Journal of Cardiothoracic and Vascular Anesthesia ▮ (▮▮▮▮) ▮▮▮–▮▮▮

Contents lists available at ScienceDirect

Journal of Cardiothoracic and Vascular Anesthesia

journal homepage: www.jcvaonline.com

Special Article

Fluids and Organ Dysfunction: A Narrative Review of the Literature and Discussion of 5 Controversial Topics

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Evidence-based clinical decision making is at the forefront of modern cardiothoracic anesthesia practice. Therefore, as a field, cardiac anesthesiologist should strive to ensure that the available evidence is of the highest possible quality. In this narrative review, 5 important topics that the authors believe require additional investigation in cardiothoracic anesthesia and critical care related to fluid therapy and organ dysfunction are outlined briefly. In particular, the authors believe that the areas of pulmonary artery catheter use, restrictive versus liberal transfusion strategies, cardiopulmonary bypass prime composition, colloid use in resuscitation and its effects on acute kidney injury, and management of acute kidney injury after cardiac surgery hold many unanswered questions and opportunities for continued improvement in the specialty of cardiac anesthesia. This article accompanies a presentation at the 46th Association of Cardiac Anesthesiologists Annual Meeting on October 22, 2017.

Key Words: fluid therapy; acute kidney injury; thoracic surgery; critical care

EVIDENCE-BASED clinical decision making is at the forefront of modern cardiothoracic anesthesia practice. Questions that arise in everyday clinical practice are attacked with great vigor and scientific rigor as the "right answer" is pursued. This often leads to multiple studies with differing methodologies and conflicting outcomes, fostering further debate in the cardiothoracic community. This can leave clinical providers confused in their pursuit of up-to-date, evidence-based clinical practice. Herein 5 important topics in cardiothoracic anesthesia and critical care as they relate to fluid therapy and organ dysfunction are outlined briefly. This review accompanies a presentation at the 46th Association of Cardiac Anesthesiologists Annual Meeting on October 22, 2017. After discussion at the Association of Cardiac Anesthesiologists meeting, the authors performed a review of the literature discussed at the meeting, using PubMed and Google Scholar to identify relevant clinical trials and meta-analyses. The authors chose these topics for discussion because they are controversial and the authors believe amenable to additional clinical trials. After a brief introduction of each topic, the state of the literature to date on the topic is outlined and possible future directions for continued research and investigation are postulated. The authors acknowledge that this is not meant to be an exhaustive, systemic review but rather a thought-provoking narrative review.

A.J. Kingeter is supported by a Foundation for Anesthesia Education and Research Mentored Research Training Grant in Healthcare Services Research (MRTG_HSR-02-15-17-Kingeter).

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https://doi.org/10.1053/j.jvca.2018.03.017
1053-0770/

Pulmonary Artery Catheter Use in Cardiac Surgery

The flow-guided, balloon-tipped pulmonary artery catheter (PAC) was introduced in 1970 and is a tool that allows measurement of right-sided heart pressure, wedge pressure, thermodilution-calculated cardiac output, and mixed venous oxygen saturation.[1] Proponents argue that the ability to measure these metrics allows providers to accurately control resuscitation and hemodynamic optimization and is beneficial when appropriately applied.[2] However, the ability of these measurements to be translated into meaningful improvements in clinical outcomes is a source of much debate. On the contrary, critics argue that PAC measurements make no difference in terms of morbidity and mortality and may be associated with harm.[3] Furthermore, placement of a PAC is an invasive procedure that is associated with complications ranging from infection and inadvertent arterial puncture to rupture of the pulmonary artery and death.[4] See Table 1 for the outcomes of studies on the use of PACs.[5–12]

Two meta-analyses and a Cochrane review of 13 randomized controlled trials demonstrated that although PACs do not lead to worse outcomes in the intensive care unit (ICU), their use does not lead to a reduction in mortality.[5–7] However, the placement of a PAC before organ dysfunction may improve mortality and organ failure in high-risk patients. In a meta-analysis, Kern and Shoemaker demonstrated that PAC-directed hemodynamic optimization in critically ill patients was associated with reduced mortality compared with patients with no PAC.[6] Logically, this benefit should extend to the perioperative period because deterioration of organ function typically occurs after surgical intervention. However, Sandham et al. randomly assigned high-risk noncardiac surgical patients to either PAC or standard therapy preoperatively and found no difference in mortality.[8]

