بسم الله الرحمن الرحيم

"فتعالي الله الملك الحق و لا تعجل بالقرآن من قبل أن يقضي اليك وحيه و قل رب زدني علما"

صدق الله العظيم.

سورة طه الآية 114

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Introduction:

Prenatal ultrasound had a marked effect on patient counseling and case management with regard to CNS anomalies. However, ultrasound (US) evaluation of fetal CNS is limited by maternal obesity and oligohydramnios (Hill et al, 1988) and (Levine et al, 1997) as well as the non-specific appearance of some anomalies. Technical factors that make visualization of the brain near the transducer difficult and visualization of the posterior fossa being difficult late in gestation, as well as, subtle parenchymal abnormalities that frequently cannot be visualized also form important limitations to prenatal US (Levine et al, 2003)

The value of an additional non-invasive technique to confirm sonographically suspected CNS abnormality cannot be overstated especially when this information aids in making pregnancy management decisions (Levine and Barnes, 1999) and (Levine et al, 1999).

Since the early descriptions of normal fetal brain morphology and maturation with MR imaging, the clinical utility of fetal MR imaging as an adjunct to screening sonography has been documented establishing the superb diagnostic capabilities of MR imaging, particularly in assessing disorders of neuronal migration and in defining the structures of the corpus callosum and posterior fossa (Armstrong et al, 1995).

One of the most valuable applications of this technology is in detection of heterotopia and other malformations of cortical development. Developmental abnormalities, such as ventriculomegaly, agenesis of the corpus callosum, and Dandy Walker malformation are associated with significantly better prognoses when they are not accompanied by cortical malformations (Levine and Barnes, 1999)

The sensitivity of sonography to these often subtle parenchymal abnormalities is low. Although the sensitivity of fetal MR imaging in detecting these entities is unknown, the ability of MR imaging to detect waves of migrating cells in the fetal brain (D' Erocle et al, 1993) and to clearly differentiate grey matter from white matter in the developing brain suggests an important role for this technique in assessment of fetal malformations or suspected brain malformations identified by sonography (Kalidasan et al, 1997).

Aim of work:

To detect the role of MRI in diagnosis of fetal CNS anomalies in comparison to ultrasound.

Anatomy of Fetal Brain

Sonographic Anatomy of the Fetal Brain

The objective of the sonographic examination of the fetal central nervous system (CNS) is to reconstruct with a two-dimensional tool a complex three-dimensional structure. In this effort, the larger the number of scanning planes obtained, the more accurate the representation will appear. The three planes traditionally used for such an evaluation are the axial, sagittal, and coronal (Romero et al, 2002).

The lateral ventricles and subarachnoid cisterns decrease steadily in size throughout gestation, resulting in important changes in the sonographic appearance of the fetal brain (Fig.1). During the early second trimester, the fluid-filled lateral ventricles are large. This causes enhancement of sound transmission, and the distal cerebral cortex appears more echoic than later in gestation. Familiarity with the normal ultrasound appearance of the fetal brain in different scanning planes and at different gestational ages is critical for the recognition of congenital anomalies(Hertzberg et al,1998).

