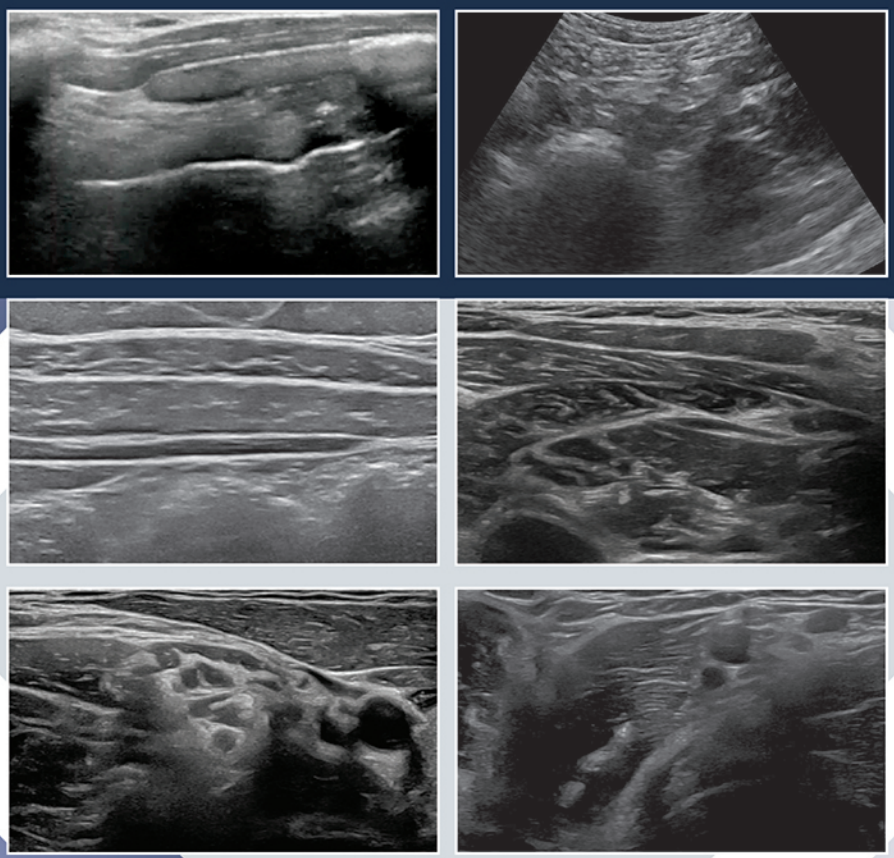
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Ultrasound-guided Regional Blocks



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SECTION 1

Fundamentals of Ultrasound-guided Regional Anesthesia

1. Introduction to Ultrasound-guided Regional Anesthesia

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CHAPTER 1

Introduction to Ultrasound-guided Regional Anesthesia

PART I: ULTRASOUND PHYSICS—BASIC PRINCIPLES

As we know, diagnostic ultrasound is an important and powerful tool which is minimally invasive that improves diagnostic and therapeutic accuracy in clinical settings of the medical field. Knowledge of the basic principles of ultrasound physics form basis of image acquisition, image optimization and image integration for minimally invasive procedures such as ultrasound-guided regional anesthesia.[1] The awareness of this knowledge of imaging manipulations and ultrasound physics role in it empowers the sonologists as well as anesthetist doing the guided procedure for optimization of their clinical use in various clinical settings.[2]

Sound is a mechanical form of energy that propagates in high- and low-pressure waves in an alternative fashion, and it requires medium which in clinical setting can be air, water, fluid, tissues, and bones. Through these media, sound waves propagate in high pressure and low-pressure phases, which are called compression and rarefaction, respectively.[1,3]

Ultrasound is high-frequency sound waves to aid in diagnosis as well as various therapeutic procedures involved in patient management, and the frequencies range from 2 to 20 MHz. The transducer is an instrument which can emit as well as receive ultrasound waves which is done with the help of the piezoelectrical crystals which convert electrical signal to sound waves and vice versa.[3] These ultrasound waves or pulses of sound emitted from the transducer are propagated through the tissues and produce echoes, which are of different strength, direction and timing from different tissues, that are returned to the transducer. These returned echoes are further converted back to electrical signals by the transducer, itself and further processing is done of these signals and image we see on ultrasound screen is formed.[4] As there is difference in density on surface of the different tissues, the reflection of the ultrasound waves will be different proportional to the difference in impedance, which means if the density of tissue is high, the amount of reflected sound will also be increased in proportion whereas its proportion being transmitted will be less.[5,6] There is no production of echoes in homogenous fluids such as blood, urine, pleural effusion, and ascites because there is no difference between the tissue densities or their interfaces. Whereas if the tissue density is different, then sound is completely reflected known as acoustic shadowing as seen in calculi, bones, air, etc.[4,7,8]

Frequency is a term used to describe the number of cycles in second emitted by the probe, and its unit is Hz (hertz).[9,10] Amplitude is the height of wave and is the distance between the peak and average of a wave, power is square of the amplitude, measure in watts or milliwatts and usually displayed on ultrasound machine as dB (decibels). Acoustic impedance is the speed of ultrasound waves in soft tissue, i.e., 1,540 m/sec and as the tissue density increases, the propagation speed increases. The angle of incidence is the angle at which the ultrasound

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waves engage with any structure on its way. The reflectivity is maximum when the object is visualized perpendicular to the angle of the ultrasound beam.[1,10,11]

The awareness of this knowledge of ultrasound physics and its role in image manipulation make the sonologists as well as anesthetists do the guided procedure to optimize it for clinical use in various clinical settings.

