



## REVIEW

# Ultrasound guided chronic pain interventions (Part I)

## Ultrason eşliğinde kronik ağrı girişimleri (1. bölüm)

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### Summary

Recently, ultrasonography (US) is an indispensable imaging technique in regional anesthesia practice. With the guidance of US, various invasive interventions in chronic pain pathologies of the musculoskeletal system, peripheral and neuroaxial pathologies has become possible. The management includes diagnostic blocks as well as radiofrequency ablation and institution of neurolytic agents. During these algologic interventions we are able to see the target tissue, the dispersion of the drug and all nearby vascular structures. Besides these the US also protects the team from ionic radiation that one encounters when using fluoroscopy or computed tomography. Latest publications in this field show that applicability of US in chronic pain syndromes is rapidly expanding with a good future. The additional equipment (echogenic needles, 3-D US etc.) will also expand its applications in algology practice. This review highlights different applications of US in chronic pain conditions.

Keywords: Chronic pain; nerve blocks; ultrasound.

### Özet

Son zamanlarda rejyonal anestezi pratiğinde ultrasonografi (US) vazgeçilmez görüntüleme tekniği olarak yerini almıştır. Ultrasonografi ile kas/iskelet, periferik ve nöroaksial bölgelerin kronik ağrılı patolojilerde çeşitli invaziv girişimler yapmak olasıdır. Bu girişimler diagnostik bloklar, radyofrekans uygulamaları ve nörolitik ajanların uygulamaları olarak özetlenebilirler. Algolojik girişimler esnasında US; hedef dokuların görüntülenmesinde, uygulanan ilacın yayılımında, çevredeki vasküler yapıların görüntülenmesinde büyük kolaylıklar sağlar. Ayrıca US ile floroskopi veya bilgisayarlı tomografi uygulamaları esnasındaki radyasyon yayılımı söz konusu değildir. Kronik ağrı girişimlerinde US ile yayınlanan klinik çalışmalar umut vericidir. Ayrıca son yıllarda bu alandaki gelişmeler (ekojen iğneler, üç boyutlu US cihazları vd.) US'nin algoloji pratiğindeki kullanımının daha da yaygınlaşacağını düşündürmektedir. Bu derlemenin amacı, US eşliğinde yapılan çeşitli kronik ağrı girişimlerini gözden geçirmektir.

Anahtar sözcükler: Kronik ağrı; sinir blokları; ultrason.

## Introduction

Ultrasonography (US) has been performed in various fields of medicine for a long time, recently it has become available for various interventions of regional anesthesia. However, it has not made into routine use in algology practices yet.

US is an imaging device which utilizes sound waves between 2–22 MHz frequency; the sound reflects from parts of the tissue and these echoes are recorded and displayed as an image.<sup>[1,2]</sup> Tissues that transmit these sound waves easily (fluid or blood)

create minimal echoes (hypoechoic), whereas tissues that transmit less of these sound waves (like fat and bone) create intense echoes (hyperechoic). Hypoechoic areas are visualized black and hyperechoic areas are visualized white on the screen. B mode, M mode and Doppler modes are commonly used in routine pain practice. B mode (brightness) enables real-time visualization of tissues. M mode (motion) is used for visualization of mobile structures (heart, valve, vascular structures, diaphragm motion). Doppler mode is used for evaluation of blood flow.<sup>[3,4]</sup>

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Compared to conventional anatomical landmark method, fluoroscopy and CT techniques, US applications have many advantages. The biggest advantage is that while visualizing blockage needle, target tissue and the injected material in real-time, patient is not subjected to harmful effects of radiation. Additionally, use of contrast material during radiological imaging poses some risks to the patient. Easy identification of the target tissue especially during nerve blockade reduces application time and time for initiation of block; therefore it increases both the patient's and provider's satisfaction.<sup>[5]</sup> Additionally, US allows repeat imaging non-invasively. Thus, it enables determination of typical and atypical anatomical and structural anomalies that stem from individual differences, and allows planning prior to intervention.<sup>[6,7]</sup>

Hence US can readily be performed at the point of care, it has increasingly been favored by the provider, progressively increasing its use in daily practice. For pain clinics where fluoroscopy has essentially been used as the imaging device, US provides a new perspective. Despite known limitations of fluoroscopy (weight, radiation exposure, requirement for a technician, etc.), it also has advantages like visualization of bone structures in particular.

