WS80A with Elite

5D CNS+ : An Useful Tool for Fetal Neurosonography

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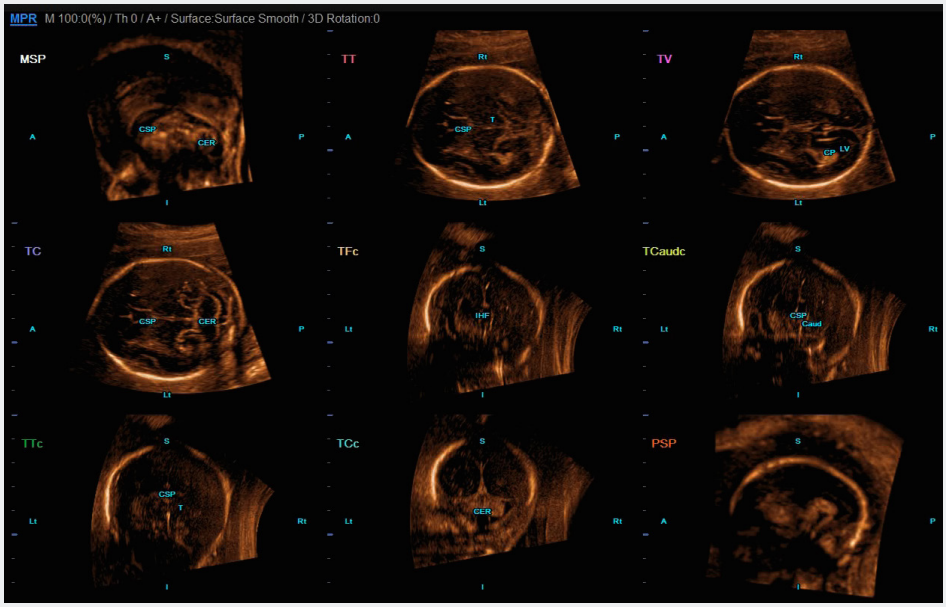

"5D CNS+ simplifies the examination of the fetal brain by reducing operator's dependency. This feature allows the use of coronal and sagittal planes in routine second trimester examinations, with the potential of improving the diagnostic efficacy of CNS anomalies."

Introduction

Central nervous system (CNS) malformations affect approximately 0.3-1% of live births thus being among the most common defects in the human fetus[1,2]. Prenatal detection and accurate definition of CNS malformations is of paramount clinical interest since these anomalies frequently have a poor prognosis and in many cases are associated with a genetic syndrome[2].

Despite the high incidence of CNS anomalies and the clinical importance of their prenatal diagnosis, the efficacy of the screening program is still far from producing satisfactory results, especially when the study of the fetal head is limited to the axial brain planes[3]. Indeed, transabdominal two dimensional (2D) ultrasonography is the standard technique to investigate fetal CNS in the general obstetrical population. During the second trimester, the examination includes only the recognition of 3 axial planes, namely the trans-thalamic, the trans-ventricular and the trans-cerebellar planes, and the acquisition of several biometric measurements of both the fetal skull and the brain structures[3].

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An extended study of fetal CNS anatomy including sagittal and coronal planes of the fetal brain can improve the diagnostic efficacy[4,5]. Therefore, the implementation of fetal brain visualization by the addition of sagittal and coronal planes has been suggested as an integral part of the study for fetal CNS4,5. However, the visualization of these additional planes requires.

either a transvaginal approach, when enabled by fetal position, or a transabdominal approach by a transfrontal view through the metopic suture. With both approaches, the success rate of obtaining correct plane views is greatly dependent on operator's expertise and fetal position, and may furthermore be time consuming. As a consequence, their visualization has been limited up to now to referral cases in specialized centers where a dedicated neurosonography is performed. Three-dimensional (3D) ultrasound has the potential to reduce operator dependenc[6,7].

Indeed, this technique allows to acquire volumes containing most of the anatomic information and these volumes can subsequently be reviewed offline to recreate the planes necessary for a comprehensive study of the fetal brain[8,9].

