Impact of Virtual Cadaveric Anatomy on Optimizing Ultrasound Guided Regional Anesthesia for Peripheral Nerve blocks

An Essay

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Asmahan Talaat Abdel Fatah

INTRODUCTION

Ultrasound technology is advancing at a rapid pace in the practice of PNB. Ultrasound is revolutionizing the approach to neural blockade. The anesthesiologists can image neural structures under live guidance, and direct a needle to its final destination. In addition, the injection of local anesthetic can be visualized, confirming its appropriate perineural location ***(Arbona et al., 2011).***

Anatomy is considered the map to an effective nerve block, through the well knowing of its course and relationship. So, understanding of regional anesthesia through cadaveric anatomy is required of the well rounded anesthesiologist ***(Arbona et al., 2011).***

In this essay we highlight the impact of understanding the cadaveric anatomy and ultrasound image for each nerve bock at the peripheral extremities (upper limb, lower limb).

In the upper limb, PNB can be done at any part of its course by identifying its roots, cords, divisions and the individual main nerves and blocking them together or each one separately ***(Hattie, 2012)***.

In the lower limb, there are various peripheral nerves to be blocked starting from their origin up to their peripheral branches. And the anatomical structure of the lower limb gives wide variable techniques for producing high efficacious nerves blockade ***(Rizzolo et al., 2012)***.

AIM OF THE ESSAY

The aim of this essay is to reveal the substantial role of interplay between cadaveric anatomy and ultrasound guided regional anesthesia for peripheral nerve blocks.

CHAPTER 1: INTRODUCTION ABOUT VIRTUAL CADAVERIC LABORATORY

Anatomy is the geography of the body and, it is a very precise science because of its universally accepted terminology for the study of all body parts with location, description and relationship to one another ***(Ghosh, 2016)***.

The word anatomy is derived from the Greek word ***anatome*** which means literally "cutting apart". Term Gross Anatomy refers to the study of the human body by dissection or by cutting it apart ***(Hattie, 2012)***.

Human anatomy can be taught with many different ways, including textbooks, lectures and interactive learning resources, but one of the most important elements to be considered as a fact that the learning of anatomy directly from the source (cadavers dissection) is the effective way of knowledge which ultimately supplies medical stuff with the professionalism they need in their career ***(Bolender et al., 2013)***.

Anesthetist, in particular, requires an accurate specialized knowledge of anatomy. Therefore an accurate knowledge of human anatomy and understanding of most anatomical relationships and their correlations especially natural variations with individuals is the cornerstone of a competent practice of regional anesthesia ***(Crow et al., 2012)***.

The real anatomy study with dissection and demonstration using cadavers has been described as the superior way to create meaning and justly, the logic understanding of the complexity of the human body is actually by seeing the inner compartments yourself. The human cadavers represent a key anatomy learning tool in most medical schools, whether theoretical or practical and the earliest explanation of vital phenomena was naturally sought in dead organs ***(Older, 2004)***.

Medical care providers have opined that cadaveric dissection deepens their understanding of anatomical structures, provides them with a three dimensional perspective of structures and helps them to recall what they learnt. It is noteworthy that the innovative modes of learning anatomy such as the interactive multimedia resources have not replaced student's perception about the importance of cadaveric dissection ***(Azer and Eizenberg, 2007)***.

Cadaver laboratories can involve the use of standard surgical or interventional supplies, imaging equipments and or mechanical testing equipments to gather information about device / tissue interface, device placement, device failure under loading conditions, etc ***(Rizzolo et al., 2012)***.

Moreover, cadaver dissection during anatomical training may be a valuable introduction for health care providers especially anesthesia trainees who are leading the transformation of regional anesthesia by using informationintervention interaction to advance the quality of regional anesthesia by identification of the correct anatomical landmarks and their relationships for performing various nerve blocks ***(Nwachukwu et al., 2015).***

The difficulties in handling and the problems of preservation of human anatomical preparations are eliminated with the process of plastination which has received worldwide acceptance for its value in preparing durable material for teaching and museum display ***(Dhingra et al., 2006)***.

"I profess to learn and to teach anatomy not from books but from dissections, not from the tenets of Philosophers but from the fabric of Nature. "— William Harvey.

CHAPTER 2: ULTRASOUND SCANNING TECHNIQUE IN PERIPHERAL NERVE BLOCKADE (PNB)

Ultrasound use has expanded dramatically among the medical specialties for diagnostic and interventional purposes, due to its affordability, portability, and practicality.

Ultrasound guidance is rapidly becoming the gold standard for regional anesthesia. There is an ever growing weight of evidence, matched with improving technology, to show that the use of ultrasound has significant benefits over conventional techniques, such as nerve stimulation and loss of resistance ***(Griffin and Nicholls, 2010)***.

