High Resolution Sonography: Anatomy and Pathology of the Cervical Plexus

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Authors: T. Moritz¹, C. Pivec², D. Lieba-Samal¹, H. Platzgummer², G. Bodner¹; ¹Vienna/AT, ²Wien/AT
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Learning objectives

1) Describe the Anatomy and Ultrasound-anatomy of the cervical plexus

2) Describe typical Ultrasound signs of small nerve pathology

3) Present exemplary cases of cervical plexus nerve pathology.
Background

Anatomy:

The cervical plexus (CP) is formed by the cervical nerve roots C1 to C4. It supplies the head and neck region with sensory innervation through several nerves, namely the minor occipital, the auricularis magnus, the transverse cervical, and the supraclavicular nerves.

With its Radix motoria the CP also supplies motor innervation to several muscles in the head and neck region, however, the most relevant being the phrenic nerve formed out of the C3 to C5 roots that gives motor innervation to the diaphragm.

The cervical ansa arises from C1 to C3 and gives - while its major part supplies the infrahyoid muscles - contributions to the hypoglossus nerve (XII). Anastomoses to the spinal accessory nerve (XI) do also exist.

Pathology:

Different factors such as external pressure, trauma, dissection, immobilisation or metabolic changes can lead to the dysfunction of a peripheral nerve.

The mechanical mechanisms of nerve injury have been classified by Seddon (see also Figure 4):

- Neuropraxia: Temporary loss of conduction without loss of axonal continuity
- Axonotmesis: Loss of continuity of axon and myelin sheath, epi-/perineural structures preserved
- Neurotmesis: Disruption of the entire nerve fiber

Pathologic conditions of the nerves around the cervical plexus do occur quite common, however, as they are difficult to diagnose these conditions may often be overlooked and therefore be underreported. Specific reasons for neuropathies of the cervical plexus most commonly involve trauma, traction injury and iatrogenic injury, inflammatory conditions of both the nerve itself and/or the surrounding tissue. Depending on the affected nerve and the degree of involvement, the clinical signs do vary between neuropathic pain, numbness, weakness, paralysis or muscle atrophy.

Keeping these facts in mind, a quick and precise diagnosis is very important in these patients. Recent developments in High-Resolution Ultrasound (HRUS) offer the potential for substantial improvement in this regard.
High-Resolution Ultrasound Imaging Technique:

Nerves are cable-like structures that consist of axons surrounded by myelin-sheaths and Schwann-cells. Several of these nerves form a fascicle, several fascicles form a nerve. The fascicles are surrounded by the epineurium. The echostructure of a nerve can be seen in Figure 3.

Important features to look for in suspected peripheral nerve pathology are:

1. Fascicular swelling
2. Increase in nerve diameter
3. Nerve discontinuity
4. Increased intraneural vascularisation
5. Disturbed mobility in relation to the surrounding tissue
6. Altered contact to the surrounding tissue (e.g. scarring)
7. Correlation with patient symptoms (e.g. positive Tinel sign).

Pathologic findings in HRUS should be correlated to the clinical findings. A dynamic documentation using examination loops is strongly emphasized to increase the confirmability of the HRUS findings.
Findings and procedure details

1 - Phrenic nerve

The phrenic nerve arises from the C3 to C5 roots and runs downwards on the surface of the anterior scalene muscle and then passes beneath the omohyoid and transversus colli muscle to descend posterior to the subclavian vessels to enter the thorax.

The best location to identify the phrenic nerve using HRUS is the anterior surface of the anterior scalene muscle (See Figure 1).

Figure 2 and 3 show images of a 72-year-old patient that complained about pain and an upraised diaphragm on the left hand side after thyroid surgery. HRUS images demonstrate a diffusely thickened left phrenic nerve on the surface of the anterior scalene muscle, representing traction injury. No discontinuity or focal neuroma was found. Symptoms disappeared in the course of several months under conservative measures.

2 - Greater Auricular Nerve

The Greater Auricular Nerve (GAN) arises from the C2 and C3 roots of the CP and innervates the skin in the area of the outer ear, the parotid gland region and the area of the mastoid process.

After its origin it runs beneath the sternocleidomastoid muscle until it reaches its anterior border where it winds around and continues on its surface to the region of the outer ear. The nerve can be followed using HRUS for almost its entire course (see Figure 4).