Although several algorithms have been developed to allow 3D reconstruction of the fetal brain[10-12], these approaches require the operator's manual "navigation" in the volume acquired. Thus, it is necessary to have specific experience and skill in 3D orientation and subsequent retrieval of the diagnostic planes.

To overcome these limitation, a software that automatically analyse fetal brain volume are required. In this paper, the performance of 5D CNS+ software (Samsung Electronics Co. Ltd., Suwon, South Korea) will be described. This software 1) automatically analyses 3D fetal brain volumes, 2) reconstructs the axial, coronal and sagittal planes of the fetal head, and 3) performs all the measurements required for the routine assessment of CNS during second trimester ultrasound.

Case Report 1

All examinations were performed using the WS80A Elite ultrasound equipment (Samsung Medison Co., Ltd, Seoul, South Korea) with a 1–8MHz transabdominal volumetric probe.

Brain volumes were acquired trans-abdominally starting from an axial view of the fetal head at the level of the transventricular axial plane. In order to include the entire fetal brain within the volume, the sweep acquisition angle was set between 45° and 60° according to the gestational age (Figure 1).

Care should be taken that all the fetal head is included inside the region of interest (ROI) box of 3D acquisition. Volumes were acquired during fetal rest and maternal apnea in an "extreme" quality mode.

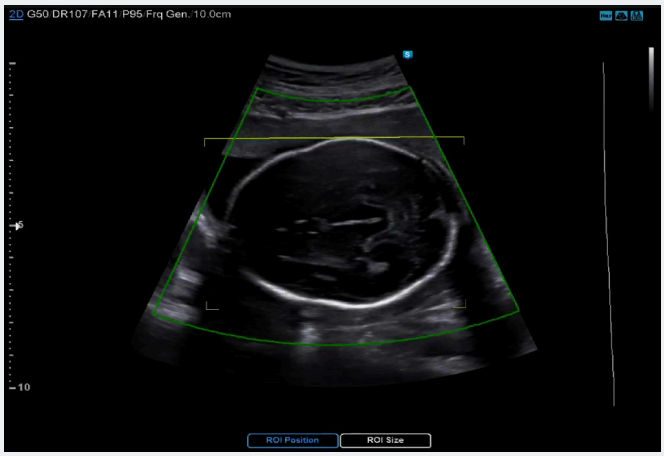

Figure1. Example of an axial section of the fetal brain with the region of interest (ROI) for 3D acquisition covering all the head circumference

5D CNS+ software function

After the activation of the 5D CNS+, the operator is asked to manually place two reference points (seeds) respectively in the middle of the fetal brain and in the cavum septi pellucidum (CSP) (Figure 2). Then, the software automatically reconstructs the axial, coronal, and sagittal planes brain as shown in Figure 3. The average time required for analysis is 18 seconds.

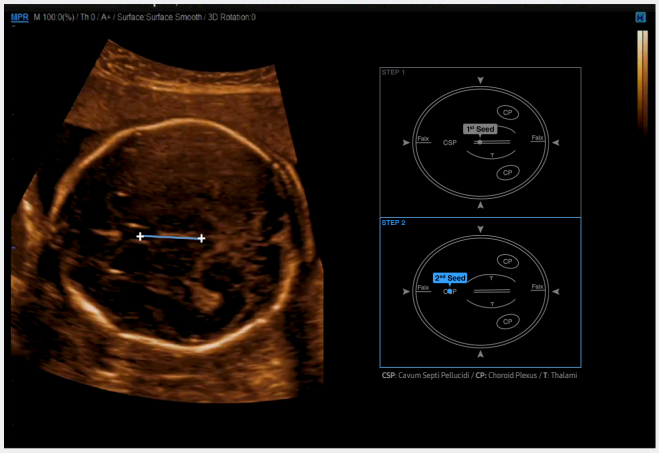

Figure2. Example of activation of the 5D CNS+ software. The two reference points (+) are placed in the middle of the fetal brain and in the cavum septi pellucidum (CSP)

