Ultrasound guided radiofrequency procedures in chronic pain management

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Abstract
Radiofrequency treatment for chronic pain management is still fighting its position in evidence based medicine hierarchy ladder. Variability of human tissue and subjectivity of pain perception are known factors affecting outcomes of clinical trials. Radiofrequency lesion size depends on many factors and precision in active tip positioning is a key factor to successful treatment. Ultrasound alone or in combination with fluoroscopy may further increase precision in neural structure targeting, thus improving outcome and increasing safety. In a very short overview, this author highlights procedures where ultrasound has changed our clinical practice and where ultrasound works better in combination with fluoroscopy. After a decade of introducing ultrasound into contemporary pain interventional practice there is a call for a critical review.

Keywords
Radiofrequency, ultrasound, chronic pain

Introduction
Radiofrequency procedures have been successfully applied over the last few decades in various medical specialties including interventional cardiology, radiology, vascular surgery, dermatology and last, but not least in pain management. Radiofrequency lesioning involves the generation of a very high frequency alternating current (300-500 kHz), from RF generator, delivered through an electrode, via a insulated cannula with the RF energy delivered at the exposed active tip aimed at the target neural structure.

At the inauguration of the first issue of the Journal of Observational Pain Medicine, the Editor in Chief Dr Rajesh Munglani quoted Sir Bradford Hill, creator of the first ever randomized clinical trial: “Another problem lies in the biological variation of the human material with which we have to deal. Can we make a useful trial if that variability is very great” 1 It could have not been truer about the efficacy of radiofrequency in chronic pain management.

In addition to variabilities of human perceptions of pain, right diagnosis and indication for procedure there are also several factors affecting actual the RF lesion size:

- Needle size
- Active tip size
- Duration
- Temperature
- Bipolar lesion
- Multiple lesions
- Cooled RF
- Pre-injection fluid

Any combination of the above-mentioned parameters may result in desirable lesion size\(^2\), but on balance, due consideration is to be observed regarding the safety of the targeted neural tissue and neighbour structures such as motor nerves, vessels and other vital organs. Provenzano investigated extensively the influence of specific fluid pre-injection on lesion size\(^3\)-\(^4\), but the most practical message came from another study showing that pre-injection of steroids reduce lesion size\(^5\). It is recommended that if steroids are to be used, as it is common practice in the UK, it should be done only after, and not before the lesioning.

Pulsed radiofrequency is a relatively newer technique that divides opinions evens amongst experts and raises even more questions than answers\(^6,7\). The concept of delivering similar amount of energy in pulses without creating a heat lesion but producing a neuromodulation effect predominantly on A-delta and C fibres has been well proven in animal studies\(^8\), but translation into clinical practice is still inconsistent. What’s is the optimal duration, frequency, pulse width, voltage for the given human tissue and distance from the needle? Complexities of those interactions have been elegantly explained on the clinical example of radicular pain\(^9\).

The Future of Interventional Pain Medicine

Along with accurate diagnosis and patient selection, precise targeting for neuroablative therapy are the benchmarks for the future of interventional pain medicine\(^9\). Recently, detailed anatomical studies have shed new light on the final active tip positionings for cervical medial branch ablation and sacroiliac joint denervation\(^10,11\).

Role of Ultrasound in Radiofrequency Procedures

Ultrasound has brought in a new dimension to interventional pain management, although compared to its influence in regional anaesthesia, the uptake has been much slower. Chronic pain physicians have already been using image-guided interventions such as fluoroscopy and CT and feel confident with their armamentarium. There are and will be technical limitations of ultrasound: different structures to be targeted, often deeper and less well-defined than peripheral nerves, limited experience and formal training and also paucity of evidence and relevant publications. Between 1982 and 2002 there were only three publications related to ultrasound guided techniques in chronic pain management, but the amount of publications in this field has been growing steadily into several hundreds by now\(^13\).

In the last few years, prominent position in literature has been gained by publications including “Atlas of Ultrasound Guided Procedures in Interventional Pain Medicine” edited by Prof. Samer Narouze\(^14\) and “Recommendations for Education and Training..."
in Ultrasound-Guided Interventional Pain Procedures” by ASRA, ESRA and AAFPS joint committee. More recently, CIPS (Certified Interventional Pain Sonologist) exam has been introduced under the auspices of the World Institute of Pain. Author online survey in 2012 revealed that almost half of the UK Pain Physicians have been using ultrasound in daily clinical practice and there has been growing interest in access to more training.

