Sonographic Evaluation of the Normal Developmental Anatomy of the Fetal Lateral Cerebral Ventricle

THESIS

Submitted for Partial Fulfilment of the
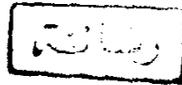
M.Sc. Degree

IN

Obstetrics and Gynaecology

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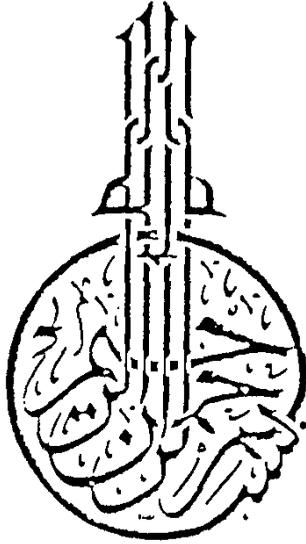# Dr. Khalid Kamal Ali

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بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا

إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ

صدق الله العظيم

بسم الله الرحمن الرحيم

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LIST OF ABBREVIATIONS

At.w .... : Atrial Width

B.P.D................ : Biparietal Diameter

C.N.S .... : Central Nervous System

C.S.F................ : Cerebro Spinal Fluid

D.W.S .... : Dandy Walker Syndrome

F.H.................. : Frontal Horn

G.A .... : Gestational Age

H.W .... : Hemispheric Width

L.V.W............... : Lateral Ventricular Width

O.F.D .... : Occipito Frontal Diameter

V.S.D .... : Ventricular Septal Defect

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AND
AIM OF THE WORK

INTRODUCTION

Congenital hydrocephalus has an incidence ranging between 0.3-1.5 per 1000 birth *(Myrionthopoulos, 1977)* and is one of the most common as well as the most severe congenital anomaly.

Campbell and Thomas (1977) have addressed the issue of prenatal diagnosis of this condition with sonography. Many reports indicate that the ultrasound can positively identify ventricular enlargement during intrauterine development *(Chervenak, 1983)*.

Sonographers efforts to diagnose hydrocephalus prenatally are hampered by the variety of modifications in ventricular geometry and size that occur normally through out gestation, the optimal approach to the prenatal diagnosis of this condition has not yet been established, although several reports exist on different portions of the lateral cerebral ventricles *(Hadlock et al., 1981, Pretorius et al., 1986)*. Comprehensive data regarding the pattern of both biological and mathematical growth of various portions of the lateral ventricles throughout the gestation are unavailable in addition it remains unclear which of these measurements offers the greatest reliability in diagnosis of hydrocephalus, the usefulness of a quantitative evaluation of the

fetal ventricles has been questioned and morphologic criteria have been suggested to be more accurate in the identification of hydrocephalus *(Chinn et al 1983)*.

AIM OF THE WORK

1. To evaluate the normal developmental anatomy of the fetal lateral cerebral ventricle among normal pregnancy.

2. Assessment of morphologic and biometrics measurements of the fetal lateral cerebral ventricle in relation to gestational age.

3. Set up the normal data in Egyptian population.

REVIEW OF LITERATURE

PHYSICS OF ULTRASOUND

SOUND WAVE THEORY

Sound is the orderly transmission of mechanical vibrations through a medium. For these vibrations to be propagated a physical medium is needed, composed of particles. The sound vibrations travel through the medium by sequence of compression followed by rarefaction of the particles. Most commonly the particles oscillate in the direction of propagation of the wave. Plotting these oscillations against time usually produces a sine wave. The amplitude (a) of a waveform is the height of the apex above the base line, whilst the wave length (λ) is the distance between two consecutive, equivalent points on the waveform. The number of vibrations that occur per second is known as the frequency and measured in hertz (Hz), 1 Hz being one cycle per second (Fig.1-1) *(Pearce and Michael, 1991)*.

The human ear can detect frequencies in the range of 20 Hz to 20 KHz (20000 Hz). Sound above this range is known as ultrasound and most instruments used in diagnostic medicine function in the range of 1-10 mega hertz (MHz), a mega hertz being one million cycle per second (Fig.1-2) *(Blackwell, 1993)*.