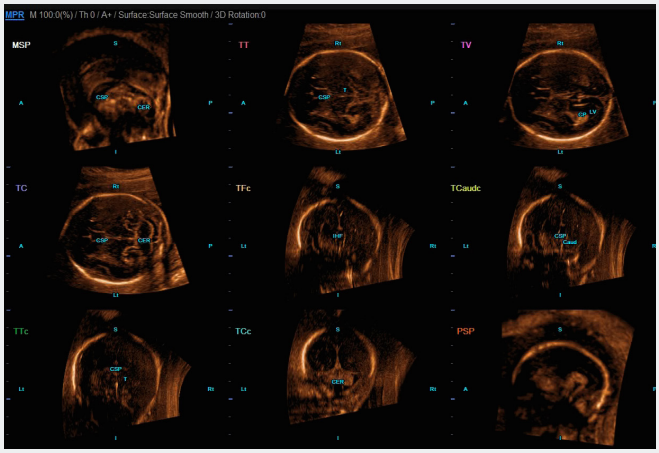

Figure3. Example of the first output generated by the 5D CNS+ software displaying all the diagnostic planes

The software then allows to review the diagnostic planes individually or in groups (e.g. axial, coronal and sagittal planes) (Figure 4,5,6) . Finally, on the axial planes, the software automatically performs the standard measurements of the fetal head and brain (Figure. 5) given as follow;

Biparietal diameter (BPD), Head circumference (HC), Occipito frontal diameter (OFD)
Posterial lateral ventrical (Vp), Transverse cerebellar diameter (CEREB), Cisterna magna width (CM)

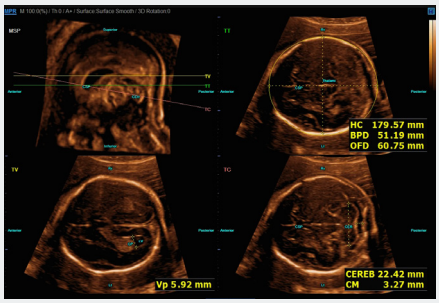

Figure4. Details of the axial planes with the automatic measurement superimposed

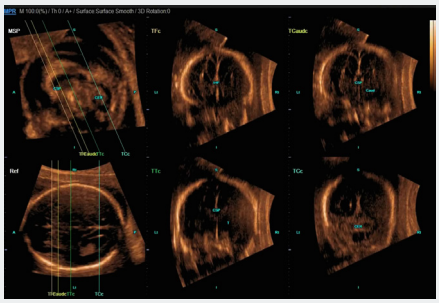

Figure5. Details of the coronal planes

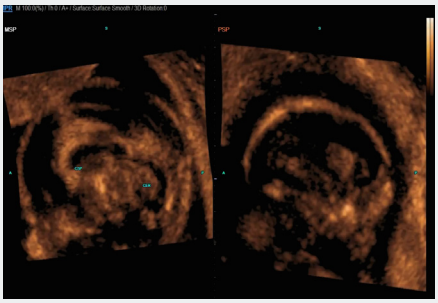

Figure6. Details of the sagittal planes

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Reliability of automatic measurements

In a recent prospective trial on 120 unselected and consecutive pregnancies undergoing second trimester examination, we demonstrated that automatic analysis is possible in 98% of the cases. The measurements obtained with 5D CNS+ showed a high degree of reliability in the measurements and reproducibility when compared to the standard 2D technique (Figure 7). Further, the use of 5D CNS+ significantly reduces the time necessary to perform the diagnostic biometric assessment of the fetal head and brain.

