

What should Medical Students Know and Understand about Fetal Ultrasonography of the Nervous System?

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Abstract

Evaluation of the developing nervous system is a standard and relatively sensitive component of routine fetal ultrasonography. Medical school learning objectives should direct students to consolidate core concepts related to normal and abnormal fetal nervous system development through critical observation of this commonly performed clinical procedure.

Keywords: Prenatal ultrasonography, diagnostic imaging, nervous system, fetal development, undergraduate medical education, curriculum.

INTRODUCTION

Beginning at about eight to nine weeks gestation, with discrete segmentation of its basic components, evaluation of the central nervous system is an essential part of any standard fetal ultrasound examination.¹⁻³ Detailed knowledge of the ultrasonographic appearance and measurement of fetal neuroanatomy is not a realistic educational expectation for the "undifferentiated" medical student. However, an understanding of the neurological components of a typical second trimester (18-20 weeks of gestation) fetal ultrasound examination is relevant to a variety of basic medical concepts, including those related to normal nervous system development and the prenatal detection of several important congenital disorders (and pragmatically, these topics are routinely included in licensing examinations).⁴ Given the rapid expansion of fundamental knowledge across the medical sciences, it is increasingly essential for medical schools to clearly identify the "core" concepts and skills their students are expected to know and understand. Thus consideration of medical student learning objectives for fetal ultrasonography is timely, and this article will suggest and explore objectives that more specifically relate to the most commonly performed prenatal examination of the nervous system.

THE FIRST TRIMESTER

Although there are a variety of potential indications for fetal ultrasonography during the first trimester, the major neuroanatomical determination that can be made at this point using standard techniques are the presence or absence of anencephaly and related devastating and early malformations of the fetal brain (Figs 1A to 2B).^{2,5,6} Anencephaly may be an incidental finding of ultrasonography performed for other reasons, or it may be detected as a result of specific investigation in high-risk situations, such as a maternal history of prior occurrence. This author would not propose a medical student learning objective related to first trimester ultrasonography of the fetal nervous system, but based on knowledge of human fetal development and objectives related to the second trimester examination, students should understand the potential for early diagnosis of anencephaly. From an undergraduate medical education perspective, and because of uncertain sensitivity, first trimester ultrasonographic detection of other nervous system anomalies should not be emphasized. Medical students should understand that, in general, the earlier fetal ultrasound is performed, the lower overall sensitivity it will have.^{7,8}



Fig. 1A: Transvaginal ultrasound of fetal brain at 12 weeks gestation

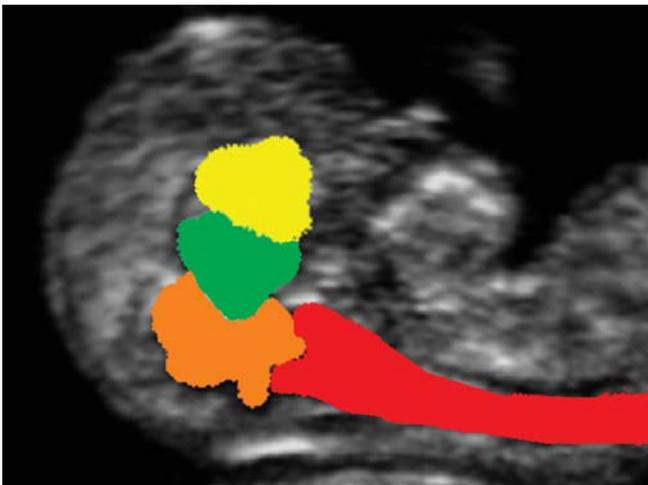


Fig. 1B: Transvaginal ultrasound of fetal brain at 12 weeks gestation. Portions of the fetal brain are displayed in colors: telencephalon (yellow), mesencephalon (green), metencephalon (orange), myelencephalon (red)



Fig. 1C: Transvaginal scan of choroid plexuses filling more than one-third of the lateral ventricles (normal finding at this gestational age)



Fig. 2A: Three-dimensional ultrasound of anencephaly at 11 weeks of gestation



Fig. 2B: Transvaginal color Doppler scan of anencephalic fetus at 11 weeks of gestation. Color signals are obtained from fetal heart, aorta and umbilical artery

THE SECOND TRIMESTER

Second trimester growth and development lead to more reliable ultrasonographic demonstration of the basic segmental organization and structure of the fetal central nervous system. Because this is the earliest phase during which a much broader spectrum of fetal anatomic anomalies may be detected and correlated with additional factors (such

as amniotic fluid analysis), and because of the technical and social issues related to termination of pregnancy, it is important that all physicians understand the use and implications of standard second trimester fetal ultrasonography. Medical student learning objectives related to the central nervous system components of this examination should be fundamental and complement objectives related to the nonneurological components. The increased likelihood of fetal aneuploidy associated with the ultrasonographic detection of multiple anatomic anomalies, including nervous system anomalies, should be emphasized.⁹⁻¹¹ The American College of Obstetrics and Gynecology recently issued guidelines that state: "The optimal timing for a single ultrasound examination in the absence of specific indications for a first trimester examination is at 18-20 weeks of gestation".² In the context of a single exam strategy, accuracy of gestational age estimation, "reasonable" potential anatomic abnormality detection, and the potential for detection of major anomalies by a time when termination of pregnancy may be acceptable are cited as the basis for this recommendation. Hence in the United States, medical school learning objectives related to fetal ultrasonography should be relevant to this stage of development. International variation in educational objectives should be related to differences in fetal ultrasound strategies and regionally accepted professional standards.

