Introduction

The uses and applications of medical U.S are increasing, particularly outside traditional areas of radiology practice. Anesthesiology, critical care and pain management are no exception. Just about every invasive procedure in the body can potentially be enhanced by the use of U.S. Historically, radiologists have used U.S to guide needle, catheter and guide wire placement for various diagnostic and therapeutic purposes. The recent introduction of portable high resolution U.S scanners has accelerated interest in its use for interventional procedures in anesthesia, pain and intensive care medicine. The introduction of small, portable, easy to use and relatively inexpensive U.S machines has accelerated the use of such devices ***(Philip et al., 2008).***

U.S transducers have a sufficient resolution to demonstrate nerves itself. For imaging peripheral nerves we use high frequency linear transducers, with these high resolution images of superficial structures can be obtained. For the visualization of most nerves we use a transducer with a frequency between 7 and 13 Mhz ***(Geert Jan Van Geffen, 2009).***

We believe that vision is the best of the primary human senses. U.S allows evaluating complex and varied neural anatomy prior to needle insertion. In addition to real time

guidance of the needle toward a nerve or plexus, U.S allows visualization of spread of local anesthesia after initiation of an injection. Ultimately, it's this visual confirmation of the perineural spread of local anaesthesia that generates a rapid and successful block ***(Brian, 2007).***

Blind blocks that rely solely on anatomical landmarks are known to produce serious complications even the technique of nerve stimulation which has been recommended as the gold standard for nerve identification fails to ensure an adequate level of nerve block, in addition it carries risk of inflicting damage to nerve structures by direct puncture ***(Marhofer et al., 2005).***

Ultrasound offers the possibility to apply regional anesthesia in patients in whom with the present nerve localizing techniques it would have been impossible to block the nerve. Ultrasound was successfully applied in patients with underlying neuropathy in whom it was impossible to elicit a motor response on nerve stimulation, also in patients with peripheral neuropathy it can be difficult to obtain motor response on nerve stimulation but ultrasound can aid in the localization of the nerve to be blocked ***(Minville et al., 2004).***

Aim of the Work

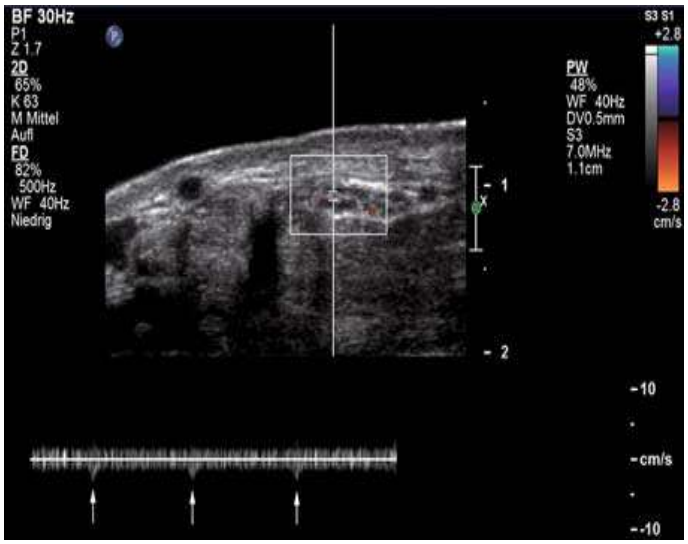
This work aims to review the literature for evaluation of the ultrasound guided nerve block, regarding its principles, different techniques, outcomes and possible complications.

