RADIOLOGICAL INTERVENTION IN ANESTHESIA

Essay

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To my
Mother

Contents

🕮 List of Tables

AVM	: Arterio-venous malformation
CBF	: Cerebral blood flow
CBFV	: Cerebral blood flow velocity
CI	: Cardiac index
CPB	: Celiac plexus block
CPP	: Cerebral perfusion pressure
CT	: Computed tomography
CTF	: Computed tomography fluoroscopy
CW Doppler	: Continuous wave Doppler
EBCT	: Electron beam tomography
Hz	: Hertz
ICP	: Intracranial pressure
IGCT	: Inverse geometry tomography
IJV	: Internal jugular vein
IR	: Intensity of reflection
JVP	: Jugular venous pressure
LVEDA	: Left ventricle end diastolic area
LVEDV	: Left ventricle end diastolic volume

List of Abbreviations (Cont.)

LVOT : Left ventricle outflow tract

MABP : Mean arterial blood pressure

MCAFV : Mean cerebral artery flow velocity

MRI : Magnetic resonance imaging

MRSI : Magnetic resonance spectroscopic imaging

MVA : Mitral valve area

NMR : Nuclear magnetic imaging

PW Doppler : Pulsed wave Doppler

RF : Radio frequency

SAH : Subarachinoid heamorrage

TCD : Transcranial Doppler

TEE : Transesophagel echo

THR : Transient hyperemia response test

US : Ultrasound

VBM : Voxel – based morphology

INTRODUCTION

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Common interventional imaging methods include X-ray fluoroscopy, computed tomography (CT), ultrasound (US), and magnetic resonance imaging (MRI). Fluoroscopy and computed tomography use ionizing radiation that may be potentially harmful to the patient and. However, both methods have the advantages of being fast and geometrically accurate. Ultrasound suffers from image quality and tissue contrast problems, but is also fast and inexpensive. Magnetic resonance imaging provides superior tissue contrast, at the cost of being expensive and requiring specialized instruments that will not interact with the magnetic fields present in the imaging volume ***(Ashton et al., ١٩٩٩)***.

As time goes by radiological intervention becomes increasingly useful to the anesthesiologist for patient monitoring, intra operative diagnosis and research. Advances in this technology brings increasing number of of indications for the usage. However, this technology is complex and anesthesiologists wishing to make full use of it will likely have to study a lot of information concerning its basic principles and methods of application ***(Bashein, ١٩٩٣)***.

One of the best of those radiological means is Ultrasound, which creats its image by emitting high frequency acoustic pulses from a piezoelectric crystal transducer and allowing the sonic pulses to travel through soft tissues. Because tissues of various types possess different acoustic properties, each interface causes a small portion of pulse energy to be reflected as an echo. The return of these echos to the transducer generates a small voltage signal ***(Arnold et al., ١٩٨٨).***

The Second radiological modality that will be discussed is Computerized tomography (CT scan) which has become the most widely used procdure by providing a series of tomographic axial slices of the head and body. The CT has provided lots of help to the anesthesiologist by both featuring the anatomy of the area of interest and mapping out the way by which can apply he different techniques to reach the desired space in human body. Example for that would be CT guided epidural anaesthesia.

Magnetic resonance imaging (MRI) is a new imaging modality that depends on magnetic fields and radio-frequency pulses for the production of the its images. Due to it especial characteristics MRI is excellent for imaging of soft tissues and differentiate them from the surroundings. However, certain precautions must be taken to allow anesthesia equipment to work in that magnetic field with being affected by the surrounding magnetic energy. ***(Ashton et al., ١٩٩٩).***

BASIC PRINCIPLES

I- Ultrasound

Nature of sound:

A sound wave is a mechanical disturbance that is propagated through a liquid, solid or gas medium. Sound waves do not propagate in vacuum. Sound waves are produced by vibrating sources. Vibrations of the source produce vibration of the adjacent molecules in the medium, which push against molecules that are more distal and so forth. The resulting mechanical disturbance travels away from the source at the speed of sound. Sound waves result in energy that is being transmitted through the medium but with no net displacement of the medium's particles. When the sound source is turned off, the particles remain in position they would have been without the wave present ***(Sabbagha, ١٩٩٤).***

Longitudinal and transverse sound waves:

When a sound wave travels through a medium, the particles in that medium are displaced in a direction that is parallel to the direction of travel of the sound wave. This is called a longitudinal wave. It is possible in some media such as quartz and direction of vibration of particles is perpendicular to the direction of travel of the wave. These are called transverse waves. In the body, they can propagate through bone. However, transverse waves will not propagate though soft tissue ***(Sabbagha, ١٩٩٤).***

Diagnostic ultrasound transducers are designed to produce longitudinal sound waves, because only longitudinal waves can be transmitted through soft tissues.

