INTRODUCTION

In the practice of neuroaxial blockade ; the golden aim is to deliver precisely to the target point exactly the right dose of local anesthetic without incurring any risk of ectopic insertion of needle or the catheter and without any risk of damage to the spinal cord or its spinal nerves ***(Peter et al., 2008)***.

Currently, we aim to achieve this by using needles and catheters, guided mostly by knowledge of the anatomy supplemented by electrical nerve stimulation or the elicitation of paresthesia. Knowledge of anatomy takes the needle to the general area of the nerve and helps to avoid other structures. The specific nerve location technique allows a close approach, without the risk of nerve damage. Unfortunately, this is essentially a blind process, but modern imaging techniques might be used to overcome this ***(Peterson et al., 1998).***

One developing area of ultrasound use in anesthesia is for performing neuroaxial blockade. Portable two dimensional ultrasound allows the clinician to place the needle with precision, guided by a real-time image of the patient's actual anatomy and not that implied by surface anatomy landmarks ***(Peter et al., 2008)***.

Such a technique offers potential advantages including:

- Improved effectiveness with accurate and reliable deposition of a local anesthetic to the target.
- Improved safety profile with the potential to eliminate traumatic nerve injury from needle placement and intravascular injection.
- Eliminates technical difficulties associated with individual anatomical variation and distortion, for example obese patients.

Thus, in order to benefit from these advantages, clinicians require training in this new technique as well as access to appropriate equipment and consumables ***(James and Barry, 2006)***.

The scope of ultrasound imaging guidance for regional anesthesia is growing rapidly. Preliminary data, although limited, suggest that ultrasound can improve block success rate and decrease complications ***(Peter et al., 2008)***.

Ultrasound technology is advancing at a rapid pace. The practice of ultrasound-guided nerve blocks may not require that all practitioners have an in-depth understanding of the physics and technical details behind today's sophisticated ultrasound equipment. However, anesthesiologists must understand some basic ultrasound principles that are relevant to the clinical practice ***(Peter et al., 2008).***

AIM OF THE WORK

The aim of this work is to verify that ultrasound guidance in neuroaxial blockade could be helpful and offering many advantages in the practice of anesthesia.

HISTORICAL REVIEW OF THE USE OF ULTRASOUND IN REGIONAL ANESTHESIA

Ultrasound-aided nerve blocks have been reported in an anesthetic literature since 1978, with an increase in interest from the mid-1990s, probably as a result of improvements in ultrasound equipment ***(Greher et al., 2002).***

Most of the studies of ultrasound in regional anesthetic practice have looked at one or more of the various approaches to the brachial plexus, some using ultrasound to identify and mark the skin over blood vessels and others using it to guide the needle or catheter to the nerve. Ultrasound has also been used to visualize the spread of local anesthetic from a catheter and to validate currently used landmarks ***(La Grange et al., 1978).***

It was tried to find whether ultrasound guidance for nerve block affected the dose of the local anesthetic required, and they proved that ultrasound guidance help maximally in codifying the dose of the local anesthetic injected. It is also worth mentioning that ultrasound has been used to assess the depth of the epidural space and to assess the lumbar epidural space during pregnancy ***(Grau et al., 2001).***

PHYSICS AND PRINCIPLES OF ULTRASOUND

Ultrasound*:*

It even travels at exactly the same speed as sound in any medium. Human can hear sound within the frequency range of about 20 to 20,000 Hz, so any sound above 20 KHz is ultrasound.

How is the image formed on the monitor

The strength or amplitude (brightness) of each reflected wave is represented by a dot, the position of the dot represents the depth from which the returning echo was received, these dots are combined to form a complete image. Indeed, the reflection differ according to the tissue type so that:

- Strong Reflections = White dots (e.g diaphragm, gallstones, bone).
- Weaker Reflections = Grey dots (e.g most solid organs, thick fluid).
- No Reflections = Black dots (e.g fluid within a cyst, urine, blood).

Position of Displayed Echos:

The display screen is divided into a matrix of PIXELS (picture elements) where the system knows the depth of the reflection by calculating how long it takes for the echo to return to the scan-head using the principle that:- Distance=Velocity/Time, where the velocity in tissue is assumed constant at (1540m/sec.) (Fig. 1).

Piezoelectric Effect:

The characteristic of the transducer elements (crystals) is to converts electrical energy into mechanical energy and vice versa. Thus, an electric field set up by a voltage applied to two electrodes on its surface, causes a dimensional change of the crystal. Most ultrasonic transducers use artificial polycrystaline ferroelectric materials such as lead zirconate titanate (PZT). It is to be mentioned that element thickness determines the resonant frequency (Fig. 2) ***(James and Barry, 2006).***

Transducer frequency and wavelength:** ***Frequency: is expressed in MHZ and is supply the number of pr. Peak/unit time and determine resolution.

