THE ROLE OF ULTRASOUND-GUIDED NERVE RELEASE IN DECOMPRESSION SURGERY

– Written by Thomas Apard and Benjamin Ferembach, France

WHY IS ULTRASONOGRAPHY MANDATORY FOR A COMPLETE CLINICAL EXAMINATION?

The advent of high-frequency electronic linear transducers (more than 13 MHz) allows superficial structures to be examined comprehensively. This includes scanning the relevant structures in at least two orthogonal planes, with dynamic and Doppler assessments. For example, in the carpal tunnel, anisotropy (the property of tissue to differentially conduct or reflect sound waves) helps the sonographer distinguish between the tendons and the nerves.

The ultrasound examination must always be comparative, for instance scanning both right and left sides, as there is a lot of anatomical variations which are incidental, and not pathological.

Ultrasonography is perfect for children since it is painless and without any side effects. Young children with congenital disorders or post-traumatic injuries can stay in the parent's arms and the ultrasound examination can be performed easily.

Ultrasound is also an important tool in confirming diagnosis in clinic, for instance to identify a type of tumor, impingement between tendon and osteosynthesis material, rheumatoid disease, a bone nonunion etc.

The non-radiologist's ultrasound examination is usually performed to answer one or two questions. The ultrasound is performed at the end of the clinical examination and should be quick and informative. Sometimes it is just to explain the problem to the patient and to reassure them. The ultrasound machine should be available in the room where the consultation happens. In case of doubt, it is reasonable to keep the image/video and ask for the opinion of an experienced radiologist.

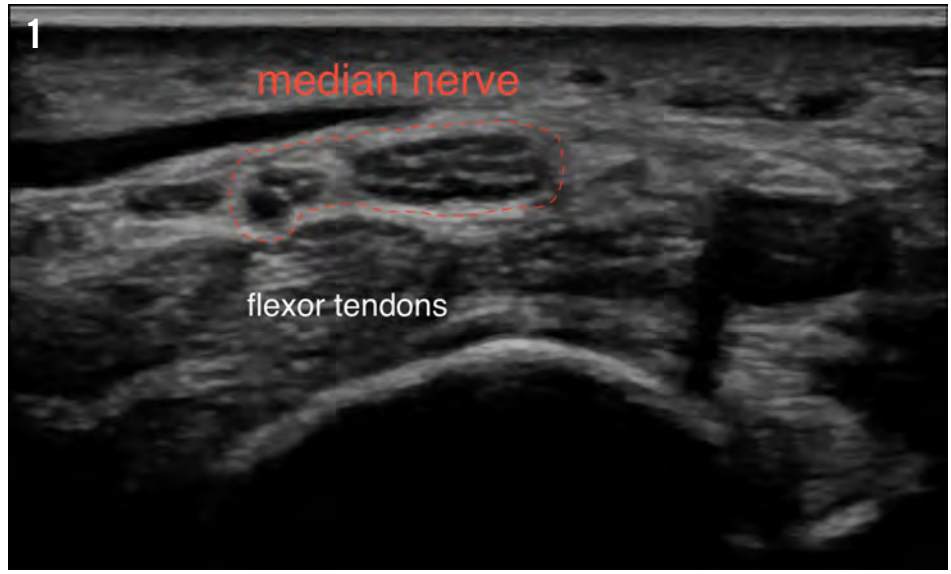
An ultrasound machine with a high-frequency probe is always easily accessible in the hospital because a lot of medical doctors use it: emergency doctors, rheumatologists, sports medicine physicians, cardiologists, and more. Today, portable machines are accurate and can be easily brought to patients' in-patient rooms, or the emergency room.

TIPS AND TRICKS

- Don't hesitate to perform a water-bath technique as it is helpful in providing

painless and high-quality images of superficial structures in areas difficult to image with standard gel application techniques. As an example, in diagnosis disorders in the nail or nail bed (glomus tumor, retronychia, mucoid cyst compressing the matrix).

