Ultrasound-guided injections in pelvic entrapment neuropathies

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Abstract

Pelvic entrapment neuropathies represent a group of chronic pain syndromes that significantly impede the quality of life. Peripheral nerve entrapment occurs at specific anatomic locations. There are several causes of pelvic entrapment neuropathies, such as intrinsic nerve abnormality or inflammation with scarring of surrounding tissues, and surgical interventions in the abdomen, pelvis and the lower limbs. Entrapment neuropathies in the pelvic region are not widely recognized, and still tend to be underdiagnosed due to numerous differential diagnoses with overlapping symptoms. However, it is important that entrapment neuropathies are correctly diagnosed, as they can be successfully treated. The lateral femoral cutaneous nerve, ischiadic nerve, genitofemoral nerve, pudendal nerve, ilioinguinal nerve and obturator nerve are the nerves most frequently causing entrapment neuropathies in the pelvic region. Understanding the anatomy as well as nerve motor and sensory functions is essential in recognizing and locating nerve entrapment. The cornerstone of the diagnostic work-up is careful physical examination. Different imaging modalities play an important role in the diagnostic process. Ultrasound is a key modality in the diagnostic work-up of pelvic entrapment neuropathies, and its use has become increasingly widespread in therapeutic procedures. In the article, the authors describe the background of pelvic entrapment neuropathies with special focus on ultrasound-guided injections.

Introduction

Entrapment neuropathy is caused either by extrinsic nerve compression (mass, inflammation, scarring etc.) or intrinsic nerve abnormality (neurogenic tumor, intraneural ganglion cyst etc.)[1,2]. The condition presents as a shooting or burning sensation associated with tingling and numbness in the cutaneous innervation area. Symptoms usually worsen during the night or in the morning due to static limb position for a prolonged period of time. In the early stages, the symptoms are intermittent, but later pain usually becomes constant and more intense[3]. Entrapment neuropathies in the pelvic region represent a group of chronic pain syndromes that significantly impede the quality of

life and affect both genders[4]. The nerves most frequently causing entrapment neuropathies in the pelvic region are the lateral femoral cutaneous nerve, ischiadic nerve, genitofemoral nerve, pudendal nerve, ilioinguinal nerve, and obturator nerve (Fig. 1)[5]. Entrapment neuropathies in the pelvic region are not widely recognized, and still tend to be underdiagnosed due to numerous differential diagnoses with overlapping symptoms. The symptoms may be poorly localized, producing a complex clinical picture which can be difficult to distinguish from more common non-neurological causes of pain[6].

Diagnosing entrapment neuropathies in the pelvic region is challenging, and detailed patient history with high
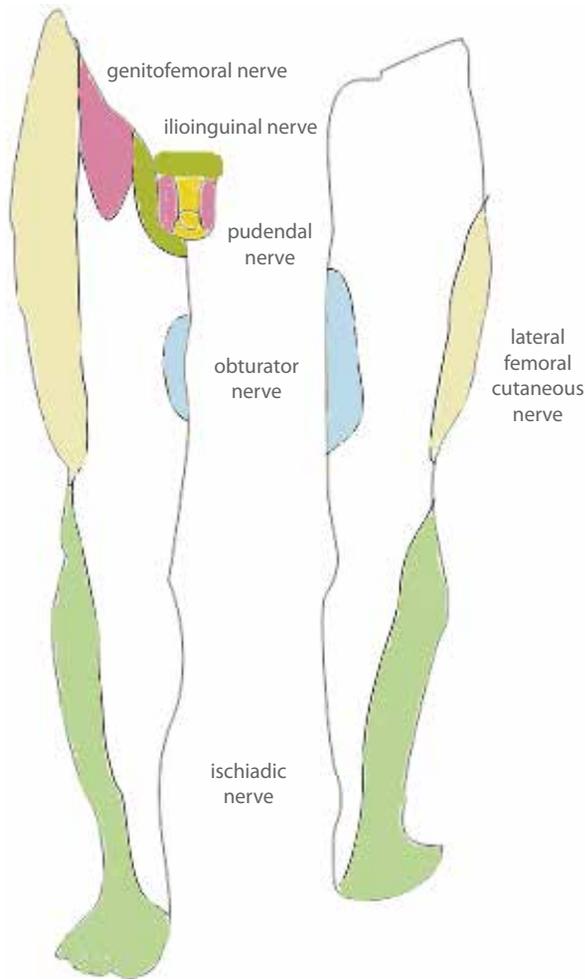
Fig. 1. *Peripheral nerve distribution of the lower extremity*

