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Evaluation of Pressure Recording Configuration Effects on Pressure-Waveform Derived Cardiac Output Measurements

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Abstract— **Pressure recording equipment with different dynamic properties may influence parameters derived from blood pressure waveforms and pressure-derived cardiac output measurements. In this work, we propose a computational approach for modeling different components of a pressure recording system to evaluate their effect on derived hemodynamic measurements.**

Clinical Relevance— **This provides insight into methods to understand the equipment-induced error in continuous pressure-derived cardiac output measurements.**

I. INTRODUCTION

Devices that calculate cardiac output from an arterial blood pressure (BP) waveform provide a minimally invasive method for continuous cardiac output estimation. These devices apply algorithms to arterial BP waveforms collected using pressure recording tubings that transmit the pressure signal to patient monitors. Differences between different tubings and monitors used in signal acquisition and processing may potentially affect the morphology and dynamics of a physiologic signal. In this work, we proposed an approach for modelling different components of a pressure monitoring system and utilized this model-based approach to investigate the effect of various pressure recording configurations on performance of pressure-derived cardiac output measurements.

II. METHODS

Multiple bench tests verified the use of Bessel filter transfer function and second-order transfer function models for simulating dynamic responses of monitors and tubing configurations with various sizes, respectively. We performed a series of model-based analyses to quantify the effect of tubing configurations with various damping ratios and natural frequencies as well as monitor systems with different bandwidths on blood pressure waveforms and cardiac output measurements using six different pulse contour analysis (PCA) methods (Fig. 1). PCA measurements were calibrated based on doppler ultrasound measurements [1].

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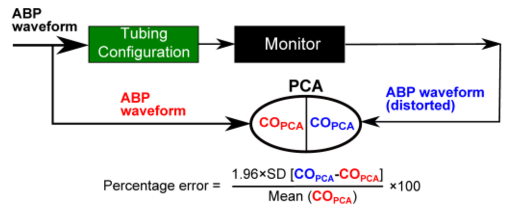

Figure 1. Block diagram illustrating the model-based procedure for obtaining the error in pressure-derived cardiac outputs (**CO**) in reference to those obtained from undistorted arterial BP (**ABP**) waveforms.

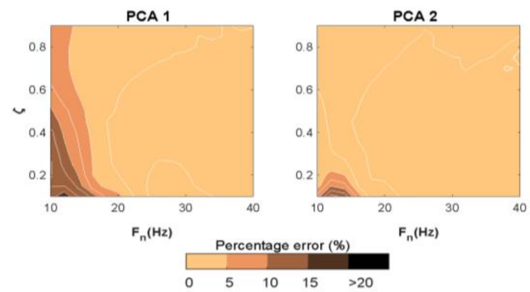

Figure 2. Example plot showing percentage error in cardiac output values (calculated using two different PCA methods) when using a catheter with a natural frequency of Fn (Hz) and damping ratio of ζ and a low-bandwidth monitor. **PCA1:** {k.(SBP-DBP/(SBP+DBP).HR}; **PCA2:** {k.($\int_{sys}$(ABP).dt).HR}. **SBP**: systolic BP, **DBP**: Diastolic BP, **sys**: systolic period, **HR**: heart rate, **t**: time and **k** is calibration coefficient.

III. RESULTS

Depending on the PCA algorithm, we observed different cardiac output measurement errors for a given tubing configuration. Also, tubing configurations with low natural frequencies altered characteristics of blood pressure waveforms in a way that affected the cardiac output measurement, some by as much as 20% (Fig. 2).

IV. DISCUSSION & CONCLUSION

Our model-based analysis approach provides a tool to quantify how pressure recording configurations with different dynamic properties can influence parameters derived from blood pressure waveforms and pressure-derived cardiac output measurements. Model-based analyses can provide insight into the effects of physiologic signal recording configurations on derived measurements.

V. REFERENCES

[1]. CG Scully et al. "Evaluation of heart rate and blood pressure variability as indicators of physiological compensation to hemorrhage before shock". Shock. 2015 May;43(5):463-9

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