- Don't forget the Doppler mode to evaluate inflammation (i.e. tenosynovitis, synovitis, inflammatory area around a foreign body, union process of a fracture or tendon lesion, etc). Don't press too hard on your probe, as this will block the Doppler from seeing the red blood cells.
- The position of the limb is very important to make the examination comfortable for the patient and the examiner. As for any procedure, you have to learn how to perform them for each structure you want to examine. For example, the distal biceps tendon is explored in the "cobra position", with the elbow on the table and probe on the posterior zone of the forearm.
- Liquid moves into the low-pressure areas. For example, to analyze the posterior zone of the elbow, you have to place the joint in extension.
- The ultrasound of an operated bone is interesting to do in order to confirm union and to assess inflammation even in case of implants. The metallic material stops the ultrasound but you can explore the healing fracture on the opposite cortical bone to assess the union.
- The ultrasound of operated tendons or ligaments must be explored dynamically. The stitches are easily visualized as hyperechoic points and move with the joint. For example, use a clenched fist maneuver for evaluation of the scapholunate ligament.
- The addition of liquid (local anesthesia or saline) permits us to see small structures such as thin tendons (i.e. the central slip of the extensor tendon) or small nerves (i.e. posterior interosseous nerve at the wrist).



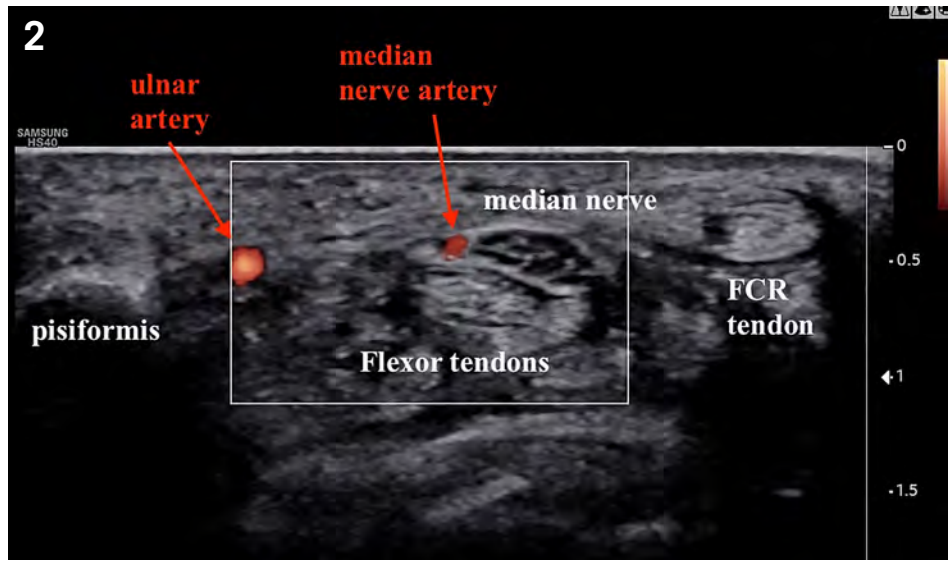


Figure 1: Transversal view of a bifid median nerve. The nerve fascicles are anechoic (black) depicted as well-circumscribed individual structures of different sizes separated by echogenic epineurium (white).

Figure 2: Median nerve artery at the carpal tunnel in Doppler mode.

WHY IS ULTRASONOGRAPHY USEFUL IN CASES OF NERVE ENTRAPMENT?

1. The ultrasound can easily see the nerve and its environment

The improved performance of high-frequency transducers has made it possible to recognize subtle anatomic details at least equal to, or even smaller, than those depicted with surface-coil magnetic resonance imaging (MRI). Even with slight pressure applied with the probe, nerves may be seen sliding over the surface of an artery or a muscle.

Unlike other structures of the musculoskeletal system, nerves do not show anisotropic properties. Therefore, appropriate probe orientation during scanning is not needed to image them. Once detected, the nerve is kept in the center of the US image in its short axis and then followed proximally and distally, which we can call the "lift technique. In a transverse view, the nerve fascicles are depicted as well-circumscribed individual structures of different sizes separated by echogenic epineurium (Figure 1).