Wavelength: is died as the distance between 2 pr peaks and determine penetration (Fig. 3).

Velocity: sounds (meta/second) Fx wave length

Frequency represent the resolution which mean its penetration. However, a 12 MHz scan-head has a very good resolution, however, it cannot penetrate very deep into the body (4-5cm).

On the other hand, a 3 MHz scan-head can penetrate deep into the body(6-9cm), but the resolution is not as good as the 12 MHz.Thus it is better to use the highest frequency transducer that will reach to the required depth (Fig. 3) ***(James and Barry, 2006)***.

*** Image Resolution:**

The ultimate goal of any ultrasound system is to make like tissues look alike and unlike tissues look different, resolving capability of the system depends on: (Fig. 4).

- ***Axial Resolution:***

Specifies how close together two objects can be along the axis of the beam, yet still be detected as two separate objects. Indeed, the frequency (wavelength) affects axial resolution.

- ***Lateral Resolution:***

The ability to resolve two adjacent objects that are perpendicular to the beam axis as separate objects. Morever, beam width affects lateral resolution.

- ***Spatial Resolution***

Also called Detail Resolution. It is the combination of AXIAL and LATERAL resolution.

• *Contrast Resolution*

The ability to resolve two adjacent objects of similar intensity and reflective properties as separate objects (Fig. 5).