clinical suspicion is of great importance[2,7]. Different imaging modalities play an important role in the diagnostic work-up. Ultrasound (US) offers superior spatial resolution compared to magnetic resonance imaging (MRI), allowing visualization even at the fascicular level[8]. US is advocated in the examination of superficially located nerves, whereas MRI should be utilized for the evaluation of deep lying nerves. A further advantage of US is real-time imaging, which makes it a useful tool for image guidance. US is an important imaging modality in the diagnostic work-up as well as a treatment guidance tool for pelvic entrapment syndromes[9–11]. Ultrasound-guided injections can be divided into diagnostic and therapeutic procedures. Diagnostic procedures are performed with a local anesthetic in order to confirm the diagnosis, while therapeutic procedures involve adjunct substances, most commonly corticosteroids, to initiate treatment[12]. In the following manuscript, we present the most common entrapment neuropathies in the pelvic region with an emphasis on US-guided treatment.

Meralgia paresthetica

The lateral femoral cutaneous nerve (LFCN) is a sensory nerve innervating the outer thigh[13]. Entrapment in the vicinity of the inguinal ligament presents clinically as meralgia paresthetica, with tingling, numbness and burning pain in the innervation area of the LFCN[3]. The reported incidence in the general population is 4.3 per 10,000 patients annually[14,15]. The condition is more common in obese and pregnant patients[14]. Meralgia paresthetica occurs after 0.4% of vaginal deliveries[16].

US is advised as the first imaging option, as it can depict the LFCN in its superficial course at or distal to the spina iliaca anterior superior. MRI and computed tomography (CT) offer poor differentiation of the LFCN. However, they should be considered in diagnostic dilemmas in order to exclude other causes of meralgia paresthetica, especially deep tumors that could irritate the nerve. Upon US examination, immediate perineural injection may be provided to confirm the suspected diagnosis or deliver treatment[17]. US depiction of the LFCN is critical for successful injection. The LFCN can be visualized by positioning the high-frequency linear transducer approximately 2 cm inferior and medial to the anterior superior iliac spine, and tracking the nerve caudally, as it courses over the sartorius muscle and further down in the subcutaneous fat just lateral to the sartorius muscle. Tracing the nerve both cranially and caudally helps to localize the course of the nerve. The LFCN separates into its branches caudally and the region just proximal to the branching is the optimal location to prevent block failure[1,11,13,18]. The needle is advanced towards the LFCN in plane with the transducer by penetrating the skin and subcutaneous fat (Fig. 2).

Studies have shown a high degree of symptom resolution after US-guided perineural injections of the LFCN[11,18]. Perineural injections are predominantly performed with a mixture of a local anesthetic and corticosteroids. Usually, injections are performed consecutively over the course of a few visits and injections at multiple levels along the LFCN to improve the outcome[18]. In the study by Tagliafico *et al.*, 80% of patients reported the resolution of symptoms after the first injection, while all patients reported symptom resolution after the second injection[19]. In the study by Klauser *et al.*, complete symptom resolution was documented in 75% of patients, while partial resolution was documented in the remaining 25% at 12-month follow-up[18]. Scarce reports on US-guided ablation techniques, such as alcohol neurolysis and pulsed radiofrequency ablation, have been described in the literature as good treatment options[20,21].