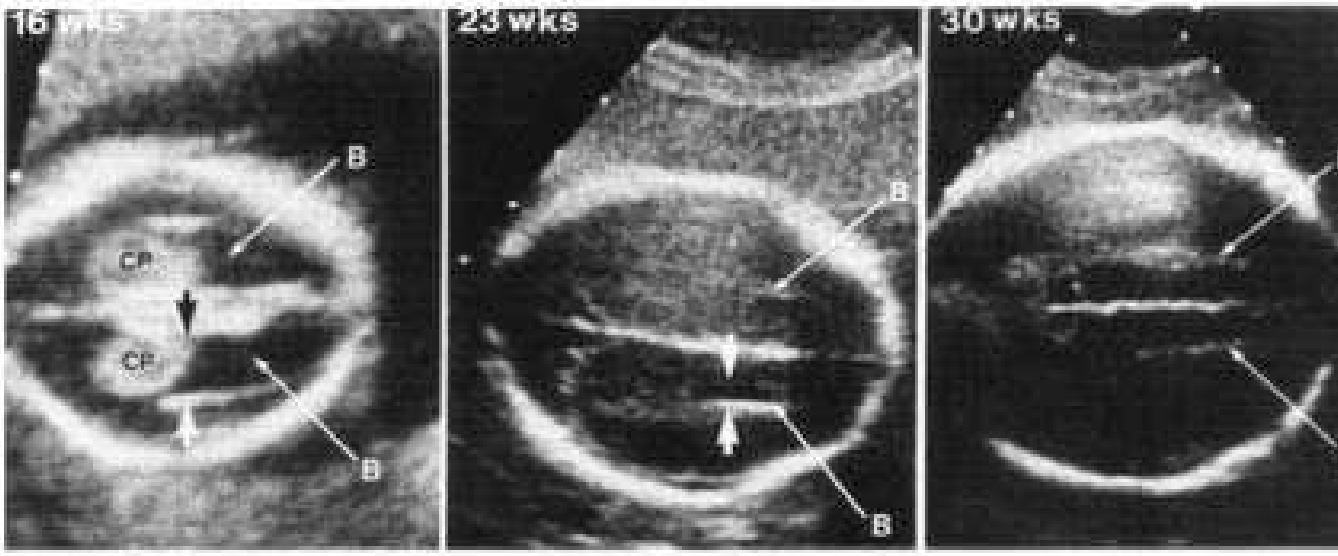
At 16 weeks; the lateral ventricles occupy most of the relative hemispheres and are partially filled with the echogenic choroid plexus. At midgestation, the size of the lateral ventricles has considerable reduction, but in many cases it is still possible to observe the two walls that line the ventricular cavity on both sides to allow measuring the ratio between lateral ventricle width(LVW) to hemisphere width(HW)(Figs. 1 and 2). During the third trimester, only the lateral wall can be visualized. In normal fetuses, it is usually possible with current high-resolution ultrasound equipment to visualize both the lateral and medial walls of the lateral ventricle (Mintz et al,1987).

The distance between the midline echo and the lateral wall of the ventricle is now approximately one third of the hemispheric width. This value will remain constant throughout life (Romero et al, 2002).

During the second trimester and early third trimester, the frontal horns are usually separated by a widely patent cavum septum pellucidum. During the late third trimester, the cavum septum pellucidum may decrease in size and
appear as either one or two lines internal to the frontal horns (Hetzberg et al,1998).

Halfway between the thalami and the calvarium, a linear echo representing the insula is seen. This structure should not be confused with the lateral wall of the lateral ventricles, because this would obviously lead to the erroneous diagnosis of hydrocephalus (Martin et al,1998).

A useful hint for the recognition of this structure is the demonstration of a pulsating echo corresponding to the middle cerebral artery (Romero et al, 2002).



A B C

Figure 1. Axial scans at the level of the bodies (B) of the lateral ventricles at 16, 23, and 30 weeks shows the prominent choroid plexus (CP) in the 16-week fetus and the progressive shrinking of the ventricular cavity. The arrowheads indicate the medial and lateral walls of the ventricle (Romero et al, 2002).

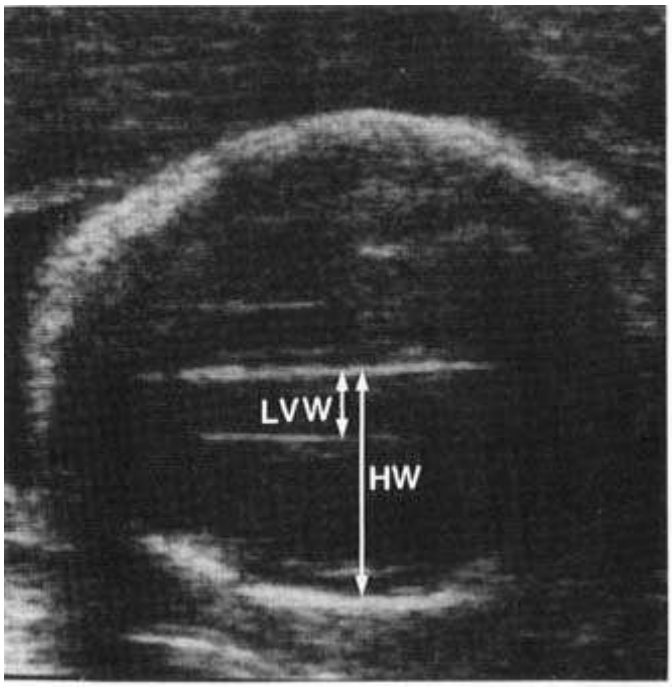


Figure 2. Measurement of the LVW:HW ratio.

