Pathogenesis and electrodiagnosis of cubital tunnel syndrome

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Background Cubital tunnel syndrome is a well-recognized clinical condition and is the second most common peripheral compression neuropathy. This study was designed to investigate the causes of cubital tunnel syndrome by surgical means and to assess the clinical value of the neurophysiological diagnosis of cubital tunnel syndrome.

Methods Twenty-one patients (involving a total of 22 limbs from 16 men and 5 women, aged 22 to 63, with a mean age of 49 years) with clinical symptoms and signs indicating a problem with their ulnar nerve underwent motor conduction velocity examinations at different sites along the ulnar nerve and examinations of sensory conduction velocity in the hand, before undergoing anterior transposition of the ulnar nerve.

Results Electromyographic abnormalities were seen in 21 of 22 limbs [motor nerve conduction velocity (MCV) range (15.9 - 47.5) m/s, mean 32.7 m/s] who underwent motor conduction velocity examinations across the elbow segment of the ulnar nerve. Reduced velocity was observed in 13 of 22 limbs [MCV (15.7 - 59.6) m/s, mean 40.4 m/s] undergoing MCV tests in the forearms. An absent or abnormal sensory nerve action potential following stimulation was detected in the little finger of 14 of 22 limbs. The factors responsible for ulnar compression based on observations made during surgery were as follows: 15 cases involved compression by arcuate ligaments, muscle tendons, or bone hyperplasia; 2 involved fibrous adhesion; 3 involved compression by the venous plexus or a concurrent thick vein; 2 involved compression by cysts.

Conclusions Factors inducing cubital tunnel syndrome include both common factors that have been reported and rare factors, involving the venous plexus, thick veins, and cysts. Tests of motor conduction velocity at different sites along the ulnar nerve should be helpful in diagnosis cubital tunnel syndrome, especially MCV tests indicating decreased velocity across the elbow segment of the ulnar nerve.

References
Osborne referred to the entrapment neuropathy of the ulnar nerve at the elbow as tardy ulnar neuritis in 1957. Feindel and Stratford renamed it cubital tunnel syndrome initially in 1958. The pathogenesis and anterior transposition of the ulnar nerve in cubital tunnel syndrome have been described extensively in the literature, but there have been few reports on cases not only examined neuroelectrophysiologically, but also that have undergone an anterior transposition operation of the ulnar nerve.

METHODS

Patients
Twenty-one patients (involving a total of 22 limbs from 16 men and 5 women, aged 22 to 63, with a mean age of 49 years) suspected of having a problem affecting their ulnar nerve, with clinical symptoms and signs of ulnar distribution or with pain, tenderness, or deformity at the elbow, were subjected to motor conduction velocity examinations at different sites along the ulnar nerve and an examination of sensory conduction velocity in the hand. These patients also underwent anterior transposition of the ulnar nerve.

The average duration of the patients’ condition was from three months to ten years. Among them, 5 patients had a duration of within 6 months, 9 patients had a duration ranging from 7 to 12 months, 4 patients had a duration of more than 12 months.

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ranging from 13 to 24 months, and 3 patients had a duration of their condition of more than 2 years (10 years in 2 cases). Eight patients had a history of elbow trauma.

**Clinical symptoms and signs**

Six patients experienced numbness only in the ulnar lateral to the ring finger and little finger as an initial symptom, and 8 patients also suffered weakness in the same areas. In addition, 6 patients had pain or restriction of movement in the elbow. None of the subjects showed signs of weakness alone as an initial symptom. A general examination revealed hypoesthesia in the little finger and in the ulnar lateral to the ring finger in 21 limbs, hypoesthesia combined with weakness in 13 limbs, and atrophy of the hypothenar or interosseous muscles in 13 limbs. Tenderness or superficial sensations above the ulnar groove upon palpation were observed in 8 limbs, and restriction of action in 8 limbs. X-ray examination of the affected elbows revealed bone hyperplasia in 13 limbs and normality in 7 limbs. In addition, cervical X-rays revealed bone hyperplasia in 3 limbs, with the other limbs all normal.

**Instruments**

The MCVs were performed using a Viking IV electromyography (EMG) machine and an evoked potential (EP) system (Nicolet, USA).

