

Title: Non-invasive placental perfusion imaging in pregnancies complicated by fetal heart disease using arterial spin labeled MRI

Authors:

Zungho Zun^{1,2,3}, Greg Zaharchuk⁴, Nickie Niforatos-Andescavage^{1,2}, Samantha Bauer¹, Mary T Donofrio^{2,3,5}, and Catherine Limperopoulos^{1,2,3}

¹Division of Diagnostic Imaging and Radiology, Children's National Medical Center, Washington, DC, United States

²Division of Fetal and Transitional Medicine, Children's National Medical Center, Washington, DC, United States

³Departments of Radiology and Pediatrics, School of Medicine and Health Sciences, George Washington University, Washington, DC, United States

⁴Department of Radiology, Stanford University, Stanford, California, USA

⁵Division of Cardiology, Children's National Medical Center, Washington, DC, United States

BACKGROUND

Brain injury and neurodevelopmental disabilities are prevalent, lifelong complications among surviving infants with congenital heart disease (CHD)^{1,2}. A growing body of evidence suggests that brain injury in CHD may have its origins in fetal life and the causes of CHD are associated with placental dysfunction³⁻⁵. However, placental function has been poorly understood namely due to the absence of non-invasive tool for monitoring placental function in utero.

OBJECTIVE

To compare placental perfusion in pregnancies complicated by fetal CHD and healthy pregnancies using arterial spin labeled (ASL) MRI.

METHODS

Seventeen pregnancies with fetal CHD and 30 healthy pregnancies were recruited for fetal MRI during 2nd or 3rd trimester. Three pregnant women with fetal CHD and 4 healthy pregnant women also underwent a second, follow-up fetal MRI. All MRI was performed on a 1.5T GE scanner. Placental ASL was performed using velocity-selective ASL⁶ and a 3D stack-of-spiral FSE acquisition with whole placenta coverage. Scan parameters included FOV = 34-40 cm, matrix size = 64x64, number of slices = 36-44, and slice thickness = 4 mm. Total scan time was 4:29 min. Global placental perfusion was estimated by averaging perfusion in the whole placenta that was manually segmented on each imaging slice.

RESULTS

All enrolled participants were included in our analysis. Mean gestational age (GA) was 32±5 weeks for CHD and 31±5 weeks for controls (p=0.438). Diagnostic categories for fetal CHD included: hypoplastic left heart syndrome (n=7), tetralogy of Fallot (n=3), ventricular septal defect (n=2), truncus arteriosus (n=2), double-outlet right ventricle (n=1), d-transposition of the great arteries (n=1), and total anomalous pulmonary venous return (n=1). Placental perfusion decreased with advancing GA in pregnancies with CHD fetuses (r=-0.667, p=0.003) while there was no correlation between placental perfusion and GA in controls (r=-0.122, p=0.521). Additionally, those who underwent two fetal MRI scans showed a similar slope of increase to those of linear regression lines of their own group. Placental perfusion data were also divided into two groups depending on the patient position during MRI scan (lateral decubitus and supine). Based on multiple linear regression, we found there was a significant difference in placental perfusion between pregnancies with CHD fetuses and controls (p=0.028) and between the lateral decubitus and supine positions (p=0.039).

CONCLUSION

We report altered placental perfusion in fetal CHD compared with healthy controls as well as perfusion dependency on the maternal position during fetal MRI. Our results show that placental perfusion decreases with advancing GA in pregnancies complicated by fetal CHD but not in healthy pregnancies, and that placental perfusion is reduced with the supine position of the mother likely due to inferior vena cava compression⁷. These data suggest placental ASL may serve as a potential early biomarker of placental dysfunction in fetal CHD.