Chapter I

Sonographic Anatomy of the Peripheral Nervous System

One of the major advantages of sonography compared to other modalities for imaging of the soft tissues, such as MRI and CT, is its ability to acquire images in virtually every orientation along the course of a peripheral nerve. This however results in a very complex regional topographic anatomy Therefore a well-founded knowledge of regional anatomy and topography is an indispensable prerequisite for the sonographic assessment of peripheral nerves. The typical sonographic appearance of nerves must be distinguished from other soft tissue structures and may change substantially depending on the type of surrounding tissue elements .Usually nerves present as longitudinal bands with a mixture of hyperechoic (peri- and epineurium) and hypoechoic elements (fascicle groups) in longitudinal sonograms. In the transverse plane a variable number of hypoechoic dots (fascicle groups) is surrounded by hyperechoic epineurium with hyperechoic septa between the fascicles ***(Silvestri et al. 1995).***

Even low-flow feeding vessels, called vasa nervorum, can be depicted using color Doppler sonography(Figure 1-1.a.) Usually one small vessel can be found showing arterial flow in pulsed wave Doppler (Fig. 1-1.b). In case of inflammation nerve entrapment or after nerve repair the detectable vessels increase in number and size and show a higher blood flow In the following chapter the regional anatomy of nerves, which may be assessed with state of the art sonographic equipment, is demonstrated by correlation of representative sonograms with anatomic cryosections of fresh cadaver specimens ***(Baert et al., 2008)***.



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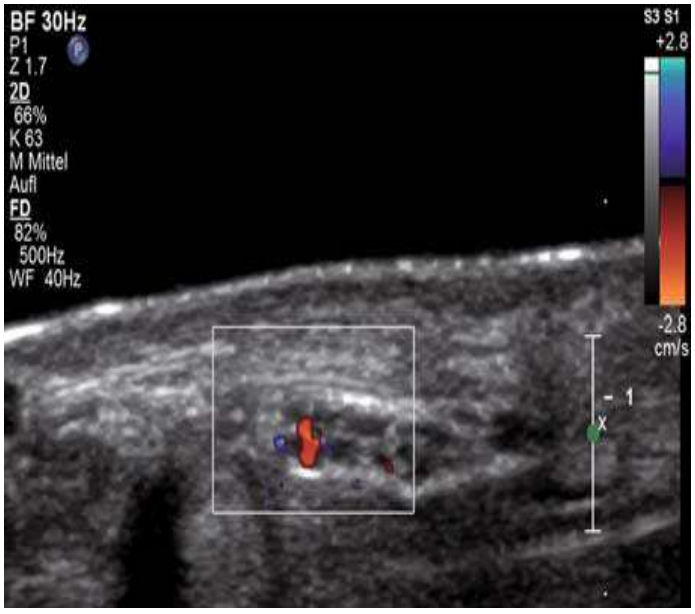


(b)

Fig. (1-1 a,b): Transverse US scan of the median nerve at the wrist using Color Doppler US (a) to depict feeding vessels (vasa nervorum), which are small in size and show low, arterial flow in pulsed wave Doppler (arrows) (b) ***(Quoted from Baert et al., 2008).***

Cervical and Brachial Plexus:

The cervical plexus forms out of the ventral roots of the first four spinal nerves (C1–C4). The recombination of the involved axons takes place in the intermuscular soft-tissue resulting in several sensible cutaneous nerves, which are all perforating the lateral superficial cervical fascia at the posterior margin of the sternocleidomastoid muscle to run onward subcutaneously (fig 1-2). The most important nerve of this plexus is the phrenic nerve, which innervates the ipsilateral hemidiaphragm. It is formed by axons from C3 and C4 and lying ventral on the anterior scalene muscle runs downward to the upper chest aperture (Fig. 1-3.a-c) ***(Baert et al., 2008)***.