Piriformis syndrome

The schiatic nerve is a mixed nerve passing the gluteal region and the posterior thigh before branching into the fibular and tibial nerves in the popliteal fossa. The schiatic nerve innervates the muscles of the posterior thigh, entire lower leg and foot. The schiatic nerve innervates the cutaneous region of the foot and the lateral aspect of the lower leg via the fibular and tibial nerves[22,23]. In the gluteal region, the nerve runs anteriorly to the piriformis muscle, where it can be compressed (i.e. the piriformis syndrome) [24]. The estimated prevalence of the piriformis syndrome
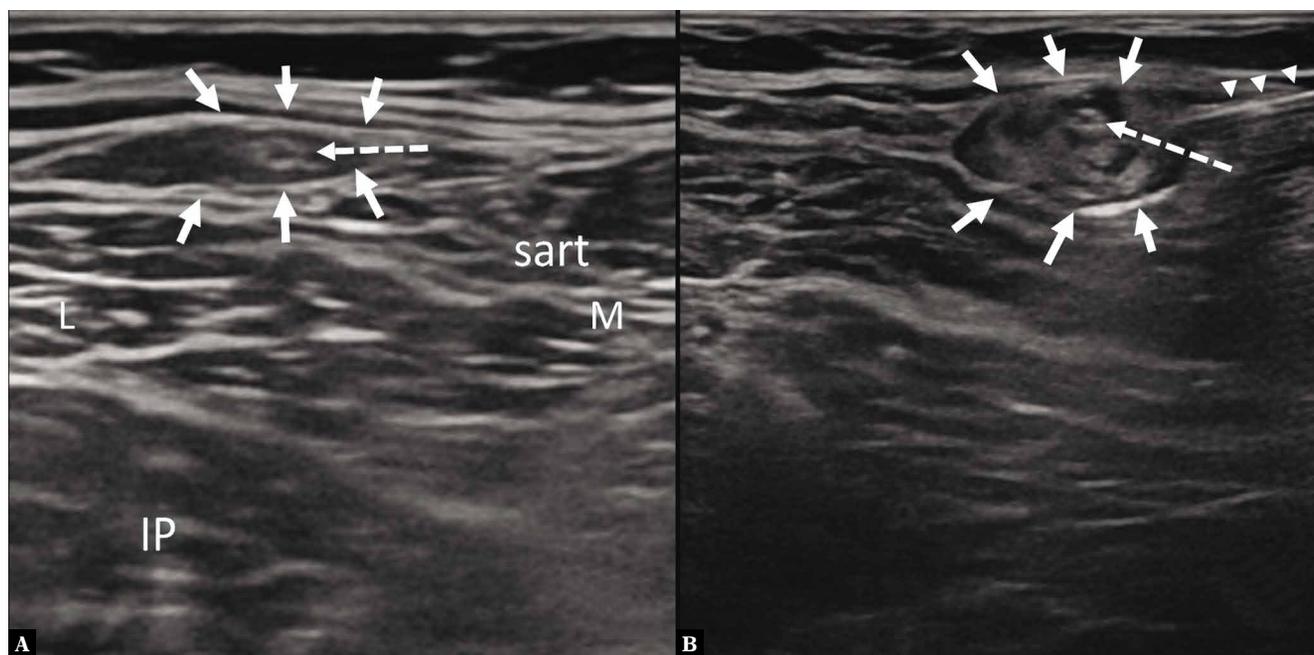
Fig. 2. A. *Axial ultrasound image of the lateral thigh, showing lateral femoral cutaneous nerve (LFCN; hatched arrows) above the sartorius muscle (sart). Iliopsoas muscle (IP), (arrows) fat pad.* **B.** *Ultrasound-guided perineural needle positioning (arrowheads) with spread of the medication within the fat pad (arrows). L – lateral, M – medial*

varies from 5 to 8%, although the actual rate is probably higher due to the overlap in the clinical presentation with other conditions[25]. It is estimated that nearly one in five patients with chronic buttock and low back pain suffer from the piriformis syndrome[26]. The female to male ratio is reported as 6:1[27].

The schiatic nerve and the piriformis muscle are well depicted with US; an important prerequisite for image-guided treatment[28–30]. US guidance is preferable to other image-guided modalities due to its simplicity, reliability,
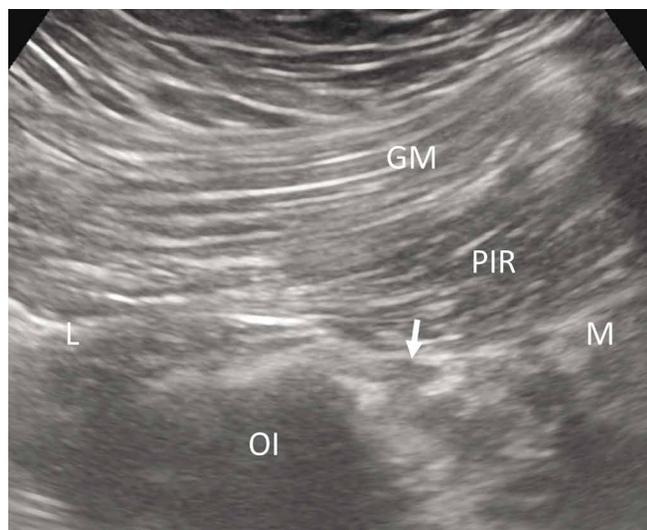