1. Sulcation, Layering, Myelination and Subarachnoid Space

The in vivo evaluation of gyrus formation has been difficult with ultrasound. In addition, the subarachnoid space is beyond the field of view of many transducers. The use of half-Fourier RARE MRI allows clear imaging of the subarachnoid space and ventricles, as well as, gyrus formation (Levine et al,1999).

2. Ventricular Size

Ventricular size can be evaluated confidently by using ultrasound and half-Fourier RARE MRI (Fig. 3),(Levine et al,1999).

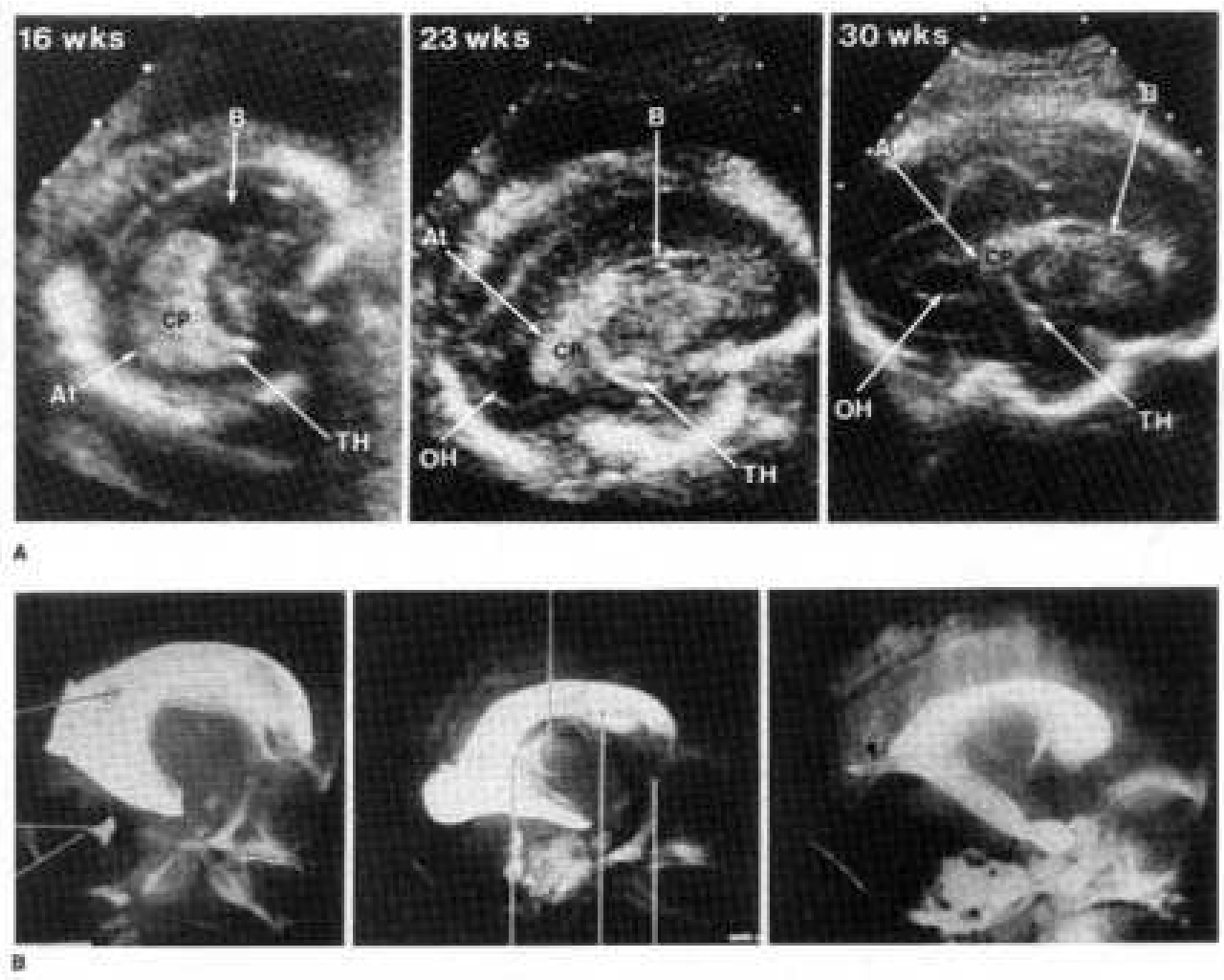


Figure 3. (A) Developmental changes of the lateral ventricles during gestation on sagittal US images shows that at 16 weeks, the ventricle occupies most of the hemisphere. The occipital horn has not yet developed, and the atrium (At) is posteriorly blunt. The prominent choroid plexus (CP) fills most of the ventricular cavity. Note the high roof of the body (B) of the lateral ventricle. At 23 weeks, the ventricle is reduced considerably in size, and the occipital horn (OH) starts to develop. At 30 weeks, the occipital horn is fully developed. TH, temporal horns. **(B)** Sagittal Barium casts of the fetal lateral ventricles at 16, 23, and 30 weeks of gestation. Note the similarity to the ultrasound images (Pilu et al, 2002).

