

Sonographic evaluation of overall and regional vascularization of fetal brain: a preliminary methodological study

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Abstract

The aim of this preliminary study is to develop a methodology to evaluate the vascularization of fetal brain in normal and abnormal conditions by three-dimensional sonography associated to Power Doppler (3DPD), with application of Virtual Organ Computer-aided Analysis (VOCAL) that allows to derive vascularization and flow indexes. In this connection, we propose a new method of standardization of the setting and the acquisition mode, choosing in different fetuses and at different gestational ages the same anatomical volumes, corresponding to five spherical regions of interest. In particular, to study the overall vascularization of the fetal brain, we use a sphere with a diameter corresponding to the bi-parietal distance. To evaluate the regional vascularization, we identify four sampling spherical sites, two in each hemisphere. This standard technical approach according to correct morphological criteria allows to exclude from the analysis vascular territories external to the brain.

Introduction

In prenatal diagnosis, bidimensional real time ultrasound allows to study fetal brain anatomy. Applying the Doppler technology, it's also possible to evaluate fetal brain vascularization and blood flow. This method analyzes the frequency shift of blood velocity information, while Power Doppler sonography uses the amplitude component of the signals received to represent the number of moving blood cells. In the last years, three-dimensional sonography has been associated to Power Doppler (3DPD) to study the vascular trees in a sample volume [1, 2]. Therefore, we decided to develop a methodology to study the vascularization of the fetal brain with 3DPD, in

particular to evaluate the brain perfusion in normal fetuses and to verify the hypothesis that a vascular dominance of one hemisphere is present during fetal life.

3DPD method

Each exam is performed by a trans-abdominal 3D multifrequencies probe of 5.0-7.0 MHz, using Voluson 730 Expert, General Electric. The ultrasound probe acquires a volume, in which we identify a region of interest (ROI), that is defined by voxels (smallest units of the volume). Gray-scale voxels contain all three-dimensional gray-scale information in grades from black to white. All three-dimensional color information is summarized by color voxels. To accentuate the difference between the amplitudes of the reflected ultrasound waves (intensity of flow), the color voxels are weighted, i.e. multiplied by a factor from 1 (= lowest amplitude) to 32 (= highest amplitude).

By application of Virtual Organ Computer-aided Analysis (VOCAL) it is possible to derive three vascular indexes:

- Vascularization Index (VI), that identifies the number of colored voxels in the volume, which is an estimate of the number of vessels within that tissue;
- Flow Index (FI) that is the average color value of all the color voxels, and shows the average blood flow intensity at the time of the three dimensional sweep;
- Vascularization Flow Index (VFI), that is a combination of vascularization and flow information relating the weighted color values to the volume.

Application of 3DPD to the study of fetal cerebral vascularization

In the analysis of fetal cerebral vascularization, all the ROI are obtained starting the volume acquisition from a trans-thalamic plane.

To study the overall vascularization, we use a sphere with a diameter corresponding to the bi-parietal distance.

To study the regional vascularization, we use four sampling spherical sites, two in each hemisphere:

- one anterior (tangent to the cavum septi pellucidi), that includes the first part of the middle cerebral artery;
- one posterior (tangent to the longitudinal median axis of the thalamus), that doesn't contain the great vessels originating directly from the circle of Willis.

The diameter of each sphere is the same in each fetus, but differs among different fetuses, because it is one/fifth of the biparietal diameter (fig. 1).

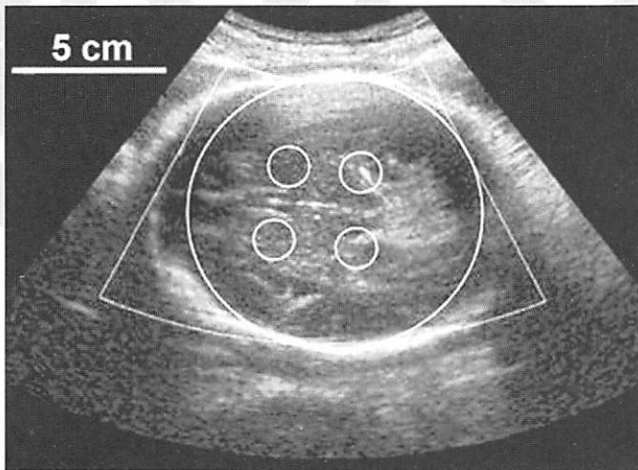


Figure 1. Ultrasound image of the head of human fetus at 38 weeks g.a. at the level of the transthalamic plane. The five circles represent our sampling sites: the biggest one is the ROI chosen for the evaluation of the overall fetal brain vascularization; the four small ones are the volumes selected to compare the vascular flow between two different zones of the left and the right hemisphere.

Discussion

The use of 3DPD is particularly useful in the evaluation of fetal brain vessels because of their small caliber [3]. So we will be able to detect and evaluate not only the blood flow of the circle of Willis but also slower cerebral flows. It must be highlighted that the use of Power Doppler in association with 3D ultrasound, increases the risk of artefacts, especially the ones due to the fetal and maternal

movements. So to obtain good results with this technique it is important to optimize the bidimensional power Doppler image before three-dimensional volume acquisition [4]. To obtain consistent data, it is always essential to standardize the setting and the acquisition mode, choosing the same anatomical volume in different fetuses and at different gestational ages [5]. Our standard technical approach according to correct morphological criteria allows to exclude from the analysis vascular territories external to the brain. This technique is non-invasive and relatively simple, it is also safe as there is no need to use contrast medium or to expose to radiation.

References

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