

SPECIAL ARTICLE

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Fetal brain assessment: new tools

Evaluación del cerebro fetal: nuevas herramientas

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ABSTRACT

The evaluation of the fetal brain is an essential point in obstetric ultrasound due to the large number of malformations that can be diagnosed. The ISUOG guide provides us with the elementary sections for the suspicion of brain pathology; but we can extend and improve our ultrasound with the visualization of easily reproducible structures, such as the anterior complex, corpus callosum, Sylvian fissure and the fourth ventricle. We present some tools to complement the assessment of the fetal brain.

Key words: Fetus, Embryonic and fetal development, Cerebrum, Corpus callosum, Cerebral aqueduct, Fourth ventricle.

RESUMEN

La evaluación del cerebro fetal es un punto imprescindible en el ultrasonido obstétrico, por la gran cantidad de malformaciones que pueden ser diagnosticadas. La guía de ISUOG nos brinda los cortes elementales para la sospecha de la patología cerebral; pero, podemos ampliar y mejorar nuestro ultrasonido con la visualización de estructuras fácilmente reproducibles, tales como el complejo anterior, cuerpo calloso, cisura de Silvio y el cuarto ventrículo. Presentamos algunas herramientas para complementar la evaluación del cerebro fetal.

Palabras clave. Feto, Desarrollo embrionario y fetal, Cerebro, Cuerpo calloso, Acueducto cerebral, Cuarto ventrículo.

INTRODUCCIÓN

Fetal brain pathologies are frequent (1-2/1 000 live births) and require in all cases a thorough assessment, not only because of their implications but also because of their long-term repercussions. Currently, the vast majority of brain malformations diagnosed during pregnancy represent gross and obvious pictures. However, many 'subtle' or 'minor' malformations - which can have serious long-term neurodevelopmental repercussions affecting the social integration of these children - are not diagnosed during routine ultrasonographic assessment.

The guidelines for routine fetal brain assessment in the second trimester⁽¹⁾ as well as the guidelines for basic fetal brain assessment⁽²⁾ proposed by ISUOG (International Society of Ultrasound in Obstetrics and Gynecology), are currently limited to a transabdominal study of axial sections of the brain. But, as we will review below, the scope of this assessment has important limitations and should generally be expanded when faced with a suspicion of fetal brain pathology.

This review is not intended to be a manual of fetal brain neurosonography (broad and dedicated examination), which is performed by an expert with experience in brain pathology⁽²⁾, but aims to provide the operator, during the basic screening, with the basics to establish an initial diagnostic suspicion and thus be able to refer the patient to a specialized examination. We will suggest and support some tools that complement, but do not replace, what is recommended by ISUOG.



