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P258 -DEVELOPMENT OF AN IN VITRO SIMULATION MODEL TO INVESTIGATE HEMODYNAMIC RESPONSES DURING HAEMODIALYSIS

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Abstract

Introduction:

Haemodialysis imposes unique stresses on the cardiovascular system that may provoke episodes of hypotension, which result in progressive cardiac and cerebral injury as well as reduced quality of life and survival. These responses are difficult to study in patients because multiple factors may interact to provoke hypotension and some, for example capillary refill, are difficult to measure. There is therefore a need for an in vitro simulation model to study the impact of multiple factors on intradialytic haemodynamic stability.

Methods:

We have developed an in vitro model of a patient receiving dialysis using a Harvard Instruments pulsatile blood pump which simulates cardiac output, modified for real-time computer control of stroke volume, heart rate and systolic/diastolic phase. The pump is attached to a circulatory system with controllable peripheral resistance and compliance, an “arm” with fistula and needle ports for arterial and venous lines connected to a Hospal Integra dialysis machine. The system is monitored at multiple points by continuous pressure and flow sensing, and is integrated in real-time via a computer and National Instruments data acquisition hardware, with model and data handling performed via The Mathworks Matlab and Simulink packages. The model [figure 1] can integrate and run pre-recorded intradialytic haemodynamic data from patients. External components such as a dialysis machine, prototype sensors, data acquisition and real time analysis seamlessly interact with the patient data via the cardiovascular simulator.

Results:

We have confirmed that this in vitro model is able to replicate flows and pressures similar to those observed in haemodialysis patients [figure 2]. The in-vitro simulator has the facility to ‘re-run’ patient physiological responses in hardware, enabling the testing of new monitoring devices, new dialysis strategies and also to investigate the effects of change, for example, in the fluid dynamics effects of constricted fistulas. The paper presents the simulator’s capability and potential in terms of modelling patient physiology in a hardware/software hybrid, novel sensor development, data analysis and visualisation capability. In addition, consideration is given to challenges in experimental physiological modelling, and future simulator development, particularly in the machine learning of physiological models and the prediction of control system instability resulting in effects such as hypotension.

Conclusions:

An in-vitro mechanical/fluid dynamic experimental model is described to augment existing modelling and simulation methods and open new pathways to developing novel solutions to improve intradialytic haemodynamic stability.