US can be more advantageous compared to fluoroscopy especially during peripheral nerve blockade owing to direct visualization of muscle, tendon, ligament, vascular and bone structures. Introduction of echogenic block needles into practice has strengthened its place in this field. In addition, US enables dynamic measurements, allowing "real time" positioning of target tissue. Thus, target tissue can be visualized from different angles, and the intervention can be made in the most appropriate position. Additionally, the ability to differentiate various tissues (vessel, diaphragm, etc.) by US may prevent complications such as intravascular injection and pneumothorax during nerve blockade.<sup>[8]</sup>

Although US applications have remarkable advantages, there are some limitations of its utilization. For example, acoustic shadows of bone structures may prevent visualization of structures behind,<sup>[9]</sup> or, though deep structures can be visualized with convex probe, image resolution may be compromised. These limitations may be alleviated as performer's experience

increases. However, it takes time to gain sufficient experience. In addition, US practice necessitates detailed sonoanatomy knowledge, which requires a serious anatomy education. In the recent years, ESRA (European Society of Regional Anesthesia) and ASRA (American Society of Regional Anesthesia) have published recommendations related to education on US applications in regional anesthesia.<sup>[10]</sup>

There is particularly not enough experience related to US practice in permanent interventions like ablation, phenol and alcohol application among chronic pain interventions. On the other hand, pulsed RF applications seem promising in US utilization, since it is less invasive and can be repeated as required.

Although no absolute contraindications for US use have been reported, it is thought that ultrasound energy results in tissue heating, and small gas pockets (cavitation) may form in tissues due to this reason. However, long-term clinical effects of tissue heating and cavitation is not known yet.<sup>[11]</sup>

In pain treatment, US is used in interventions performed on peripheral nerves, neuroaxial structures and musculoskeletal structures. These common interventions are listed below:

*Musculoskeletal interventions:* Joint injections, Ligaments, Peritendinous injections, Intramuscular Botox injection, Bursa injection, Lavage.

*Peripheral interventions:* Greater occipital nerve block, intercostal nerve block, Suprascapular and axillary nerve blocks, Iliohypogastric/ilioinguinal nerve block, Lateral femoral cutaneous nerve block, Pudendal nerve block, saphenous nerve block.

*Neuroaxial interventions:* Stellate ganglion block, Cervical and lumbar spine procedures (nerve root, facet periarticular, medial branch), Thoracic paravertebral block, Caudal epidural, Ganglion impar block, sacroiliac joint injections.

### **Musculoskeletal interventions in chronic pain**

In musculoskeletal interventions, the performer should have a thorough understanding of normal and abnormal sonographic appearances of the anatomical structures. These structures can often be differen-

tiated by their echogenicity, compressibility, anisotropy and Doppler flow characteristics.<sup>[12]</sup> In chronic pain treatment musculoskeletal interventions that are frequently performed under US guidance include calcific tendinitis lavage, pulsed radiofrequency, botulinum toxin or sclerosing agent injection, trigger point injections.

US is used for diagnostic purposes in conditions related to shoulder such as bursitis, calcific tendonitis, septic arthritis and impingement syndrome. Additionally, during intraarticular injections to subacromial bursa or glenohumeral joint for treatment purposes, US increases the chance to apply it to target area precisely by 94%.<sup>[13]</sup>

For elbow, US is commonly used for diagnosis of lateral and medial epicondylitis, synovitis, triceps tendon injury, septic arthritis, effusions or entrapment neuropathies and for effusion aspiration.<sup>[14]</sup> For wrist, US has been used for diagnosis of anatomical anomalies like bifid median nerve and for therapeutic interventions.<sup>[15]</sup>

US has been found quite useful in trochanteric pain during interventions in hip joint, in interventions related to knee joint and plantar fascia.<sup>[16]</sup>