Fig. 3. *Ultrasound image showing the anatomic relations between the gluteus maximus (GM), piriformis muscle (PIR), the sciatic nerve (arrow) and os ischium (OI). L – lateral, M – medial*

and absence of ionizing radiation[27,31]. Piriformis muscle enlargement may be seen in patients with piriformis syndrome[22,32–34]. US-guided treatment can be directed either towards the intramuscular or perineural injection deposition[35,36]. Treatment is predominantly directed toward intramuscular injection with a goal of achieving piriformis muscle atrophy and, consequently, reducing nerve compression. The aim of perineural injection deposition is to achieve perineural hydrodissection of the schiatic nerve[37]. In order to perform US-guided injection, the low frequency curvilinear transducer is placed over the upper third of the buttock, where the piriformis muscle is depicted in the long axis and schiatic nerve just anterior to it. The sciatic nerve may be difficult to differentiate from the surrounding tissues, thus probe tilting may improve nerve visualization. The needle is advanced towards the piriformis muscle in plane with transducer by penetrating the skin, subcutaneous fat, and the gluteus maximus muscle. If schiatic nerve hydrodissection is attempted, the needle is progressed through the muscle until perineural position of the needle tip (Fig. 3)[36,38]. In the publication by Chang *et al.*, a video presentation of the US-guided injection provides good visualization of the procedure[39].

Studies on US-guided treatment of the piriformis syndrome have shown safety and good symptom relief[27,37,38]. According to Aquino-Jose *et al.*, successful US-guided injection of a short-acting local anesthetic into the piriformis muscle leads to pain relief for up to 48 hours[38]. In a randomized controlled trial, no difference in outcome was observed between intramuscular deposition of a local anesthetic and corticosteroid versus local anesthetic only, which gives the idea that piriformis syndrome is mostly muscular in origin, and corticosteroids do not give an
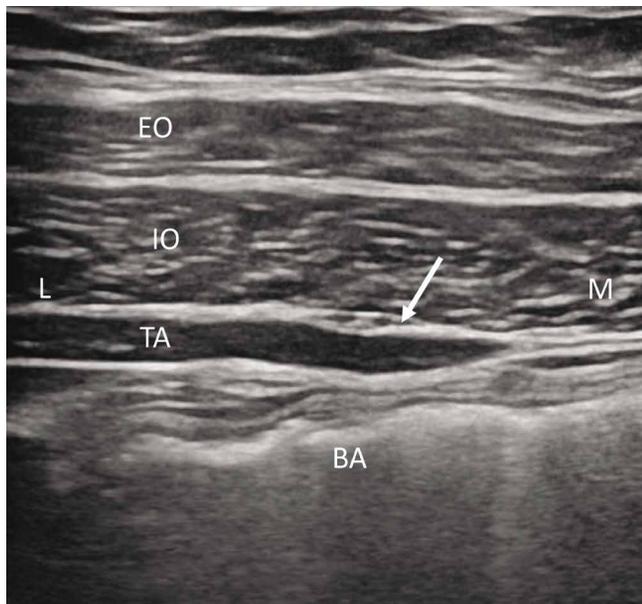
Fig. 4. *Ultrasound image showing anatomic relations between external oblique muscle (EO), internal oblique muscle (IO) and transversus abdominis muscle (TA). Arrow is depicting neurovascular bundle in the course of the ilioinguinal nerve, the injection for should be performed in its plane. (BA) bowel air. L – lateral, M – medial*

additional benefit[27]. Intramuscular injection of botulinum toxin into the piriformis muscle has shown good symptom relief for up to 4 months[40,41]. Schiatic perineural hydrodissection with sterile saline followed by therapeutic corticosteroid injection offers good symptom relief for up to 1 month[37].

