMMARY

**Aim:** This study was conducted to measure the cross sectional area (CSA) of the ulnar nerve (UN) in the cubital tunnel and to evaluate the role of high-resolution ultrasonography in the diagnosis of ulnar nerve neuropathy (UNN).

**Materials and Methods** This was a cross sectional study with 64 arms from 32 patients (34 neuropathic, 30 non-neuropathic). Diagnosis was confirmed by nerve conduction study and electromyography. The ulnar nerves were evaluated with 15MHz small footprint linear array transducer. The ulnar nerve CSA was measured at three levels with arm extended: at medial epicondyle (ME), 5cm proximal and 5cm distal to ME. Results from the neuropathic and non-neuropathic arms were compared. Independent T-tests and Pearson correlation tests were used. P value of less than 0.05 was considered significant.

**Results:** Mean CSA values for the UN at levels 5cm proximal to ME, ME and 5cm distal to ME were 0.055, 0.109, 0.045 cm<sup>2</sup> respectively in the neuropathic group and 0.049, 0.075, 0.042 cm<sup>2</sup> respectively in the non-neuropathic group. The CSA of the UN at the ME level was significantly larger in the neuropathic group, with p value of 0.005. However, there was no statistical difference between the groups at 5cm proximal and distal to the ME, with p values of 0.10 and 0.35 respectively.

**Conclusion:** There is significant difference in CSA values of the UN at ME between the neuropathic and non-neuropathic groups with mean CSA value above the predetermined 0.10cm<sup>2</sup> cut-off point. High-resolution ultrasonography is therefore useful to diagnose and follow up cases of elbow UNN.

## KEY WORDS:

*Ulnar nerve, neuropathy, elbow, cubital tunnel, high resolution ultrasonography*

## INTRODUCTION

Ulnar nerve neuropathy is the second most common type of nerve entrapment in the upper extremity, ranked after

median nerve neuropathy in carpal tunnel syndrome.<sup>1</sup> The elbow is the commonest site of affliction for ulnar nerve neuropathy (UNN) whereby the nerve passes through a fibro-osseous canal known as the cubital tunnel.

There are various causes of UNN, among which include compression, trauma, deformity, surgery, and metabolic derangement, such as diabetes mellitus. In most cases however, the cause is unknown. It is believed that ulnar neuropathy occurs more commonly in men than women. The larger tubercle of the coronoid process in men can lead to external compression of the ulnar nerve. Moreover, the ulnar nerve is less protected in the male elbow due to the lesser amount of subcutaneous fat.<sup>2</sup>

The diagnosis of UNN was traditionally evaluated with a combination of history, clinical examination and nerve conduction or electrophysiological studies.<sup>3</sup> Although high-resolution ultrasonography has been proven to be a useful tool in the diagnosis of carpal tunnel syndrome, the use of ultrasound in UNN is not widespread. Over the past decade, there were several articles which employed ultrasound in the diagnosis of UNN. These studies had demonstrated that ulnar nerve enlargement is a reliable measure of UNN. However, there is lack of local studies to assess the use of ultrasound in the assessment of the ulnar nerve in the local population. Hence, the authors designed this study to determine its usefulness in UNN.

The aim of the present study was to measure the cross sectional area (CSA) of the ulnar nerve in the cubital tunnel and to determine if the CSA of the ulnar nerve is larger in those patients with UNN.

## MATERIALS AND METHODS

The period of data collection was from August 2010 to November 2012. This study comprised of two groups, namely the neuropathic and non-neuropathic arms. We performed the ultrasound assessment on 72 arms from 36 patients. Eight arms were excluded due to the absence of the electrophysiological results. The remaining 64 arms from 32 patients were included, which consisted of 34 neuropathic and 30 non-neuropathic arms. Two patients had bilateral

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UNN. All patients diagnosed with UNN presented with numbness of the ring and small fingers, and weakness or pain of the hands involving the ulnar nerve distribution. Their electrophysiological findings were consistent with UNN. Electrophysiology study was set as a reference standard for diagnosing UNN in our subjects. They were 33 female elbows and 31 male elbows with the age range from 24 to 76 years (mean age 49.9 years). Malays, Chinese and Indians were recruited, with Malays comprising the largest number at 23 (72%), six Chinese (19%) and three Indian subjects (9%).

