Modified Thermodilution in Extracorporeal Therapy

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Video Abstract

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Abstract

Extracorporeal membrane oxygenation, or ECMO, is a vital rescue therapy for patients experiencing severe cardiopulmonary failure. With ECMO, a specialized heart-lung machine re-oxygenates blood and pumps it throughout the body, bypassing the heart and lungs for extended periods. But when patients are weaned off of ECMO, there is no good way of evaluating a patient’s heart function. To solve this problem, scientists at the University of Bern in Switzerland adapted a thermodilution technique. Publishing in Anesthesiology, the researchers report that when using the novel method on pigs, they could reliably estimate the output and function of the right ventricle. In thermodilution, bursts of cold saline are injected into the heart, and the resulting temperature changes can be tracked to estimate cardiac output. While the technique is considered the gold standard for cardiac measurement, it has not been used in ECMO because the cold solution gets passed into the patient’s lung and into the ECMO circuit—causing the standard measurement formulas to fail. To address this issue, the Swiss scientists placed a thermistor in the pulmonary artery and another in the ECMO circuit to measure how much of the indicator solution passes through each compartment, allowing them to calculate the pulmonary blood flow. The researchers tested their hypothesis in 16 pigs that were centrally cannulated for veno-arterial ECMO. First, calibration constants were calculated with injections of 3, 5, and 10 milliliters of cold saline into the ECMO circuit at a flow rate of 4 liters per minute. Then, the ECMO flow was reduced in 1-liter steps, and saline was injected five times into the right atrium, followed by the right ventricle. Compared with ultrasound-measured blood flow, the team found that this method allowed them to calculate the blood flow with a low bias of almost 0 liters per minute and limits of agreement of roughly 0.6 liters per minute, which resulted in a percentage error of approximately 30%. The temperature signals also allowed for an assessment of the ejection fraction and evaluation of right heart function. The results suggest that at least in healthy animals, right heart function remains constant and the right ventricle dilates to accommodate a larger preload. This may have implications for echocardiography weaning, since dilation is interpreted to be a sign of failure. The ability to continuously monitor patients during ECMO weaning could be highly valuable to clinicians, as it could identify patients who are worsening or those who are undergoing weaning failure.