Genitofemoral neuralgia

The genitofemoral nerve is a mixed nerve innervating the sensory and motor portions of the cremasteric reflex. The genital and femoral branches typically split superiorly to the inguinal ligament, but variations are common[42]. The genital branch provides sensation to the labia majora and mons pubis in women, and to the scrotum in men. The femoral branch innervates the skin in the femoral triangle, which is located in the superomedial part of the anterior thigh[17,43]. Genitofemoral neuralgia is mostly reported after an iatrogenic lesion. The reported incidence after laparoscopic hernia repair is 2%[44].

The diagnosis can be made based on the clinical presentation of pain, parethesias, and a burning sensation[45]. However, accurate diagnosis is difficult due to very similar clinical presentations of the iliohypogastric and ilioinguinal nerves, which innervate the transitional area between the abdomen and the lower extremity[5,44,45]. Diagnostic or therapeutic US-guided nerve block can be performed on different levels in order to block the nerve or its branches seperately. To block the genital branch, a high-frequency linear US transducer is oriented perpendicular to the inguinal ligament approximately 2 cm lateral to the pubic tubercle. The genital branch is not directly

visualized, but the external iliac artery with the inferior epigastric branch is easily found and the genital branch is immediately adjunct to the inferior epigastric artery[5]. In males, the approach may be simplified, as the genital branch travels within the spermatic cord with the testicular artery[5,46,47]. The femoral branch is blocked by depositing injection just medial to the the common fermoal artery just before bifurcation. Care must be taken that the deposit is low in volume in order not to spread the injectate toward the femoral nerve[47–49].

There are only small sample size studies on US-guided treatment reporting promising results. In a case report by Shanthanna *et al.* (2014), a mixture of a local anesthetic and corticosteroid led to pain relief persisting for 3 months[50]. US-guided ablation techniques such as radiofrequency and microwave ablation have shown good symptom relief, too[51,52]. Lee *et al.* (2019) retrospectively reported complete symptom resolution at 12-months' follow-up after US-guided microwave ablation[51]. Terkawi *et al.* (2014) showed good symptom relief at 7 months after US-guided pulsed radiofrequency ablation of the genital branch[52].

Ilioinguinal neuralgia

The ilioinguinal nerve is a mixed nerve with motor innervation of the transversus abdominis and external oblique muscles[5,53]. The sensory innervation area covers the inguinal region to the iliac crest, the penis, and the upper part of the scrotum in males, or the mons pubis and labia majora in females[54]. Most commonly, lesions of the ilioinguinal nerve are due to a iatrogenic cause in lower abdominal surgeries[55]. Herniorraphy surgeries result in severe ilioinguinal neuralgia in 2%, while the incidence of ilioinguinal neuralgia after laparoscopic gynecological surgery with fascial closure is 4.9%[55,56].

US-guided nerve block is usually performed to the ilioinguinal and iliohypogastric nerves simultaneously due to an overlap in clinical presentation[5,44,45]. MRI is helpful in order to exclude lumbar radiculopathies and potential masses in the course of the nerve[57,58]. In order to depict the ilioinguinal nerve, a high-frequency linear transducer is placed over the anterior superior iliac spine and slowly moved along the anterior superior iliac spine – umbilicus line. In the deep fascial layer, the ilioinguinal nerve lies between the internal oblique and transverse muscles, lateral to the iliohypogastric nerve at the level of the anterior superior iliac spine. With the in-plane technique, a needle is advanced through the subcutaneous tissue, and the external and internal oblique muscles towards the fascial plane between the internal oblique muscle and the transversus abdominis muscle[54,59,60]. It needs to be noted that precise nerve targeting is not essential, as the injection will spread in the fascial plane between the internal oblique muscle and the transversus abdominis muscle, where the sensory nerves from T6 to L1 spinal roots innervate the anterolateral abdominal wall, including the ilioinguinal nerve. In anesthesiology, the infiltration in the described fascial plane is reffered to as the transverse abdominis plane (TAP) block[61,62]. Differences in the analgetic result have been

Fig. 5. *Ultrasound image showing anatomic relations between (IS) ischial spine, sacrospinous ligament (arrows) and internal pudendal artery (hatched arrow). The pudendal nerve is deep lies adjunct to the internal pudendal artery. L – lateral, M – medial*

described depending on the approach (lateral, posterior or subcostal) is used for performing the TAP block (Fig. 4)[61].