Real-time sonographic evaluation of the ulnar nerve was performed by the same operator using the Phillips iU22 ultrasound system (Philips Healthcare Bothell, Washington, USA). A 15 MHz small footprint 'Hockey stick' linear array transducer was utilized. The patient lay supine with the arm fully extended during the scan to avoid stretching of the nerve which may reduce its diameter.<sup>3,4</sup> We measured the CSA of the ulnar nerve at three levels, at the medial epicondyle, 5 cm proximal and 5 cm distal to medial epicondyle. The CSA was measured using continuous manual tracing just within the hyperechoic line that surrounds the nerve perineurium.<sup>3</sup> Three measurements were obtained and the mean value was chosen for analysis. CSA of bilateral ulnar nerves were obtained in each patient. The values obtained were correlated with the results of the electrophysiology study.

Both the nerve conduction study (NCS) and electromyography (EMG) were carried out by a senior consultant neurologist. The electrophysiological studies were conducted using Medelec Synergy 2 channels EMG/Evoked potential (EP) system (T2EP) (VIASYS Healthcare UK) in a PC based system for data storage. The positive electrophysiology results to indicate UNN include absent or reduced ulnar sensory nerve action potentials (SNAP), reduced (20-30%) or absent ulnar compound motor action potentials (CMAP), delayed distal motor latencies (DML) and slow ulnar conduction velocity (CV) (more than 10 m/sec) across the elbow. This was supported by presence of reinnervation changes in the ulnar innervated muscles on EMG.

Patients who did not provide informed consent or whom were uncontactable were excluded in this study. The ethical approval for this study was obtained from the UKM Medical Centre ethics committee (FF-225-2011). The data were analyzed using IBM SPSS software version 20. Level of significance was fixed at 0.05. Independent T-tests and Pearson correlation tests were used.

## RESULTS

A total of 32 patients were consecutively recruited and gave their informed consent to participate in the ultrasound study of their elbows. The total included arms for analysis were 64, which consisted of 34 neuropathic and 30 non-neuropathic arms. Out of the 64 arms, there were 12 arms in diabetic patients, three arms in patients with history of trauma and the rest of the arms had no pre-existing conditions. Table I and Table II show the demographic data of the subjects included in this study.

The measurement of the CSA in the neuropathic group ranged from 0.048 cm<sup>2</sup> to 0.254 cm<sup>2</sup> at the level of medial epicondyle (ME), from 0.033 cm<sup>2</sup> to 0.081 cm<sup>2</sup> at 5 cm proximal to ME and from 0.021 cm<sup>2</sup> to 0.12 cm<sup>2</sup> at 5 cm distal to the ME. Meanwhile, the values of CSA in the non-neuropathic arms ranged from 0.037 cm<sup>2</sup> to 0.146 cm<sup>2</sup> at the level of ME, from 0.020 cm<sup>2</sup> to 0.076 cm<sup>2</sup> at 5 cm proximal to ME and from 0.024 cm<sup>2</sup> to 0.069 cm<sup>2</sup> at 5 cm distal to the ME (Table III).

The mean CSA values for the ulnar nerve at 5 cm proximal to ME, at the level of ME and distal to ME levels were 0.055 cm<sup>2</sup>, 0.109 cm<sup>2</sup>, 0.045 cm<sup>2</sup> respectively in the neuropathic group and were 0.049 cm<sup>2</sup>, 0.075 cm<sup>2</sup>, 0.042 cm<sup>2</sup> respectively in the non-neuropathic group. The CSA at the epicondyle level was significantly larger in the neuropathic than in the non-neuropathic groups, with p value of 0.005, which was less than the pre-determined p < 0.05. However, there was no statistical difference between the groups at the level 5 cm proximal and distal to the medial epicondyle, with p value of 0.10 and 0.35 respectively (Table III).

