**Fundamentals of ultrasound-guided therapy for the relief of musculoskeletal pain: pharmacology and techniques**

*Ultrasound-guided intervention is rapidly becoming one of the preferred approaches to the treatment of musculoskeletal pain. However, such procedures require not only the use of the appropriate pharmacological molecule to obtain the best results but also an all-round understanding of ultrasound anatomy so that the molecule may be safely conveyed to the target.*

**INTRODUCTION**

Pain is the leading cause of absence from work and has a deep impact on society and economy [1]. Three of the four principal types of pain, namely back pain, arthritis pain, other musculoskeletal pain and headache, are susceptible to treatment with ultrasound (US)-guided interventional methods.

In the past, the treatment of pain involved pharmacological or surgical approaches. However, the pharmacological approach suffers from the problem that it is difficult to achieve long-lasting relief without running into significant side-effects. As for surgery, this is generally very expensive and time-consuming, and has a relatively long recovery time.

US-guided interventional methods enable the positive aspects of both approaches to be retained while avoiding most of the disadvantages [2]. The procedures are fast, repeatable, and can be performed outside the operating room, mostly without the support of an anesthesiologist. They also can achieve long-lasting relief from the pain.

For these reasons, US-guided intervention is being increasingly adopted and is rapidly becoming one of the preferred approaches to musculoskeletal pain treatment. However, an extensive knowledge of several fields (anatomy, physiology, US imaging, and pharmacology) is required to properly carry out these procedures [2].

The aim of this article is to briefly address some of these topics, and highlight some key papers that can give a more in-depth analysis of individual aspects and problems.

**PHarmacology**

Generally, when choosing the drugs to inject during a procedure the basic criteria used are that they should be fast-acting and provide long-lasting relief from the pain. The choice of drug varies according to the underlying problem (e.g., degenerative or inflammatory), the site to treat (e.g., elbow, wrist or ankle), and the structure involved (e.g., tendons or ligaments). In some cases, several drugs can be administered together to obtain combined effects: for example, corticosteroid together with an anesthetic to achieve fast (anesthetic) and long-lasting (corticosteroid) relief from pain in subacromial-deltoid bursitis.

With local administration of the drug, systemic side effects are usually minimal, but in some cases, local side effects can be severely threatening (e.g., tendon rupture after corticosteroid injection). Thus, there are no magic formulas and no "one size fits all" solution; each treatment needs a careful choice of drug to obtain the best results.

It is impossible within the scope of this article to cover this topic in detail, but the following is at least a preliminary description of the categories of drugs generally used in US-guided musculoskeletal intervention.

1. Corticosteroids. These are the most widely used category of molecules but the physicians carrying out interventional procedures frequently have a love-hate relationship with the drugs. Their anti-inflammatory action is powerful, giving best results between 1 and 5 weeks [3], but their immunosuppressive effect increases the risk of infectious complications. There also seems to be a detrimental effect on cartilage as well as on tendons. Corticosteroids are mainly used intra-articularly (shoulder and knee) and inside the bursae.

2. Sclerosing agents (e.g., polydocanol). These molecules block pain by reducing the neovascularization typically associated with the degenerative process of tendons and ligaments [4]. Their main use is in tendinopathy whether the site be the Achilles tendon, quadricipital tendon, or the patellar tendon.
3. Hyaluronic acid. The lubricant and dividing effects of hyaluronic acid on the articular surface reduce pain in degenerative articular disorders with cartilage damage. Although the results are not extraordinary and long-lasting, there are few side effects (mainly clumsiness and heaviness at the treated articulation). Hyaluronic acid is mainly used on degenerative diseases of the knee [5].

4. Ozone. This is used in small articulations such as interapophyseal facets of the vertebral column or the temporo-mandibular joint because of its ability to reduce pain.

5. Normal saline (NaCl 0.9%) is usually used to wash away calcification (e.g., supraspinatus calcification) simply through dissolution during repeated “flushing” [Figure 1].

6. Autologous blood. This is naturally rich in growth factors (such as fibroblast growth factor [FGF] and transforming growth factor [TGF]), which can boost the natural repair process of degenerated structures. These processes are generally associated with the technique known as “dry-needling”, which consist of scarification of the tendon, causing direct bleeding.