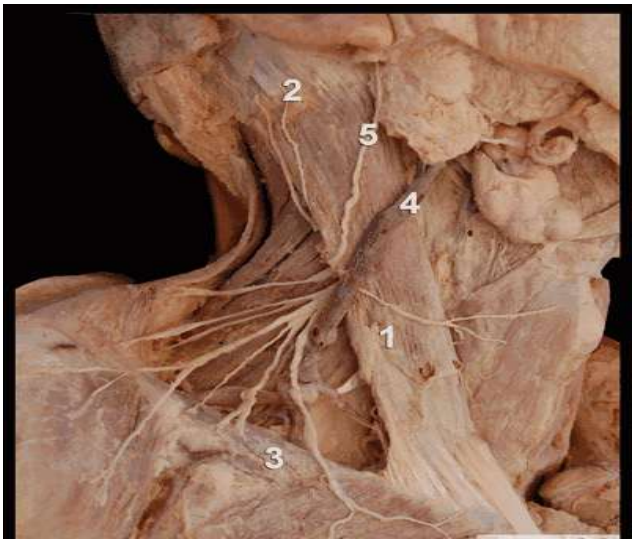
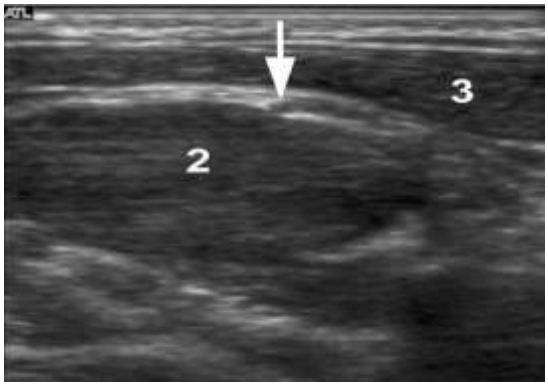


Fig. (1-2): Anatomy of the superficial cervical plexus. 1.Sternocleidomastoid muscle; 2.mastoid process; 3. clavicle; 4.external jugular vein. Superficial cervical plexus is seen emerging behind the posterior border of the sternocleidomastoid muscle at the intersection of the muscle with the external jugular vein. 5.Greater auricular nerve.

(a)



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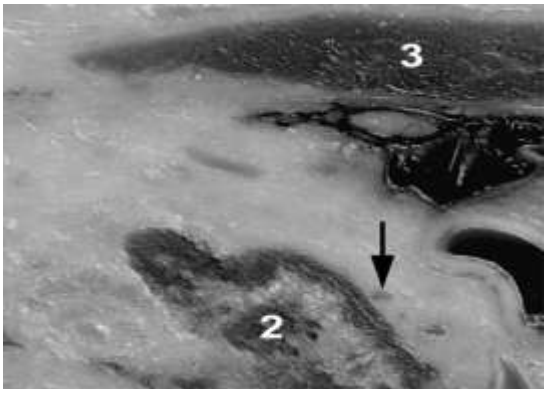

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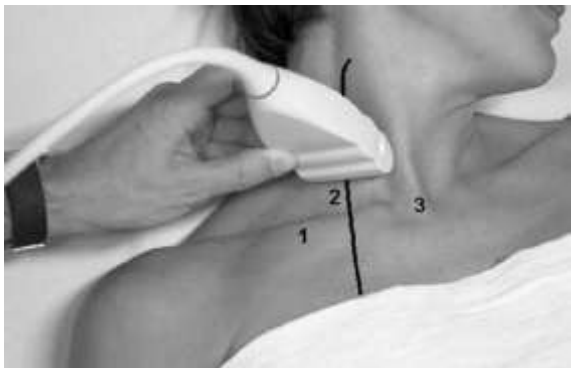


Fig. (1-3.a–c): Transverse US scan (a) with the corresponding cryosection (b) showing the phrenic nerve (arrow) typically positioned directly ventral to the anterior scalene muscle (2) depending on the scanning level) covered by the sternocleidomastoid muscle (3) (section of the clavicle 1). c Scheme with the projection of the phrenic nerve onto the skin surface with the according landmarks: clavicle (1), anterior scalene muscle (2), medial head of the sternocleidomastoid muscle (3) ***(Quoted from Baert et al., 2008).***

The brachial plexus forms out of the ventral roots of the spinal nerves (C5–Th1). Its supra-clavicular section consists of a superior, a medial and an inferior trunk (primary chords). These trunks form within or somewhat lateral to the gap between the anterior and medial scalene muscle (inter-scalene gap). Inferior to the clavicle the three plexus fascicles (medial, lateral and posterior or dorsal) are formed by interchange of axons between the different trunks and they are named according to their relation to the axillary artery (secondary chords). Out of these fascicles the three main nerves of the upper extremity (median, ulnar and radial nerve) as well as the axillary, the musculocutaneous and several cutaneous nerves are formed.