**Methods**

The subjects were asked to lie in a supine position and to relax in a warm, shielded, and quiet room. Their extremity skin temperatures were measured at 32°C or above. The room temperature was kept at 22 - 25°C. Ulnar nerve sensory action potential responses in the hand and motor nerve conduction velocity (MCV) in the upper arm, across the elbow and forearm segments of the ulnar nerve, were recorded bilaterally in all patients.

When recording ulnar sensory nerve action potential responses, both latency and amplitude of the responses were recorded using orthodromic techniques. Needle electrodes were used in the wrists for recording purposes, and Disc Sellar-shaped electrodes were used in the little fingers for the purposes of stimulation.

In recording the MCVs, the recording surface electrodes containing a cavity with conductive material were placed in the abductor digiti minimi, and the reference electrodes were placed 3 cm distally. The stimulation sites were all along the ulnar nerve, with stimulations made in the wrist, 5 cm distal to the medial epicondyle, 5 cm proximal to the medial epicondyle, and in the axilla.

**Statistical analysis**

For this study, an MCV value less than the normal mean value minus two times the standard difference and a latency value greater than the normal mean value plus two times the standard difference, when compared to healthy individuals of the same age, were both considered abnormal.

**RESULTS**

**Surgical observations**

The causes of compression of the elbow segment of the ulnar nerve were found to include hypertrophy of the arcuate ligaments in 9 cases (combined with adhesion in 3 cases), bone hyperplasia in 5 cases, ulnar nerve adhesion to the tissues of the groove in 2 cases, hypertrophic muscle tendons of the flexor carpi ulnaris in one case, expanding venous plexus at the base of the groove in 2 cases, concurrent thick veins along the ulnar nerve inter groove in one case, and cysts inter groove in 2 cases. Except in the case of the one ulnar nerve compressed by a thick vein, which showed little change in appearance, the other nerves inside the ulnar groove appeared pale, dim, and thin, and were swollen proximal to the groove.

**Electrophysiological findings**

Sensory nerve-evoked potentials were examined in 21 patients (22 ulnar nerves). The results indicated that 8 ulnar nerves had normal sensory conduction velocities [{(64.5 - 70.4) m/s, mean 66.8 m/s}]: 14 ulnar nerves had abnormal sensory nerve induced potentials, with no sensory nerve action potential in 12 cases and reduced sensory conduction velocity in 2 cases [{(43.3 - 45.3) m/s, mean 44.3 m/s}].

Motor nerve-evoked potentials were measured in 21 patients (22 limbs). The distal latency values ranged from 2.8 to 9.2 ms, with a mean value of 4.0 ms. All but one case was abnormal. The mean latency of 21 abnormal ulnar nerves was 4.1 ms. The motor conduction velocities of ulnar nerves in the forearm segments ranged from 60.0 to 90.0 m/s, with a mean value of 72.2 m/s in the 8 normal ulnar nerves and with the MCV of 13 ulnar nerves reduced, with values ranging from 15.7 to 59.6 m/s and a mean value of 40.4 m/s. The percent reduction in MCV ranged from 11.0 % to 77.0 %, with a mean value of 39.7 %. All but one ulnar nerve showed reduced MCV in its elbow segment. The reduced MCV values ranged from (15.9 - 47.5) m/s, with
a mean value of 32.7 m/s. The percent of reduction in MCV ranged from 20.3% to 72.0%, with a mean value of 43.8%. The MCV values of the upper arm segments of the ulnar nerves in 12 limbs were recorded, and all were normal.

**DISCUSSION**

Cubital tunnel syndrome is related to the anatomy of the elbow and has been described repeatedly in the literature. The common causes that have been reported include the following: ① Direct compression of the ulnar nerve as a result of thickening of the middle portion of the arcuate ligament, or the ulnar nerve was pulled or fricted during flexion of the elbow joint. Macnicol found this to be the cause of about 50% of the 110 cases of cubital tunnel syndrome that he operated on. In our study, there were 9 (41%) cases of ulnar nerves at the elbow being compressed by the arcuate ligaments, with a prevalence comparable to the prevalences reported of the literature. ② Compression of the ulnar nerve at the elbow by the thickening fiber epineurium of the ulnar nerve at the elbow groove represents the early stage of nerve conduction block and nerve demyelination; prolonging the period of nerve compression leads to a reduction in nerve conduction velocity and a reduction in motor nerve latency. In this study, 12 patients (involving 13 limbs) showed reduced MCV in the forearm segment of the ulnar nerve, with an average reduction of 39.7%. In addition, prolongation of the distal latencies was observed in 21 cases and is thought to correlate with the duration of illness. The MCV values of the upper arm segment of the ulnar nerve were normal in 12 tested limbs, indicating that there was no compression or degeneration of the proximal segment of the ulnar nerve.