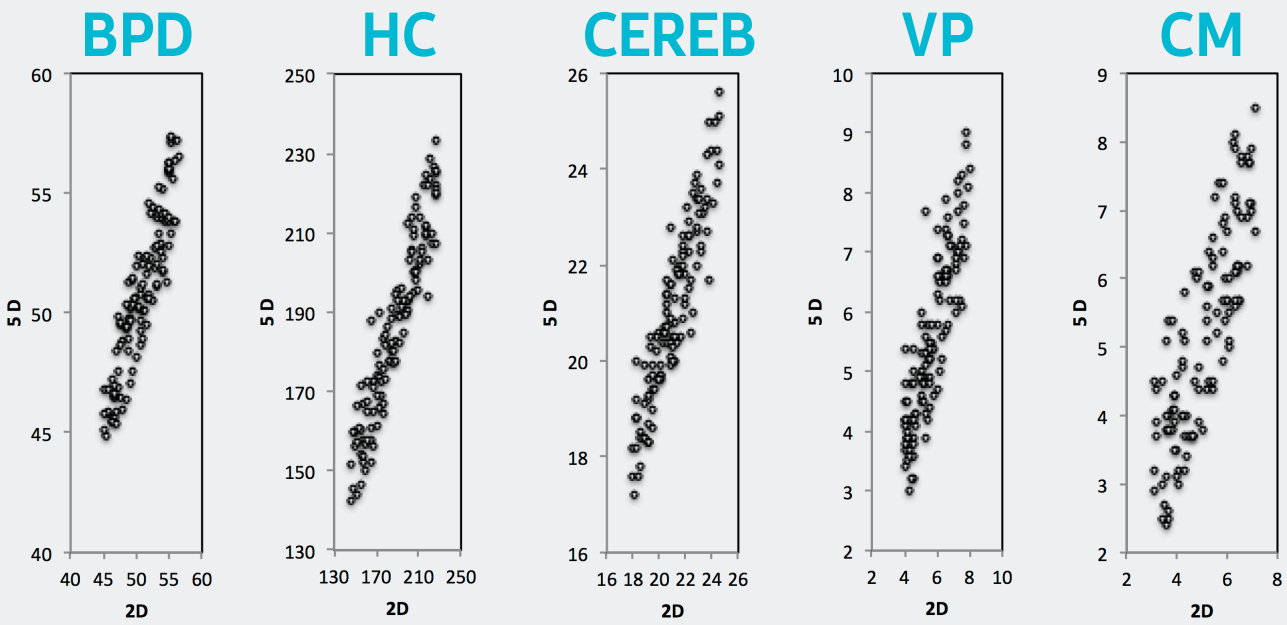

Figure7. Agreement between 2D and 5D CNS+ in the measurements of the standard biometric variables of the fetal head and brain

Quality of the reconstructed brain diagnostic planes

In order to test the quality of reconstructed planes two different observers independently evaluated the automatic representation of a serie of 180 consecutive volumes obtained in an unselected and consecutive population of second trimester pregnancies. Satisfactory views were obtained in more than 90% of the cases with an excellent agreement between the 2 observers. These findings suggest clinically acceptable repeatability of fetal brain examinations by using 5D CNS+ software. Furthermore the short time of analysis (median 50 sec) necessary to analyze all the diagnostic planes support an easy clinical applicability.

Clinical experience with abnormal brain

We tested the 5D CNS+ software on 22 volumes of fetuses with brain anomalies included in a larger series containing volume datasets from normal fetuses. The reviewer, blinded of the sequence of cases, correctly identified all the 22 pathological CNS volumes and performed the correct diagnosis in 21/22 (95.4%) of the cases. None of the normal volumes was incorrectly identified as abnormal. Examples are reported in Figure 8 and 9.

