"ULTRASOUND IN PEDIATRICS"

THESIS

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TO MY FAMILY

بسم الله الرحمن الرحيم

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INTRODUCTION

Ultrasound is one of the most valuable diagnostic tools of preferable use in pediatric age group.

It is painless, noninvasive, nonionizing, safely repeatable and requires the least preparation of the patient.

Technical refinements during the past decade have greatly improved the quality of ultrasonic images and have provided pediatricians with a wider scope of application.

The terms "Ultrasound" and "Ultrasonics" are interchangeable. They refer to sound waves with freq- uencies above those audible to the human ear. While the terms "Ultrasonography", "Sonography" and "Echography" refer to the graphic display and recording of ultrasound waves.

Our aims in this review are to summarize briefly the ultrasonic terminology, to emphasize diagnostic applications of ultrasonography in children and to encourage a thoughtful, cooperative effort for the use of imaging modalities.

HISTORICAL REVIEW

It was not until 1917, under the stimulus of the first world war, that Langevin first achieved the generation of high frequency ultrasonic power as a mean for remote detection of submarines. Attempts were made to apply ultrasound to medical diagnosis just prior to the second world war, when Dussik thought to visualize the cerebral ventricles by measuring attenuation of ultrasound beams transmitted through the head (Kossoff, 1974).

Douglas Howry (1952), developed the principle of compound scanning and recorded echoes on a large phosphorous screen to improve the image quality. John Wild (1956), demonstrated that ultrasound can detect differencies between normal tissues, benign tumours and cancers with 90% accuracy (Goldberg, 1975).

Ian Donald (1958), developed the contact scanning concept and was credited with pioneering the extensive application of ultrasonic imaging in obstetrics and gynaecology. Through the efforts of these early investigators, diagnostic ultrasound has evolved as a useful tool in clinical medicine (Kossoff, 1974).

CHAPTER [I]

PHYSICAL PRINCIPLES OF ULTRASONOGRAPHY

Ultrasound is defined as a sound with a pitch too high to be perceived by the human ear (Goldberg, 1975).

The normal adult can detect sound with frequencies ranging from 20 to 20,000 Hertz (cycle/second).

Sound with frequency higher than 20,000 is called Ultrasound, while that with frequency lower than 20 is called Infrasound, and both can not be heard.

Characteristics of sound waves:

Sound waves are mechanical waves transmitted through molecular media by causing alternative condensation and rarefaction. One condensation and one rarefaction constitute one cycle.

Wave Length:

It is defined as the distance from one pressure peak to the next pressure peak. In medical application, it ranges from 0.1-1.5 mm (Goldberg, 1975).

Frequency:

It is defined as the number of complete cycles undergone in a unit time. The unit of frequency is the Hertz (cycle/second) and is commonly expressed as Mega Hertz (MHZ).

Mega Hertz = 1000,000 cycle/second.

For pediatric ultrasonography, the commonly used range of frequency is 2 to 10 MHZ (Bowen et al, 1981).

Velocity:

It is defined as the transmission speed of the sound wave in a given medium. It equals the frequency multiplied by the wave length. As the sound travels through different media, velocity varies according to density and elasticity of these media. It is more in solids than in liquids, and is more in liquids than in gases. Velocity, in medical studies, usually ranges from 1.535 to 1.540 meter/second as it is the average for soft tissues (Miskin, 1979).

Intensity:

It is defined as the power per unit area and is the approved measurement for the strength of ultrasound beam.

It is measured in terms of milliwatts per square surface area (M.W/sq.cm).

Acoustic Impedance:

Acoustic impedance of a given medium equals the density multiplied by the velocity of sound in that medium. It expresses the overall transmission of ultrasound in a given medium.

Sound wave resembles a beam of light. Both are directional in nature and obey the same optical laws of reflection and refraction. When an ultrasound beam crosses an interface between two media having different acoustic impedance, it is subjected to three possibilities:

A) Reflection: If the incident beam is perpendicular to the direction of the interface. The magnitude of reflection is proportional to the extent of impedance mismatch between the two media (Garrett et al, 1975).

B) Some refraction may occur, particularly when the ultrasound beam is not at right angle to the plane of the interface.

C) Some of the energy may be absorbed and heat is produced.

Attenuation:

It refers to the decrease of intensity of a sound beam as it passes through a given medium. This can be caused by divergance, absorption, refraction or scattering of the incident beam. Attenuation depends on the properties of the medium and the frequency of the wave. At very high frequencies, absorption and scattering increases with less energy available for deep penetration into the body. Thus, as frequency of the ultrasound increases, the depth of penetration of the sonic beam decreases (Shirley et al., 1978).

Resolution:

It is the capability of ultrasound to distinguish small closely spaced structures. (Haller et al, 1980). It depends in part upon the wave length. As the wave length is inversely proportional to the frequency, thus, the higher the frequency, the smaller is the wave length and the better is the resolution (Miskin, 1979).

There are two types of resolution:

1) Axial resolution: to distinguish two objects in a line parallel to the sound wave.

2) Lateral resolution: to distinguish two objects in a line perpendicular to the sound wave.

Mechanism of ultrasound production:

Piezo-electric effect:

It is the property of certain crystals to convert electric energy into acoustic energy and vice versa (Carlsen, 1974).

The term 'piezo' is derived from the Greek word 'piesis' means to press.

