

Is central venous pressure a reliable indicator of fluid responsiveness in the critically ill?

Central venous pressure is the pressure recorded from the right atrium or superior vena cava and is often used to guide fluid therapy in critically ill patients. In most studies, fluid responsiveness is defined as an increase in stroke volume of 10–15% after administration of 500 ml fluid over 10–15 minutes (Michard and Teboul, 2000; Marik et al, 2008). The basis for the utility of central venous pressure comes from the assumption that it is a good indicator of right ventricular preload. As right ventricular stroke volume determines left ventricular filling, it is assumed that central venous pressure reflects left ventricular preload and the patient's position on the Frank–Starling curve (Michard and Teboul, 2000).

Evidence supporting use of central venous pressure

Hu et al (2013) showed that despite central venous pressure itself not being a good predictor, in a subgroup analysis, there was a greater correlation between changes in cardiac index and central venous pressure in younger patients with hypovolaemia.

Despite scarce data and poor evidence (level IV) for use of central venous pressure as a predictor of fluid responsiveness, a survey of Canadian intensivists' resuscitation practices in septic shock found that 89.2% of clinicians use central venous pressure to guide fluid management (McIntyre et al, 2007). This popularity may partly be explained by its recommendation as an end-point for fluid resuscitation by international guidelines (Dellinger et al, 2013).

Dr Vasileios Zochios is Cardiac Intensive Care Unit Fellow, **Dr Bilal Ansari** is Cardiac Anaesthesia and Intensive Care Fellow and **Dr Nicola Jones** is Consultant in Cardiothoracic Anaesthesia and Intensive Care in the Department of Anaesthesia and Critical Care, Critical Care Area, Papworth Hospital NHS Foundation Trust, Papworth Everard, Cambridge CB23 3RE

Correspondence to: Dr V Zochios
(vasileioszochios@doctors.org.uk)

Evidence opposing use of central venous pressure

During mechanical ventilation, changes in venous tone, intrathoracic pressures and left and right ventricular compliance mean that the relationship between central venous pressure and right ventricular end-diastolic volume becomes less accurate (Michard and Teboul, 2000).

A systematic review of 24 studies demonstrated a poor relationship between central venous pressure and circulating volume, found that central venous pressure is a poor indicator of right and left ventricular pre-load and that neither central venous pressure nor delta-central venous pressure can predict response to a fluid challenge (Marik et al, 2008). In an updated meta-analysis of 43 studies examining the ability of central venous pressure to determine whether a fluid bolus increases cardiac output, Marik and Cavallazi (2013) concluded that central venous pressure was unreliable and of limited value (area under receiver-operating characteristic curve 0.56).

Discussion

High quality systematic reviews and meta-analyses (no heterogeneity among studies) have shown that using central venous pressure alone, as a static parameter, to guide fluid resuscitation might be unhelpful and potentially harmful. On existing clinical evidence, central venous pressure is unable to determine whether a critically ill patient is a fluid-responder or non-responder and the correlation between central venous pressure and intravascular fluid volume is poor. Therefore, it should not be used to make clinical decisions regarding fluid management (Marik and Cavallazi, 2013). Despite that, the Surviving Sepsis campaign guidelines recommend targeting central venous pressure to guide fluid therapy in septic shock (Dellinger et al, 2013). The validity of these guidelines is under increasing scrutiny as most of the recommendations are not based on the best current scientific evidence and should probably be revised.

A number of alternate technologies with increasing evidence bases, such as trans-

oesophageal Doppler, PICCO system (Pulsion Medical Systems, Munich, Germany) and LiDCO monitor (LiDCO, Cambridge, UK), that can track changes in stroke volume and cardiac output dynamically and in real time, can be used to determine fluid responsiveness, making the use of central venous pressure even less appropriate (Zochios and Wilkinson, 2011).

Conclusions

Whether central venous pressure-based treatment strategies should be abandoned remains controversial. It might just be that central venous pressure has been inappropriately used as a tool to guide fluid therapy. Adequately powered studies are needed to determine whether rapid dynamic changes in central venous pressure, in response to fluid loading, can provide useful information about cardiac function and better define fluid responsiveness. **BJHM**

- Dellinger RP, Levy MM, Rhodes A et al (2013) Surviving sepsis campaign: international guidelines for management of severe sepsis and septic shock: 2012. *Crit Care Med* **41**(2): 580–637 (doi: 10.1097/CCM.0b013e31827e83af)
- Hu B, Xiang H, Liang H et al (2013) Assessment effect of central venous pressure in fluid resuscitation in the patients with shock: a multicenter retrospective research. *Chin Med J (Engl)* **126**(10): 1844–9
- Marik PE, Baram M, Vahid B (2008) Does the central venous pressure predict fluid responsiveness? A systematic review of the literature and the tale of seven mares. *Chest* **134**(1): 172–8 (doi: 10.1378/chest.07-2331)
- Marik PE, Cavallazi R (2013) Does the central venous pressure predict fluid responsiveness? An updated meta-analysis and a plea for some common sense. *Crit Care Med* **41**(7): 1774–81 (doi: 10.1097/CCM.0b013e31828a25fd)
- McIntyre LA, Hebert PC, Fergusson D et al (2007) A survey of Canadian intensivists' resuscitation practices in early septic shock. *Crit Care* **11**: R74
- Michard F, Teboul JL (2000) Using heart-lung interactions to assess fluid responsiveness during mechanical ventilation. *Crit Care* **4**(5): 282–9
- Zochios V, Wilkinson J (2011) Assessment of intravascular fluid status and fluid responsiveness during mechanical ventilation surgical and intensive care patients. *JICS* **12**(4): 295–300

Anaesthetic and critical care dilemmas are coordinated by Dr Matthew Henley, Specialist Registrar in Anaesthetics, Royal Free Hospital, London and Dr Ramanathan Kasivisvanathan, Speciality Registrar in Anaesthetics, University College Hospitals London, London