Vibrating speaker

Compressions

Rarefactions

Pressure: P_o, 0, $-P_o$
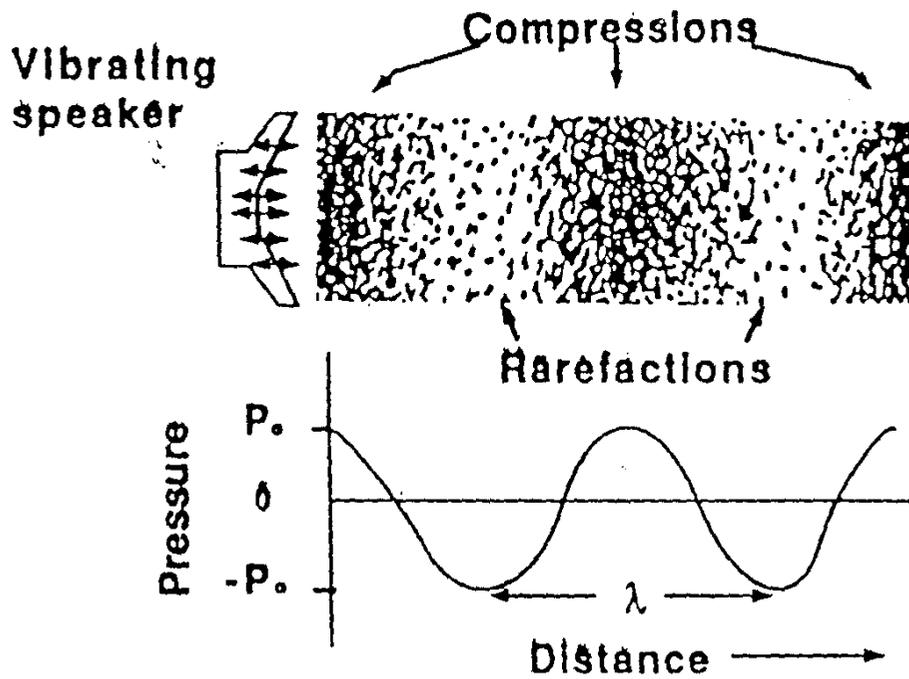
λ

Distance

Figure 1-1: Sound waves generated by a loudspeaker. Vibrations of the speaker surface produce compressions and rarefactions in the medium. The diagram depicts the particles in the medium at an instant of time. The lower diagram shows the variation in pressure at the same instant. P_o is the pressure amplitude and λ the wavelength.

infrasonic | audible | ultrasonic

Medical diagnosis

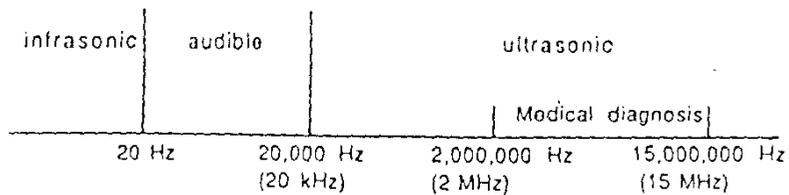| 20 Hz | 20,000 Hz (20 kHz) | 2,000,000 Hz (2 MHz) | 15,000,000 Hz (15 MHz) |

Figure 1-2: Classification of sound waves according to frequency. Ultrasound waves have frequencies greater than 20 KHz. Diagnostic ultrasound uses the 2- to 15-MHz range.

SPEED OF SOUND

The distance traveled per unit time is called the speed of an object or a wave. Sound waves travel through tissue and other media at a speed that depends on properties of the medium. Specially the elasticity (or stiffness) of the medium and the density govern the propagating speed *(Kremkaw, 1989)*. Units used for speed are meters per second (m/second). The propagation speed in air is quite low, in water and soft tissue it is an intermediate value, and in bone it is relatively high *(Zagzebski, 1988)*.

Ultrasound is used to image soft tissues in the body. The average speed of sound in soft tissues is about 1540 m/second.

Most clinical instruments are calibrated assuming that sound propagates through the body at this speed *(Zagzebski, 1988)*.

FREQUENCY AND PERIOD

The frequency of a sound wave is determined by the number of oscillations per second made by the vibrating source. The unit for frequency is the hertz or cycle per second. Medical ultrasound frequencies generally fall in the 2 to 15 MHz frequency range. The specific operating frequency for medical ultrasound instrument

usually results from a compromise between requirements for adequate resolution or spatial detail on an image, and requirements to obtain adequate penetration of the sound beam into tissue *(Zagzebski, 1988)*.

The amount of time required for 1 cycle of vibration is the period of the wave. Period (T) is the inverse of frequency (f) that is $T = 1/f$.

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So the period for a 100 Hz audible sound wave is 0.01 second, whereas the period for a 1 MHz ultrasound wave is 1 micro second *(Zagzebski, 1988)*.

WAVE LENGTH

The wave length of a sound beam refers to the distance over which wave vibrates. The wave length is indicated by (λ) which can be determined if the speed of sound and the frequency are known. It is calculated using the relation: $\lambda = C/f$, where (C) is the speed of sound and (f) the frequency *(Kermkau, 1989)*.