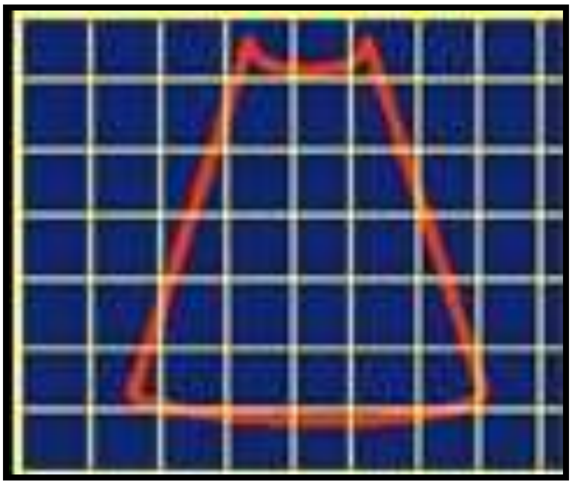


Figure (1): Position of displayed echos ***(James and Barry, 2006)***

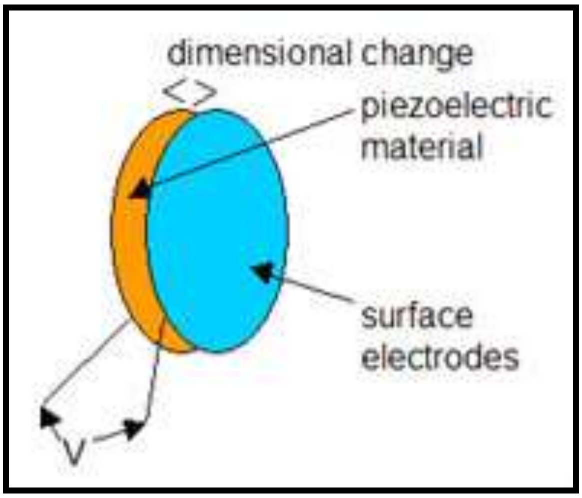


Figure (2): Piezoelectric effect ***(James and Barry, 2006).***

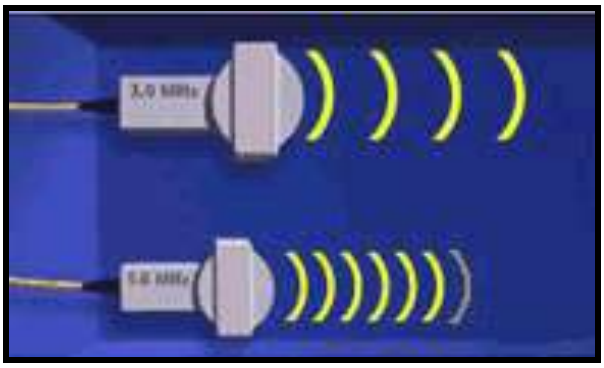


Figure (3): Transducer frequency and wave length ***(James and Barry, 2006)***

Figure (4): Image resolution ***(James and Barry, 2006)***

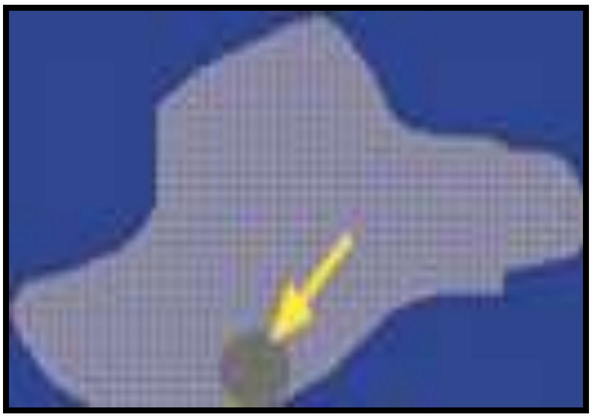


Figure (5): Contrast resolution ***(James and Barry, 2006)***

* Ultrasound System Concept

System beam-former initiates sound wave then scan-head produces “pulses” of ultrasound which is transmited through the medium and soon reflected from tissue interfaces and signal returns to the system.An image of all reflections is formed on the monitor (Fig. 6).

Transducers turn electrical energy into mechanical waves and visa versa, after encountering reflective structures, some of the sound waves travel deeper into the body which will be reflected from deeper structures ***(James and Barry, 2006).***

* Echo Location:

Sound is reflected any time. A wave changes mediums and energy peaks occur when the transducer receives a reflection. Indeed, the size of the peak depends on the strength of reflection and the delay of reflection is interpreted as distance from the probe. It is to be mentioned that sound travels at a speed of 1540 m/s in tissue at 37°C (Fig. 7) ***(James and Barry, 2006)***.

* What is doppler?

Doppler Effect is based on the work done by the Austrian physicist Johann Christian Doppler, which is the apparent change in received frequency due to relative motion between a sound source and sound receiver. Thus, a source moving ***toward*** the receiver will yield a ***higher*** frequency and a source moving ***away*** from the receiver will give a ***lower*** frequency ***(James and Barry, 2006)***.

*** Doppler in ultrasound:**

It is used to evaluate blood flow and the scan head is the sound source and receiver, meanwhile, flow is in motion relative to the scanhead. Doppler produces an audible signal as well as a graphical representation and flow equals spectral waveform.

The Doppler shift produced by moving blood flow is calculated by the ultrasound system using the following equation ***(James and Barry, 2006)***:

$$F_d = \frac{2F_t V COS\theta}{C}$$

Where Ft is the transmitted Doppler frequency, V is the speed of blood flow, Cosθ is the Cosine of the blood flow to beam angle , C is the speed of sound in tissue and F_d *is the Doppler shift frequency .*