INFORMATION SEARCH METHODOLOGY

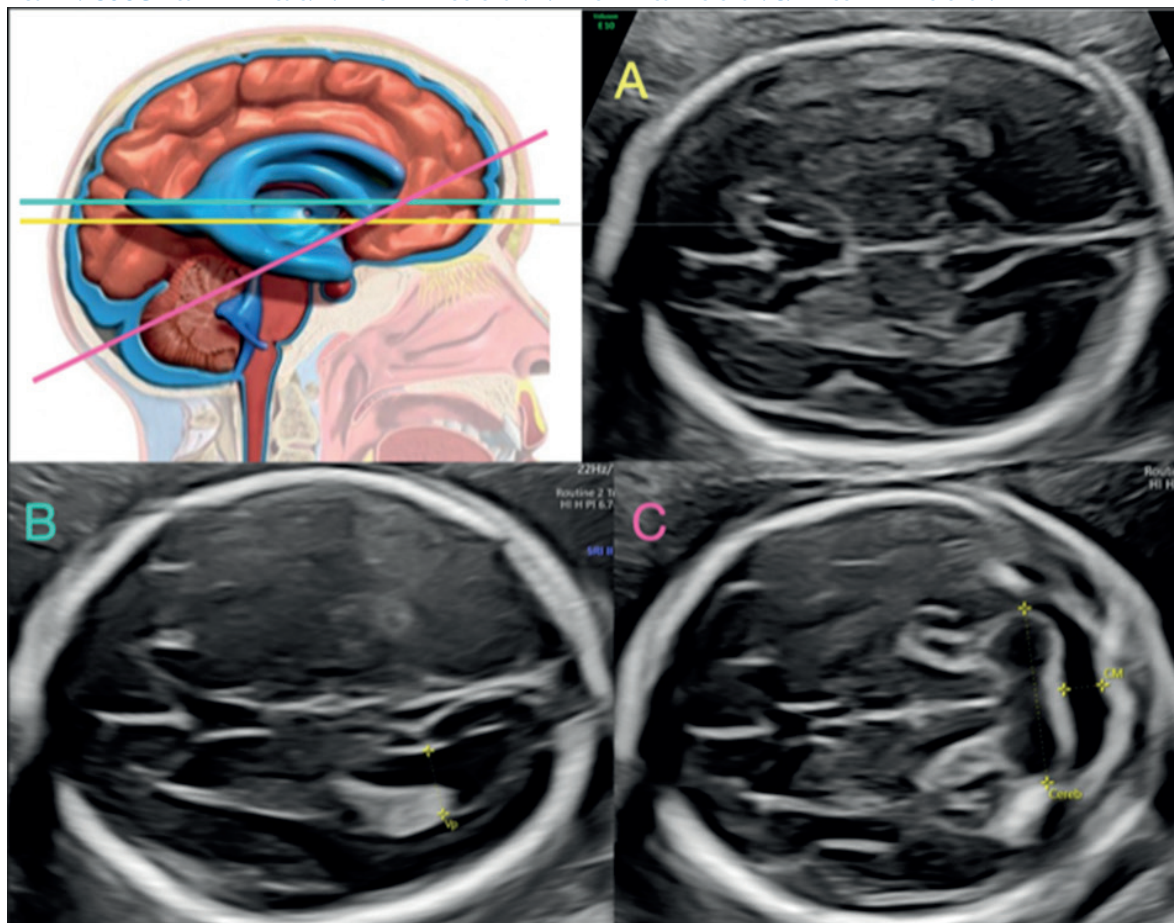
We searched for original articles and reviews in the databases OVIDSP, ScienceDirect, SciELO and PUBMED, with the search terms 'fetal neurosonography', 'anterior complex', 'corpus callosum', 'Sylvian fissure', 'fourth ventricle'. The most relevant prenatal and perinatal studies in the last 5 years were selected; some older than 10 years were included due to their historical and scientific relevance.

FETAL BRAIN ASSESSMENT

Routine assessment of the fetal brain begins with identification of the midline, shape and integrity of the skull. An essential part of this first study is the identification of brain structures such as the thalami and the cavum de septum pellucidum (CSP). Cephalic biometries - biparietal diameter and cephalic circumference - are performed, always valued in percentiles according to gestational age (transthalamic or biparietal plane) (Figures 1A and 2A).

The second brain image requires the identification of the ventricular system, especially the ventricular atrium. A plane is established in which the CSP and the anterior horns of the ventricular system are also visualized (transventricular plane). It is performed with the intention of ruling out dilatations of the cerebral ventricular system (ventriculomegaly, a very frequent sign common to many cerebral pathologies)⁽³⁻¹⁰⁾. The anatomical repairs for its correct measurement involve the identification of the parieto-occipital fissure, which marks the place where the in-to-in measurement of the walls of the ventricular atrium is performed^(1,2); the classic value of 9.9 mm is still maintained as the dogma of normality⁽³⁻⁵⁾ (Figures 1B and 2B). During the first trimester and up to week 20, this value should not be taken into account. The diagnostic suspicion is based on the qualitative assessment of the lateral ventricle and its relationship with the choroid plexus, which normally should occupy the entire width of the atrium^(11,12).