For interventions in knee joint, US has limited use due to limited visualization of cruciate ligament, meniscopathy and fractures.<sup>[14]</sup> For interventions related to ankle, US has been used in interventions to lesions such as Morton ganglioma and plantar fasciitis.<sup>[17]</sup>

### Peripheral interventions

**Blockade of trigeminal ganglion and its branches:** Today fluoroscopy is still commonly used in orofacial pain interventions. However, lateral pterygoid plate, maxillary artery and pterygopalatine fossa can readily be visualized with US. Nader et al. performed trigeminal nerve blockade in 15 patients with US (4 mL of bupivacaine 0.25%, one mL of steroids were injected).<sup>[18]</sup> In all patients, pain subsided after 5 minutes following blockade. Analgesic period was described to last for up to 15 months.

**Greater occipital nerve blockade:** Greater occipital nerve (GON) arises from the dorsal primary ramus of the second cervical nerve with contribution from

the third cervical nerve. It supplies sensory innervation to the medial portion of the posterior scalp as far anterior as the vertex. GON blockade is used in various type of headaches like migraine, occipital neuralgia, cervicogenic headache, postdural puncture headache (PDPH) with generally favorable clinical outcomes.<sup>[19,20]</sup> For a long time, GON blockade has been performed by classical approach using anatomical landmarks (Figure 1). In one related study, 10 patients who received GON pulsed radiofrequency (PRF) by classical landmark technique due to occipital neuralgia were followed up for 7.5 months on average, and their pain scores decreased to 0.8 after PRF from 6.9.<sup>[21]</sup> Additionally 80% of the patients discontinued their analgesic use.

In our clinic, we prefer GON blockade technique described by Greher et al. using new anatomical landmark<sup>[22]</sup> (Figure 2). This new proximal technique has some important advantages over the classical

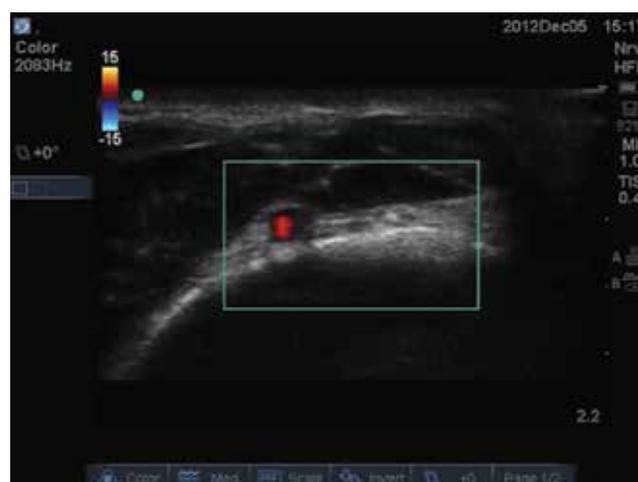


Figure 1. Greater occipital nerve and artery.

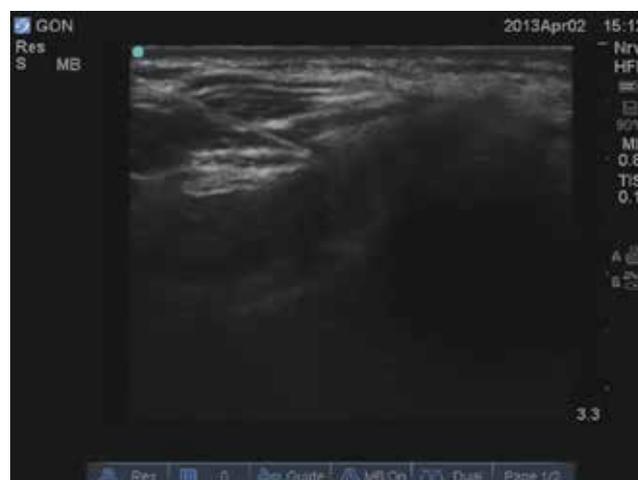
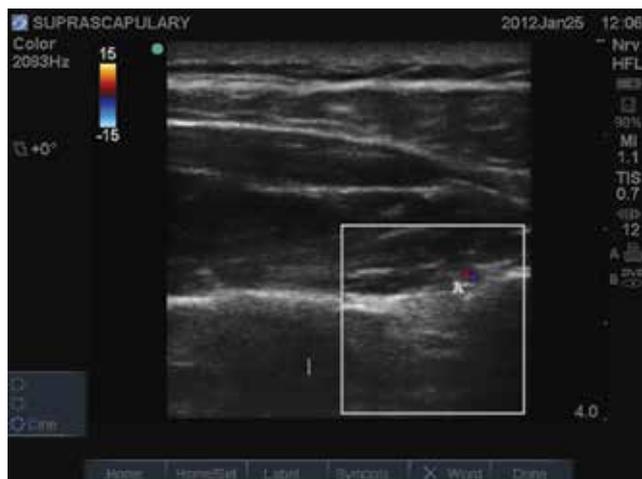