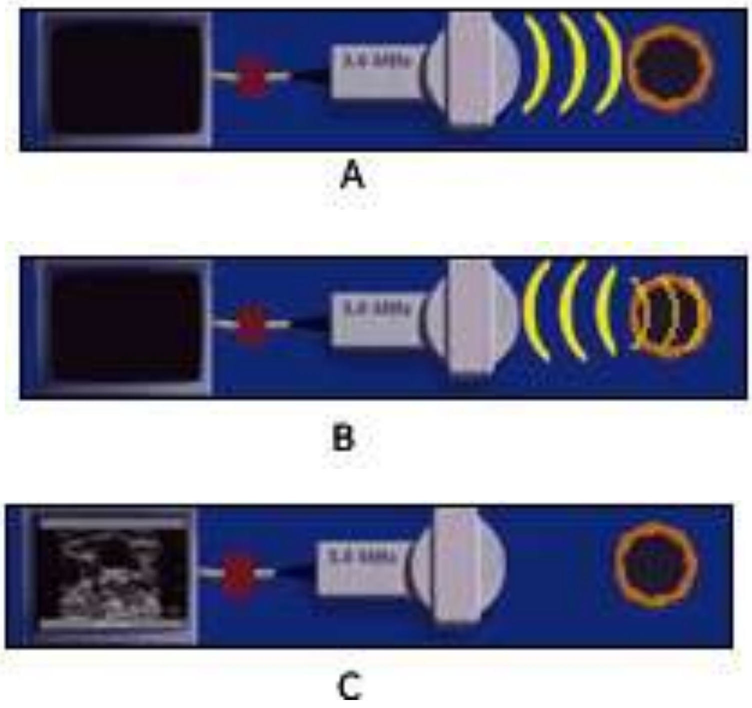


Figure (6): U/S concept ***(James and Barry, 2006)***

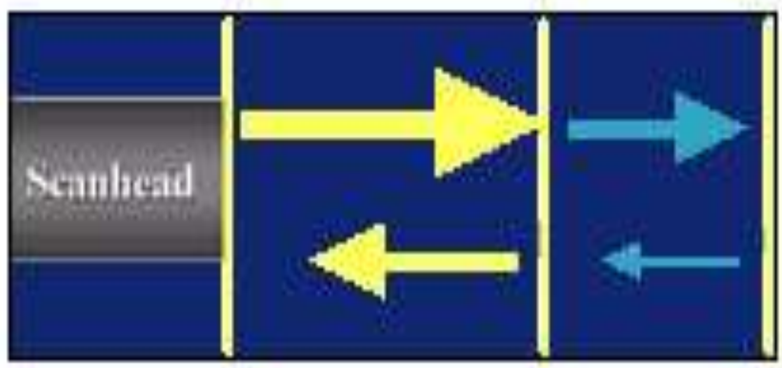


Figure (7): Echo location ***(James and Barry, 2006)***

*** What is Colour Doppler?**

It utilizes pulse-echo Doppler flow principles to generate a colour image Fig (8 a). This image is superimposed on the 2D image Fig(8 b). The red and blue display provides information regarding direction and velocity of flow Fig(8 c), regardless of the colour, the top of the bar represents flow coming towards the scan head and the bottom of the bar represents flow going away from the scan head ***(James and Barry, 2006)***.

*** Relative 2D B-mode (brightness) ultrasound:**

Two dimensional gray-scale display of anatomy (i.e solid areas in "white" and fluid areas in "black"). Currently it is considered the most common form of imaging .It allows the physician to assess both motion and anatomy, including the motion of the heart valves, the movement of the intestine and lungs and also to guide needle biopsies to various organs. To produce a visual of motion, the ultrasound beam is swept repeatedly over the area being examined (this generates a rapid series of individual 2-D images which show motion) ***(James and Barry, 2006)***.

*** The machine:** The most commonly used machines are:

SonoSite® MicroMaxx™ (Fig. 9 a)

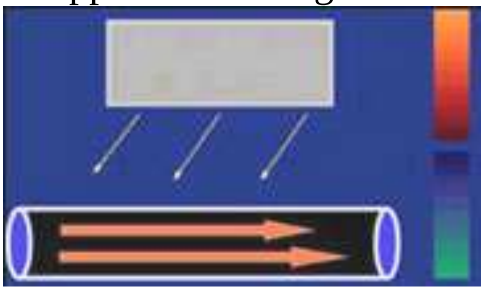
SonoSite TITAN™ (Fig .9 b)

SonoSite® 180plus (Fig .9 c)

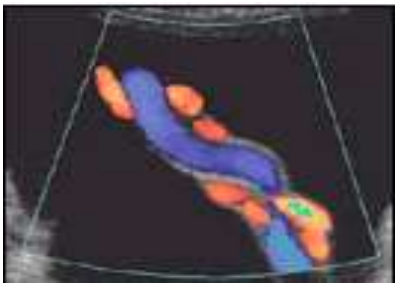
SonoSite® iLook™ (Fig .9 d)

- The SonoSite MicroMaxx laptop-sized unit represents the technology crossover point between hand-carried ultrasound and larger, high-performance, cart-based systems. The system yields high-quality images with speed and reliability while efficiently operating on either alternating current AC or battery power. It can be used for all approaches in regional anesthesia.

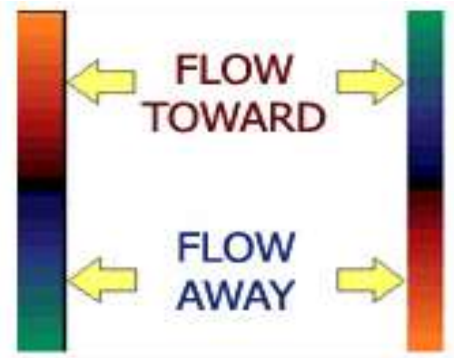
- The SonoSite TITAN is a high-resolution ultrasound solution providing health care professionals with state of the art high-resolution imaging wherever needed for responsive rapid patient care. It can be used for all approaches in regional anesthesia.



A



B



C

Figure (8): a,b,c: Colour Doppler

A- SonoSite® MicroMaxx™ **B- SonoSite TITAN™**

C- SonoSite® 180plus **D- SonoSite® iLook™**

Figure (9): a,b,c,d) Types of ultrasound machine ***(James and Barry, 2006)***

- The SonoSite 180 plus is a high quality point-of-care ultrasound solution. It produces a digital image on the integrated screen, weighs approximately 2.6kg and can be either battery or AC powered. It can be used for all approaches although limited resolution of the screen may make interpretation difficult - especially for deeper blocks.