Highlights

- MR imaging of the peripheral nerves (also referred to as MR neurography) is technically demanding and critical elements may include high field strength, high spatial resolution and 3D sequences
- The etiology of neuropathy includes trauma, inflammation, neoplasia and hereditary disorders and MR imaging features can be useful in documenting and discriminating these conditions
- MR imaging of abnormal peripheral nerves includes the following features, which may occur in isolation or combination: fluid-like signal hyper-intensity, enlargement (focal or diffuse), and loss of a normal fascicular appearance
- MR imaging muscle signal alteration can document denervation in the acute setting with the presence of edema-like signal subsumed by a particular nerve distribution, subacute setting with mixed edema and fatty streaks, and the chronic setting with complete/near complete fatty replacement.
- MR neurography can influence medical decision making in terms of diagnostic confidence and timing of surgery
- DTI may be useful for in vivo assessment of peripheral nerve regeneration

Introduction

The specific application of Magnetic Resonance (MR) imaging for nerve imaging is known as MR Neurography (MRN) and attempts the direct imaging of nerves using routine and special modifications of pulse sequences.

Technical elements

Neuromuscular imaging with MR neurography can be challenging technically because of requirements for high spatial resolution sometimes over an extended field of view such as an entire extremity unless the lesion or symptoms are well localized. Thus the concept of a "target zone" is useful to tailor protocols for high resolution portions. The trend is to use 3T MRI because of increased signal to noise ratio (SNR). The use of surface coils combinations may be needed to cover the entire region of interest or to evaluate distal muscles innervated. The availability of 3D isotropic pulse sequences avoids multiple 2D planar acquisitions and facilitates arbitrary reconstruction planes along and orthogonal to the structures of interest. The administration of intravenous contrast material is selectively used for mass lesions, post-operative situations or inflammatory conditions. Novel MRI techniques including diffusion-weighted imaging (DWI) and diffusion tensor imaging (DTI) may have a role in MR Neurography. DTI parameters such as FA (fractional anisotrophy) and radial diffusivity may be indicators of nerve regeneration.

Indications

The general indication for MR Neurography is a suspected peripheral nerve dysfunction and is complementary to electrodiagnostic testing. Broad categories of indications include confirming a diagnosis (e.g. brachial neuritis), elucidating pathoanatomy (e.g. thoracic outlet syndrome), establishing the location of a lesion for (e.g. nerve avulsion for pre-surgical planning), to evaluate unexplained neuromuscular symptoms (e.g. extra-spinal sciatica with a normal lumbar spine MRI) or to exclude a neoplasm (e.g. neurofibroma).

Pathologies

MR imaging findings may be related to nerve, muscle or compressive etiology (tumor, pathoanatomy or predisposing variant). Normal peripheral nerves will often although not invariably show a fasicular appearance on axial images. Contrast enhancement cannot always distinguish different pathoetiologies of neuropathy and is more likely to be abnormal with an inflammatory or neoplastic etiology. Endoneurial fluid increases when a nerve is compressed, irritated or injured, leading to nerve image hyperintensity with a fluid sensitive sequence. Acute axonal nerve lesions cause a hyperintense signal on STIR or T2-weighted images at and distal to the lesion site corresponding to Wallerian degeneration. Denervation produces a non-specific muscle edema-like signal alteration. Muscle signal alteration occurs as early as 72 hours of denervation. Muscle atrophy is a late finding likely reflecting disuse. Fatty replacement (retained bulk and contour of muscle with fibers replaced by fat) is associated with neuromuscular etiologies (neurogenic or myogenic) or inflammatory myopathies. The MR imaging signal changes are reversible when the recovery of motor function occurs as a result of further muscle innervation.

Tumor related neuropathy may be caused by a primary nerve neoplasm or a lesion compressing or infiltrating the nerve. Peripehral nerve sheath tumors (PNST) include neurilemmoma (schwanoma) and neurofibroma. The majority of PNST lesions are benign. Malignant PNST (MPNST) typically occurs in the setting of neurofibromatosis. It may be difficult for MR imaging to distinguish benign from malignant PNST even with DWI. Larger heterogeneous appearing lesions that have changed over time, either by clinical symptoms or imaging features suggests MPNST. Compressive lesions include non-neoplastic tumors (ganglions, hematoma), benign neoplasms (osteochondromas) or malignant neoplasm (sarcoma) that residing along the course of a nerve or within a fibro-osseous tunnel. Nerve infiltration and invasion may occur from lymphoma or metastatic neoplasm.

Conclusion

Successful neuromuscular imaging with MR neurography requires high quality imaging systems optimized for imaging peripheral nerve and muscles, disease focused radiologists and referring providers with well-formed clinical questions. A decision support system can help observer performance by organizing and facilitating the diagnostic task with feature detection checklist providing cues for MR imaging findings, an ontology describing relationships of findings to syndromes/disorders and structured report generation for effective communication.

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