Transthoracic Thermodilution Measurements Guiding Management of Postoperative Cardiogenic Shock Case Report

Clark CA*, Teegarden BMT, Kottkamp GS, Field LC and Rieke H

*Department of Anesthesia and Perioperative Medicine, Medical University of South Carolina, USA

Abstract

This case report describes the complicated postoperative course of a 73 year-old male patient with pre-existing congestive heart failure after uneventful hepaticojejunostomy for benign biliary stricture. The hemodynamic and respiratory failure resulting from cardiogenic shock was successfully treated by using transthoracic thermodilution measurements to guide the choice of catecholamines, antiarrhythmic drugs, and repeated attempts at cardioversion. Determination of global end-diastolic volume, extravascular lung water, thermodilution-calibrated pulse-contour derived continuous cardiac output as well as the ratio of cardiac output per global end-diastolic volume (cardiac function index) was deemed to be advantageous for management of this clinically challenging patient.

Keywords: Global end diastolic volume (GEDV); Extravascular lung water index (ELWI); Cardiac function index (CFI); Pulmonary artery catheters (PAC); Ejection fraction (EF)

Introduction

Standard recommendations for assessment of hemodynamic instability, particularly in sepsis, are often limited to heart rate and blood pressure together with a clinical holistic impression [1]. Further details obtained by ultrasound evaluation, chest x-rays, imaging studies and other various invasive methods are often based on individual preferences, leading to more or less heuristic therapeutic concepts [2].

Currently, use of stroke volume variation for estimates of the volume status of a mechanically ventilated patient seems to be widely used, which also includes estimates of cardiac output from arterial blood pressure curves [3]. Availability of this newer technology and concerns regarding the inaccuracy of assessments of the intravascular volume status from central venous pressure and the pulmonary capillary wedge pressure during positive pressure ventilation have led to reduced usage of pulmonary artery catheters (PAC) [4].

Ultrasound parameters have been introduced and become major tools because of their excellent support of clinical impressions, showing moving pictures of anatomical structures that are meaningful for hemodynamic function [5]. However, ultrasound imaging is often hard to obtain due to postsurgical wounds and dressings, posture and general condition of the patient. Moreover, even trans-esophageal echocardiography cannot offer the continuity of data for an extended time course secondary to patient sedation requirements.

The transthoracic thermodilution technique with volumetrically determined global end-diastolic volume (GEDV) has been suggested in recent decades [6]. It allows consideration of the ratio of cardiac output to GEDV, which is termed “cardiac function index” (CFI) [7]. In fact, the CFI is physiologically similar to the classic ejection fraction (EF), representing principally the amount of blood being ejected from the heart per pre-ejection filling [7].

Beyond that, the determination of extravascular lung water index (ELWI) allows for estimating the leakage of water from the intravascular space into lung tissue. For conditions with high intrathoracic blood volume (GEDI provides a measure of this), elevated ELWI indicates pulmonary edema from congestion, versus high ELWI with reduced intra-thoracic blood volume. This clinical situation is typical for capillary leak secondary to endothelial dysfunction and inflammation [8].
In recent years, most reports have focused on the use of the transthoracic thermodilution for hemodynamic management of sepsis, where detailed information helps guide controlled volume resuscitation and management of impaired cardiac function [3]. This case report attempts to describe the advantages of basing clinical management of a patient with severe cardiac failure after abdominal surgery on the therapeutic concept derived from data obtained from transthoracic thermodilution.

**Case Presentation**

The patient, a well optimized 73 year-old male with a medical history of ischemic cardiomyopathy and paroxysmal atrial fibrillation, underwent an uneventful hepaticojejunostomy for recurrent choledocholithiasis. On the morning of postoperative day one, the patient developed respiratory failure, altered mental status and atrial fibrillation with rapid ventricular rate requiring admission to the intensive care unit (ICU) (Figure 1). Upon admission to the ICU he was hypoxemic ($S_\text{O}_2 \approx 80\%$) and tachycardic (150–160/ min) despite attempts to slow his rapid ventricular rate (RVR) with metoprolol and diltiazem.

Regarding his worsening mental status and clinical picture, endotracheal intubation and positive pressure ventilation was immediately initiated under sedation with fentanyl and propofol. A central line was placed into the right internal jugular vein, as well as a 20 gauge thermistor arterial catheter (PICCO Pulsion) into the right femoral artery. Norepinephrine was started for maintenance of mean arterial blood pressure (MAP) > 60 mmHg. Initial chest x-ray showed right lower lobe consolidation, possibly indicative of aspiration as well as mild interstitial edema (Figure 2). Broad-spectrum antibiotic coverage with vancomycin and cefepime was started for possible sepsis. Anticoagulation with a heparin drip was initiated for the concern for an underlying pulmonary embolism. A transthoracic ultrasound study showed global hypokinesis with an estimated ejection fraction < 20%, but could not comment on the volume status. Visualization of the inferior vena cava was not attempted due to surgical wound dressings. Initial labs showed a troponin of 13.15 ng/ml, arterial lactate of 3.80 mmol/L and procalcitonin of 14.08 microgram/l.