To the authors' knowledge there have been no randomized controlled trials on PAC use in cardiac surgical patients. Several retrospective and prospective observational studies have examined PAC use in cardiac operating rooms and failed to demonstrate any significant benefit.[9–12] Two of these studies examined coronary artery bypass grafting (CABG) procedures only and found no improvement in outcomes.[9,10] It is possible that these type of patients are not sick enough and the surgeries are not complex enough to detect a difference in care and that these patients may do well regardless of their PAC status. The latter 2 studies broadened their criteria to include valves and more complex surgeries but still did not detect a difference.[11,12]

Without a randomized controlled trial in the cardiac surgical population, it is difficult to fully account for unmeasured confounders and sources of bias. These include the presence of pulmonary hypertension and right ventricular dysfunction, the familiarity of the institution with the management of PACs, and the presence of an ICU PAC management protocol. Furthermore, the use of transesophageal echocardiography (TEE) and its potential synergistic relationship with the PAC also has not been investigated fully in this population. In addition, although TEE is able to provide much of the same information as the PAC intraoperatively, it is not feasible to use TEE indefinitely while patients are in the ICU; transthoracic echocardiography can be of limited use in the postoperative cardiac patient with multiple chest tubes and dressings in place.

The authors believe that additional randomized controlled trials, including multiple types of cardiac surgeries and surgical patients of varying preoperative risk, are necessary to better define the utility of PACs in this population. In designing these trials, the specific information to be obtained by the PAC should be stated a priori. For example, the use of PAC to assess volume responsiveness and guide resuscitation in cardiac surgery patients compared with other validated and less invasive modalities is one such area of potential investigation. In particular, comparing TEE with PAC would be informative because not all centers have TEE experience readily available 24 hours a day, and as previously stated, TEE cannot be used indefinitely. Ideally all providers, including nursing and support staff, at participating institutions would be familiar with using PACs to minimize iatrogenic complications. These trials should be sufficiently powered to investigate clinically meaningful outcomes, such as major morbidity and mortality, and ideally would involve large scale, multi-institutional investigations.

Restrictive Versus Liberal Blood Transfusion Strategies

Outcome optimization in medicine requires careful balancing of therapeutic risks and benefits. The utilization of red blood cell transfusions in cardiac surgery is a paradigm of this balancing act. Perioperative anemia has been shown to be an independent risk factor for adverse outcomes in cardiac surgery.[13–16] However, intraoperative transfusion of blood in the cardiac surgery population also has been shown to have an adverse effect on major outcomes and morbidity.[17,18] As such, there has been much debate as to the lowest hemoglobin level that can be tolerated safely in the cardiac surgery population and the superiority of restrictive or liberal transfusion strategies (Table 2).[19–24]

In 2010, the first randomized controlled trial investigating the noninferiority of liberal versus restrictive transfusions in cardiac surgery (TRACS) was published.[19] No difference in rates of mortality and complications was found; however, there was a nonsignificant trend toward increased incidence of cardiogenic shock in the restrictive transfusion group. This subgroup subsequently was reanalyzed in 2015, confirming a significant increase in cardiogenic shock in patients older than 60 years in the restrictive arm.[20] Subsequent studies followed to better evaluate the safety and efficacy of restrictive transfusion practices. The Transfusion Indication Threshold Reduction (TITRe2) trial in 2015 examined morbidity and cost decreases in restrictive transfusions.[21] No significant decrease in either primary outcome was found in the restrictive transfusion cohort; however, there was a significant increase in 90-day all-cause mortality in the restrictive transfusion cohort.

Additional studies also have found increased risk with restrictive transfusion practices in certain populations.

Please cite this article as: Kingeter AJ, et al. (2018), https://doi.org/10.1053/j.jvca.2018.03.017