It is very important to analyze the environment of a nerve in relation to anatomical variations (bifid, pushed by a muscle or tendons) or pathological situations (increase of the nerve cross-sectional area, anomaly of the vascularization at Doppler mode). For example, at the carpal tunnel, a median nerve artery may be detected in Doppler mode (Figure 2).

It is a classic situation to see a ganglion cyst compressing the ulnar nerve at the elbow or the common peroneal nerve at the knee.

© BENOIT DOPPAGNE/BELGA MAG/AFP/Getty Images

The ultrasound examination of the nerves and their branches has to be compared to the contralateral side, to rule out possible pathological and anatomical variations. The more you practice ultrasonography, the more you see bizarre images on both sides. Two situations are particularly tricky: 1. The palmar branch of the median nerve is not easy to follow because of its direction and small size. 2. The ulnar digital nerve of the 5th finger in case of Dupuytren's contracture which is separated from the digital artery and in a flexed position.

2. The ultrasound is a dynamic examination: let's see the nerve gliding

As with a clinical examination of a muscle or a tendon, the examiner has to analyze nerves dynamically i.e. passively, actively, and against resistance.

The position of the joint is very important to learn to avoid misdiagnosis. For example, the instability of the ulnar nerve at the elbow can be hidden by the pressure of the probe.

Another interesting ultrasound investigation is the case of snapping triceps: the ultrasound shows the difference of muscle instability and nerve instability (use elbow extension against resistance and passive flexion of the elbow).

Finally, after a surgery, it is very important to evaluate the inflammatory response (Doppler mode) and the collagen response for the gliding of the nerve (adhesions).

3. The probe is the prolongation of your hand

Put the probe on the pathological site and the patient may feel pain. Finally, the clinician has to encourage the patient to verbalize his/her feelings: there are two examiners! When it is a complex case, give the probe to the patient and let him/her put it where the problem is located, and then, see the screen.

A PARTICULAR AND RARE SITUATION: THE HOURGLASS-LIKE CONSTRICTION SYNDROME

This is a peripheral nerve injury with no apparent cause, and the pathomorphological change is an unexplained narrowing of the diseased nerve. High-frequency ultrasonography is a reliable, convenient, and non-invasive diagnostic imaging method for accurately locating the hourglass-like constriction neuropathy.

The treatment of this disease is still somewhat controversial, with a general preference for conservative treatment first, and surgical intervention being beneficial in selected patients who do not recover promptly within 3 months.

ULTRASOUND-GUIDED INJECTIONS AROUND THE NERVE

1. Injections must be performed under ultrasound for four reasons: 1. To be precise; 2. To control the volume you inject; 3. To store an image; 4. To show what you do to your patient.
2. Injections must be painless: 27G needles are very well seen under the probe and are tolerable when crossing the skin and decrease the flow while injecting.
3. Remove the air in the syringe (air is the enemy of the echos).
4. Liquid is black (anechoic) and the nerve is much more visible if you inject around it (like the burger technique for troncular anesthesia).

Injecting around the nerve (so-called hydrodissection) is more and more popular for a transitory effect to confirm a diagnosis: steroid, lidocaine, fat graft,...The advantage of ultrasound is to be able inject around the nerve without damaging it. The nerve gliding is improved and then, the clinician can immediately re-do the clinical triad of the nerve entrapment (pain, weakness, and scratch collapse test) to assess the effectiveness of the procedure.

HOW TO INJECT AROUND THE NERVE?

The safest way is the inplane view, which allows for a transverse view of the nerve while seeing the needle approaching progressively. We use a 40mm long 27G needle. At approximately 1 cm from the nerve, the needle is turned to see the direction of the bevel. Start by injecting the liquid to create an anechoic area which pushes the nerve. Finally, inject above and below the nerve, and keep talking to the patient to be aware of his/her tolerance to the procedure.

WHAT IS ULTRASONOSURGERY?

Ultrasonography is a useful diagnostic tool in upper or lower limb disease but is also useful for surgical procedures: ultrasonosurgery is a new surgical specialty where surgery is performed under ultrasound.

The sonographer must have appropriate experience to successfully perform ultrasound-guided procedures and must be familiar with the basics of US imaging. Surgeons know the anatomy and generally have easy access to the cadaver lab: learning ultrasonography is not so difficult for them.

