

# Fetal and placental oxygenation estimated by BOLD MRI

*PhD Thesis Anne Sørensen, MD, PhD*

*Department of Obstetrics and Gynecology, Aalborg University Hospital, DK, January 2014*

## Abstract

Placental function is crucial for fetal growth and development. Fetal growth restriction (FGR) due to impaired placental function is associated with an increased risk of neonatal morbidity and mortality because of reduced supply of oxygen. The aim of fetal monitoring is to identify the growth restricted fetus to ensure rational monitoring intervals and timely delivery. Fetal monitoring is based on various methods, such as CTG, biophysical profile and ultrasound Doppler measurements of fetal and umbilical blood flow. Current methods focus on fetal wellbeing and thus only indirectly estimate placental function. Today, the only method available for direct assessment of placental oxygen transport is cordocentesis. This invasive procedure is associated with an increased risk of fetal loss and is therefore not used. In neuroscience Blood Oxygen Level Dependent (BOLD) magnetic resonance imaging (MRI) provides non-invasive information about brain oxygenation as changes in BOLD signal reflect changes in the saturation of hemoglobin. Furthermore, the transversal relaxation time ( $T2^*$ ) reflect tissue morphology and tissue oxygenation. Over the last decade BOLD MRI has become the main method in mapping brain function in cognitive studies; however, in fetal medicine the method is only briefly described. In this PhD thesis the feasibility of BOLD MR as a non-invasive method for estimating fetal and placental oxygenation is investigated in healthy pregnancies.

The first study of the PhD project was performed in an animal model. In a sheep fetuses oxygenation changes were induced by changing the oxygen content of the maternal breathing air, and the corresponding changes in the BOLD signal were measured in selected fetal organs. In the fetal liver the tissue oxygenation was estimated directly by internal oxygen sensors, and a close association was demonstrated between changes in the BOLD signal and changes in tissue oxygenation. Following BOLD MRI scan was performed in healthy human pregnancies, and fetal and placental hyperoxia was induced by increasing the oxygen content of maternal breathing air. In the human fetus the oxygenation of the spleen, liver and kidney was increased. The total placental oxygenation was also increased; however, this increase was predominantly seen in the fetal part of the placenta. Thus, from this thesis it can be concluded, that BOLD MRI is a feasible method to estimate fetal and placental oxygenation non-invasively.

The future perspective of this method is a non invasive test of placental function in cases of FGR. Placental BOLD MRI might be an additional tool to support obstetricians in the very difficult decision of when to deliver these high risk fetuses.

## Papers

### *Paper 1*

Sørensen A, Pedersen M, Tietze A, Ottosen L, Duus L, Uldbjerg N.  
BOLD MRI in sheep fetuses: a non-invasive method for measuring changes in tissue oxygenation.  
Ultrasound Obstet Gynecol. 2009 Dec;34(6):687-92.

### *Paper 2*

Sørensen A, Holm D, Pedersen M, Tietze A, Stausbøl-Grøn B, Duus L, Uldbjerg N.  
Left-right difference in fetal liver oxygenation during hypoxia estimated by BOLD MRI in a fetal sheep model.  
Ultrasound Obstet Gynecol. 2011 Dec;38(6):665-72

### *Paper 3*

Sørensen A, Peters D, Simonsen C, Pedersen M, Stausbøl-Grøn B, Christiansen OB, Lingman G, Uldbjerg N.  
Changes in human fetal oxygenation during maternal hyperoxia as estimated by BOLD MRI..  
Prenat Diagn. 2013 Feb;33(2):141-5

### *Paper 4*

Sørensen A, Peters D, Fründ E, Lingman G, Christiansen O, Uldbjerg N.  
Changes in human placental oxygenation during maternal hyperoxia as estimated by BOLD MRI.  
Ultrasound Obstet Gynecol. 2013 Sep;42(3):310-4

### *Paper 5*

Peters D, Sørensen A, Simonsen C, M. Sinding, Uldbjerg N.  
The reproducibility of human placental T2\* measurements and the hyperoxic response. (Submitted)