FIGURE 1. ISUOG RECOMMENDED CUTS. A: TRANSTHALAMIC SECTION. B: TRANSVENTRICULAR SECTION. C: TRANSCEREBELLAR SECTION.





The third plane focuses on the posterior fossa: the cerebellum is identified and the vermis is differentiated from the cerebellar hemispheres (hyperechogenic central structure). Again, a plane is required in which the CSP and the anterior horns of the ventricular system are also visualized^(1,2). The cisterna magna (CM), which runs from the vermis to the internal table of the occipital bone, is measured (2 to 10 mm in the second and third trimester). Both collapse and dilatation are signs common to many pathologies of the posterior fossa and spine^(13,14). Likewise, the transcebellar diameter is measured (assessing its size in percentiles in relation to gestational age), which includes the hemispheres and vermis. Subjectively, the normality of the cerebellum is added by assessing the shape of its contour and the lack of 'communication' of the fourth ventricle with the cisterna magna⁽¹⁵⁾ (Figures 1C and 2C).

'ANTERIOR COMPLEX' ASSESSMENT

During the assessment of the brain, the identification of the CSP is a cardinal point of repair for the three sections recommended by ISUOG^(1,2); however, we pay little attention to the information that this structure offers us. We must begin to assess the relationship of the anterior horns of the ventricular system and the CSP, what Cagneaux and Guibaud⁽¹⁶⁾ termed the 'anterior complex'. In this anterior complex there are key structures that we must identify, such as the knee of the corpus callosum, the integrity of the midline and the shape of the anterior horns (Figure 3). Viñals⁽¹⁷⁾ describes the normal morphology of the anterior complex, making it clear that the CSP can be rectangular in shape or an anteriorly based triangle, and the anterior horns of the ventricular system look like a 'comma' or a triangle (Figure 3B and 3C).

FIGURE 2. VOLUMETRIC IMAGE ANALYSIS OF THE FETAL BRAIN, SHOWING THE LEVEL OF EACH SECTION RECOMMENDED BY ISUOG. A: TRANSTHALMIC SECTION. B: TRANSVENTRICULAR SECTION. C: TRANSCEREBELLAR SECTION.