The mean CSA of the ulnar nerve in men and women at the proximal, ME and distal levels were 0.055 cm<sup>2</sup>, 0.092 cm<sup>2</sup>, 0.040 cm<sup>2</sup> for men and 0.050 cm<sup>2</sup>, 0.094 cm<sup>2</sup>, 0.046 cm<sup>2</sup> for women respectively. Although the mean CSA of the ulnar nerve in women was higher than in men at the ME and distal levels but the difference was not statistically significant (Table IV).

The mean CSA of the ulnar nerve in the right-handed (n=30) and left-handed (n=2) groups were 0.053 cm<sup>2</sup>, 0.096 cm<sup>2</sup>, 0.044 cm<sup>2</sup> and 0.047 cm<sup>2</sup>, 0.057 cm<sup>2</sup>, 0.040 cm<sup>2</sup> respectively. The CSA of the right-handed subjects were larger than the left handed group, but no strong statistical significance was found (Table IV).

The mean CSA of the ulnar nerve in diabetic arms at the proximal, ME and distal levels 0.053 cm<sup>2</sup>, 0.105 cm<sup>2</sup>, 0.048 cm<sup>2</sup>. Meanwhile, mean CSA values for non-diabetic arms were 0.053 cm<sup>2</sup>, 0.091 cm<sup>2</sup> and 0.043 cm<sup>2</sup> respectively. There was no significant difference between the mean CSA of the ulnar nerve in diabetic arms and in the non-diabetic counterpart at all three levels (P > 0.05) (Table IV).

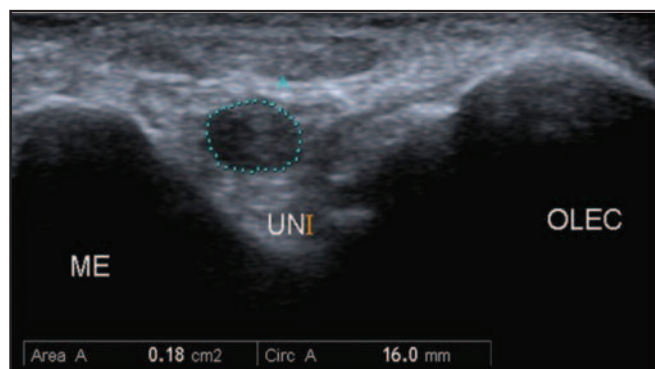
The mean CSA of the ulnar nerve with previous history of trauma at the proximal, ME and distal levels were 0.049 cm<sup>2</sup>, 0.139 cm<sup>2</sup> and 0.051 cm<sup>2</sup> respectively. The values for non-traumatic arms were 0.053 cm<sup>2</sup>, 0.090 cm<sup>2</sup> and 0.043 cm<sup>2</sup> at the respective levels. The differences between these two groups were also statistically not significant (p > 0.05) (Table IV).

## DISCUSSION

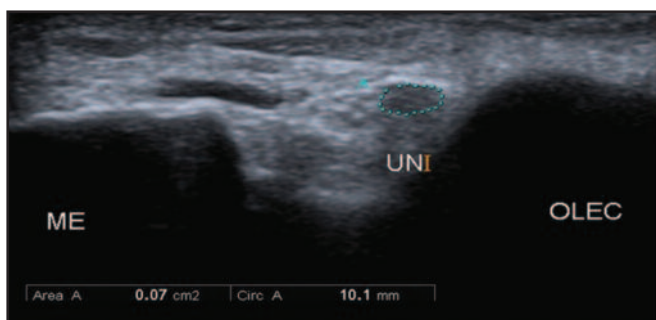
There is lack of studies in Malaysia looking at the difference in CSA of the ulnar nerve for those with and without neuropathy. Previous studies excluded patients with ulnar neuropathy secondary to trauma and diabetes mellitus. In the current study, patients with all causes of neuropathy were included to give a general overview of CSA of the ulnar nerve



**Fig. 1:** Patient with pain and numbness of the ulnar side of forearm as well as ring and little fingers of the left hand. High-resolution ultrasound at the level of medial epicondyle (ME) showed oval shaped hypoechoic ulnar nerve (UN) measuring 0.107 cm<sup>2</sup>.