Ultrasound is commonly used by anesthetists for accurate injecting during placing local anesthetic solutions near nerves. It is also used for gaining vascular access such as central venous and difficult arterial cannulation ***(Bourgeois and Lamagna et al., 2011).***

Direct ultrasound visualization significantly improves the outcome of most techniques in regional anesthesia. With the help of high resolution ultrasonography, the anesthetists can directly visualize relevant structures for upper and lower extremities nerve blocks at all levels. Such direct visualization can improve the quality of nerve blocks and avoid complications. The benefits of direct visualizing targeted structures and monitoring to the distribution of local anesthetic are significant. This ultrasound monitoring allows the anesthetists to reposition the block needle in the event of misdistribution of the injected local anesthetic. The relationship between the block needle tip and target nerve is of paramount importance to the safe conduct of peripheral nerve block (PNB) ***(Marhofer et al., 2005)***.

Physical aspects of ultrasound waves:

Ultrasound waves are generated from high frequency sound waves but with specific frequency ranges. Ultrasound waves penetrate a tissue by depending on the range of the frequency produced. Lower frequencies penetrate deeper than high frequencies ***(Torres et al., 2016).***

Wave motion transports energy and momentum from one point in space to another without transport of matter ***(Larson, 2009)***.

As the sound waves passes through tissues, it is absorbed, reflected or allowed to pass through, depending on the echo-density of the tissue. Substances with high water content (e.g. blood, cerebrospinal fluid) conduct sound waves very well and reflect very poorly and thus are termed echo-lucent. Because they reflect very little of the sound waves, they appear as dark areas. Substances low in water content or high in materials that are poor sound waves conductors (e.g. air, bone) reflect almost all the sound waves and appear very bright. Substances with the sound waves conduction properties between these extremes appear darker to lighter, depending on the amount of wave energy they reflect ***(Thomas et al., 2004)***.

In general, the highest frequency capable of adequate penetration to the depth of interest should be used for imaging ***(Aldrrich, 2007)***.

Beam width:

Ultrasound systems assume all reflectors lie directly along the main axis of the ultrasound beam, however, ultrasound beams have a finite size, it also can be focused to reduce the beam width and thereby improve Image quality ***(Goldstein and Madrazo, 2008)***.

Ultrasound guidance is considered a standard nerve localization technique for peripheral nerve block (PNB). As an accurate deposition of local anesthetic next to the nerve is essential to the success of the nerve block procedure. Importantly, nerve injury may result both from an inappropriately placed needle tip and inappropriately placed local anesthetic ***(Mahler et al., 2010)***.

Ultrasound brings an ultimate improve of safety and efficacy to regional anesthesia and that will help promote its use and realize the benefits that regional anesthesia has over general anesthesia, such as decreased morbidity and mortality, superior postoperative analgesia, cost-effectiveness, decreased postoperative complications and improved postoperative course ***(Dawson, 2011)***.

Visualizing nerves by sound waves requires the use of high frequencies offering high-resolution images. However, the higher the frequency is, the smaller the penetration depth. Most nerve block applications require frequencies in the range of (10–14) MHz. Broad-band transducers covering a band width of (5–12) or (8–14) MHz offer excellent resolution of superficial structures in the upper and good penetration depth in the lower frequency range. The connective tissue inside the nerves (perineurium and epineurium) reflects ultrasound waves in an anisotropic manner. Essentially, the intensity of the reflection depends on the angle of the ultrasound wave relative to the long axis of the nerve. The true echogenicity of a nerve is only captured if the sound beam is oriented perpendicularly to the nerve axis. Consequently, linear array transducers with parallel sound beam emission offer advantages over sector transducers, which are characterized by diverging sound waves, such that the echo texture of the nerves will only be displayed in the centre of the image ***(Konay et al., 2004)***.

Ultrasound-guided nerve block can be performed with modern ultrasound systems. They should be equipped with software to visualize both superficial tissues and musculoskeletal structures. High-resolution ultrasound (HRUS) systems are provided with software that allows optimal visualization of tissue contrast ***(Greher et al., 2004)***.

Sonographic appearance of peripheral nerves:

Peripheral nerves may have a hypoechoic (dark structures) or hyperechoic (bright structures) sonographic appearance, depending on the size of the nerve, the sonographic frequency, and the angle of ultrasound beam. Most peripheral nerves can be visualized over their entire course. Their visibility might be limited where dorsal shadows of bone structures or large vessels are present ***(Marhofer et al., 2005)***.

There are two basic approaches to ultrasound guidance.