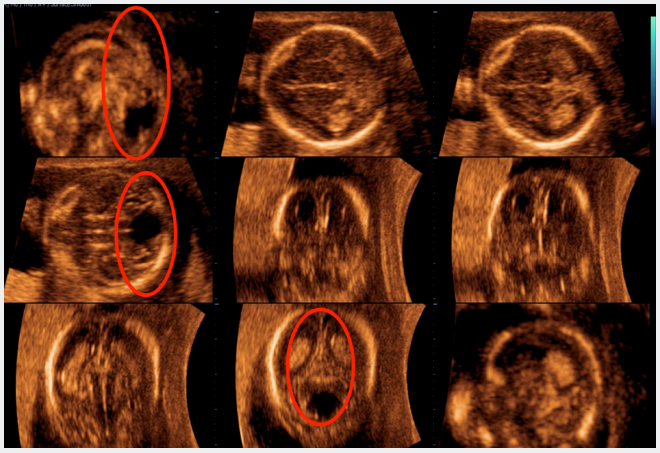

Figure8. Example of cerebellar vermis hypoplasia. The red circles indicates the small vermis in the midsagittal plane, tans cerebellar axial plane and coronal transcerebellar plane.

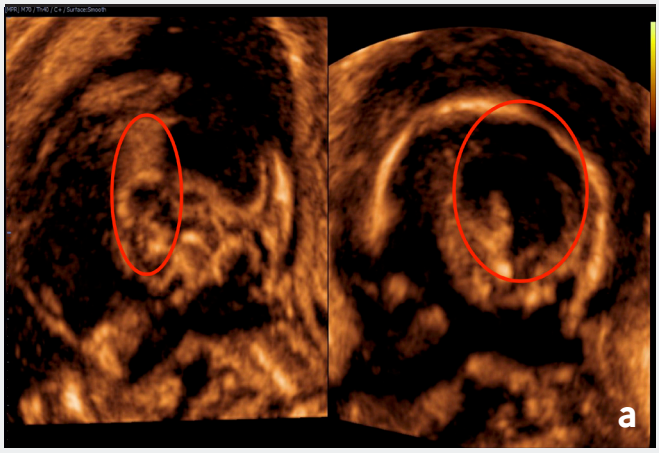

Figure9a. The red circles indicates the absence of the corpus callosum in the mid sagittal plane and the concomitant ventriculomegalia in the transventricular axial plane

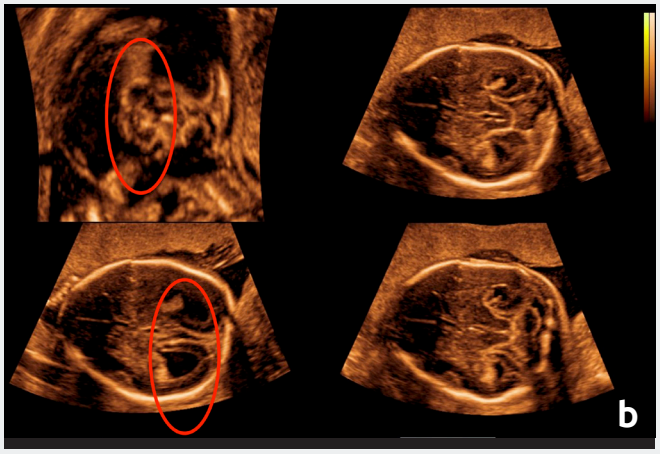

Figure9b. The absence of corpus callosum and the ventriculomegaly are shown in the sagittal planes

