Imaging in Pudendal Neuropathy

Poster No.: C-2319
Congress: ECR 2013
Type: Educational Exhibit
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Keywords: Diagnostic procedure, Ultrasound, MR, Neuroradiology peripheral nerve, Interventional non-vascular, Trauma, Athletic injuries
DOI: 10.1594/ecr2013/C-2319

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Learning objectives

The purpose of this educational exhibit is to:

1) Describe typical clinical features of pudendal neuropathy
2) Describe the Imaging Anatomy of the pudendal nerve
3) Describe typical Ultrasound & MRI signs of nerve pathology
4) Present exemplary cases of pudendal nerve pathology.
Background

Pudendal Neuropathy

The pudendal nerve is a mixed nerve carrying sensory, motor and autonomic fibres. Patients with pudendal neuropathy typically present with pain in the genital, perineal, and anorectal region. It may present unilateral or bilateral, the pain may even radiate to the proximal thigh.

Affected patients usually have a high degree of suffering not only due to the sometimes massive pain itself, but by the impairment of sexual activity and daily activity in general (e.g. sitting).

Pudendal Neuropathy (PNE) is generally considered as a rare disease. However, the diagnosis is frequently delayed or the condition is misdiagnosed. Unnecessary surgery because of PNE (e.g. spine surgery) is not uncommon in these patients.

Typical causes for PNE include pelvic trauma and nerve entrapment, especially between the sacrotuberous and sacrospinous ligaments or by compression of the nerve as it courses through Alcock’s canal. Other causes are direct injuries to the pudendal nerve, typically from cycling with inadequate bicycle seats, iatrogenic damage, especially during pelvic surgical procedures or due to traction in lower limb orthopedic procedures, infectious damage to the nerve, tumors compressing or infiltrating the nerve, sometimes Tarlov cysts or radiation for cancer in the pelvic region (e.g. rectal cancer).

Commonly, affected individuals have long patient careers with consultation of multiple physicians and multiple diagnostic and therapeutic procedures. Keeping this fact in mind, a quick and precise diagnosis is especially important an at the same time challenging in these patients.

Recent developments in both High-Resolution Ultrasound (HRUS) and Magnetic Resonance Imaging (MRI) offer the potential for substantial improvement in this regard.

Pudendal Nerve Anatomy
The pudendal nerve (PN) arises from the S2 to S4 roots of the sacral spine. The PN runs medially and caudally of the sciatic nerve and enters the pelvic region through the infrapiriform canal and the greater sciatic foramen.

It then runs between the sacrospinous and the sacrotuberous ligament. It the descends into the ischiorectal fossa where it runs in a duplication of the fascia of the obturator internus muscle, the so-called Alcock's canal. It is accompanied by the pudendal artery. In this area it branches into the three branches of the neurovascular bundle: the inferior rectal nerve, the perineal nerve, and the dorsal nerve of the clitoris/penis.

The inferior rectal nerve supplies the area around the anus and provides motor innervation to the external anal sphincter.

The second branch is the perineal nerve. It provides sensation to the perineum and the posterior surface of the labia majora. It also provides motor innervation to the perineal muscles, the bulbospongiosus, the ischiocavernosus, the sphincter urethra, and the levator ani muscles.

The dorsal nerve of the clitoris/penis carries sensory information from the clitoris/glans penis.

Note that although the anatomy of the pudendal nerve is well outlined, a great variation exists, especially in the ischiorectal fossa.

General Nerve 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:

- 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

Imaging Technique

Sonomorphology of peripheral nerves
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 2.

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

(see also Figure 3)

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).

**Basic principles of MRI nerve imaging**

MR is able to visualize the peripheral nerves and the surrounding tissues. For the visualization of small peripheral nerves, a sophisticated examination protocol is needed. A careful patient history and clinical and apparative examination (ENG, Ultrasound) is important to exactly determine the examination region.

The standard examination protocol includes T1-w sequences for morphological analysis and fluid sensitive fat-suppressed T2w-sequences (e.g. turbo inversion recovery with magnitude (TIRM, Figure 4), short tau inversion recovery (STIR)). Furthermore, High-Resolution fast 3D Gradient Echo sequences are used to image the nerve ultrastructure.

Normal peripheral nerves appear isointense compared to muscle tissue and present with fascicular pattern. Damaged nerve tissue have an elevated T2-signal. Disruption of fibres or surrounding tissue can be depicted ot T1w sequences.

An important finding in acute and subacute nerve damage is the elevated T2w-signal of corresponding denervated muscles. Chronic denervation of muscles leads to a fatty atrophy (see Figure 5).
Fig. 1: Short introduction Video to Pudendal Nerve Anatomy and typical Entrapment Sites

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Fig. 2: Typical echostructure of a peripheral nerve (in this case the median nerve). It is easy to depict the nerve fascicles (1) and the surrounding epineural stuctures (2)
Fig. 3: Typical Ultrasound features of nerve pathology

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**Fig. 4:** Fluid sensitive fat-suppressed T2w-sequence shows nerve edema of the sciatic nerve on the right side (black arrows) compared to the normal left side (white arrows).