Figures 5 and 6 show the case of a 45-year old patient who complained of massive pain around the left ear during head movements after a whiplash injury. HRUS images again show a marked swelling of the left auricularis magnus nerve in comparison to the contralateral side.

3 - Spinal Accessory Nerve

The Spinal Accessory Nerve (CN XI) exits the skullbase through the jugular foramen and then obliquely backwards beneath the digstric and stylohyoid muscle from where it
reaches and then pierces the upper part of the sternocleidomastoid muscle. Thereafter it crosses obliquely across the posterior neck triangle and ends in the fascial plane beneath the trapezius muscle.

Pathology of this nerve most commonly occurs due to iatrogenic injury during neck dissections or lymph node exstirpations. The latter is the case in the next patient presenting with paralysis of the trapezius muscle on the right-hand side after exstirpation of a suspicious lymph node that turned out to be benign. The HRUS images demonstrate extensive scarring in the course of the spinal accessory nerve.

4 - Supraclavicular Nerves

The supraclavicular nerves (medial, intermedial, lateral) originate from C3 and C4, then run beneath the sternocleidomastoid muscle to emerge at its posterior border. From there they descend beneath the Platysma and the deep cervical fascia to the posterior cervical triangle. They become subcutaneous in vicinity of the clavicle and provide sensory innervation to the skin of the clavicular, pectoral and shoulder region. The Sonanatomy is presented in Figure 9.

Neuropathy of these nerves most commonly occurs in trauma, especially fractures of the clavicle, or after iatrogenic injury during local surgery or nerve blockades. In Figure 10 a patient is presented who complained about strong persistent pain in the pectoral region after a fracture of his clavicle with surgical reposition. In the video you can see the supraclavicular nerves (marked in yellow) running into a large scar (marked in red).
Fig. 1: Sonographic anatomy of the phrenic nerve in the posterior cervical triangle.

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**Fig. 2:** HRUS images of a 72-year-old patient that complained about pain and an upraised diaphragm on the left hand side after thyroid surgery. HRUS images demonstrate a diffusely thickened left phrenic nerve on the surface of the anterior scalene muscle, representing traction injury.

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**Fig. 3:** Illustrated HRUS images of a 72-year-old patient that complained about pain and an upraised diaphragm on the left hand side after thyroid surgery. HRUS images demonstrate a diffusely thickened left phrenic nerve on the surface of the anterior scalene muscle, representing traction injury.
Fig. 4: Sonographic anatomy of the greater auricular nerve in the posterior cervical triangle.

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Fig. 5: HRUS images of a 45-year old patient who complained of massive pain around the left ear during head movements after a whiplash injury. HRUS images again show a marked swelling of the left auricularis magnus nerve in comparison to the contralateral side.

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Fig. 6: Illustrated HRUS images of a 45-year old patient who complained of massive pain around the left ear during head movements after a whiplash injury. HRUS images again show a marked swelling of the left auricularis magnus nerve in comparison to the contralateral side.

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Fig. 7: Sonographic anatomy of the spinal accessory nerve.

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Fig. 8: Patient presenting with paralysis of the trapezius muscle on the right-hand side after extirpation of a suspicious lymph node that turned out to be benign. The HRUS images demonstrate extensive scarring in the course of the spinal accessory nerve.

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Fig. 9: Sonographic anatomy of the supraclavicular nerves in the posterior cervical triangle

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Fig. 10: patient complained about strong persistent pain in the pectoral region after a fracture of his clavicle with surgical reposition. In the video you can see the supraclavicular nerves (marked in yellow) running into a large scar (marked in red).

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Conclusion

Due to its high spatial resolution and flexibility, High-Resolution Ultrasound is a powerful tool for small nerve imaging, also in the anatomical area of the cervical plexus. It should therefore be used in the evaluation of patients with suspected small nerve neuropathy.
Personal information

Thomas Moritz, MD is a resident at the Department of Biomedical Imaging and Image-guided Therapy (formerly Department of Radiology), Medical University of Vienna.

His main area of interest is both the diagnostic and therapeutic use of High Resolution Ultrasound in peripheral nerves and musculoskeletal applications.
References