This author along with Dr Barry Nicholls and RA-UK organize a yearly training course and hands-on workshop - Ultrasound in Pain Medicine (USPM) in London; this course has a renowned international faculty and has been hugely popular in attracting candidates from all over the world.

Up-to-date evidence and experience suggests dividing ultrasound guided procedures in at least two categories as shown on the below. All of the structures shown in Table 1 can be identified clearly solely using ultrasound, thus increasing precision, safety, reducing cost and procedure time; this would be changing clinical practice positively.

**Table 1**

<table>
<thead>
<tr>
<th><strong>Radiofrequency procedures performed under ultrasound guidance</strong></th>
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<tr>
<td>Greater Occipital Nerve</td>
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<tr>
<td>Cervical Roots</td>
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<tr>
<td>Stellate Ganglion</td>
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<tr>
<td>Suprascapular nerve</td>
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<tr>
<td>Genicular Nerves</td>
</tr>
<tr>
<td>Other peripheral nerves</td>
</tr>
<tr>
<td>Joints- shoulder, knee, hip</td>
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<tr>
<td>Trigger Points</td>
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This author is a great advocate of combining fluoroscopy with ultrasound when indicated as shown in Table 2. It helps to compare to the existing “gold-standard” technique, to identify the desired level straight away without additional scanning; this is especially important for medial branches and intercostal nerves. It has been shown to reduce the total procedure time, amount of X-ray radiation and also increased the operator confidence and patient safety as showed on example of sacroiliac joint denervation.

**Table 2**

<table>
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<th><strong>Radiofrequency procedures where ultrasound complement fluoroscopy</strong></th>
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<tr>
<td>Cervical medial branch</td>
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<tr>
<td>Lumbar medial branch</td>
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<tr>
<td>Intercostal nerves</td>
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<tr>
<td>Sacroiliac joint</td>
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Cervical medial branch is a very good example of combining both techniques. Fluoroscopy helps to define the desired level and initial needle direction. Ultrasound
helps to position the needle parallel to the medial branch along the articular pillar and identify surrounding neurovascular structures such as the vertebral artery, radicular artery and the anterior nerve root before proceeding to perform a thermal lesion and therefore increasing safety as well precision of the procedure as illustrated in Figure 1 below

**Figure 1**

Example of combined ultrasound and fluoroscopy for cervical medial branch radiofrequency denervation.
a) Lateral and A-P view of fluoroscopy images in patient in prone position. Note needle “tunnel vision” in A-P position. Lateral view shows needle position at the level of articular pillar from single entry point
b) Ultrasound probe position in longitudinal and transverse neck scans to assess needle position.
c) Ultrasound images in transverse scan. Needle alongside and close to the articular pillar, parallel to the medial branch

Modern ultrasound machines have various softwares such as beam steering and other navigation systems to reduce scattering and improve needle visibility. Operator has to be aware of the system capability to optimize image. The size of the needle will also increase visibility but often at the cost of patient discomfort if awake or lightly sedated. Needle guidance systems such as Sonix GPS has been introduced recently to improve needle trajectory especially for deeper structures such a lumbar medial branch block\(^9\).

Radiofrequency echogenic needles has been evaluated by the author. Standard RF cannula and echogenic cannula are shown (See Figure 2) at the decreasing angle to the US beam: 75°, 60°, 45°. There is noticeable difference of needle visibility, but only at the angle below 60°
Conclusions

Radiofrequency procedures for chronic pain under ultrasound guidance are becoming increasingly popular, merging experience from musculoskeletal (MSK) ultrasound such as diagnostic imaging, joint injection and interventions used typically under fluoroscopy or CT guidance. Precise final RF cannula position may not only increase effectiveness of radiofrequency treatment, but also improve safety. The author acknowledges that more robust evidence is to be gathered. Avoiding ionising radiation and the portability of equipment are other important advantages. Pain physicians practicing interventional pain management should consider ultrasound use in their daily practice for radiofrequency procedure.
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