In vivo ^{31}P MR spectroscopy of human placenta

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Introduction

Placenta is a specialized organ that provides nutrients to and excretes waste products from the fetus. Despite over 20 years of using ^{31}P magnetic resonance spectroscopy (^{31}P MRS) in research of human tissues (muscles, heart, liver, brain), there are only a few studies of the placenta. The majority of ^{31}P MRS experiments have been performed in vitro [1, 2] or ex vivo using perfused models [3, 4]. However, to the best of our knowledge, only one in vivo study has been published so far [5]. The present work was designed to quantify the major metabolites of normal human placenta and placentas from women with preeclampsia (a pregnancy-specific disorder of hypertension and proteinuria).

Materials and Methods

Seven women with uncomplicated pregnancies (median gestational age 31.5 weeks, range 24-38) and six women with their pregnancies complicated by preeclampsia (median gestational age 37 weeks, range 24-40) were included in this study.

All experiments were preformed on a 1.5 T Gyroscan Intera MR scanner (Philips). Single-voxel ^{31}P spectra were measured by a transmit-receiver surface coil (Φ = 14 cm). Image-selected in vivo spectroscopy (ISIS) localization sequence [6] was combined with broad band proton decoupling (WALTZ-4 modulation) and with the nuclear Overhauser effect (NOE) enhancement. Whole body coil was used for both decoupling and NOE enhancement. The main measurement parameters were as follows: spectral bandwidth, 1500 Hz; repetition time, 2500 ms; 512 points; NOE mixing time, 2000 ms; 512 acquisitions. Typical voxel size was 80 x 90 x 20 mm^3 (Fig. 1). The net measurement time was 21.3 minutes. Spectra were processed by AMARES algorithm [7], which is a part of the jMRUI software package [8]. The following metabolites were fitted: phosphomonoesters (PME = phosphoethanolamine (PE) + phosphocholine (PC)), inorganic phosphate (Pi), phospho-diesters (PDE = glycerophosphoethanolamine (GPE) + glycerophosphocholine (GPC)), phospho-creatine (PCr), and adenosine triphosphate (ATP). PCr line was placed to 0 ppm and 13 resonances were fitted by Lorentzians (Fig. 2). Each metabolite was quantified as a fraction of the total phosphorus signal (Fig. 3).

Results

Figure 1 shows typical voxel position in the placenta. Representative spectra from a healthy human placenta at 38 weeks's gestation and from a placenta of a women with preeclampsia (gestational age 36 weeks) are shown in Fig. 2. Percentage ratios of the metabolite spectral intensities to total phosphorus signal are shown in Fig. 3. The results represent mean spectral intensity ratio and standard deviations of seven normal pregnancies and six pregnancies complicated by preeclampsia. No significant differences ($P > 0.05$) in metabolite ratio were found between the two groups of placentas.

Discussion

Our results demonstrate that the proposed ^{31}P MRS technique is able to measure spectra of the placenta with acceptable quality and measurement time. Although no significant differences in PME and PDE metabolite ratio were found between normal and abnormal pregnancies (preeclampsia) (Fig. 3), there is a clear trend towards lower PME and higher PDE in pregnancies influenced by preeclampsia. This trend could be a sign of placental degradation, because PDE metabolites are thought to represent cell membrane degradation products and PME levels are associated with cell mitosis and growth [9]. Moreover, numerical differences in mean ATP and Pi levels were observed between healthy pregnancies and those complicated by preeclampsia that are consistent with a restricted use of ATP in preeclamptic pregnancies. The primary disadvantage of this study was that the volunteers were limited to those with anterior placentas and low body fat since receiver coil sensitivity was limited to 4 – 5 cm.

Conclusions

In vivo ^{31}P MRS is a promising tool to detect changes in human placental metabolites.

References

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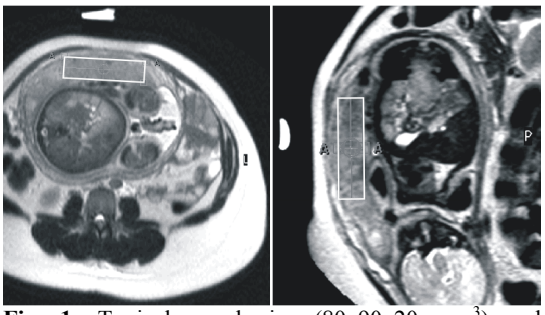

Fig. 1: Typical voxel size (80x90x20 mm^3) and position in abdominal placenta.

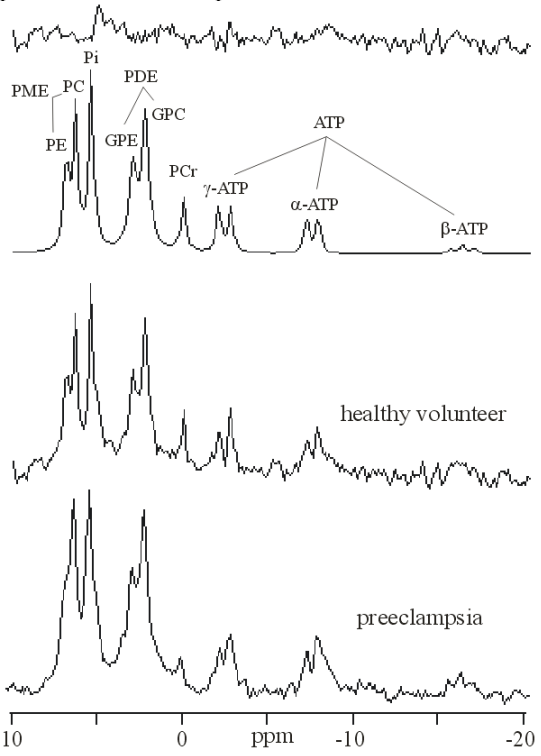

Fig. 2: Representative ^{31}P spectra of the placenta, fitted spectrum of healthy volunteer and residue.

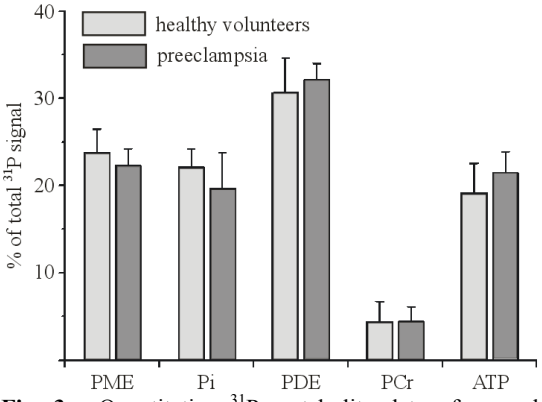

Fig. 3: Quantitative ^{31}P metabolite data of normal placenta and placentas from women with preeclampsia.