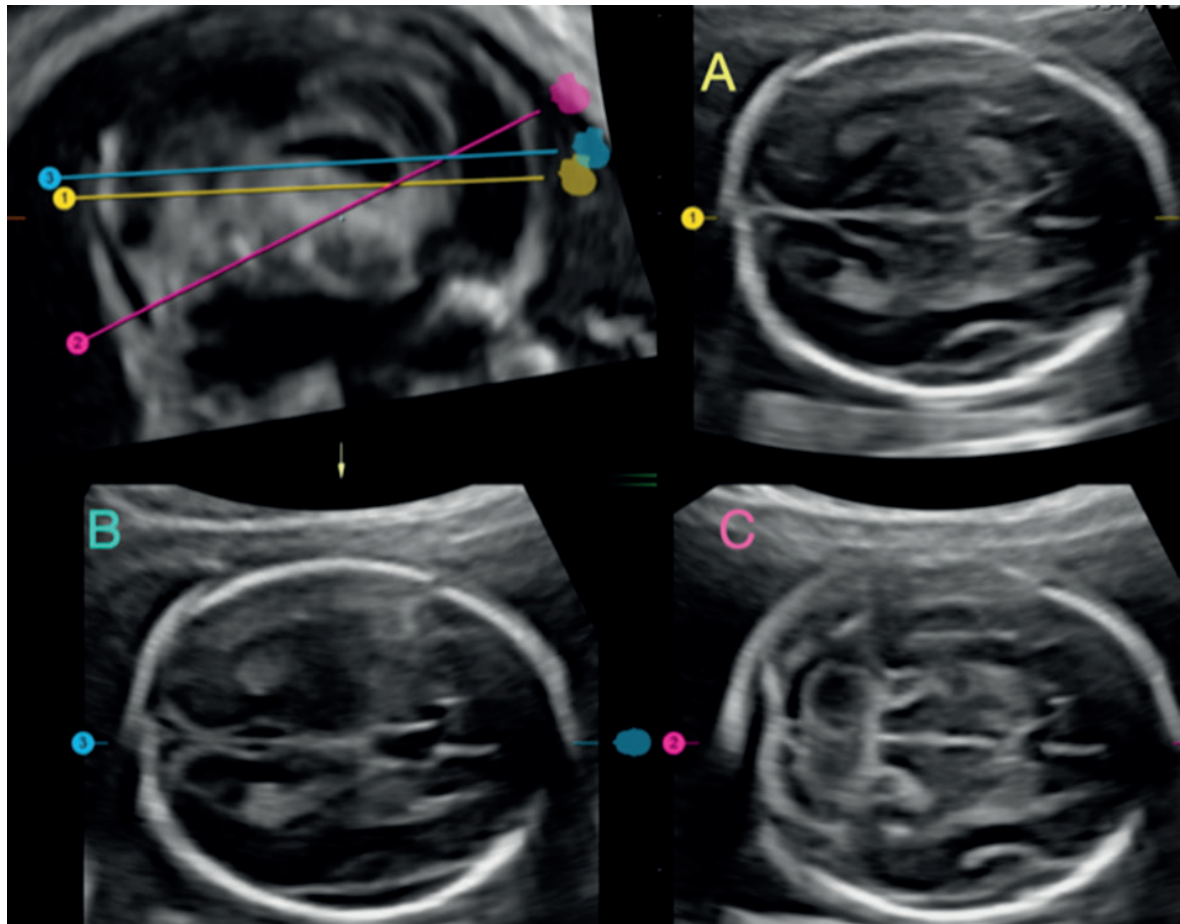
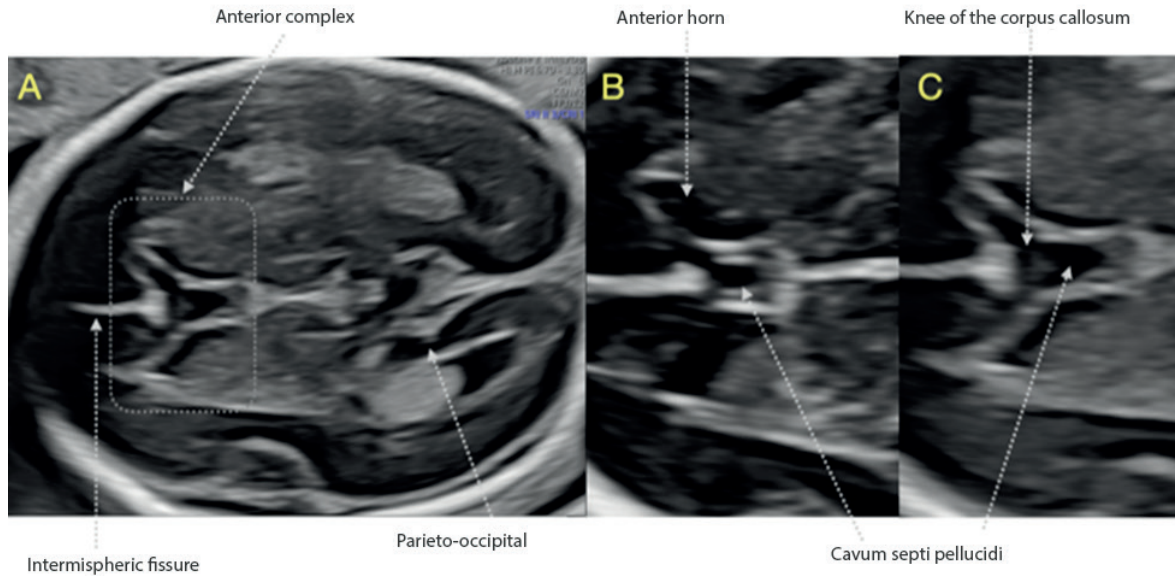