**Fig. 2:** Axial view ultrasonographic image of another patient with ulnar nerve neuropathy (UNN) showed increased CSA of the ulnar nerve (UN) at the level of medial epicondyle (ME). Similarly, the nerve was hypoechoic with CSA of 0.18 cm<sup>2</sup>.



**Fig. 3:** Axial view ultrasonographic image of the ulnar nerve of a non-neuropathic arm. The CSA of the UN is 0.07 cm<sup>2</sup>. (OLEC= olecranon).

in the neuropathic nerve compared with those that are not neuropathic. The authors did not intend to assess the difference of CSA between the flexed or extended arm. Sonography was done at the cubital tunnel without intention to differentiate between the entering and exiting ulnar nerve within the tunnel. To our knowledge, this is the first study of its kind in Malaysia.

The understanding of the basic anatomy and the course of the ulnar nerve in the elbow helps in identifying the nerve during ultrasonography. At the cubital tunnel of the elbow, the ulnar nerve lies posterior to the medial epicondyle. The cross section of the ulnar nerve appears as a hypoechoic oval to round structure, which is surrounded by hyperechoic rim of perineurium. It is slightly hyperechoic in comparison to muscle.<sup>5</sup>

One of the most common aetiologies of ulnar neuropathy at the elbow is due to nerve entrapment. The ulnar nerve is most vulnerable for compression at the groove of medial epicondyle (ME) because of the nerve's superficial course at this level. This is consistent with the results of this study which showed a statistical difference in the CSA of the ulnar

nerve at the ME level between the neuropathic and non-neuropathic groups. Narrowing of the cubital tunnel would cause constriction of the ulnar nerve, adding to the likelihood of nerve damage.<sup>6</sup> Furthermore, ulnar nerve subluxation from repeated elbow flexion can also cause compression.<sup>7</sup> The mean CSA value of the ulnar nerve at ME level in the neuropathic group from this study was above the 0.10cm<sup>2</sup> cut-off point for ulnar nerve neuropathy as determined by previous studies.<sup>4,8,9</sup> The presence of clinically established UNN cases that fell below the cut-off value however, should raise awareness that mild cases might still have normal or mildly altered CSA values.<sup>9</sup> Fig. 1 and 2 illustrate the increased CSA at the ME level in neuropathic patients whereas Fig. 3 shows a normal CSA value for a non-neuropathic patient.

The sites of measurement of the ulnar nerve were chosen at the ME level as well as 5 cm proximal and 5cm distal to the ME. This is in view of the fact that the other potential sites for compression are between the arcades of Struthers (medial intermuscular septum) proximally and the flexor-pronator aponeurosis distally. However, primary ulnar nerve entrapment by the arcade of Struthers as well as the deep flexor pronator aponeurosis are not as common.<sup>10,11</sup> These findings again are mirrored in the results of this study which showed no statistical difference between the groups at the level 5cm proximal and distal to the ME.

Apart from the anatomical relationship of the ulnar nerve to the surrounding structures that predispose to ulnar nerve neuropathy, the external pressures from neoplasm, ganglia, cyst, trauma, osteophytes, scar tissue and congenital abnormalities such as cubital valgus can lead to compressive ulnar nerve neuropathy.<sup>12</sup> Despite the various reasons, a significant number of patients with ulnar nerve neuropathy are idiopathic in aetiology. In this study, results showed that gender, hand dominance and diabetic status did not appear to influence the occurrence of ulnar neuropathy.



