Semi-automatic assessment of the fetal cardiac axis in fetuses affected by congenital heart disease using Fetal Intelligent Navigation Echocardiography (FINE)

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Objectives
Congenital heart disease (CHD) is the most prevalent organ-specific birth defect and a major cause of infant morbidity and mortality. Depending on the studied population the reported incidence varies from about 4/1,000 to 50/1,000 live births. Despite ultrasound screening guidelines and almost general access to ultrasound screening the majority of cardiac defects are missed prenatally. Fetal Intelligent Navigation Echocardiography (FINE) has been introduced to support operators to extract reference planes and cardiac axis from a cardiac spatiotemporal image correlation (STIC) volume.

Methods
In our retrospective study patients with fetuses affected by congenital cardiac defects/thoracic masses and stored STIC volumes have been identified (n=542) and were compared with 1543 volumes of normal fetal hearts. The CHD include HLHS, AVSD, DORV as well as other major cardiac defects. After marking seven anatomical structures the FINE software generated semi-automatically nine echocardiography standard planes according to the guidelines issued by the International Society of Ultrasound in Obstetrics and Gynecology (ISUOG) and the American Institute of Ultrasound in Medicine (AIUM) and calculated the cardiac axis.

Results
Our study shows that depending on the type of the cardiac pathology the cardiac axis varied. In approximately 87% (471 of 542 volumes) of our pathological cases an abnormal cardiac axis (normal=40-45°) was detectable. Significant differences to normal hearts were observed in volumes of fetuses affected by DORV**, HLHS****, Pulmonary Atresia****, RAA***, Situs ambiguous***, TOF**** and thoracic masses**.

Conclusion
This study confirms and expands on previous studies suggesting that FINE is a valuable tool to identify cardiac defects. Beyond that our data show that combining the results with semi-automatic assessment of the cardiac axis might improve the detection rate of fetuses with CHD.

Figure 1: Semi-automatic extraction of the cardiac axis (57.7°) using FINE in a fetus affected by HLHS (aortic stenosis, hypoplastic aortic arch, restrictive foramen ovale, LPSVC)

Figure 2: Median and interquartile ranges of the cardiac axis extracted by FINE. Kruskal-Wallis-Test with multiple comparisons vs normal, significance with adjusted P values: ****:<0.0001; ***:0.0001 to 0.001; **:0.001 to 0.01, remaining ns