The transthoracic thermodilution measurement revealed significantly reduced cardiac index of 1.6 [l/min*m$^{-2}$], global end-diastolic volume index within the upper range of normal values with slightly elevated extravascular lung water, thus indicating mild cardiogenic pulmonary edema. Systemic vascular resistance was close to the upper range of normal values. Stroke volume was severely reduced due to supraventricular tachyarrhythmia.

Cardiology suggested continued titration of inotropes and vasopressors to an appropriate cardiac index. An attempt to improve cardiac output with dobutamine resulted expectedly in worsened tachyarrhythmia. Infusions of epinephrine (4 – 6 micrograms / min) and norepinephrine (6 – 10 micrograms / min) were initiated which transiently stabilized the MAP, but this neither improved cardiac index nor cardiac function index. On postoperative day two, the cardiac index and stroke volume remained below normal, so when the patient’s heart rate increased acutely to 163 bpm, electrical cardioversion was attempted. Initial failure to convert to sinus rhythm resulted in electrolyte optimization and the initiation of an amiodarone infusion (Figure 3). Repeat cardioversion was successful and the resulting sinus rhythm significantly improved stroke volume (Table 1).

Despite the concern for sepsis and its need for increased preload, the patient remained afebrile with negative cultures. Controlled preload reduction was begun while continuously measuring GEDI and CFI and MAP support with norepinephrine and vasopressin. Although the GEDI was found to be within the normal range at the beginning of this attempt, the cardiac function index improved slightly after a 20 mg dose of Furosemide. Reduction of GEDI from
To other practical assessments of the volume status [6]. All in all, semi-continuous volumetric measurement of preload as opposed clinically proven [7]. Its advantage could be attributed to a real potential fatal outcome [9].

might have contributed to worsened myocardial ischemia and have caused a prolonged phase of “experimental” treatment, which the clinical holistic impression of how the patient presented could “Blind” attempts based on standard hemodynamic monitoring and approaches than the one that ultimately led to his improvement.

different strategies of fluid management and pharmacologic diagnoses, the underlying pathophysiology would have required failure or even a pulmonary embolus. Assuming one of these failure could have been interpreted as postoperative systemic failure in terms of global end-diastolic volume to even subnormal values to improve cardiac function.

Discussion

This patient was clinically challenging because his hemodynamic function could have been interpreted as postoperative systemic inflammation response, sepsis, an exacerbation of congestive heart failure or even a pulmonary embolus. Assuming one of these diagnoses, the underlying pathophysiology would have required different strategies of fluid management and pharmacologic approaches than the one that ultimately led to his improvement.

“Blind” attempts based on standard hemodynamic monitoring and the clinical holistic impression of how the patient presented could have caused a prolonged phase of “experimental” treatment, which might have contributed to worsened myocardial ischemia and potential fatal outcome [9].

Transthoracic thermodilution technology has a long history that has been extensively described elsewhere, and can be considered clinically proven [7]. Its advantage could be attributed to a real semi-continuous volumetric measurement of preload as opposed to other practical assessments of the volume status [6]. All in all, this technology offers independence from cardiac arrhythmia, as opposed to stroke volume or pulse pressure variation measurements. Although the continuous cardiac output is based on calculations of stroke volume derived from the area under the curve of the intravascular blood pressure measurement, and with this one has to assume reduced accuracy during arrhythmia, the results are internally correlated to the thermodilution derived cardiac output and stroke volume. Hence, there is a “calibration” of the continuous cardiac output.

Sepsis usually requires initial aggressive fluid resuscitation that can be guided by measuring extravascular lung water. This is particularly helpful, because the inflammatory response leads to capillary leak and extravasation into the lung tissue [8]. In our case there was only a slightly elevated ELWI with an elevated intra-thoracic blood volume, indicating a more likely cardiogenic pulmonary edema.

Visualization of the inferior vena cava could be impeded by abdominal wound and dressing, as it was in this case, but there is also the limitation of easily deriving continuous numeric values like cardiac output, systemic vascular resistance and values indicative of preload. The ultrasound imaging on the other hand offers the unbeatable advantage of showing real-time movement and dimensions of the various anatomical structures of the heart and the great vessels. For the experienced eye there might be nothing comparable to this, even if there would be an underlying pathologic cardiac anatomy [5].

Finally the pulmonary artery catheter would have had the risk of iatrogenic arrhythmia on top of the already existing tachyarrhythmia. Beyond that there is the unreliable information about volume with regards to preload derived from PCWP and CVP [10]. The remaining advantage of the PAC would lie in the possibility of getting mixed venous oxygen saturation to calculate oxygen balance, although the SVO2 from the central line may be a useful alternative.

In conclusion this report endorses using transthoracic thermodilution technology for clinically challenging cases in the setting of perioperative and critical care medicine.

References