Out-of-plane approach:

With ***out-of-plane*** approach technique, the needle tip enters the skin and crosses the plane of imaging as an echogenic dot, away from the probe. The out-of-plane approach uses a shorter needle path than in-plane approaches. If short-axis views of the nerve are used, an out-of-plane approach results in catheter placement with ultrasound guidance along the path of the nerve. One disadvantage of the out-of-plane approach is the extent of the non imaged needle path (structures that may lie short of or beyond the scan plane). If the needle tip crosses the scan plane without recognition, it can be advanced beyond the scan plane into undesired tissue ***(Gabriel et al., 2007)***.

In-Plane approach:

With ***in-plane*** approach, the needle enters the skin at the side of the probe. The needle traverses the plane of ultrasound and the whole shaft is visualized as it progresses towards the target structure. There are several advantages of the in-plane approach. It provides the most direct visualization of the needle tip and injection. The needle is visualized before advancement. One disadvantage is the long needle path, which results in more tissue for the needle to cross. Large-bore needles are often used with this approach to facilitate alignment. Partial line-ups (visualization of the needle shaft without visualization of the needle tip in the scan plane) create a false sense of security and therefore compromise safety of the technique ***(Graham and Barry, 2016).***

Out-of-plane transverse approach | In-plane longitudinal approach | Out-of-plane oblique approach

Fig. (1): Approach techniques to ultrasound guided peripheral nerve block ***(Ban et al., 2010).***

CHAPTER 3: UPPER EXTREMITIES NERVE BLOCK

The risk-benefit ratio often favors regional anesthesia in patients with multiple comorbidities for whom general anesthetics carry a greater risk as, who have cardiac problems or obstructive/restrictive lung diseases or morbid obesity, pregnancy, also patients who intolerant to systemic analgesics. So, the goal is to bathe all the required nerves with sufficient anesthesia so that sensory conduction will be completely arrested ***(Burnham, 2012).***

Anatomy of the upper limb:

The knowledge of sensory and motor nerve supply of the upper limb is essential for regional anesthesia, the cutaneous nerve supply of the upper limb which carries sensation of pain, touch, temperature and pressure is derived from the ventral rami of spinal nerves from C3 to T2 of spinal segments. During dissection, the nerves are seen to arise from the source which is (Cervical Plexus, Brachial Plexus and Intercostobrachial Nerves) ***(Joseph et al., 2009).***

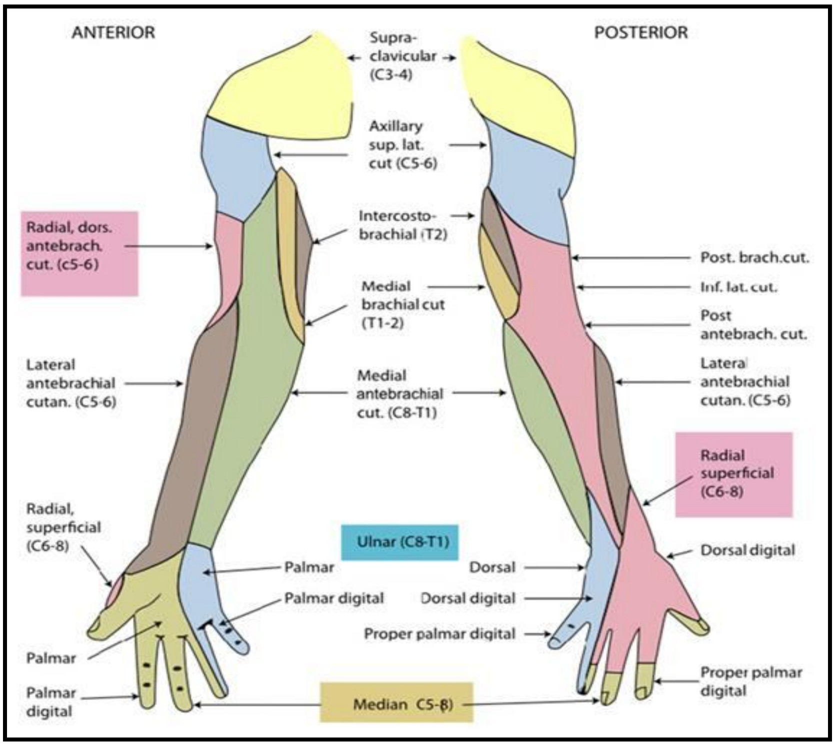

Fig. (2): Innervations of the upper limb ***(Henry, 2012).***

Nerve supply of the upper limb goes as follows:

1- Pectoral region:

Above the 2nd rib, this region is supplied by the supraclavicular nerves (C3-C4).

2- Axilla:

The skin of armpit is supplied by inercostobrachial nerves T2 and small branches of T3.

3- Shoulder:

- Upper half of the deltoid region is supplied by supraclavicular nerves (C3-C4).