The sonographic identification of the plexus trunks is best achieved in a transverse plane through the interscalene gap, with a slight cranial tilt of the transducer (Fig.1-4). The three trunks present as hypoechoic nodules positioned on a virtual line from dorso-cranial to ventro-caudal. They are embedded in loose connective and fatty soft tissue and must not be mixed up with small regional lymph nodes on transverse sonograms. Orientation of the probe in a longitudinal plane along the course of the trunks reveals the typical fascicular pattern of peripheral nerves ***(Yang et al., 1998).***

Two distinct nerves leave the plexus trunks at this level: the long thoracic nerve with fibers from the superior and medial trunk and the thoracodorsal nerve with fibers from the medial and inferior trunk. These two nerves are responsible for the lateral, superficial rump muscles (serratus anterior muscle and dorsal latissimus muscle) and run downwards almost perpendicular to each other. The thoracodorsal nerve is in its distal course usually accompanied by a branch of the axillary artery (thoracodorsal artery) ***(Baert et al., 2008)***.

Due to only minimal difference in echotexture against the surrounding tissue a clear visualization of these nerves is only achieved in selected cases. The plexus fascicles in proximity of the axillary artery can be visualized best with an abducted or elevated arm and with the transducer oriented along the course of the axillary artery. The posterior fascicle continues into the axillary and radial nerve the lateral fascicle together with axons of the medial fascicle (median loop) after releasing the musculocutaneous nerve directly underneath the clavicle into the median nerve. The medial fascicle forms the ulnar nerve and the nerves responsible for the sensibility of the medial arm ***(Baert et al., 2008).***