The pathophysiology of the nerve enlargement in ulnar neuropathy seems to be a biological response after compression. It results in inflammation, endoneural oedema, leading to demyelination and axonal degeneration and subsequently fibrosis, growth of new axons, remyelination and thickening of the perineurium.<sup>13</sup> Thicker nerve in turn makes the nerves more vulnerable to injury by entrapment or external pressure, for instance, in cases of habitual elbow leaning.<sup>14</sup>

Magnetic resonance imaging (MRI) is a highly sensitive and specific modality in the diagnosis of ulnar nerve neuropathy.<sup>4</sup> However, it is costly and time consuming as compared to ultrasound. With the advancement of technology and development in ultrasonography, the quality of sonographic image is highly convincing and the peripheral nerves can be depicted with good image resolution. Therefore, we sought to determine the diagnostic value of high-resolution ultrasonography in patients with clinical symptoms of UNN. Electrophysiology studies such as EMG and NCS examinations are useful to diagnose ulnar neuropathy. These tests can define the type of pathology, distinguishing axonal degeneration, segmental demyelination and abnormal nerve irritability from one another.<sup>15,16</sup> However, it is invasive when needle electrode examination is carried out during EMG.<sup>12</sup> In this aspect, ultrasound is deemed non-invasive and convenient in assessing the peripheral ulnar nerve.

In previous literatures, the maximum diameter or short and long axes of the nerve were measured instead of the CSA. Meanwhile, some authors advocate measurements of CSA for more accurate values.<sup>14,17,18</sup> A study has shown the sensitivity and specificity for CSA measurement to be at 93% and 98% respectively.<sup>8</sup> Furthermore, Kutlay et al stated that the nerves have rather inconsistent shapes from round to oval or even triangular. They considered CSA to be a more reliable measurement.<sup>4</sup> Taking into consideration the findings from these previous studies, we employed CSA measurements for our study. Additionally, the mean of three CSA measurements was obtained to reduce the inconsistency of the values.

Several previous literature reviews measured the CSA of the ulnar nerve with elbows in both flexion and extension. The conclusion of these studies revealed significant difference of the CSA values between the two positions. Yoon et al and Kutlay et al evaluated the ulnar nerves in both flexion and extension of the elbow.<sup>14</sup> However, both of their studies showed conflicting results. Yoon et al demonstrated that the mean CSA of the ulnar nerve was greater in those with neuropathy than in the control group, but this was only statistically significant when the elbow was flexed.<sup>1</sup> On the other hand, Kutlay and colleagues found that the degree of ulnar nerve flattening was greater in elbow flexion resulting in the reduction of the CSA.<sup>4</sup> This finding could be attributed by dislocation or subluxation of the nerve during flexion, which alters the morphological appearance of the nerve. In this context, we only scanned patient with arm in extension, as it is known that elbow flexion stretches and elongates the nerve, with a consequent reduction of its diameter.<sup>3,12</sup> The authors acknowledge the limitations in our study as we conducted this study among the population of patients who lived in the proximity of our institution. Regions far from our

medical centre were not included. Moreover, the sample size was small. Hence, the ulnar nerve CSA measurements in the study subjects may not be representative of the entire population in this country.

## CONCLUSION

Results of our study have proven that there was a statistically significant difference in the CSA values of the ulnar nerve at the level of ME for patients with ulnar nerve neuropathy as compared to their counterparts without neuropathy. Additionally, the mean CSA value of the ulnar nerve at ME level in the neuropathic group from this study was above the 0.10cm<sup>2</sup> cut-off point for ulnar nerve neuropathy as determined by previous studies. Hence, high resolution ultrasound is a useful tool to diagnose and follow-up cases of UNN at the elbow.

High resolution ultrasound machines are widely available currently, especially in large diagnostic centers or tertiary hospitals. However, the evaluation of peripheral nerves requires expertise and is operator dependent. The personal training of the operator might be relevant in our local setting.

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