Median nerve ultrasonography in carpal tunnel syndrome

Carpal tunnel syndrome is the most common mononeuropathy. Patients may present with a variety of symptoms, the most common symptoms being an altered sensation or pain in the hand, wrist and forearm. The pathology relates to compression, entrapment or irritation of the median nerve within the carpal tunnel. The diagnosis may be a clinical one supported by electrophysiological findings. The electrophysiological investigations consist of motor nerve conduction studies, where prolonged distal motorlatency (DML), lower amplitude or the prolonged duration of distal compound muscle action potential (CMAP) are the most sensitive procedures. In sensory neurography low-amplitude and prolonged sensory nerve action potential (SNAP) develop in the early stages. However, later on the SNAP becomes ineluctable. Routine nerve conduction studies present a practical, technically easy, rapid and reproducible investigative method for CTS diagnosis. During the needle EMG, fibrillations and positive waves found in denervations syndromes together with reinnervation changes of motor unit potentials (MUP) are present.

Electrodiagnostic testing can be uncomfortable for patients and time consuming. Furthermore this type of testing has false-positive rates of 10–20% and false-negative rates of 16–34% (Roll et al., 2015). During recent years the use of neuromuscular ultrasonography has increased in orthopedists, neurologists and neurosurgeons. Median nerve ultrasonography is nowadays widely used, the examinations are relatively short lasting, cost-efficient, and tolerated well by patients. In addition, sonographs are portable and easily transported.

The compression of the median nerve in carpal tunnel leads to edema and the proliferation of the fibrous tissue proximal to the compression site, which in turns results in swelling of the nerve and increased cross-sectional area (CSA) in 2D image (Tas et al., 2015).

The most important parameter of median nerve ultrasonography is CSA. If CSA is greater than 10 mm^2, the CTS diagnosis is probable. The second important ultrasonographic parameter is the longitudinal noched or waistline appearance of the median nerve. The compression of the median nerve as it passes under retinaculum flexorum can be observed. The nerve compression could be described with bulbous swelling. Sensitivity of this sign has not been evaluated but the specificity has ranged between 95.8% and 100% (Wang et al., 2008). The third parameter is higher intraneural vascularity. This could be observed on gray-scale imaging and better on Color Doppler with an accuracy rate of 91% for CTS (Malouhi et al., 2006).

There are many risk factors for CTS. These include female gender, obesity, diabetes, hypothyreosis, rheumatoid arthritis and family history. One theory is that increased pressure into the carpal tunnel causes microvascular trauma and results in a lesion of the median nerve and CTS. Most patients with CTS have idiopathic CTS. There are many patients, in whom an ultrasonography of disclosed anatomic abnormalities of carpal tunnel revealed some pathological content. Cartwright et al. (2014) examined 1026 wrists of physically working professionals and found more muscle (muscle intrusion into carpal tunnel) in workers with CTS than in workers without CTS. Ultrasounds revealed hypertrophy of lumbrical muscles or flexor digitorum profundus with a shift of muscle tissue into the carpal tunnel. In patients with painful diabetic neuropathy high-resolution Doppler sonography found diffuse thickening of peripheral nerves with significantly higher CSA of the median and ulnar nerves when compared to normal matched controls. In patients with CTS the same authors found CSA 13.9 mm^2, whereas in matched controls only 7.89 mm^2. There was also significant difference in wrist-forearm ratio (which is the ratio of the CSA of the median nerve at the carpal tunnel with that in the forearm). Neurogenic tumors were found in the carpal tunnel, more schwannomas and in exceptional cases, neurofibroma. In typical cases the tumors are of hypoechoic appearance and used to have continuity with the parent nerve. Ultrasonography is also important in patients with nerve trauma of the wrist and hand. The epineurium could be easily visualized and nerve injury could be classified as axonotmesis, partial or complete transsection. If some posttraumatic complication develops, then ultrasonography is helpful for the detection of scar formation, discontinuity of the epineurium or neuroma. In cases with iatrogenic nerve lesions – e.g. transsection of median nerve muscular branch during the endoscopic CTS surgery – the detection of the nerve lesion is a strong indication for immediate median nerve surgery.