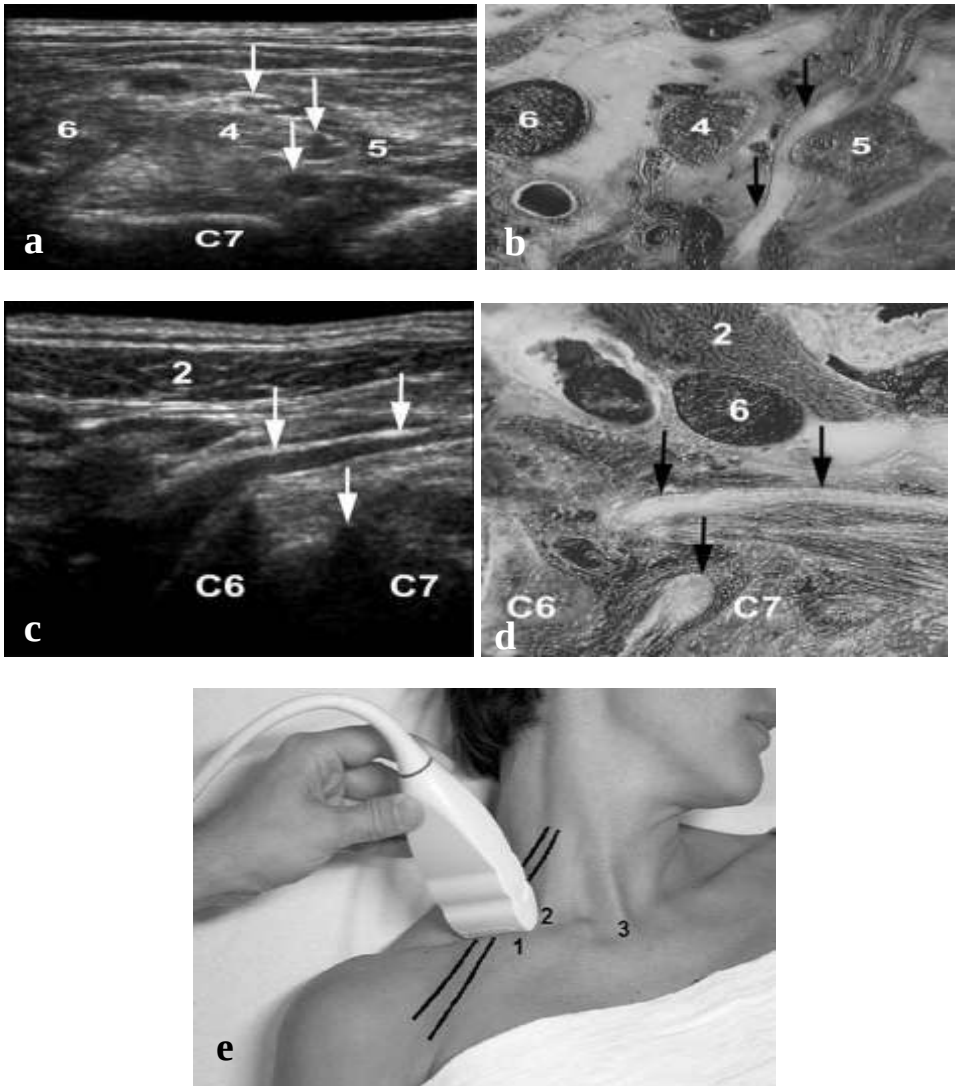


Fig. (1-4 a–e): Transverse US scan (a) with the corresponding cryosection (b) showing the roots and trunks of the brachial plexus (arrows) between the anterior (4) and middle (5) scalene muscle in typical topographic relation to the internal jugular vein (6) (body of the seventh cervical vertebra C7. US scan (c) and corresponding cryosection (d) according to the course of the roots and the proximal trunks of the brachial plexus (arrows) sternocleidomastoid muscle 2, internal jugular vein 6 and bodies of the sixth and seventh vertebra C6, C7). e) Scheme with the projection of the trunks of the brachial plexus onto the skin surface with the according landmarks: lateral (2) and medial (3) part of the sternocleidomastoid muscle, clavicle (1) ***(Quoted from Baert et al., (2008).***

Sonographic Anatomic Correlation in the Lower Extremity:

Just like the proximal extremity, the lower extremity forms paddle-like in the fetal period. It is supplied by the according neural segments (metamer segmentation) of the rump wall. In later life this ontological specialty results in the distinct distribution of the sensible dermatomes in correlation with the supplying spinal roots. For the lower extremity these are the segments L1–S3. The annular organization of the dermatomes on the rump wall is transferred to a somewhat longitudinal representation in the lower just as it is in the upper extremity, however with some kind of inward rotation of the dermatomes. The recombination of the axons with formation of the peripheral nerves itself takes place at the level of the lumbar and sacral plexus, with the ventral parts of the lower extremity supplied by the lumbar and the dorsal parts as well as the pelvic floor by the sacral plexus ***(Baert et al., 2008).***

Nerves of the Thigh:

The recombination of the neural fascicles of the femoral nerve takes place within the psoas muscle where it is split into a superficial and profound section. The proximal part of the nerve leaves the psoas muscle at its lateral border, running downward to the inguinal region in the retroperitoneum inside a groove

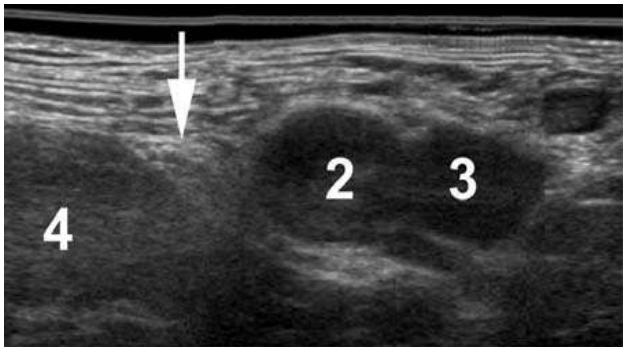
formed medially by the psoas muscle and laterally by the iliac muscle. It leaves the muscles lacuna as the most medial structure separated from the adjacent femoral artery only by the ileopectineal arch (Fig. 1-5). The latter is a thin tendinous structure which is part of the inguinal ligament complex and connects the inguinal ligament and the body of the iliac bone ***(Gruber et al. 2002).***