Medical students should understand that a routine second trimester fetal ultrasound examination is based on a well-defined process.¹² Published guidelines indicate a general consensus regarding the fundamental components of a standard second trimester fetal ultrasound examination.



Fig. 3A: Measurement of biparietal and occipitofrontal diameter are standard measurements for second and third trimester sonography

From a neurological perspective, this includes a systematic survey of the brain, brainstem, cerebellum, ventricles, cisterns and spinal cord (Figs 3A to C). Although medical students should not be expected to acquire detailed knowledge of the technical aspects and specific biometric procedures of fetal ultrasound, their basic knowledge of human development and major patterns of malformation, combined with their clinical training in prenatal care, should lead to an understanding of the potential for detection of many major abnormalities of the nervous system by second trimester fetal ultrasound (Table 1). Although the sensitivity of fetal ultrasonography for detection of major central nervous system anomalies approaches 80% in some reports, this remains controversial and subject to further study.^{14,15} Confounding factors include variations in operator expertise, equipment quality and validation. Although more advanced strategies such as three-dimensional ultrasonography and vascular imaging with power Doppler techniques have the potential to improve detection and definition of central nervous system anomalies, they are not widely available and not recommended for routine use in low-risk pregnancies.

THE THIRD TRIMESTER

Medical students should understand that fetal ultrasonography in the third trimester is usually based on specific indications related to findings from the second trimester examination or other special risks. Some central nervous system anomalies may not be detected until the third trimester; however, given the general limitations of



Fig. 3B: Ultrasound assessment of the atrial width. The calipers are positioned inside the echoes of the walls of the ventricles, and are oriented perpendicular to the cavity

Table 1: List of anatomical characteristics detectable by standard second trimester ultrasound and associated CNS anomalies medical students should be able to define and discuss. Opportunities to correlate the practical application of fetal ultrasound with basic embryological, anatomical and pathological learning objectives should be exploited during the preclerkship curriculum. Although medical students may not encounter these syndromes during a brief clinical rotation, student participation in fetal ultrasonography provides a clinical context for review and consolidation of the relevant scientific concepts.

<i>Fundamental anatomical characteristics detectable by standard second trimester fetal ultrasound^{7,12,13}</i>	<i>Central nervous system anomalies detectable by standard second trimester fetal ultrasound (medical student level of training)</i>
Absence of a structure normally present	<ul style="list-style-type: none"> • Anencephaly • Alobar holoprosencephaly • Dandy-Walker malformation • Agenesis of the corpus callosum
Dilatation of a structure related to obstruction	<ul style="list-style-type: none"> • Hydrocephalus
Herniation of a structure involving a defect	<ul style="list-style-type: none"> • Encephalocele • Spina bifida (meningomyelocele)
Abnormal location or shape of a structure	<ul style="list-style-type: none"> • Arnold-Chiari malformation
Presence of an additional structure	<ul style="list-style-type: none"> • Choroid plexus cyst • Intracranial hemorrhage • Porencephalic cyst • Tumors <ul style="list-style-type: none"> – Teratoma – Craniopharyngioma – Hemangioblastoma – Choroid plexus papilloma
Abnormal biometry	<ul style="list-style-type: none"> • Microcephaly • Megalencephaly • Hemimegalencephaly



Fig. 3C: Standardized cranial level for measurement of cerebellum and cisterna magna. Note the symmetry of the calvarial bones and cerebellar hemispheres. This axial plane of section is at the level of the inferior portion of the third ventricle, slightly inclined in relation to canthomeatal line

routine fetal ultrasonography and the lack of evidence for improvement in perinatal mortality based on routine ultrasound in late pregnancy, third trimester examinations are essentially a tool for the evaluation and management of special circumstances.¹⁶

CONCLUDING REMARKS

Medical students should be encouraged to observe the acquisition and interpretation of fetal ultrasound, and to correlate both normal and abnormal findings with their knowledge of underlying developmental, anatomical and clinical concepts. This is particularly true for ultrasonography of the fetal central nervous system because of the relative ease with which consistent and standardized examinations can be obtained and their relatively high sensitivity to major central nervous system anomalies. From a curriculum development perspective, this is an opportunity to integrate basic scientific and clinical concepts through exploration of a common and important medical practice. Students are likely to maximally benefit from clear and progressive learning objectives that emphasize this process.

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