7. Platelet-rich plasma (PRP). This is a more powerful (and expensive) version of autologous blood. The increased performance caused by the high concentration of growth factor and similar molecules in PRP has to be weighed against its increased cost. Its main use is intra-tendinous [6] but intra-articular use is currently being carried out by several groups around the world.

**FUNDAMENTALS OF US INTERVENTIONAL TECHNIQUE**

The patient should be comfortably positioned in an appropriately lit environment with well regulated temperature. The main concern of the team (for most procedures, a physician and a nurse are enough) should be to assure complete asepsis [7]. The operative area must be shaved and correctly disinfected (e.g., povidone iodine, Betadine) and the probe must be correctly disinfected. Frequently single-use plastic probe covers are used to avoid the disinfectant damaging the probe itself. The needle, generally inserted on the short side of the probe, can be directly inserted with the aid of a needle guide or free hand by experienced users. The choice of probe and needle depends on the site being treated, the drug being administered and the clinical problem being addressed. Before injection it may be necessary to evacuate various materials [Figure 2]. Correct needle placement can be confirmed by a test injection of saline.

The literature contains a great number of US techniques describing how the target of the procedure can be reached. These techniques involve the operator using landmarks for orientation to ensure a safe and short trajectory to the area of interest. In some cases, several different, but nonetheless correct approaches exist, so the operator’s personal preference is generally the only factor that matters. This is particularly true in the shoulder and ankle. However knowledge and recognition of anatomic variants are extremely important, as these may require a change in approach or trajectory.

1. Hand and wrist. At this level, recognition of normal anatomy [8] and its variants, even if these are seldom described [9], is extremely important. The median nerve is generally reached through the flexor retinaculum, which is particularly important in the paratendinous approach. When reaching the distal radioulnar joint, passing from the ulnar to the fifth osteofibrous tunnel ensures avoidance of all the locoregional neurovascular structures.

2. Elbow. The ulnar nerve is approached using the cubital tunnel as a landmark. The medial epicondyle (epitrochlea) reveals the common flexor tendon [Figure 3], while on the other (lateral) side the target is generally represented by the common extensor tendon [10].

3. Shoulder. The main targets are the
subdeltoit bursa [11] and the supraspinatus tendon which are easily reached by every experienced sonographer [Figure 4]. More challenging is the shoulder joint, for which a large number of approaches exist; we prefer the posterior one of artrographic derivation.

4. Hip. This is generally reached anterolaterally on the anterior articular recess but this approach is particularly challenging because of the depth and the presence of the neurovascular bundle [12].

5. Knee. The quadriceps and patellar tendon are easily reachable, as well as the articular space (passing lateral to the patella).

6. Ankle. This is one of the most challenging areas and is particularly rich in small articulations, which have peculiar landmarks and pathways to follow [13]. Among the simplest targets are the fibular tendon (the landmark is the lateral malleolus) and the Achilles tendon (which is also the structure most frequently involved in painful degenerative pathology).

FUTURE DEVELOPMENTS

Although the current priority must remain the acquisition of confidence in and familiarity with basic sonographic anatomy and pharmacology, it is worth taking a look at possible future developments. We think that the most significant future improvement to the procedure — which was after all only relatively recently introduced yet is rapidly spreading on all levels,— is likely to be the possibility of co-registration of different datasets from other imaging methods. In the past this used to be a long and inaccurate process, but recently it has become increasingly reliable and fast. The technology allows the operator to see not only the US image but, at the same time, a previously acquired computed tomography or magnetic resonance volume, moving and changing real-time with the probe during the procedure [14]. This makes it easier to see and avoid dangerous structures such as neurovascular bundles and to reach deep and barely visible structures such as the pudendal nerve.

Of course, the most experienced operator may often not need the support of co-registered images, but they enhance confidence and can add safety to the procedure if carried out by a less expert physician.

CONCLUSION

US-guided musculoskeletal intervention is a rapidly growing field. To achieve optimal results, a deep and all-round understanding of the fundamentals of pharmacology and US anatomy is required [2]. This basic knowledge is elegantly and effectively communicated in several literature articles that explore in depth specific aspects or anatomical sites [10-13].

REFERENCES