Figure 2. GON blockade (New approach).



**Figure 3.** Anatomic landmarks for suprascapular nerve blockade.



**Figure 5.** Intercostal nerve blockade.



**Figure 4.** Anatomic landmarks for axillary nerve blockade (H: Humerus; CA: Circumflex artery; PDM: Posterior part of the deltoid muscle; AN: Axillary nerve).

one. Greater occipital nerve is located deeper, just superior to obliquus inferior capitis muscle, additionally spinous process of C2 vertebrae can easily be visualized. Pain caused by irritation of the bone during classical technique is not encountered with this approach. In this proximal technique, the nerve can easily be visualized. Additionally, greater occipital artery and vertebral artery can also be visualized with Doppler technique.

**Suprascapular and axillary nerve blockades:** In painful clinical conditions like frozen shoulder, shoulder osteoarthritis, malignancy of upper lobe of lung (Pancoast tumor), suprascapular nerve blockade yields highly successful outcomes. Suprascapular and axillary nerves supply major innervation of the shoulder. These two nerves can readily be visualized with US<sup>[23]</sup> (Figure 3). Visualizing suprascapular notch is essen-

tial during suprascapular nerve blockade. Suprascapular notch can show quite different anatomical variations.<sup>[24]</sup> Blockade can be performed with success by visualization of superior transverse scapular ligament, suprascapular artery and nerve. Blockade of axillary nerve together with suprascapular nerve under guidance of US yields good patient satisfaction and postoperative analgesia in rotator cuff operations.<sup>[25]</sup> Axillary nerve blockade is particularly very effective in pathologies of proximal humerus. There are successful reports of suprascapular nerve PRF in various shoulder pathologies; however, clinical studies related to axillary nerve is limited.<sup>[26]</sup> During US guided axillary nerve blockade, posterior circumflex humeral artery can be used as a landmark (Figure 4).

**Intercostal nerve blockade:** The intercostal nerves supply skin and musculature of chest and abdominal wall. Intercostal nerves are mixed sensory-motor nerves. Apart from various acute pain conditions, intercostal blockade is also effective in many chronic pain situations (Intercostal neuralgia, Post-mastectomy Syndrome, Post-thoracotomy Syndrome, Post-herpetic neuralgia). Bhatia et al. compared anatomical landmark and US guided intercostal blockade techniques in cadavers.<sup>[27]</sup> They reported it is possible to perform more successful blockade using less volume of dye with US. During intercostal blockade with US, costae, pleura, internal and external intercostal muscles can easily be visualized (Figure 5). Additionally, intercostal artery can easily be visualized with Doppler, which provides great convenience. In various pain syndromes intercostal pulsed RF applications can provide successful analgesia that lasts for approximately 6 months.<sup>[28]</sup>

**Ilioinguinal and Iliohypogastric nerve blockades:** These nerves originate from Th12 and L1. Following lower abdominal operations and particularly inguinal hernia operations, intractable neuropathic pain may develop along the trace of these nerves. Possibly more than one mechanism are responsible for these pain, like direct nerve trauma also accompanied by neuroma and scar tissues. Trace of ilioinguinal (ILI) and iliohypogastric (ILH) nerves may show important anatomical variations. Failure rates in classical anatomical landmark techniques are 10-45%.<sup>[29]</sup> Wrong guidance of blockade needle can result in femoral nerve blockade, pelvic hematoma and bowel perforation. During visualization of these nerves with US, external, internal oblique (EO, IO) and transverse abdominal (TA) muscles can easily be seen. ILI and ILH nerves trace along the fascial plane between IO and TA muscles (Figure 6).

