A parameter identification approach towards analyzing hemodynamics based on capnography

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Rapid and reliable detection of return of spontaneous circulation (ROSC) during cardiopulmonary resuscitation (CPR) is an important, but difficult task. While manual pulse palpation is time-consuming and poorly specific, a sudden rise in end-tidal CO_2 ($etCO_2$) is regularly associated with ROSC. Additionally, $etCO_2$ is commonly used as a surrogate parameter for systemic blood flow during clinical CPR, as metabolic CO_2 from the tissues is transported to the lungs and exhaled through the alveoli. Thus, increasing $etCO_2$ levels during CPR indicate improved systemic perfusion, but a number of variables such as tidal volume and ventilation rates complicate the interpretation of measured $etCO_2$.
In this work, we model this system in a simple compartment-based ODE model and try to determine the parameters like airway resistance, compliance and a slowly time-dependent scalar describing the estimated level of systemic perfusion using a multishooting parameter identification approach. We test our model on synthetically generated data of tidal flow, capnography, and ventilation pressure as well as on data from a porcine model of cardiac arrest. In the porcine model, we compare the estimated level of systemic perfusion with discretely measured cardiac output and invasively measured mean arterial pressure, while on the synthetic data, the parameter estimation is compared to the forward input variables.
First experiments on both synthetic and real-world data show good identifiability for the level of systemic perfusion based on the capnography data. A validated simple ODE model for CO_2-extraction during CPR could help to quantify the effects of tidal volumes and ventilation rates on $etCO_2$ and furthermore assist physicians to detect a ROSC more reliably during out-of-hospital cardiac arrest.

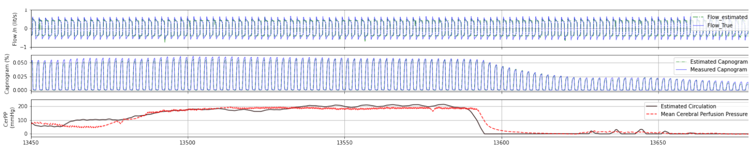

Figure 1: Exemplary circulation estimation, based on capnography

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