Ooi et al. (2014) investigated their patients with high-resolution Doppler ultrasonography and with sophisticated nerve conductions studies (NCS). The aim of their study was to evaluate the diagnostic performance of grey-scale, color- Doppler, and dynamic ultrasonographic features for diagnosing CTS while using NCS as a standard of reference. The second aim was to validate the relationship between median nerve CSA with the severity of CTS as depicted on NCS. The third task was to validate the interoperator reliability of US in the evaluation of CTS. There were 51 patients with CTS completely evaluated (clinical findings, NCS and ultrasonography). After statistical analysis a positive correlation between CSA at pisiform level and symptom duration was found. No relationship between other US features and chronicity of CTS were found. US disclosed bifid median nerve was found in 4 patients, and tenosynovitis with gouty tophi as the primary cause in another 3 patients. The ability of US to assess the morphology of median nerve and surrounding structures may help avoid severe misdiagnosis of CTS such as tumors that can mimic CTS, especially in patients with atypical neurophysiological findings. The authors are convinced that US measurement of CSA is an accurate means to diagnose the CTS, contributing additional information about the severity of median nerve involvement. They suggest an appropriately designed and standard protocol. US is a reliable and reproducible tool for the subjective assessment as well as an objective evaluation of the median nerve compression.

Fu et al. (2015) evaluated the diagnostic importance of inlet-to-outlet median nerve area ratio (IOR) in patients with clinically and electrophysiologically confirmed CTS. Using ultrasonography, they examined 46 hands in 46 consecutive patients with clinical and electrodiagnostic evidence of CTS and 44 wrists in 44 healthy volunteers. The CSA was measured at the CT inlet (the level of scaphoid-pisiform) and outlet (the level of the hook of the hamate). For each wrist IOR was calculated. Receiver operating characteristic (ROC) curves were use to evaluate the diagnostic value between the inlet CSA and IOR. The mean inlet CSA in healthy controls was 8.7 mm^2 and 14.6 mm^2 in the CTS group. The mean IOR in healthy volunteers (1.0) was smaller than that in patients (1.6). ROC analysis revealed a diagnostic advantage to using the IOR rather than the inlet CSA. An IOR cut-off value of more than 1.3 would yield 93% specificity and 91% sensitivity in the diagnosis of CTS.

It is not clear whether high definition ultrasonography may play a role in the postoperative period. Patients who suffer from persistent or recurring symptoms may have a nerve that is still compressed or has been compressed again. These patients may benefit from a second decompression. If surgical decompression results in median nerve CSA normalizations, this could help select patients who may benefit from the repeat surgery. If the nerve does not change morphologically after surgery, then ultrasonography may not be helpful in distinguishing patients whose nerve is still compressed or has been compressed again and patients whose nerve is decompressed (Tas et al., 2015).

Ultrasonography in patients with CTS is increasingly used. US investigation in patients with neurophysiologically confirmed CTS has the advantage of not only confirming structural changes characterizing the compressed median nerve (especially increased CSA), but also to find another pathology not diagnosed by electrophysiology (e.g. muscle hypertrophy, median nerve bifid, pathological tissue, tumors). US is helpful in patients with problems after CT surgery and in median nerve trauma (including iatrogenic nerve lesions). Ultrasonography of the hand and carpal tunnel is developing and new data is needed for the progressive use of this method.

Billakota and Hobson-Webb present in this issue of Clinical Neurology Practice their large cohort of patients with carpal tunnel syndrome, who were investigated by US and EMG (Billakota and Hobson-Webb, 2017). There is a retrospective analysis. They present a small group of patients (n = 79) with negative EMG and abnormal US studies with the final diagnosis CTS.

Conflict of interest and funding sources

None.

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Available online 18 September 2017