FIGURE 3. ANTERIOR COMPLEX. A: TRANSVENTRICULAR SECTION IN WHICH THE ANTERIOR COMPLEX IS DISPLAYED. B AND C: STRUCTURES IDENTIFIED IN THE ANTERIOR COMPLEX. NOTE THE DIFFERENCE IN THE NORMAL MORPHOLOGY OF THE CSP AND THE ANTERIOR LOOPS BETWEEN BOTH IMAGES.

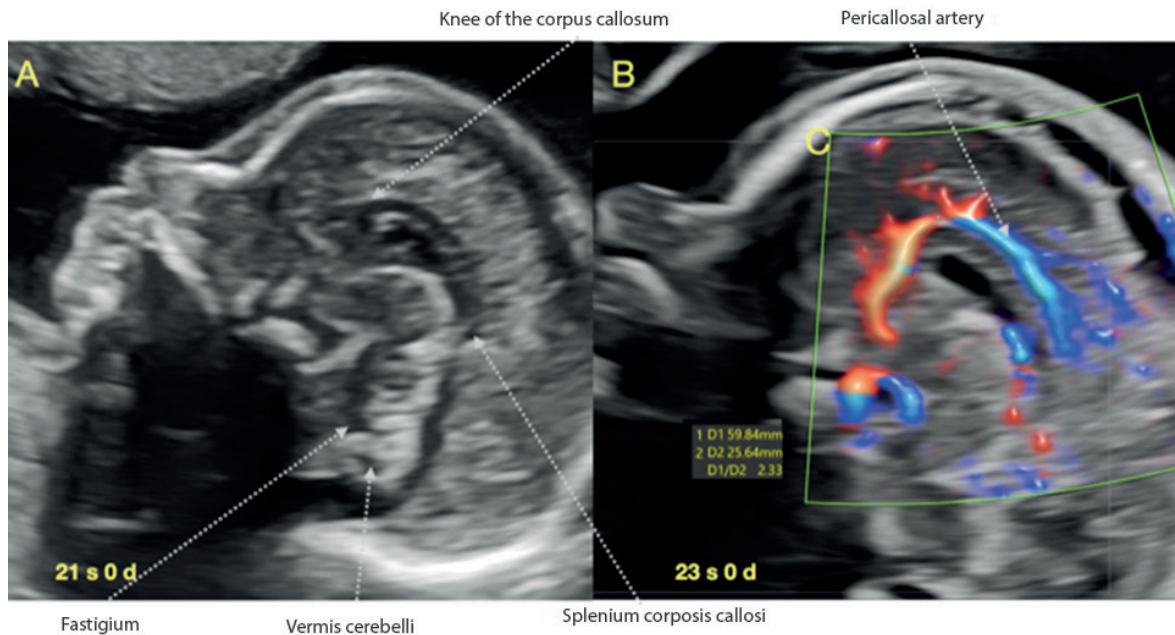


This rapid qualitative assessment provides important information on the existence of at least a portion of the corpus callosum, and the symmetry of the ventricular system and the periventricular zone, which may be the site of cortical developmental, hemorrhagic or infectious pathology^(18,19). All this positions it as a tool with potential for the detection of holoprosencephaly^(20,21), commissural anomalies (complete agenesis of the corpus callosum, septo-preoptic dysplasia)⁽²²⁻²⁸⁾, schizencephaly⁽²⁹⁾ and barotrauma (obstructive ventriculomegaly)^(30,31).