Close correlation between elbow trauma and cubital tunnel syndrome has been reported in the literature. In this study, 8 patients had a history of trauma, fewer in percentage than in previous reports. Factors causing cubital tunnel syndrome as a result of trauma may involve regional hemorrhages, edema, fibrosis, bone fracture, or displacement of bone fracture fragments into the cubital tunnel, causing narrowing of the tunnel. Finally, the nerve can degenerate because of compression, pulling, or adhesion.

The diagnosis of cubital tunnel syndrome by electrophysiological methods has been described in many reports. Since the first report by Simpson in 1956 that electrophysiological methods can be used to diagnose cubital tunnel syndrome and other related disorders, Kincaid et al. have reported diagnostic methods and criteria for cubital tunnel syndrome using nerve conduction velocity. In the present study, 21 patients (22 limbs) with cubital tunnel syndrome confirmed by surgical means were diagnosed by clinical presentations and electrophysiological examinations preoperation. All but one showed abnormalities during electrophysiological examination of the ulnar nerve. A reduction in MCV of the ulnar nerve in the elbow segment was observed in 21 ulnar nerves (in 20 patients), with a mean percentage reduction in MCV of 43.8%. Therefore, the reduction in MCV at the elbow segment of the ulnar nerve has definite value for diagnosing cubital tunnel syndrome. This conclusion coincides with other reports that testing conduction velocity of the ulnar nerve at the elbow may diagnose cubital tunnel syndrome. Other authors have proposed that compression of the ulnar nerve in the elbow groove represents the early stage of nerve conduction block and nerve demyelination; prolonging the period of nerve compression leads to a reduction in nerve conduction velocity and a reduction in motor nerve-evoked amplitude in the distal segment of the ulnar nerve. In this study, 12 patients (involving 13 limbs) showed reduced MCV in the forearm segment of the ulnar nerve, with an average reduction of 39.7%. In addition, prolongation of the distal latencies was observed in 21 cases and is thought to correlate with the duration of illness. The MCV values of the upper arm segment of the ulnar nerve were normal in 12 tested limbs, indicating that there was no compression or degeneration of the proximal segment of the ulnar nerve.

In this study, the electrophysiological findings may correlate with pathogenesis. Only one limb produced normal electrophysiological results in the elbow segment of the ulnar nerve. In this case, the nerve was compressed by congestive dilatation of the venous plexus, so the degree of compression was mild and the nerve was normal in appearance. The MCV of the ulnar nerve across the elbow may have been normal because of a shorter duration of illness. Nine limbs showed reductions in MCV of the ulnar nerve at the elbow segment of greater than 50.0%. Of those cases that represented the greatest reductions in MCV, the ulnar nerve at the elbow was compressed by the arcuate ligament (mean reduction in velocity of 61.2%) in 4 cases, by bone hyperplasia leading to tunnel narrowing (mean reduction in velocity of 54.2%).
in two cases, and by the two heads of the flexor carpi ulnaris (mean reduction in velocity of 54.2%) in one case. In two other cases, the ulnar nerve was compressed by a cyst or by adhesion, both leading to reductions in velocity of 51.2%. These results indicate that the ulnar nerve can be compressed more severely when tendons or ligaments are involved. The reason for this may be the sharpness and rigidity of tendons and ligaments or their ability to exert more direct compression. The degree of reduction in MCV across the elbow segment of the ulnar nerve caused by compression due to adhesion was greater than 50%. This may have been due to a longer duration of illness (over 10 years).

In summary, electrophysiological methods are a useful tool for the diagnosis of cubital tunnel syndrome, especially when used to detect reductions in MCV across the elbow segment of the ulnar nerve.

REFERENCES