At this point, we understand that ultrasonosurgery opens the path to a new mini-invasive technique with a very precise technology. Obviously, the tourniquet is not mandatory as we want to see the arteries beating. As a result, wide-awake surgery is the perfect condition to operate under ultrasound and permits to control dynamically the immediate result after surgery.

Mini-invasive treatment does not mean we can forget all the hygienic recommendations. As for arthroscopic surgery, the probe must be protected in a sterile cover with a sterile gel. The operation site has to be cleaned according to the operating room protocols. All the devices have to be sterile (usually single-use instruments).

Figure 3: Retrograde technique with a hook for percutaneous ultrasound guided carpal tunnel release at the office under walant.

THE ULTRASONOSURGERY OF CARPAL TUNNEL SYNDROME

Four options are available for surgical treatment of carpal tunnel syndrome: open carpal tunnel release, endoscopic carpal tunnel release, mini-open carpal tunnel release, and reconstruction of the transverse carpal ligament. The authors regularly perform a new procedure known as percutaneous US-guided carpal tunnel release under local anesthesia with no tourniquet.

The release of the deepest fibrous layer of the carpal tunnel through a proximal incision of 1 mm needs a hook running under the carpal ligament in the “safe zone” (defined by the median nerve, the ulnar artery, and the superficial carpal artery). The ultrasonography allows control of the perfect positioning of the hook before the section of the transverse carpal ligament. The carpal tunnel release is done by pulling the hook for a retrograde section (Figure 3).

This technique allows the two following methods to assess the complete release: the ability of the hook to go into and outside the carpal tunnel (transverse view) and the return of the power in the abductor pollicis brevis (thumb volar abduction).

A 24h circular dressing is mandatory, after which the patient can use his/her hand for daily activites as long as avoiding making any forceful efforts until the ligament heals (usually two weeks). No stitches are needed, and no nursing care nor slings.

THE ULTRASONOSURGERY OF LACERTUS SYNDROME

As the superficial fascia of the pronator teres muscle is visible with high resolution transducers with no major nerve or vessel crossing the area of intervention, a similar technique of carpal tunnel release may be considered for lacertus syndrome.

The release of the lacertus fibrosus is performed under in-plane ultrasound guidance with a retrograde hook knife. After a 1-mm skin incision (3 cm distal to the lacertus fibrosus), the hook is proximally advanced superficial to the pronator teres until it reaches the predefined proximal edge of the muscle. At this point, the knife is rotated to hook this edge, and the lacertus fibrosus is cut in a retrograde fasion while constantly monitoring both the brachial artery and the median nerve (Figure 4).

The procedure is much easier than the carpal tunnel release as there is no risk for the brachial artery and the median nerve, but care should be taken to avoid the occasional small artery crossing on the superficial pronator teres fascia.

As with the wide-awake open technique, the power of flexor pollicis longus (FPL), deep flexor to the index (FDP2), and flexor carpi radialis (FCR) (thumb, index and wrist flexion, respectively) is immediately observed by the patient and surgeon.

THE ULTRASONOSURGERY OF ULNAR NERVE ENTRAPMENT AT THE ELBOW

This procedure is difficult and must be done by very experimenced ultrasonosurgeons.

The indications are a stable ulnar nerve (controlled under ultrasound at the consultation) compressed under the flexor carpi ulnaris (FCU) muscle (arcade of Amadio), and the level of compression is confirmed by the scratch collapse test. The nerve is identified in its groove beyond the elbow joint in longitudinal and transverse views. The proximal border of the FCU is marked. The future entry point is then located on a transverse section with an intramuscular needle. The objective is to obtain the best angle of approach for an antegrade section with a very small knife. The position of the nerve is continuously monitored during the procedure. When the knife is in place, the sectioning of the FCU arcade is performed by a section from proximal to distal with a longitudinal control view. The stability of the ulnar nerve is assessed by dynamic maneuver of flexion/extension of the elbow under ultrasound control.

