In-vitro Analysis of Fetal Blood Flow in a Whole Organ Ex-vivo Placenta

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Placental insufficiency is associated with a wide class of pathological conditions and can be identified when about 70% of the placental microvasculature is already obstructed. Currently, the Doppler ultrasound (DUS) measurements from umbilical vessels provide the hemodynamic factors in obstetrics diagnosis of fetal development and well-being. In this in vitro study we simulated pulsatile blood flow through the ex-vivo placenta using a pulse duplicator. Power DUS measurements of arterial flow velocities were taken at the umbilical cord insertion and at the first bifurcations of the chorionic arteries (Fig.1). In addition, continuous pressure signals were recorded from the placental inlet and at different bifurcations of the chorionic arteries (Fig.2). In this study we conducted experiments with 5 normal placentae, which were obtained immediately after a full-term singleton delivery from women with uncomplicated pregnancies. The results showed that peak systolic velocities were 20-36 m/s at the umbilical artery insertion; 15-35 m/s, 14-20 m/s and 8-13 m/s at the first, second and third generations, respectively. As expected the flow velocities along the arterial bifurcations on the chorionic plate decrease towards smaller vessels. The outcome of the experiments also demonstrated reverse or absent end-diastolic flow in a case of high placental resistance. The perfusion pressures in the intra-placental vessels were lower then in the cord insertion and ranged from 30 to 80 mmHg. In this experiment, as in previously published works, in-vitro perfusion of the ex-vivo placenta could not reveal physiologic pressures (Fig.3).

Fig. 1. *In vitro* experimental system for simulation of the placental circulation.

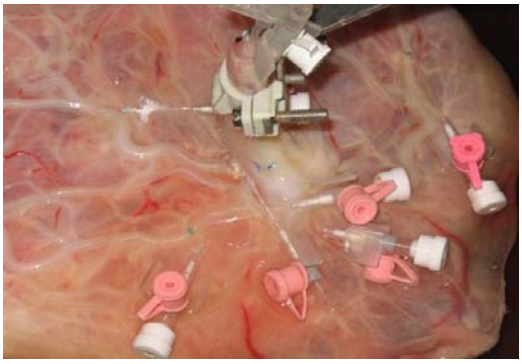

Fig. 2. *Ex-vivo* placenta with catheters for pressure measurements.

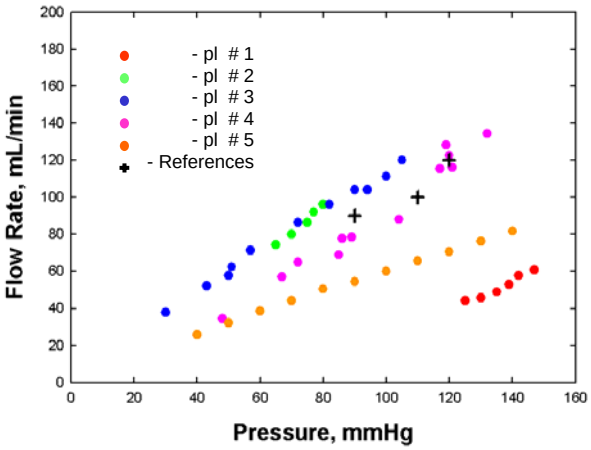

Fig. 3. Pressure-flow measurements at the umbilical cords insertion of 5 placentae.