REFERENCES

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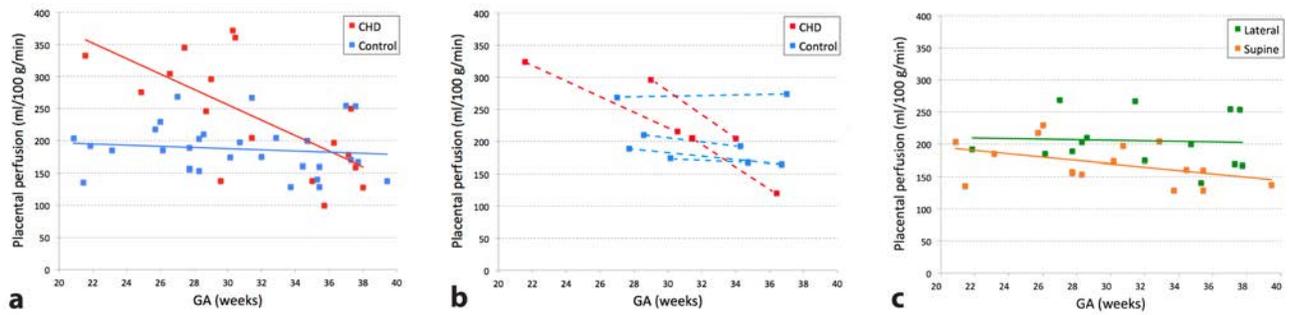


Figure 1. Scatter plots of placental perfusion and GA for (a) all subjects excluding follow-up scans, (b) those who underwent MRI scans twice (dotted line connecting the two data points within each subject), and (c) healthy controls only. Placental perfusion decreased with advancing GA in pregnancies with CHD fetuses only ($r=-0.667$, $p=0.003$), but not in healthy controls ($r=-0.122$, $p=0.521$). There was a significant difference in placental perfusion between pregnancies with CHD fetuses and controls ($p=0.028$) and between the lateral decubitus and supine positions ($p=0.039$).

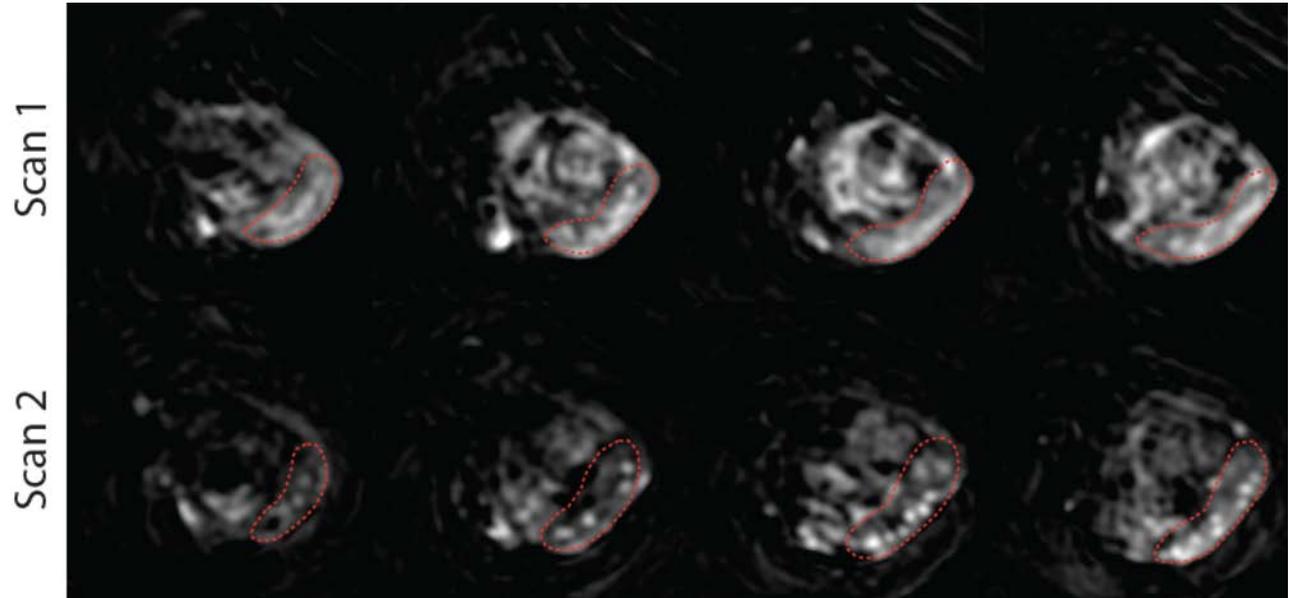


Figure 2. ASL images of a pregnant woman with fetal CHD (diagnosis: hypoplastic left heart syndrome) in the first (GA: 29 weeks) and follow-up (GA: 34 weeks) MRI scans. The placenta is delineated with the dotted line on each image. The follow-up scan showed reduced ASL signal in the placenta compared to the first scan.