**Genitofemoral nerve blockade:** The genitofemoral nerve (GF) arises from L1 and L2 nerve roots. GF nerve divides into genital and femoral branches above the level of the inguinal ligament. The point of division is variable. GF nerve mainly provides cutaneous innervation. It provides motor innervation only for cremasteric muscle. Genitofemoral neuralgia is an iatrogenic injury usually observed following operation to the inguinal region. Genitofemoral neuralgia is a neuropathic pain syndrome manifested as scrotal pain in men and pain in labium major and mons pubis in women.<sup>[30]</sup> It is not easy to visualize the genital branch with US when it is in inguinal canal. In men, genital branch may trace inside or outside spermatic cord. It is possible to visualize the femoral branch easily just over mons pubis.

**Lateral Femoral Cutaneous Nerve Block:** Lateral femoral cutaneous nerve (LFCN) provides sensory innervation to the antero-lateral part of leg up to the knee. Complex of pain, numbness, tingling and paresthesia symptoms observed in this area is described as Meralgia Paresthetica. In one cadaveric study, LFCN blockade was performed at high rate as 84.2% using US guidance, however this rate was 5.3% with classical landmark technique.<sup>[31]</sup> Fowler et al. performed US guided PRF (42°C, 2x120 second) in a patient diagnosed with Meralgia Paresthetica who was unresponsive to various treatments.<sup>[32]</sup> They reported excellent pain relief in controls at 1.5<sup>th</sup> and 3<sup>rd</sup> month. Authors report US provides great convenience in identification of LFCN. LFCN can be visualized in



**Figure 6.** Ilioinguinal and iliohypogastric nerve blockade (ILHY: Iliohypogastric nerve; ILIO: Ilioinguinal nerve; A: Artery).

various ultrasonographic patterns (hyperechoic, hypoechoic or mixed type) along its trace that shows great variations (under or through the inguinal ligament or over the iliac crest).

**Piriformis muscle injection:** Piriformis muscle originates from the level of S2–S4 and exits the pelvis via the greater sciatic foramen, inserting into the greater trochanter. Piriformis muscle is an abductor and external rotator of hip, and also provides slight flexion to hip during walking. Piriformis Syndrome is an uncommon cause of pain in the buttock and leg. Some authors call Piriformis Syndrome as “Pseudo-sciatalgia”. It may clinically be confused with other pathologies of this area. US guided injection into piriformis muscle was virtually a revolution because, successful piriformis injection rate was 30% with fluoroscopy, but this rate has reached up to 95% with US.<sup>[33]</sup> During US guided Piriformis muscle injection, posterior superior iliac spine, ileum, gluteus maximus muscle can be used as a landmark in the patient when lying in prone position (Figure 7). Confirmation of the piriformis muscle can be made by having an assistant rotating the hip externally and internally with the knee flexed. Anatomical relation of sciatic nerve and piriformis muscle can show great variation. For this reason, it has been recommended to use nerve stimulator during piriformis injection in order to prevent damage to sciatic nerve.