There are several studies on perioperative analgesia, however only a few reports on chronic pain treatment are available[63–66]. In a case series in patients with chronic abdominal wall pain, Baciarello *et al*. reported symptom resolution up to 12 months after performing the TAP block[67]. In a retrospective study involving patients with chronic postherniorraphy groin pain, Trainor *et al*. (2015) showed good symptom resolution after ilioinguinal nerve block with a mixture of a local anesthetic and corticosteroid performed with either landmark-based or ultrasound guidance. However, the study showed no superiority in outcomes[63].

Pudendal neuralgia

The pudendal nerve is a mixed nerve with motor innervation to the perineal musculature, and the external urethral and anal sphincter. It also innervates the cutaneous region of the external genitalia, anus and perineum. Pudendal neuralgia is also referred to as Alcock's syndrome due to the passage of the pudendal nerve through the Alcock's canal in the pelvis[5,6,17]. The incidence is approximately 1/100,000[66,67], although the actual rate is probably higher[46,68,69]. Women are more frequently affected than men[69].

The diagnosis of pudendal neuralgia can be very difficult, thus high suspicion is warranted in order to achieve the correct diagnostic work-up[70,71]. According to the Nantes criteria published by Labat *et al*., at least five clinical presentations must be present in order to diagnose pudendal neuralgia: (1) pain in the pudendal nerve innervation area, (2) predominantly while sitting, (3) not present during the night, (4) without any objective sensory impairment, and (5) relieved after the pudendal nerve block[72]. US-guided

injections represent the best diagnostic and treatment options[5,73]. MRI is considered in diagnostic dilemmas in order to exclude structural abnormalities in the course of the pudendal nerve[68,74]. Anterior and posterior approaches exist for US-guided injections. In the posterior approach, the patient lies supine and a high-frequency linear transducer is placed in the middle third of the buttocks in order to visualize the ischial spine. The sacrospinous ligament attaches to the ischial spine and sacrotuberous ligament lies over the sacrospinous ligament. Between these two ligaments, the pudendal nerve lies next to the pudendal artery. The needle is advanced towards the pudendal nerve in plane with the transducer by penetrating the skin, subcutaneous fat and the gluteus maximus muscle. In the anterior approach, the patient is positioned in lithotomy position, and a transducer is placed lateral to the vulvar/scrotal junction with rectum in an oblique sagittal or transverse position[75]. At this position, the ishiopubic ramus of the ischial tuberosity is visualized and with the aid of color Doppler the pudendal neurovascular bundle can be depicted. The branches of the pudendal nerve course in the proximity of the internal pudendal artery[5,75]. The needle is advanced towards the artery in plane with the transducer by penetrating the skin, subcutaneous fat and superficial transverse perineal muscle. In both approaches, the artery or the vicinity of the artery is targeted, thus prior injecting aspiration is recommended in order to confirm the extravascular position (Fig. 5). In the paper by Chang *et al*., a video presentation of the US-guided injection provides good visualization of the procedure[39].

The US-guided approach is superior to other methods in terms of simplicity and correct detection of the target structures[75]. The dominant treatment option is US-guided pudendal nerve block using a local anesthetic[76,77]. Hong *et al*. reported good symptom relief in two patients for up to 10 months after US-guided pudendal nerve block with a local anesthetic[76]. A randomized controlled trial by Bellingham *et al*. showed that injections with a mixture of a long-acting local anesthetic and corticosteroids performed either by fluoroscopic or US guidance are equally effective[78]. Due to the vicinity of the sciatic nerve, a temporary adverse effect of numbness or foot drop may develop following the injection[73].

Obturator neuralgia

The obturator nerve is a mixed nerve with motor innervation to the thigh adductor muscles and cutaneous innervation of the medial aspect of the thigh. Obturator nerve entrapment, also referred to as obturator tunnel syndrome, is most frequently associated with trauma, sport injuries, and childbirth[5,79,80]. Obturator neuralgia accounts for 1.6% of all nerve palsies in total hip arthroplasty[81].