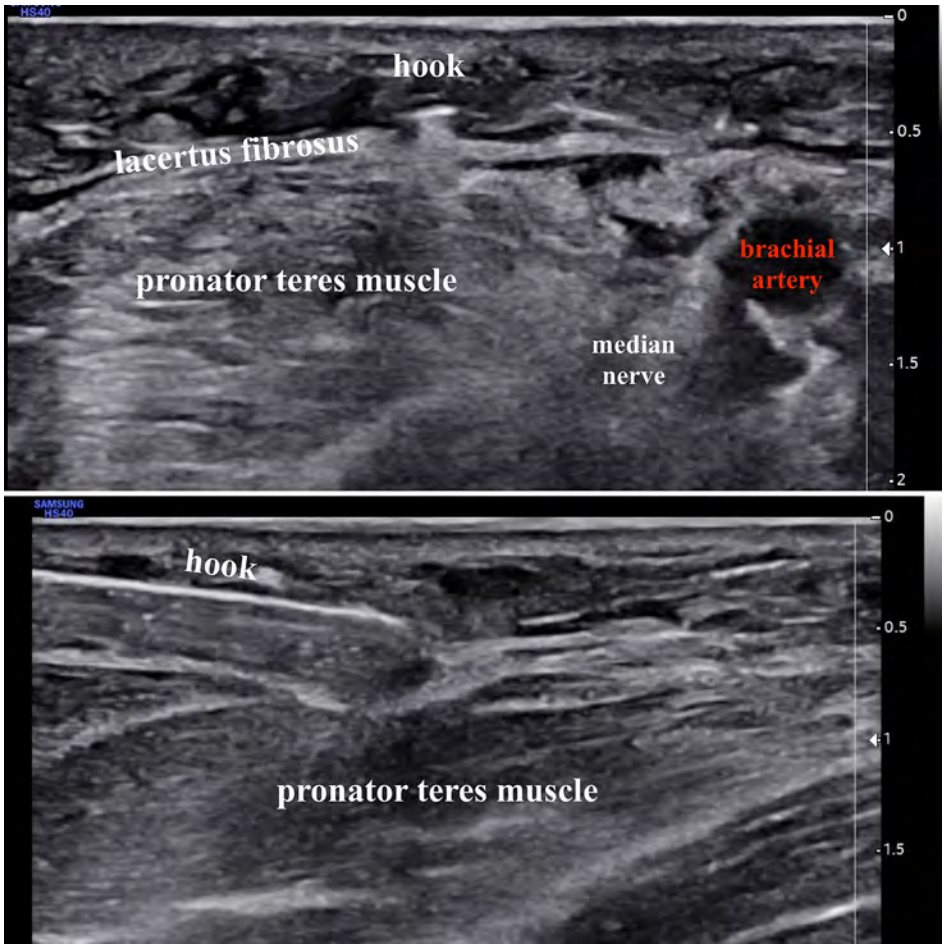


Figure 4: Anterograde technique with a hook for percutaneous ultrasound guided lacertus release at the office under walant.

THE FUTURE OF ULTRASONOSURGERY

- The future of hand- and upper limb surgery is wide awake surgery because it is simple, sustainable, cheap and safe.
- The future is office surgery because of the lack of anesthesiologists all over the world and the difficulties to access the operating room (lack of nurses, cost of electricity, pandemic).
- The future is mini-invasive surgery because it is important to decrease the occurrence of infection and adherence.
- The future is technology: machines will be cheaper and more powerful.

As a result, ultrasonosurgery is following all of these trends: the more you can combine them, the more you will have access to the next step for the benefit of your patients.

References
Available at www.aspetar.com/journal

THE 4 REASONS WHY YOU WILL LOVE ULTRASOUND FOR THE NERVES

1. *You and your patient will see the dynamic anatomy*
2. *You will compare your pictures with the other side (don't forget the Doppler mode)*
3. *You will be precise in your procedures*
4. *You will perform a mini-invasive and wide-awake surgery at the office*

Thomas Apard M.D., FEBHS
Ultrasound guided hand surgery
Versailles and Paris, France

Benjamin Ferembach M.D.
Dynervologie, Chirurgie orthopédique,
Clinique de l'Alliance
Tours, France

Contact: thomasapard@yahoo.fr