PART II: THE ULTRASOUND EQUIPMENT AND KNOBOLOGY

The technological advances lead to dramatic evolvement of use of ultrasonography; however, the basic principles and functions remain essentially same.[12] For optimal performance of ultrasound-guided regional anesthesia, the knowledge as well as awareness of ultrasound knobs and equipment is important. The knowledge of the management of images generated through these knobs help us to become familiar with knobs as well as machine and optimize the ultrasound-guided procedures.[13]

ULTRASOUND PROBE OR TRANSDUCER[12,14]

These can be labeled as true workhorses of ultrasonography equipment that is an instrument, which can emit as well as receive ultrasound waves, which is done with the help of the piezoelectrical crystals, which convert electrical signals to sound waves and vice versa and generate images from returned echoes from tissues. The commonly used probes are:

- *Linear array:* High frequency (5–15 MHz) and is ideal for superficial soft tissue evaluation, neurovascular structures thus standing apart as the true workhorse for ultrasonography-guided regional anesthesia.
- *Curved array:* Low frequency (2–5 MHz) with large footprint referred as abdominal probe
- *Endocavitary:* Moderate frequency (8–15 MHz) and ideal for transvaginal use
- *Hockey stick:* High frequency (6–20 MHz) and ideal for musculoskeletal imaging and interventions

Modes

- B-mode (brightness mode) is a standard scanning mode that creates a 2-dimensional grayscale image on the ultrasound screen.[12,13]
- M-mode (motion mode) gives motion versus time display which detects motion/dynamic change in a specific location on image over a period of time.[13]
- Color Doppler mode makes use of Doppler shift, i.e., an evoked change in frequency of the returning movement to determine movement red implies that flow is toward the ultrasound probe and blue means that the flow is away from the ultrasound probe.[14,15]
- *Power Doppler mode:* It is also color Doppler but without assigning color to direction but uses shades of color commonly yellow; this mode is useful in low flow conditions.[12-15]
- Spectral Doppler allows assessment and quantification of flow velocity at specific point on an image.[15,16]

Presets: Numerous presets are available on machines which labeled as MSK, cardiac, abdominal, etc., thus, equivalent to automatically selecting particular frequency, depth and gain ideal for particular scan one needs to perform.

Power button: Mixture of "0" which indicates off and "1" which indicates on, thus a binary numbering system.

Depth: This determines how deep one wants the ultrasound machine to scan.

Gain: This makes the image brighter or darker.

Time gain compensation: This tailors the gain in near or far field as per requirement.

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Fig. 1: Knobology of the ultrasound machine marked 1–28.

Focus: Adjusting the focus at specific depth leads to concentration of ultrasound waves, thus maximizing the resolution of the image.

Freeze: It freezes the particular desire frame thus more detailed evaluation can be done.

Caliper: It is an important knob, which enables the user to measure specific region of interest.[15-18]

Optimal performance of ultrasound-guided regional anesthesia requires proper understanding of machine, equipment and knobs **(Fig. 1)**.

Knobology:

1. Curved array transducer
2. Hockey stick transducer
3. Linear array transducer
4. Phased array transducer
5. Endo cavitary transducer
6. USB port
7. Touch screen panel
8. Track ball
9. Time gain compensation
10. Power button
11. Advanced application presets
12. Advanced image improvement features
13. M-mode
14. Continuous wave Doppler
15. Pulsed wave Doppler
16. Power Doppler imaging
17. Color flow
18. Soft keys to adjust options on touch screen

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19. Pointer options
20. Annotations
21. Splitting screen or dual screen option
22. Print and save buttons
23. Freeze
24. Audio options
25. B-mode
26. Gel warmer with ultrasound gel bottle
27. USG display monitor
28. Saving button for cine clips and videos

PART III: NEEDLE VISUALIZATION AND GUIDANCE TECHNIQUES AND TRICKS

The optimization of needle imaging plays a pivotal role in ultrasound-guided regional blocks. Appropriate transducer having optimal frequency needs to be selected, then one has to do assessment of anatomy.[8]

Adjusting the patient couch to appropriate height and ergonomically placement of ultrasound machine is important as it gives better hand eye movements on the patient as well as screen.[8,19,20]

Pressure is applied on the transducer in a variable amount in real time visualizing sonographic anatomy, alignment with underlying nerve is done, fine tuning if required done with rotation and tilting of the probe with optimal anatomic recognition of the target nerve.[8,20-22]

Nerve imaging may be done along short axis where the probe is perpendicular to nerve axis, or the probe is in long axis where the probe is parallel to axis of the nerve, but it is more often seen that interventionist/anesthetist having probe and needle aligned to his/her axis. Preblock scan with Doppler analysis is highly recommended to do preintervention planning.[23]

The maintenance of needle tip visualization and advancing it avoiding injury to vital structures is of utmost importance and is achieved by using a shallow angle, heeling of one end of transducer, rotating and tilting for better visualization and use of echogenic needle which are available nowadays.[24]

"Hydro-location" is the technique/trick which has proven to be beneficial in majority of interventions. In this, a small amount of fluid is injected, which helps in revealing needle tip and its path better, especially if difficult situation.[23,24]

On obtaining adequate needle placement in the vicinity of the nerve which is targeted and with negative pressure to ensure that tip is not located inside intravascular structure. Local anesthetic is injected in small doses ensuring that the injectate is spread at the needle tip and is visualized in real time and negative pressure still to be given. A halo of injectate is needed to be created around, especially solitary nerves. Another tip to prevent intraneural injection and nerve injury is that when the needle has reached the interface with the nerve, withdraw the needle tip slightly and ensure that nerve does not move along with needle tip retraction. Fascial planes and sheaths, wherever available, should be taken use of in the optimal spread of the local anesthetic injectate along the longitudinal axials of the nerve.[8,25]

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