What is Ultrasound?

The normal range of sound that human beings can perceive is ٢٠-٢٠,٠٠٠Hz. A sound wave of a frequency higher than ٢٠,٠٠٠ Hz is called ultrasound. For medical purposes, frequencies between ١ and ٤٠ MHz (mega Hertz) are used ***(Rolandi et al., ١٩٩٣).***

Production of ultrasound:

When electrical current is applied to each side of a piece of quartz coaled with silver, the quartz expands or contracts from its original thickness, depending on the polarity of the current applied. This phenomenon is called a piez electric effect, and a substance with this polarity current, the Piezo electric element returns to its original shape and the energy produced is propagated to the surrounding media as ultrasound. The frequency of ultrasound is a function off the physical characteristics of the crystal itself. When a piezo electric element is physically compressed by externally applied ultrasound, it produces a current. Hence, the Piezo electric element serves a dual function as both transmitter and receives ***(Higashi et al., ١٩٩١).***

Attenuation and time gain compensation:

Because the sound is propagated by oscillations of the conduction medium part of its energy is lost in this process. The degree of this attenuation of ultrasound is directly proportional to its frequency. This tends to limit the maximum distance that the higher frequency ultrasound can penetrate before it is completely absorbed. Since the intensity of ultrasound decreases as it travels through the medium, the echo apparatus incorporates a mechanism to amplify echoes from greater depth. This mechanism is called time gain compensation ***(Higashi el al., ١٩٩١).***

Reflection, refraction, and scattering of ultrasound:

The principle characteristic of ultrasound that forms the basis for its use in imaging is its reflection from surfaces encountered in its path. A surface can be defined as the interface between two media of different acoustic impedance (z), which is determined by density and velocity of sound conductance of individual materials. If the surface is large with respect to the wavelength of the sound, then the reflection is specular or mirror like and the angle of reflection is equal to the angle of incidence of the wave. The intensity of a secularly reflected wave (IR) is proportional to that of the incident wave (Ii) and the difference in impedances (Z١ , Z٢) of the adjacent media ***(Collins et al., ١٩٨٦).***

If on the other hand, the reflection surface is small in comparison to the sound wavelength specular reflection is not observed, but the waveform is scattered, with only a small portion of its energy being reflected to the source. Also, irregularities in a large surface can act as individual small surfaces and cause significant scattering of ultrasound beam. Thus using higher frequency, shorter wavelength ultrasound, enhances desirable specular reflection. As noted, a reflected wave indicates that the surface exists between different media. Knowing the velocity of ultrasound (v) and the time (t) required for transmission and reflection determines the distance (d) of the surface from the transducer: d = vt/٢ ***(Michael, ١٩٩٤).***

Resolution:

Resolution refers to the ability to separate two small objects that are placed close to each other ***(Higashi et al, ١٩٩١).***

Choice of ultrasound frequency:

As mentioned before, the amount of attenuation of ultrasound is directly proportional to its frequency. This frequency ultrasound can penetrate before it is completely absorbed. On one hand, the higher frequencies allow better resolution of the details of the internal organs of the human body. Echocardiography typically involves intermittent pulses of ultrasound waves with a frequency of ٢.٥ to ٧.٥MHz. Frequencies greater than ٧.٥ MHz are not routinely used in echocardiography because penetration into tissues is too limited (penetration is inversely related to frequency). Frequencies less than ٢.٥MHz are not routinely used because resolution of small objects is too limited (resolution is directly related to frequency). Ultrasound waves in the range of ٢.٥ to ٧.٥MHz provide tissue penetration of ١٠ to ٢٥ cm and resolve objects ١ mm or less in size ***(Michael, ١٩٩٤).***

Imaging Modes:

١- ***A (Amplitude) mode:***

It provides display of the amplitude of the echo signals in relation to the distance from the probe along a single observation direction. The height of a peak is influenced not only by the difference in the media that define the particular surface, but also by the distance of the object from the transducer. This point to the importance of time gain compensation to correct for ultrasound attenuation.

٢- ***B (Brightness) mode:***

B mode display converts a mode peaks to dots of an intensity that is proportional to the amplitude of the signal ***(Michael, ٢٠٠٠).***