Volumetric assessment of fetal organ development using whole-body 3D-true-FISP

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Introduction

Volumetric assessment is one of the important methods to assess the fetal development. Previously this had been done using ultrasonography or 2D MRI [1-3]. However, fetal abnormalities sometimes occur at multiple organs, and we thought whole body fetal imaging can be of value.

The purpose of this study was to assess the volumetric changes of the fetal organs along with development using whole-body 3D-FISP imaging.

Subjects and Methods

The ethical review board approved this study. MRI was performed on a 1.5T unit (Avanto, Siemens). Seven fetutal whole-body images (gestational age at MRI, 20-37 weeks) of four normal fetuses (volunteer) and the two fetuses suspected for a minor abnormality at ultrasonography (bowel dilatation (n=1), small cyst in the lung (n=1)). The fetal whole-body 3D-true-FISP was performed under pregnant woman's breath-holding with the scanning parameters as follows: TR/TE, 3.53/1.56 msec; flip angle, 45-50 degrees; matrix, 256× 256; slice thickness, 3 mm with interpolation to 1.5 mm; field of view, 380 mm. The images were transferred to a workstation, where segmentation of the fetal organs was performed using semi-automated and manually-corrected method using an in-house program. Volumes of the segmented organs included the brain, lung, heart, liver, and kidneys were calculated. The relation between the measured volume of each organ and the gestational weeks at MRI were assessed using Pearson's correlation coefficient.

Results

The measured volume of each organ ranged from 41.1 to 281.9 cm^3 at the brain, from 23.4 to 100.5 cm^3 at the lung, from 1.9 to 34.2 cm^3 at the heart, from 13.0 to 105.0 cm^3 at the liver, and from 2.0 to 15.0 cm^3 at the kidneys, respectively. There were positive correlations between the fetal organ volumes and the gestational week at the brain ($p<0.001$, $R=0.97$, the lung ($p=0.006$, $R=0.90$), the heart ($p=0.018$, $R=0.84$), the liver ($p<0.001$, $R=0.97$) and the kidneys ($p<0.001$, $R=0.96$).

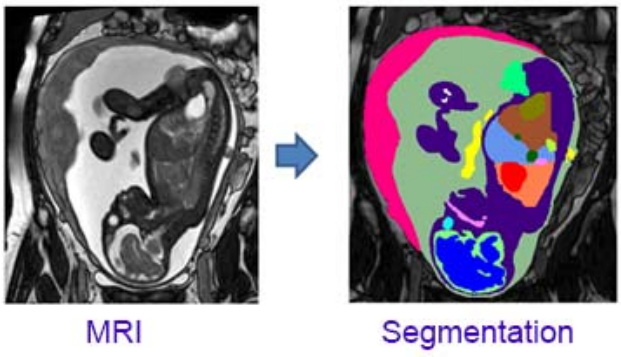

Figure 1. Fetal organ segmentation
Image show how fetal organs are segmented. First, smoothing filter was applied to remove the imaging noise. Second, 3D region growing method was used to identify the tissues with relatively high contrast to the surrounding structures. Finally, fetal organs were segmented with manual edit.

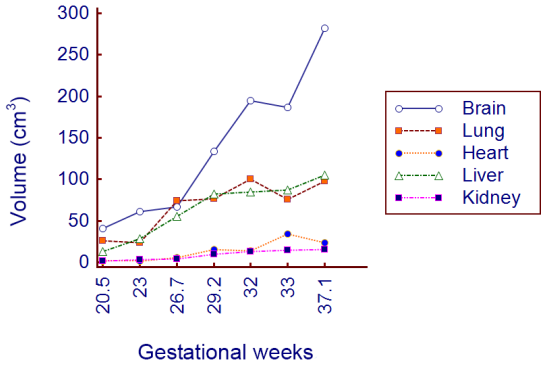

Figure 2. Relationship between gestational age and organs' volume.

There was a positigve correlation between gestational weeks and organs' volume.

Discussion and Conclusions

The volumes of the fetal organs linearly increased as the increment of the gestational age at MRI in this study. Therefore whole-body fetal imaging with 3D-true-FISP can be a reproducible method for the assessment of the fetal development. Although we set shorter acquisition of MR imaging, this still is not free from fetal motion. Furthermore, lower imaging contrast compared to spin-echo sequence was disadvantage for assessment of the small tissue.

Whole-body 3D-true-FISP imaging may reflect the volumetric development of the fetal organs along with the gestational age.

References

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