Ultrasonography of Peripheral Nerves
Anatomy and Pathology

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KEYWORDS

• Peripheral nerve • Ultrasonography • Anatomy • Pathology

KEY POINTS

- High-resolution ultrasonography (US) allows swift evaluation of peripheral nerves of the upper and lower extremities.
- Peripheral nerves are characterized by fascicular echotexture, made up of alternated bands of hypoechoic fascicles and hyperechoic epineurium.
- High-resolution US provides morphologic information regarding a variety of nerve abnormalities, including entrapment syndromes, traumatic injuries, polyneuropathies, and neurogenic masses.
- US can improve clinical decision making regarding conservative or surgical treatment.
- US is an important complement to clinical and electrophysiology for the diagnostic assessment of patients with peripheral neuropathies.

INTRODUCTION

Peripheral nerve imaging is an important complement to clinical and neurophysiologic assessment in the evaluation of peripheral nerves. For this assessment, ultrasonography (US) and magnetic resonance (MR) imaging represent the techniques of choice. Conventional MR and its promising techniques, such as MR neurography, diffusion tensor imaging, and fiber tractography,[1] are especially recommended for the settings of deep nerve or central diseases but are not always available and need a long acquisition time. US is the first-choice imaging technique for the assessment of peripheral nerves: it is a low-cost, widely available technique that allows dynamic imaging and evaluation of the entire segment of a nerve during one examination,[1] but it requires a long learning curve and anatomic competence.

ANATOMY AND US TECHNIQUE

The internal structure of the peripheral nerves consists of myelinated and nonmyelinated nerve fibers. Each nerve fiber is embedded in an intimate connective tissue sheath, the endoneurium. Fibers are banded together in nerve fascicles, which are surrounded by the interfascicular perineurium, which consists of perineurial cells and collagen. Nerve fascicles are then bounded by the outer epineurium, which represents the nerve sheath.[2] Nerves differ from each other in size and the number of fascicles.

US images of peripheral nerves correlate considerably with nerve structure (**Fig. 1**), showing, during a long-axis scan, a characteristic fascicular appearance because of the parallel course of nerve fascicles, which look like hypoechoic bands, alternated with hyperechoic bands related to the

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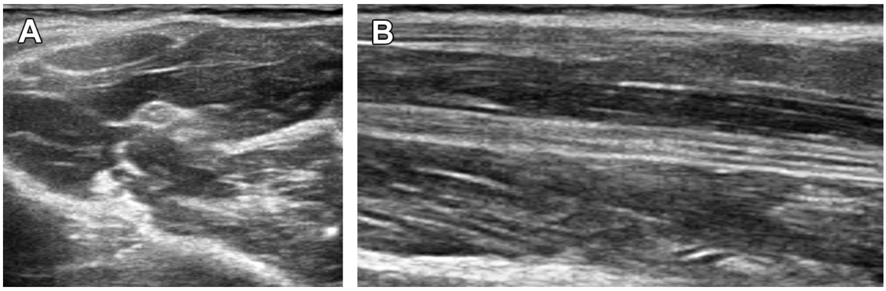

Fig. 1. (*A*) Short-axis scan and (*B*) long-axis scan showing the normal US appearance of a peripheral nerve. Note the characteristic fascicular pattern of the peripheral nerve.

epineurium; a short-axis scan shows the nerve as an oval or round structure with hypoechoic rounded fascicles surrounded by hyperechoic areas of connective tissue.[3]

The analogous hyperechoic appearances of the epineurium and the perineural fat make the nerve contour difficult to define.

Peripheral nerves are mobile structures, and during US dynamic examination, they can slip over the surface of an artery, tendon, or muscle. Nerves are less susceptible to anisotropy than tendons, so tilting the probe does not change the appearance of the nerve.[3]

Deep technical skills and anatomic knowledge are necessary for a good scanning technique. US of peripheral nerves requires a linear high-frequency (center frequency >10 MHz) transducer. A US scan begins in the short axis and proceeds by moving the transducer proximally and distally, using an elevator technique, to assess the entire course of the nerve.[3] In particular, it is important to evaluate the size, shape, and texture of the nerve and the appearance of adjacent structures. Longitudinal US evaluation of the nerve is subsequently performed. It is then possible to perform a dynamic examination, which can show nerve instability or compression in relation to muscle contraction or movement of the joints.

US can show nerves that are in a superficial position and are not covered by bone structures; however, it cannot visualize deep nerves or a nerve course under bony structures, such as cranial nerves, nerve roots exiting in the dorsal, lumbar, and sacral spine, sympathetic chains, and the splanchnic nerves in the abdomen.

ANATOMIC VARIANTS

The importance of anatomic variants of peripheral nerves is related to the patient's symptoms and the surgical treatment plan.

The most frequent variant found in clinical practice is the bifid median nerve at the wrist,[4,5] which consists of 2 contiguous bundles of fascicles within the carpal tunnel (**Fig. 2**).

The bifid median nerve can be associated with the persistent median artery, which originates from the ulnar artery at the proximal forearm and passes close to the median nerve throughout the forearm and carpal tunnel. This accessory artery can also occur with a normal nerve.

Nerve variants also include an unusual course, such as the C5 root, which runs in front of the anterior scalene muscle.[6]

There are several extrinsic abnormalities that may determine nerve compression. An example is the supracondylar process, which may occur with Struthers ligament, which inserts on the medial epicondyle of the distal humerus, forming an osteofibrous tunnel, in which the median nerve and brachial artery pass and may predispose to entrapment syndrome. Moreover, there are several anomalous muscles that may entrap a nerve; for example, the chondroepitrochlearis and the anconeus epitrochlearis may both cause compression of the ulnar nerve, respectively, at the axilla and at the elbow.[7] The Gantzer muscle is an accessory head of the flexor pollicis longus that can determine entrapment of the anterior interosseous nerve in the proximal forearm.[7] A proximal tendon and a distal muscle bell characterize

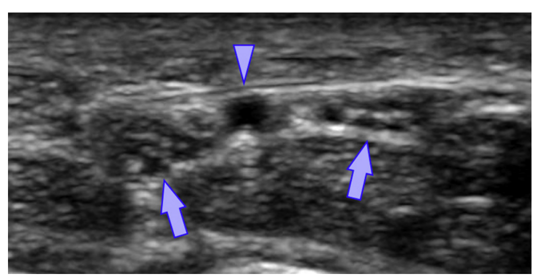

Fig. 2. Grayscale transverse US image of the bifid median nerve. Note the 2 contiguous bundles of fascicles (*arrows*) within the carpal tunnel. *Arrowhead*, persistent median artery.