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Fig. 5: T2w image shows fatty muscle atrophy of gluteus medius and minimus and tensor fasciae latae muscle after gluteus medius injury with chronic muscle denervation.

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Imaging findings OR Procedure details

Case 1:

A 55-year-old male is presenting with chronic pain in the penis and scrotum, especially while sitting or during sexual intercourse. The pain starting immediately after a pelvic surgical procedure (tranurethral sling procedure) performed for mild incontinence about 10 years ago. 6 years ago the sling was removed, with no improvement of symptoms.

A High-Resolution sonography is performed transperineal (see Figure 6). The perineal nerve is depicted close to the inferior ramus of the pubic bone. A zone of circumscribed nerve thickening and a positive Tinel-sign is seen close to a structure in the bone resembling a screwhead.

An additional X-ray of the pelvis is performed and several screws can be depicted in the inferior ramus of the pubic bone (see Figure 7).

The intraoperative view (Figure 8) upon screw removal and neurolysis confirms the close proximity of the nerve (left image, arrow) to the screws (left image, arrowheads) in the pubic bone (asterisk). Fascicular swelling and fibrosis of the nerve can be seen in the image on the right (arrow).

The patient showed a marked improvement of the symptoms postoperatively.

Case 2:

A long-time cycle racing professional presents with increasing pain in the penis and scrotum on both sides (more on the left side), especially during exercise. A Magnetic Resonance examination is performed.

The T2-weighted image (Figure 9) shows marked fibrosis in the area of the pubic ramus canal (white arrowheads), a finding very typical in pudendal neuralgia associated with cycling.

Upon neurolysis the fibrotic changes around the pudendal nerve in the pubic ramus canal can be seen. After nerve release, the fascicular swelling of the entrapped nerve can be depicted (Figure 10).
Case 3:

Three months after a transvaginal hysterectomy a 50-year-old female patient is complaining of severe pain in the clitoris and labia minora on both sides.

The MRI examination reveals scarring in the perineal diaphragm on both sides marked with arrowheads (Figure 11). Corresponding US image on the right side shows a thickened pudendal nerve and surrounding fibrotic tissue (Figure 12).

Case 4:

A 37-year-old female complains about sudden-onset pain in the perineal region on both sides (accentuated on the right-side), especially while standing. MRI and US of the pudendal nerve are normal. However, two cystic lesions can be seen around the S4 nerve root, representing Tarlov-cysts (Figure 13). Be aware that these cysts may expand in an upright position.

Subjects having such cysts are usually asymptomatic. However, the literature reports a rate of symptomatic Tarlov cysts at a little more than 10%. These cysts can be aspirated with imaging guidance under sterile conditions.

Case 5:

A 53-year old male is presenting with pain in the right perineal region radiating to the proximal medial thigh after a blunt trauma to the right buttock, exacerbated while sitting. The MRI shows a marked thickening of the pudendal nerve in between the sacrotuberous and sacrospinous ligament. These changes could well be posttraumatic or exacerbated by trauma in this region.
Fig. 6: High-Resolution Sonography of the pudendal nerve (yellow) demonstrates marked thickening of the nerve near a screwhead (red) at the inferior ramus of the pubic bone (blue).

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Fig. 7: Xray of the pelvis confirms several residual screws in the pubic bone.

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Fig. 8: Left: Intraoperative view demonstrates the close proximity of the nerve (arrow) to the screws (arrowheads) in the pubic bone (asterisk). Right: Marked fascicular thickening and fibrosis of the pudendal nerve can be seen (arrow).

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**Fig. 9:** The T2-weighted image shows marked fibrosis in the area of the pubic ramus canal (white arrowheads)

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Fig. 10: Fibrotic changes around the pudendal nerve in the pubic ramus canal can be seen (left). After nerve release, the fascicular swelling of the entrapped nerve can be depicted (right).

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**Fig. 11:** Axial T2w MRI examination reveals scarring in the ischiorectal fossa on both sides (arrowheads) in the area of the perineal branches of the pudendal nerve.

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Fig. 12: US image on the right side shows a thickened pudendal nerve and beginning fibrotic changes in the surrounding tissue

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Fig. 13: Video of an MRI-examination demonstrating Tarlov cysts in a female patient with increasing perineal pain that gets pronounced in upright position. The examination shows an otherwise inconspicuous nerve course.

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**Fig. 14:** High-Resolution PD-weighted MRI shows thickening of pudendal nerve fibers in between the sacrospinous and sacrotuberous ligament when compared to the normal side.

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Conclusion

MRI and US have great potential in detecting and characterising peripheral nerve pathology. Both techniques have their unique value and strongly complement each other in this respect.

Therefore, both modalities should be combined for the diagnosis and treatment planning in suspected peripheral nerve pathology. Both US and MRI should be used for a quick diagnosis in patients with suspected Pudendal Neuropathy.
References


Personal Information

Thomas Moritz, MD is a resident at the 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.