When an electric potential is applied across the crystal, which has a piezo electric effect, it vibrates just as a gong would, producing a sound whose frequency is related to the size of the crystal. On the other hand, mechanical pressure in the form of sound waves applied to the crystal, produces an electric current.

Crystalline quartz, lithium sulphate, lead zirconate and synthetic titanates are known to have this piezo-electric effect (Carlsen, 1974).

Ultrasound apparatus: (Fig.1)

An ultrasound apparatus is formed of a transducer, a transmitter, a receiver, a signal amplifier and a cathode ray tube.

Transducer: (Fig.2)

It is the heart of any ultrasound system. It is based on the piezo-electric principle. Two electrodes are connected to the sides of a piezo-electric crystal and an electric potential is applied. The crystal is deformed giving rise to ultrasound waves. Returning ultrasound waves (echoes), after they are reflected at interfaces between media of different acoustic impedance, are picked up by the crystal which converts them into electric impulses. In this way, the transducer acts as a sender and a receiver of ultrasonic waves (Shirley et al, 1978).

The frequency of the ultrasonic transducer is determined by the thickness of the piezo-electric crystal.

Ultrasound waves spread in longitudinal, transverse and surface directions from the point of emission (Carlsen, 1974).

The longitudinal waves are of primary interest in diagnostic ultrasound. To provide a unidirectional sound beam, heavy backing materials are necessary. It absorb waves produced in the unwanted direction and also damp the vibration or ringing of the crystal. In contrast, therapeutic ultrasound uses air backing to allow maximum ringing which result in transfer of maximum energy into the body.

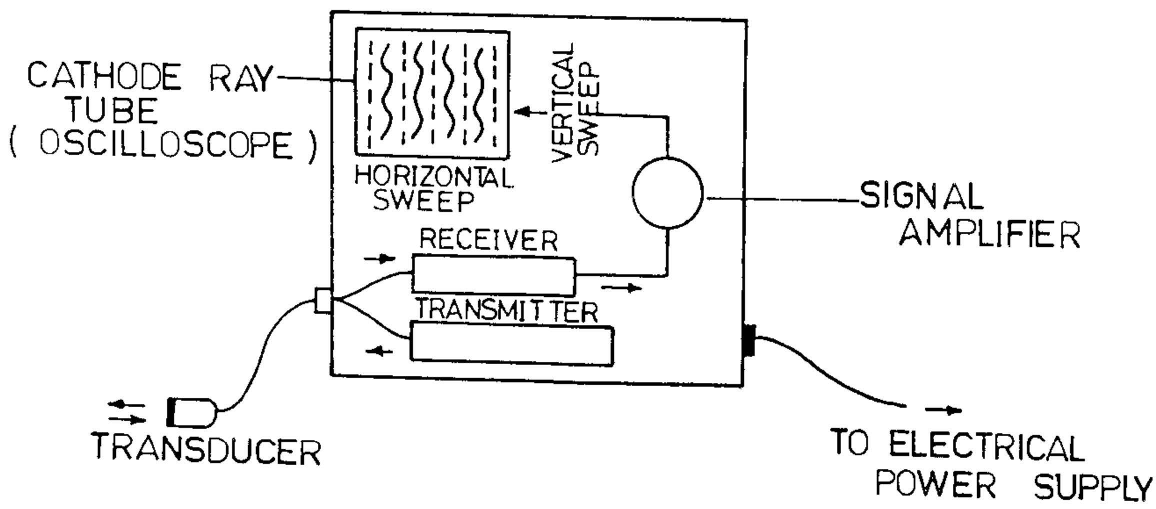

Fig.(1): The ultrasound apparatus

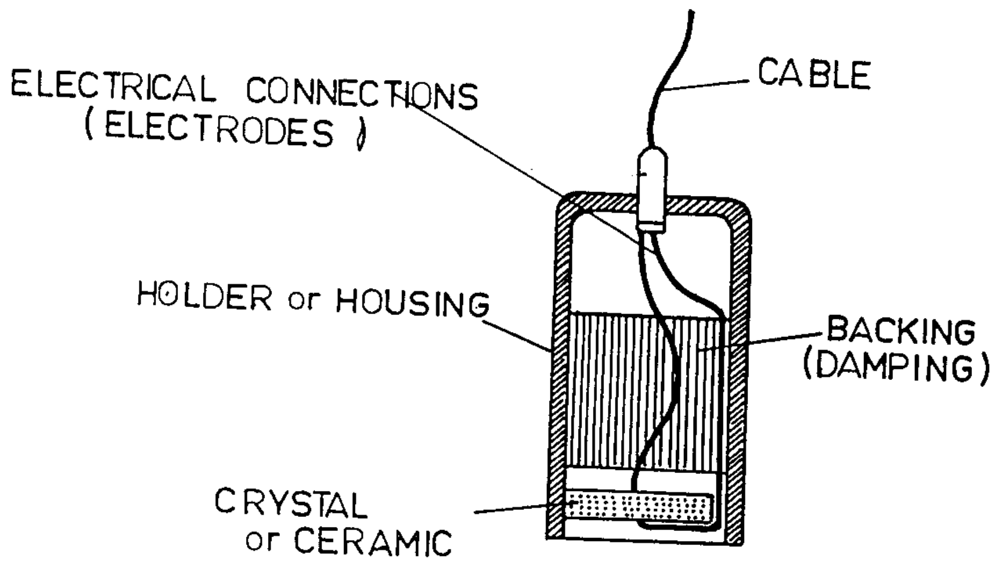

Fig.(2): Basic structure of the transducer