DISPLAY OF THE CORPUS CALLOSUM

Within the assessment of the fetal face recommended by ISUOG⁽¹⁾, the fetal profile is a mandatory view, constituting a valuable opportunity for the visualization of the corpus callosum (CC) (Figure 4A). If we are in a strict sagittal section and we manage to take advantage of the metopic suture or the anterior fontanel, the visualization of the CC will generally be adequate, and we can quickly verify its presence, normal morphology and relation-

FIGURE 4. A: SAGITTAL SECTION OF THE FETAL BRAIN SHOWING THE CORPUS CALLOSUM IN A FETAL PROFILE SECTION. B: VISUALIZATION OF THE PERICALLOSAL ARTERY.





ship with nearby structures, establishing suspicion of partial or total agenesis or dysgenesis⁽³²⁻³⁸⁾. Also, as recommended by Youssef and Pilu⁽³⁹⁾, the use of Doppler could be added to facilitate visualization due to the shape of the vasculature (pericallosal arteries) (Figure 4B). If we would like to apply some simple measure beyond the direct visualization of the structure, in relation to the dimensions of the CC, we suggest assessing the relationship between the length of the corpus callosum with the antero-posterior diameter, in a sagittal section. This relationship remains constant between 3.4 and 3.8 from week 20 to term and is related to the values found in neonates⁽⁴⁰⁻⁴²⁾.

DISPLAY OF THE SYLVIAN FISSURE

The cerebral cortex assessment has always been a complex and systematically elusive topic⁽⁴³⁻⁵⁰⁾. When performing the assessment of the ventricular atrium, we necessarily visualize the parieto-occipital fissure as a reference point and have an intuitive idea of the correspondence of its shape

with gestational age⁽⁴³⁻⁴⁵⁾. We can add to this the visualization of Sylvian fissure (CS) in an easily reproducible axial view^(51,52). In 2008, Quarello⁽⁵³⁾ assessed in 200 fetuses the evolution of the relationship between the insula and the temporal lobe (CS operculature), from 22 to 32 weeks, and proposed a score from 0 to 10 related to gestational age. This assessment is given in an axial section, a little more caudal to the transthalamic view, in which we must achieve to display three points of standardization of the CS level: the columns of the fornix in the lower part of the CSP, third ventricle in the central part and the cisterna ambiens in the posterior part (Figure 5). Guibaud⁽⁵⁴⁾ simplifies the CS assessment table (Figure 5A) and applies it against various brain malformations, showing that abnormal development of CS operculature is found not only in cortical malformations but also in commissural pathology, neural tube and posterior fossa defects^(47,49,52,55). Therefore, the development of CS operculature is a valuable, reproducible and effective element in the suspicion of fetal brain pathology.

FIGURE 5. REPRESENTATIVE IMAGES OF THE CHANGE IN SYLVIAN FISSURE MORPHOLOGY AS GESTATIONAL AGE PROGRESSES. A: SCHEME PROPOSED BY GUIBAUD⁽⁵⁴⁾ FOR SYLVIAN FISSURE ASSESSMENT.