MRI Anatomy of Fetal Brain

The development of the central nervous system during intrauterine life is the result of morphologic changes and maturation, which include histogenesis and myelination. The morphologic changes in the fetal brain lead to the change in signal intensity between gray and white matter (Lowe et al,1995).

Investigators in several studies already have described MR images of the fetal brain; however, few were concerned with the normal fetal brain. The results show that sequential changes in the normal fetal brain in relation to the stage of the pregnancy can be demonstrated clearly on half-Fourier RARE images (Lan et al, 2000) and (Levine et al,2003).

Normal Fetal Brain Development

1. Sulcation

The in vivo evaluation of gyrus formation has been difficult with US or conventional MR imaging. Half-Fourier RARE imaging very clearly shows gyrus formation in vivo (Vanderknaap et al,1996).

Normal fetal cortical maturation at MR imaging follows a predictable course. This maturation is often delayed in fetuses with CNS abnormalities (Levine et al, 2003).

Anticipating that an individual fissure or sulcus would be difficult to image, the following grouped appearances of fissures or sulci, as suggested in the article by Chi et al (Figs.4 to 11) and (Fig 13) : Sylvian, interhemispheric (10–15 weeks)circular, calcarine, parieto-occipital, cingulate (16–19 weeks); central, superior temporal (20–23 weeks); precentral, postcentral, superior frontal (24–27 weeks); inferior frontal, inferior temporal (28–31 weeks) insular, parietal, superior occipital, secondary frontal, secondary parietal, secondary temporal (32–35 weeks); and inferior occipital, tertiary frontal, and tertiary parietal (36–39 weeks)(Levine and Barnes,1999).

From 30 weeks of gestation, the cortex begins to undergo infolding, which is first apparent in the occipital lobe, particularly medially, in the region of the calcarine fissure. In fetuses of 30–32 weeks gestational age, deep sulcation was seen in the whole cerebral cortex. As early as 33 weeks gestational age, sulcation was completed and appeared similar to that in an adult. At 36–38 weeks of gestation, mature sulcation was seen in all fetuses in this age group (Lan et al, 2000).

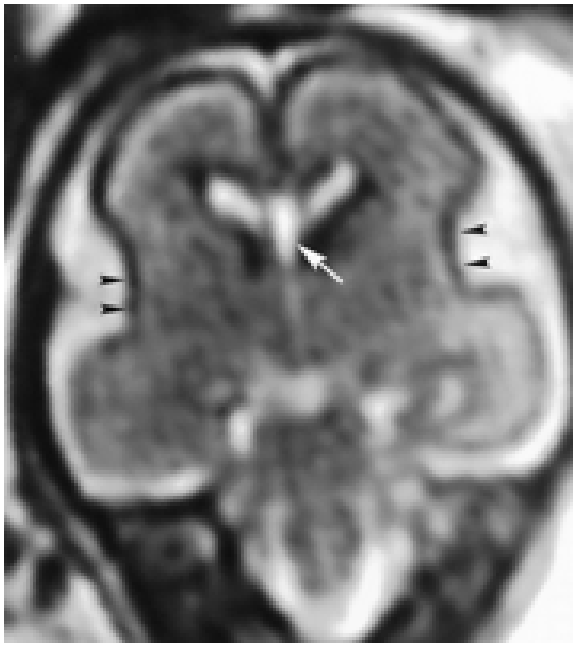
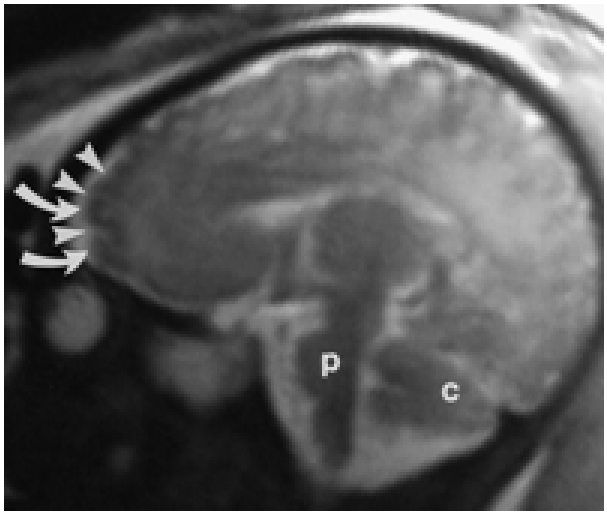