After a variable distance the nerve spreads into several terminal branches: ventral and medial cutaneous nerve branches and motor branches for the supplied muscles. The main direction of the course of the femoral nerve and its branches is always parallel to the underneath lying sartorial muscle. The final branch of the femoral nerve, the saphenus nerve lies adjacent to the superficial femoral artery and perforates the vasto-adductorial membrane in its distal third of the thigh together with the descendent knee artery, a branch of the superficial femoral artery. The saphenus nerve supplies the knee and the medial aspect of the lower leg with sensory fibers and runs subcutaneously to the region of the superficial pesanserinus. The femoral nerve is best assessed with sonography in its groin section ***(Gruber et al. 2002).***

Here it can be found next to the pulsating femoral artery with an oval or triangular cross-sectional appearance. The distal section of the femoral nerve in its pelvic course up to 10 cm proximal to the inguinal ligament may also be visualized with

sonography after sufficient evacuation of air in the hypogastric bowel. The proximal thigh-section of the nerve may sometimes be difficult to assess due to early branching as well as to low contrast differences between the nerve and surrounding soft tissues. The saphenus nerve may only be visualized in favorable conditions in its subcutaneous course at the medial aspect of the knee. The deep muscle-supplying branches of the femoral nerve cannot be visualized with present sonographic equipment ***(Gruber et al. 2002).***

(a)



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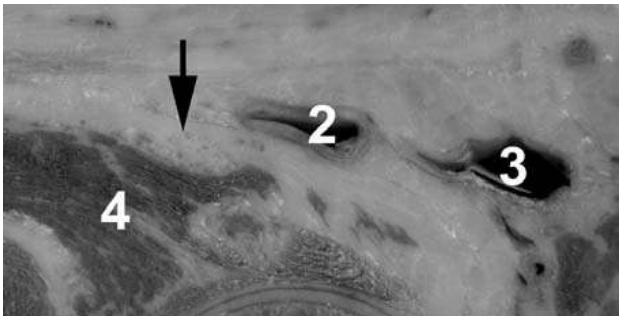

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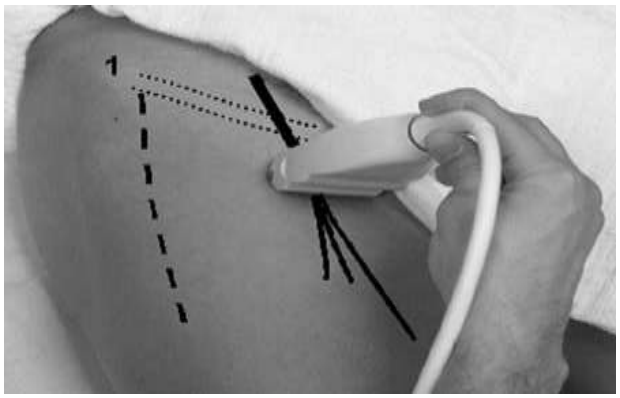

Fig. (1-5a–c): Transverse US scan (extended panoramic scan) (a) with the corresponding cryosection (b) showing the triangular cross-section of the femoral nerve (arrow) (accompanied closely by the femoral artery (2) and vein (3) altogether on the iliopsoas muscle (4). C Scheme with skin projection of the femoral nerve (lines), the lateral femoral cutaneous nerve (broken line) and the inguinal ligament (dotted lines). Superior anterior iliac spine (1) ***(Quoted from Baert et al., 2008).***