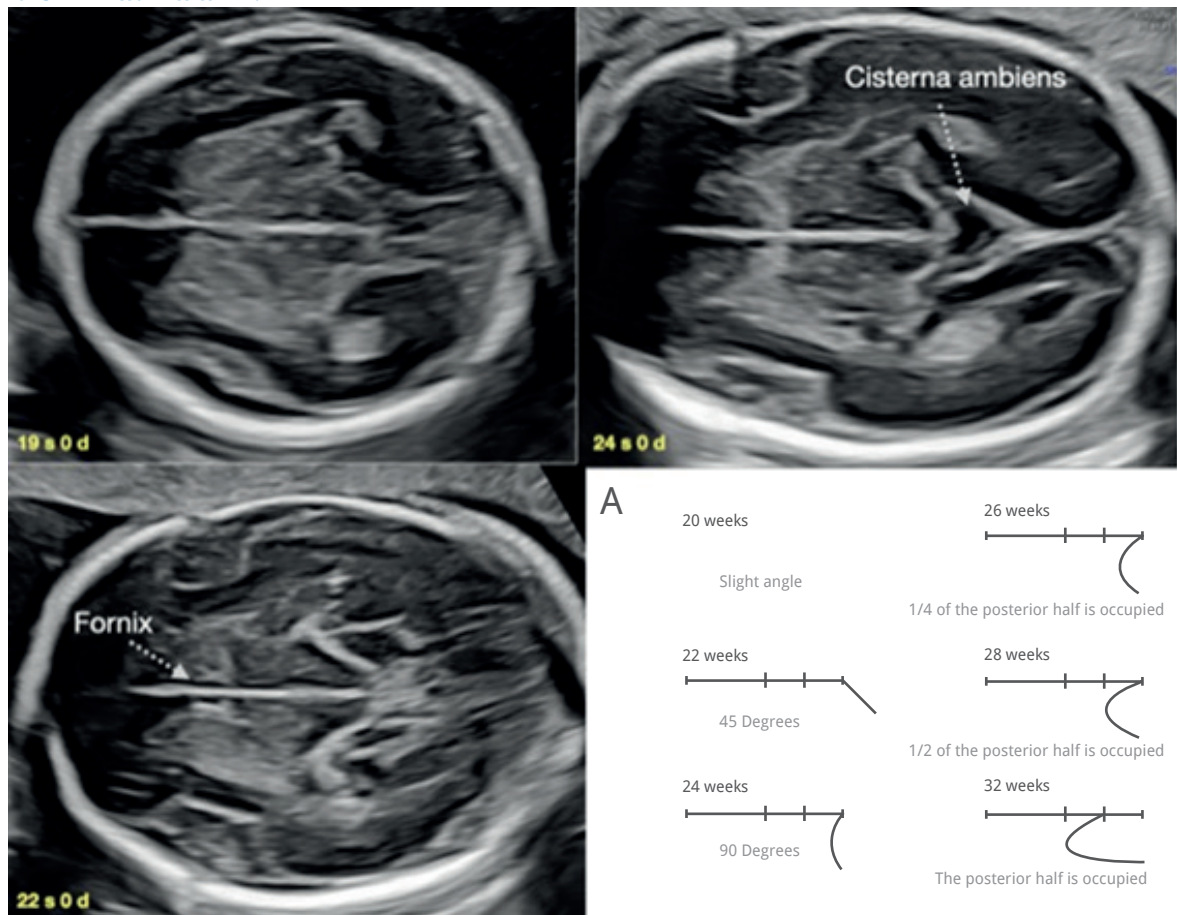
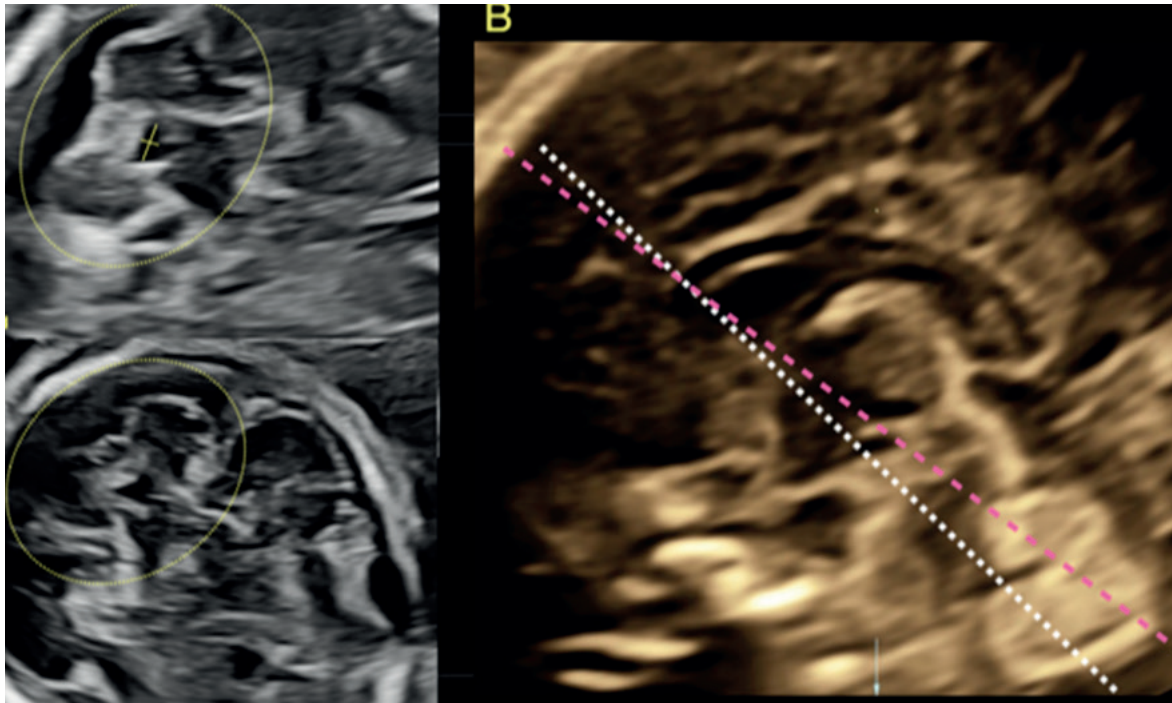