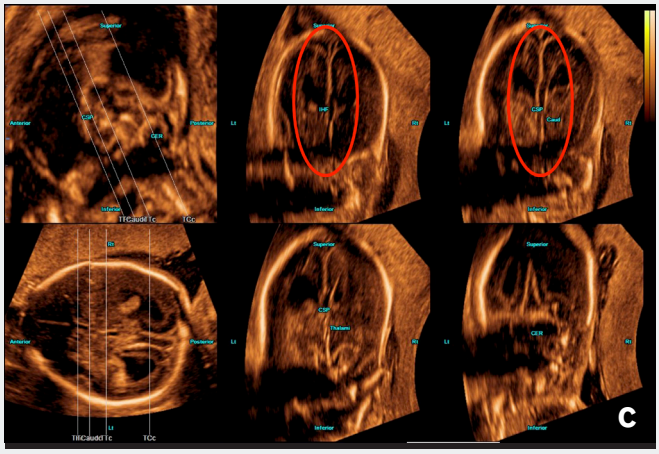

Figure9c. The absence of corpus callosum is evidenced in the coronal planes

Conclusion

3D ultrasonography can be used to visualize all the diagnostic planes in fetal brain and the addition of 5D CNS+ allows to semi-automatically obtain standard measurements of the fetal head and brain and to visualize all the diagnostic axial coronal and sagittal planes. This approach simplifies the examination of the fetal brain by reducing operator's dependency, and it allows the use of coronal and sagittal planes in routine second trimester examinations, with the potential of improving the diagnostic efficacy of CNS anomalies.

Supported Systems

- WS80A with Elite

References

1. von Wendt L , Rantakallio P. Congenital malformations of the central nervous system in a 1-year birth cohort followed to the age of 14 years. Child's Nervous System 2: 80-82; 1986
2. Chytty LS, Pilu G. The challenge of imaging the fetal central nervous system: an aid to prenatal diagnosis, management and prognosis Prenat Diagn 2009; 29: 301-302
3. International Society of Ultrasound in Obstetrics & Gynecology Education Committee. Sonographic examination of the fetal central nervous system: guidelines for performing the basic examination and the fetal neurosonogram. Ultrasound Obstet Gynecol 2007; 29: 109-116
4. Timor-Tritsch IE, Monteagudo A. Transvaginal fetal neurosonography: standardization of the planes and sections by anatomic landmarks. Ultrasound Obstet Gynecol 1996; 8: 42–47.
5. Monteagudo A. Fetal neurosonography: should it be routine? Should it be detailed? Ultrasound Obstet Gynecol 1998; 12: 1-5.
6. Benacerraf BR, Shipp TD, Bromley B. Three-dimensional US of the fetus: volume imaging Radiology. 2006; 238: 988-96
7. Abuhamad AZ. Standardization of 3-dimensional volumes in obstetric sonography: a required step for training and automation. J Ultrasound Med. 2005; 24: 397-401
8. Monteagudo A, Timor-Tritsch IE, Mayberry P. Three-dimensional transvaginal neurosonography of the fetal brain: navigating in the volume scan. Ultrasound Obstet Gynecol 2000; 16: 307–313.
9. Pilu G, Ghi A, Segata M, Perolo A, Rizzo N. Three-dimensional ultrasound examination of the fetal central nervous system. Ultrasound Obstet Gynecol 2007; 30: 233–345.
10. Viñals F, Muñoz M, Naveas R, Giuliano A. Transfrontal three-dimensional visualization of midline cerebral s tructures. Ultrasound Obstet Gynecol 2007; 30: 162-168
11. Correa FF, Lara C, Bellver J, Remohli J, Pellicer A, Serra V. Examination of the fetal brain by transabdominal three-dimensional ultrasound: potential for routine neurosonographic studies. Ultrasound Obstet Gynecol 2006; 27: 503-508
12. Rizzo G, Capponi A, Pietrolucci ME, Capece A, Aiello E, Mammarella S, Arduini, D. An algorithm based on OmniView technology to reconstruct sagittal and coronal planes of the fetal brain from volume datasets acquired by three-dimensional ultrasound. Ultrasound Obstet Gynecol 2011, 38: 158–164
13. Rizzo G, Aiello E, Elena Pietrolucci M, Arduini D. The feasibility of using 5D CNS software in obtaining standard fetal head measurements from volumes acquired by three-dimensional ultrasonography: comparison with two-dimensional ultrasound. J Matern Fetal Neonatal Med. 2015DOI:10.3109/14767058.2015.1081891
14. Rizzo G, Capponi A, Persico N, Ghi T, Nazzaro G, Boito S, Pietrolucci ME, Arduini D 5D CNS plus software for automatically imaging axial sagittal and coronal planes of normal and abnormal second trimester fetal brain. J Ultras Med 2016 in presss

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