

# A multi-compartment lumped-parameter model for assessing the role of haematocrit in foetal circulation

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Foetal circulation, being different from neonatal and adult circulation, is an intricate system. Current knowledge of its haemodynamics is limited<sup>1</sup>, while the role of haematocrit at different gestational ages has not yet been examined extensively. This work aims to investigate the effect of haematocrit variations using a multi-compartment lumped parameter model (LPM) of the foetal circulation. The LPM model is developed in Simulink® and includes 19 elastic arterial segments and 12 peripheral vascular beds, represented, respectively, by electrical circuits and a 3-element Windkessel model<sup>2,3</sup>. Previous data<sup>1,2</sup> and allometric laws<sup>4</sup> were used to calculate the inflow and boundary conditions for a 33-week gestational age and foetus weight. Two validation studies were completed, one comparing results with adult flow waveforms and another examining the foetal Isthmic Flow Index. Different values of haematocrit (Hct), ranging from 10% to 80% Hct, were investigated, representing a range of anaemic, healthy, and polycythaemic conditions. Results from the validation studies were in good agreement with literature. The foetal LPM enabled calculations of blood flow waveforms at various arterial positions. Computations with 10%, 45%, and 80% Hct were further performed to demonstrate the effect of haematocrit on the foetal arterial flow. A clear difference between the 45% and 80% Hct models at the position of the ascending aorta was evident, whereas no apparent difference was detected between the models for 10% and 45% Hct. Similarly, this effect was manifested at the positions of the aortic isthmus, the thoracic aorta, and the umbilical artery. However, at the position of the ductus arteriosus there was no difference between the three models. Finally, the calculations revealed an almost exponential relationship between mean resistance and Hematocrit. Investigating haematocrit variations revealed an important effect on the foetal circulation, resulting in significant changes in vascular resistances and the pulsatility indices of the flow rate waveforms. Further investigation is required aiming at the improvement of the accuracy of the inflow and boundary conditions.

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## References

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