FIGURE 6. A: VISUALIZATION OF THE FOURTH VENTRICLE AND HOW TO MEASURE THE DIAMETERS. B: PINK LINE REPRESENTS THE LEVEL OF THE TRANSCEREBELLAR SLICE, WHITE LINE IS THE LEVEL OF THE CUT FOR VISUALIZATION OF THE FOURTH VENTRICLE. C: NOTE THE BOOMERANG-SHAPED MORPHOLOGY OF THE FOURTH VENTRICLE.



FOURTH VENTRICLE ASSESSMENT

The posterior fossa assessment presents limitations, especially in cases with CM measurements less than 10 mm, since there is a tendency to assess only the presence of the superior vermis, leaving aside the alterations in position (rotation) and shape⁽⁵⁶⁻⁵⁸⁾. The assessment of the shape of the fourth ventricle in an axial view can give us additional information, as it is an indirect indicator of normality in the vermis and midbrain (cerebral peduncles), although sagittal assessment is ideal for an advanced assessment⁽⁵⁹⁻⁶¹⁾.

In 1994, Baumeister⁽⁶²⁾ described the technique for the fourth ventricle assessment in an axial section, by tilting the cut of the trans cerebellar diameter until the visualization of the fourth ventricle and cerebellar hemispheres is achieved (Figures 6A and 6C). Three shapes are identified: ovoid, triangular and boomerang (Figures 6A and 6B). Quarello⁽⁶³⁾ highlights the normal quadrangular shape of the fourth ventricle with the transverse diameter larger than the antero-posterior and, in cases with Joubert's syndrome, he observed that the shape of the fourth ventricle

was elongated. Haratz⁽⁶⁴⁾, based on these studies, in a prospective series of 384 normal fetuses, proposes the rapid evaluation of the fourth ventricle by the relation between the latero-lateral and antero-posterior diameter, denominating it fourth ventricle index (4VI), which is greater than 1 in normal fetuses, independent of gestational age (Figure 6A). By means of this assessment, pathologies such as Joubert's syndrome, rhombencephalosynapsis, pontocerebellar hypoplasia and cobblestone cortical malformations could be detected⁽⁶⁵⁻⁷⁰⁾.

CONCLUSION

In fetal brain assessment during ultrasound screening, it is feasible to examine the anterior complex, corpus callosum, Sylvian fissure and fourth ventricle (not mandatory according to ISUOG guidelines). This potentially has an impact on the diagnostic suspicion of some of the main fetal neurological anomalies. These visualizations are complementary to those recommended by ISUOG and, being generally reproducible in daily clinical practice, can expand our ability to detect fetal brain pathology.



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