The diagnosis of obturator neuralgia is usually established on the basis of electromyography and nerve conduction studies[80]. US imaging is useful for the diagnosis as well as treatment because of high reliability and simplicity[9,49]. MRI and CT examinations are advised to exclude tumors or to
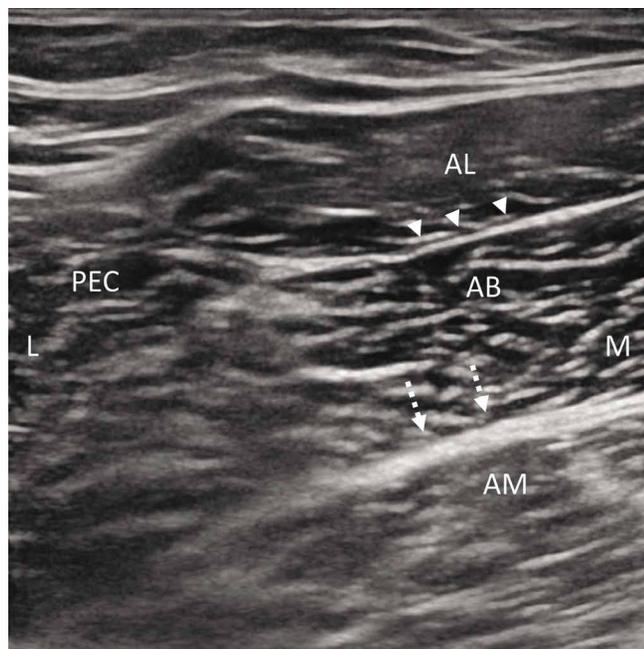
Fig. 6. *Ultrasound image shows anatomic relations between adductor muscles. The anterior branch of the obturator nerve lies within fascia (arrowheads) between the adductor longus muscle (AL) and adductor brevis muscle (AB). The posterior branch of the obturator nerve lies within fascia (hatched arrows) between the adductor brevis (AB) muscle and adductor magnus muscle (AM). L – lateral, M – medial*

present muscle atrophy innervated by the obturator nerve[80]. Nerve injection may be performed at different levels. In the distal approach, the anterior and posterior branches of the obturator nerve are blocked separately by two injections, whereas in the proximal approach a single injection blocks both branches[82]. In the distal approach, the patient lies supine, with the thigh slightly abducted and externally rotated. A high-frequency linear transducer is placed at the inguinal crease in order to visualize the pectineus, adductor longus, adductor brevis and adductor magnus muscles. The needle is directed towards the fascia between the adductor

longus in order to block the anterior branch of the obturator nerve. Afterwards, the needle is advanced towards the fascia between the adductor brevis and the adductor magnus muscles in order to block the posterior branch of the obturator nerve. In the proximal approach, the patient is positioned similarly as in the distal approach. The transducer is placed in the pubic region between the femoral vein and the pubic tubercle in the sagittal plane in order to visualize the superior pubic ramus, the obturator externus muscle, and the pectineus muscle. The needle is directed in plane with the transducer towards the fascia between the pectineus and the obturator externus muscles (Fig. 6)[82,83].

US-guided obturator nerve block is technically easy, with very high success rates[84,85]. Good symptom relief may be achieved with US-guided perineural injections with a mixture of a local anesthetic and corticosteroids[83,84,85]. In the case report by Shankar *et al*. (2008), a patent with posttraumatic obturator neuralgia showed complete symptom resolution at 5 months after US-guided injection of an anesthetic and corticosteroid[83].

Conclusions

Pelvic entrapment neuropathies are not widely recognized, and still tend to be underdiagnosed due to numerous differential diagnoses with overlapping symptoms. However, it is important that entrapment neuropathies are correctly diagnosed, as they can be successfully treated. The ultrasound is a key modality in the diagnostic work-up of pelvic entraptment neuropathies, and it is also becoming increasingly important in therapeutic procedures.

Conflict of interest

The authors do not report any financial or personal connections with other persons or organizations which might negatively affect the contents of this publication and/or claim authorship rights to this publication.

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