**Pudendal nerve blockade:** The pudendal nerve arises from S2 to S4, and passes through the greater sciatic notch and interligamentous plane to enter the pelvis through Alcock’s canal. There are three termi-

nal branches; the dorsal nerve of the penis (clitoris), inferior rectal nerve, and perineal nerve. Pudendal nerve plays important role in the etiology of chronic perineal pain. Apart from pathologies related to the anatomical trace of the nerve (Pudendal Entrapment Syndrome), complex perineal pain syndromes can also be observed, such as Pudendal Neuralgia in which etiology is not very clear.<sup>[34]</sup> In addition, many pelvic interventions can cause injury to this nerve. Various approaches have been described for pudendal nerve blockade (S2-S4 blockade, transgluteal approach, transvaginal approach).<sup>[35-37]</sup> It is possible to visualize pudendal nerve with US in extrapelvic localization. In patients undergoing TUR-P, it was reported that postoperative analgesia was better in US guided pudendal nerve blockade performed with transperineal approach.<sup>[38]</sup> During pudendal nerve blockade with transperineal approach, ischiadicum tuberculum, sacrotuberous ligament and pudendal artery can be used as landmarks (Figure 8). The nerve can be reached with block needle under sacrotuberous ligament. This approach can yield successful outcomes in patients with chronic pelvic pain due to various etiologies.

**Saphenous nerve blockade:** Saphenous nerve is the most important sensory branch of the femoral nerve. In chronic pain of anteromedial area of the knee like saphenous neuralgia, saphenous nerve blockade is an effective analgesic option. Vas et al. performed US guided PRF in two patients who had chronic postsurgical pain after total knee replacement (TKR).<sup>[39]</sup> PRF was applied to saphenous, tibial, common peroneal nerves and peripatellar, subsartorial and popliteal plexus. Dry needling was performed with US at the

same time. During 6 months follow up period, good analgesia and improvement in knee functions were observed. Knee has quite complex sensorial innervation, and no interventional method has been proven to be effective for the treatment of pathologies of knee with chronic pain. During saphenous nerve blockade with US, anatomical landmarks are sartorius muscle, femoral artery, vastus medialis muscle and adductor magnus muscle.<sup>[40]</sup> Chronic pain observed in middle part of the knee following total knee prosthesis has neuropathic character. Adhesion and scars developing around infrapatellar nerve at postoperative period are the cause of this type of pain. Up to 6 months pain-free period has been reported by local anesthetic + cortisone mixture administered around infrapatellar nerve that is exposed by applying hydrodissection at interfascial plane with US.<sup>[41]</sup>

**Genicular nerve blockade:** In the first genicular nerve RF study performed on older patients with osteoarthritis, 50% reduction in pain complaints was achieved for approximately 12 weeks.<sup>[42]</sup> Also, remarkable improvement was reported in Oxford Knee scores. Application was done with fluoroscopy guidance. In another study using US, Vas et al. performed blockade on saphenous nerve, peripatellar, subsartorial and popliteal plexus along with the genicular nerve.<sup>[43]</sup> PRF was applied on these predetermined nerves and plexus for 8 minutes at 42°C. Remarkable improvement was observed in patient's pain at rest and during activities for 6 months time. Additionally, there was also remarkable improvement in standing, walking and climbing step functions.

**Obturator nerve blockade:** Advanced coxarthrosis



**Figure 7.** Piriformis muscle injection.



**Figure 8.** Pudendal nerve blockade (New approach).

and various malignancies are the major causes of chronic hip pain. Hip joint is mainly innervated by LFCN, femoral and obturator nerves. US guided femoral and obturator nerve blockade techniques in patients with coxarthrosis have been first described by Kawaguchi et al.<sup>[44]</sup> Favorable analgesia was achieved in patients with conventional RF (80 seconds, 80°C). Similarly, good analgesia was achieved with US guided conventional RF performed on obturator, femoral nerves and LFCN in patients who had metastatic hip pain caused by lung cancer.<sup>[45]</sup> In our pain clinic, US guided obturator nerve blockade (diagnostic or with ablation techniques) is commonly performed alone or together with blockade of other nerves in obturator neuralgia, adductor muscle spasm and some chronic hip and knee pains.

*Ankle blockade:* Foot and ankle are mainly innervated by tibial, deep and superficial peroneal and sural nerves. Instead of neuroaxial techniques, blockade of these nerves is sufficient for treatment of pain that is in neuropathic character observed particularly after orthopedic operations. Up to 97% blockade success have been reported with US guided blockade of these nerves.<sup>[46]</sup> Also, PRF treatment can be performed on these nerves separately.

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