USING DIGITAL TWIN TECHNOLOGY TO REDUCE ANIMAL STUDIES FOR DEVELOPMENT OF PERINATAL LIFE SUPPORT SYSTEMS

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Introduction

To reduce the mortality and morbidity rate of extremely preterm infants (< 28 weeks of gestational age, GA), the Perinatal Life Support (PLS) consortium is developing a PLS system (https://perinatallifesupport.eu). The PLS system serves as a liquid-based incubator where the infant is submerged in fluid and the umbilical cord is connected to an artificial placenta [1]. This way, the organs of the preterm infant can mature similar as in the natural womb.

Several research groups [2–4] started animal experiments to define the optimal environment for fetal development. Besides the concern of ethics, animal studies require trained manpower, time, and money.

A digital twin of the experiment can overcome these drawbacks. Digital twin technology enables testing and tuning of the set-up before the actual experiment and allows for animal specific optimization of the experiment. Moreover, it provides support to operate the PLS system during the experiment. This study presents a mathematical model of a human fetus and how this model is translated to a digital twin that mimics the interaction between a PLS system and a fetal pig [3].

Methods

Based on [5,6], a human fetal cardiovascular mathematical model including gas-exchange and fetal growth is developed. This model is adapted to the fetal pig anatomy. Subsequently, the placenta is replaced by an artificial placenta and adapted to the experimental set-up of [3]. Figure 1 shows the development process of the mathematical models.

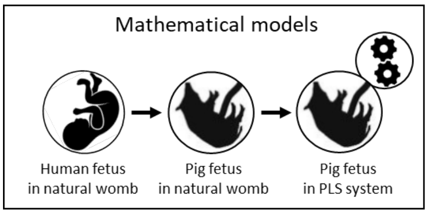

Figure 1: Overview of the development process of the mathematical models.

Results

Figure 2 shows the results of the mathematical model describing an average healthy human fetus in a natural womb. As verification, the mean flow through the foramen ovale, ductus arteriosus, the ascending aorta, and main pulmonary artery simulated by the model (green) is compared with literature data [7] (black).

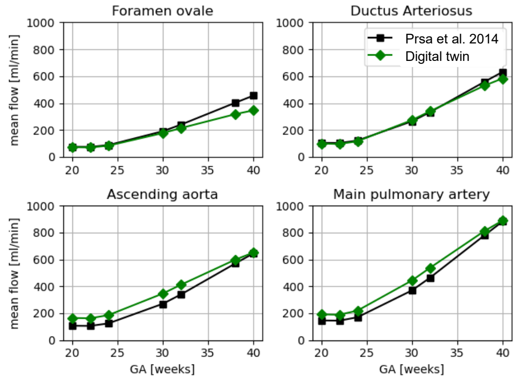

Figure 2: Comparison of the mean flow between the mathematical model describing a human fetus (green) and literature data [7](black).

Discussion

We developed a mathematical model that can describe the fetal hemodynamics. To develop a digital twin, the model should be dynamically paired with the experimental set-up data. Figure 3 shows the method proposal that will be carried out in April-June 2023 in collaboration with the research group of [3].

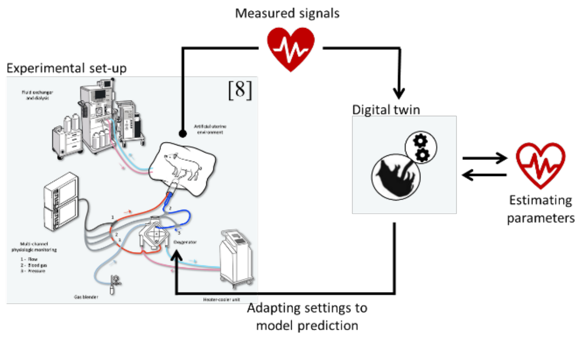

Figure 3: Schematic overview of the model dynamically paired with the experimental set-up [3].

References

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