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Prenatal diagnosis of fetal central nervous system by update neuroimaging technology

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Fetal brain assessment by transvaginal 2D ultrasound

Antenatal sonographic assessment of the fetal central nervous system (CNS) plays an important role in the field of perinatology. Introduction of high-frequency transvaginal transducer has contributed to establishing sonoembryology. In the middle and late pregnancy, fetal CNS is generally evaluated through maternal abdominal wall. By transabdominal sonography, fetal brain is mostly demonstrated in transcranial axial sections. The brain, however, is three-dimensional structure, and should be assessed in basic three planes of sagittal, coronal and axial sections. Sonographic assessment of the fetal brain in the sagittal and coronal sections, requires an approach from fetal parietal direction. Transvaginal sonography of the fetal brain opened a new field in medicine, neurosonography in 1990s. Transvaginal observation of the fetal brain offers sagittal and coronal views of the brain from fetal parietal direction through the fontanelles and/or the sagittal suture as ultrasound windows. Serial oblique sections via the same ultrasound window reveal the intracranial morphology in detail. This method has contributed to the prenatal sonographic assessment of congenital CNS anomalies and acquired brain damage *in utero*, especially when compared with conventional transabdominal method.

Introduction of 3D ultrasound in fetal brain assessment

Recent introduction of three-dimensional (3D) ultrasound in obstetrics has produced not only objective imaging of fetal superficial structure but also multiplanar analysis of inside morphology, sono-angiography, and volumetry. Combination of both transvaginal sonography and 3D ultrasound is a great diagnostic tool for evaluation of three-dimensional structure of fetal CNS.

3D Surface imaging of the fetal head

Surface imaging has been most widely accepted among the abilities of 3D ultrasound and used for demonstrating fetal superficial structure. Surface imaging demonstrates fetal facial structure and limb structure which are strongly related to fetal CNS abnormalities.



Bony structural 3D imaging

We utilized volume rendering for investigation of the fetal bone structure. Fetal cranial bone, sutures and fontanelles can be demonstrated from early pregnancy. Vertebral imaging is helpful for identifying the exact location of spina bifida. Thus, 3D surface mode produces direct information on fetal calvaria and vertebra, and contributes prenatal CNS assessment.

Intraorgan Multiplanar analysis

3D multiplanar image analysis increased the information of fetal organ structures. Three-orthogonal views are set in sagittal, coronal and axial sections. Intraorgan structures can be assessed in any cutting section by rotating the image. Parallel slicing provides a tomographic visualization of internal morphology similar to MR imaging. off-line multiplanar image analysis provides an intelligible information *in utero*.

Volume calculation of the brain structure

To estimate volume of target organ, enlarged tumor/cyst, pooled effusion etc. has been one of the most important roles in a fetal assessment. 3D ultrasound has enabled to demonstrate extracted images of target organs and target lesions. We used 3D ultrasound and 3D View 2000 (Kretztechnik AG, Zipf, Austria) for volumetric assessment of the chest cavity, lung volume, intraabdominal tumor, as well as fetal brain structures such as lateral ventricle, choroids plexus, intracranial space-occupying lesions. Volume analysis of the structure of interest provides an intelligible and longitudinal evaluation of the fetal organ structure and diseases.

Volume Contrast (thick-slice) imaging

Recent advance of 3D/4D ultrasound technology has enabled us to demonstrate the thick-slice images, which has been utilized in magnetic-resonance imaging (MRI) technology. By this technology of volume contrast imaging, real-time images with increased contrast resolution can be obtained in not only longitudinal plane but also vertical plane of 2D scanning section. The novel unique technology of volume contrast imaging provides additional information simultaneously with conventional 2D imaging, without the process of off-line 3D reconstruction.

3D sono-angiography of the brain circulation

According to the anatomical location of the brain vessels, many intracranial vessels rise and fall within the sagittal and coronal planes. Therefore, transvaginal approach to the fetal brain from the fetal parietal direction plays an important role in a brain circulatory assessment as well. It is possible to demonstrate

fetal cerebral vasculature by transvaginal 2D Doppler system. By using transvaginal 3D Doppler, however, three-dimensional vascular anatomy of the fetal brain becomes more comprehensively demonstrated. Further device development and more clinical studies will be required to find a clinical significance in the application of 3D angiography.

Magnetic Resonance Imaging (MRI)

Recent advances in fast MR imaging technology, such as half-Fourier and the 0.5-signal-acquired single-shot fast spin-echo (SE), half-Fourier rapid acquisition with relaxation enhancement (RARE) sequences, has remarkably improved the T2-weighted image resolution despite a short acquisition time, and minimized fetal and/or maternal respiratory motion artifacts. The MR images demonstrate the brain structure in detail, including the brainstem which cannot be clearly depicted by even transvaginal sonography.

Conclusion

Transvaginal approach of the fetal brain, and 3D sonographic analysis of the fetal brain are great tools for the objective and accurate diagnosis and assessment of the fetal CNS. The technology is easy, non-invasive, and reproducible methods, and produces comprehensible and objective information. Easy storage/extraction of raw volume data set enables off-line analysis and consultation to neurologists and neurosurgeons. Fast MR imaging technology has also contributed prenatal diagnosis of fetal CNS. Accurate prenatal CNS evaluation leads to better obstetrical management, and prompt and proper treatment after birth.

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