Figure 4. Coronal MR image of a fetal brain at 18 weeks gestation. A cavum septum pellucidum (arrow) is seen. Note the wide Sylvian fissures (arrowheads). The Sylvian fissure begins as a shallow depression at 14 weeks gestation and subsequently becomes grooved (Levine and Barnes, 1999).



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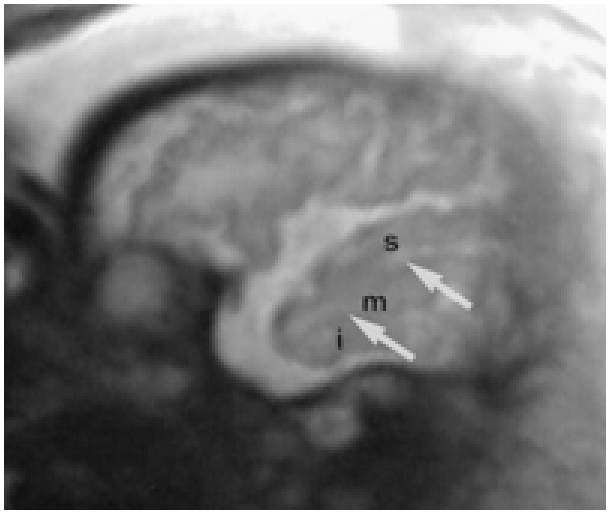
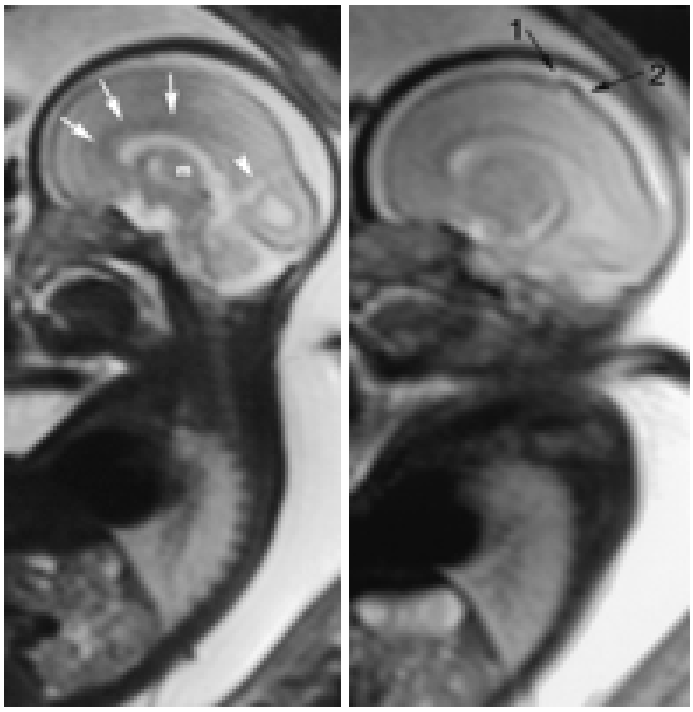


B

Figure 5. Sagittal MR images of a fetal brain at 37 weeks gestation. **(A)** Just lateral to the midline, the pons (p) and cerebellum (c) are well seen. This image demonstrates secondary frontal sulci (arrowheads) and gyri (arrows), which are landmarks of 32–35 weeks gestation. **(B)** Lateral to **A,** the temporal sulci (arrows) are seen separating the superior (s), middle (m), and inferior (i) temporal gyri (Levine and Barnes, 1999).



A **B**

Figure 6. Sagittal MR images of a fetus at 26 weeks gestation. **(A)** Slightly oblique and off-midline view shows the corpus callosum (arrows), massa intermedia (m), and parieto-occipital fissure (arrowhead). **(B)** Slightly lateral to **A**, a smooth cerebral surface, along with the early appearance of the precentral (arrow 1) and central (arrow 2) sulci, is depicted. The central sulcus is a landmark of 20 weeks gestation, and the precentral sulcus is a landmark of 24 weeks gestation (Levine and Barnes, 1999).