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Current concepts in fluid therapy and non-invasive haemodynamic monitoring

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ABSTRACT

Advantages of goal directed therapy (GDT) have recently become more and more difficult to prove in the face of newly implemented protocolised patient care approaches that also clearly improve patient outcome. However, individualised approach using GDT has been suggested to be superior to protocolised care and large meta-analyses still consistently show beneficial effects of GDT. Concerns of invasiveness were the reason why some patients' haemodynamics was not measured and in turn were not included in any GDT protocols. Recently, non-invasive devices to measure arterial blood pressure and haemodynamic variables emerged, and although they are very appealing and easy to use, they require further validation both by comparison to more invasive methods and by outcome trials.

Keywords: Haemodynamic monitoring, non-invasive haemodynamic monitoring, goal-directed therapy, fluid therapy, validation

INTRODUCTION

Fluid therapy is an integral part of perioperative management. Often more attention is given to administered drugs, and very little to choice and rate of administration of fluids.

Major surgery or critical illness result in systemic inflammatory response with increased oxygen demands. The ability to provide for these demands with an increase in oxygen delivery (driven by cardiac output) is an important factor of good outcome (1). It seems that just the right amount of fluids to support organ perfusion is necessary and too little or too much fluids can increase complication rate and length of hospital stay (2). Reduction of postoperative complications and duration of stay has a dramatic impact on costs (3). What is more, postoperative complications have been linked to reduced long term survival (4).

Therefore, there is a lot of interest in cardiac output guided fluid therapy and haemodynamic monitoring. Following is a discussion on current concepts in fluid therapy, haemodynamic monitoring and newer non-invasive devices.

HOW TO DETERMINE THE RIGHT AMOUNT OF FLUID

Various guidelines for intravenous fluid therapy suggest that whenever fluids are given, they should be directed towards a particular goal. This is where goal-directed therapy (GDT) plays its role (5). By proving that patients who accumulated less oxygen debt did better, Shoemaker and his colleagues (1,6) opened the doors towards an important field of research in anaesthesia and intensive care and changed the way of managing fluids and using vasoactive drugs. Through the increased awareness that fluid therapy matters, mind flow when treating surgical patients changed and protocolised strategies like the Enhanced Recovery After Surgery (7) were developed. They were shown to reduce complication rates and hospital stay (5,8–10). Although protocols can improve outcomes, it has been suggested that an individualised approach using GDT is superior in preventing complications (10). It seems that it is not only important how much fluid is given but also when it is given. As suggested by Minto and Mythen, (5) one should distinguish resuscitation from replacement from regular maintenance when deciding what fluid and in what amount to give.

CURRENT PRACTICE

In surgery, evidence of current practice in the US shows a very messy state with huge individual differences in the amount of fluids administered to similar patients for similar surgical procedures (11). Interestingly, the most important predictor of how much fluids an individual patient receives seems to be the provider of anaesthesia. It is unlikely that European situation is much different. And despite that, a survey among American and European anaesthesiologists showed big reluctance towards using haemodynamic monitors (12).

WHO BENEFITS THE MOST?

GDT for guidance of fluid therapy can be applied to many patient populations, but recent evidence suggests that some subgroups may benefit more than others. Although widely used in septic patients after the now-famous Rivers study (13) recent literature does not support that (14). It is possible that treatment of septic patients, especially with wide adoption of the Surviving Sepsis Campaign guidelines (15) has improved enough for benefits of GDT to be more difficult to prove in trials. In surgical patients, it seems that GDT is beneficial throughout the population, but those at higher risk for complications benefit more (16–19). GDT has also been established as an important part of intensive care therapy (20).

HOW TO DO IT

Only using a haemodynamic monitor without coupling it to a medical intervention will not do much good. In GDT, the "holy-grail" of the right goal to follow is still debatable and probably needs to be set for an individual patient rather than universally. We need to understand that being responsive to fluids does not necessarily mean that the administered fluid will take effect in providing better tissue perfusion (21). Anaesthesiologists are familiar with the effects of anaesthetic drugs on vascular tone and relative hypovolaemia that they

cause. Loss of vascular tone caused by anaesthetics will render the patient fluid responsive, and an excessive amount of fluids could be administered.
Probably, the focus should lie on several haemodynamic parameters working in orchestra rather than trying to optimise one single parameter (22,23). More thought should be given to whether it is needed to intervene at the current haemodynamic status in a patient at all, and if so, what causes haemodynamic instability. As suggested by Oscier and Cecconi, ventriculoarterial coupling should play a bigger role in the thinking process (23). Namely, left ventricle works at its best when ventricular contractility and vascular tone are optimally coupled. Only looking at arterial pressure and increasing vascular tone with vasopressors can, in this view, be very deleterious. Pressure should be thought of in the context of flow and vice versa and microcirculation is becoming an important factor to consider.

ROLE OF NON-INVASIVE HAEMODYNAMIC MONITORS

Association of the pulmonary artery (PA) catheter that enabled pioneer haemodynamic studies and treatment, with a relatively high complication rate (and indeed also at least similar if not increased mortality in intensive care) (24) led to development of newer, less invasive methods like transpulmonary thermodilution, lithium dilution, pulse contour analysis and transoesophageal Doppler. However, the need for an arterial cannula and sometimes a central venous catheter to be inserted or for general anaesthesia (as is the case with transoesophageal Doppler), limited the use of these methods to sicker patients. A large group of less at-risk patients whose general condition did not require arterial cannulation (or did not receive general anaesthesia) underwent surgical procedures associated with high complication risk, but was left out of advanced haemodynamic management. In recent years, newer, non-invasive methods of arterial blood pressure and cardiac output measurements were developed.

VALIDATION OF NEW TECHNOLOGIES

It is difficult to validate new haemodynamic technologies reliably. One of the main reasons for this is the lack of the appropriate criterion standard. Physiologically, this would be direct measurement of blood flow at the aortic root, clinically probably thermodilution by the PA catheter. But the question remains whether newer, completely non-invasive methods should be compared to the invasive PA technique (or rather less-invasive ones) (25,26). There is also the importance of using the appropriate statistical method, such as the Bland-Altman analysis. Lack of consensus on the acceptable cut off value of limits of agreement between the two compared methods creates more dilemmas (26). Some critical thinking is therefore required when assessing validation studies.
Thoracic bioimpedance and bioreactance have not shown adequate reliability. Pulse wave transit time probably needs more validation, and so does the promising radial artery applanation tonometry. Vascular unloading technique (also known as the volume clamp Peňáz method) uses a finger cuff to produce arterial pressure wave. It has had better results, especially in cardiac surgery patients. Some concerns have been raised in patients with thick fingers due to oedema and in states of profound shock. The technology is used in ClearSight system (Edwards Lifesciences, Irwine, CA, USA; formerly known as Nexfin) and CNAP (CNSystems Medizintechnik AG, Graz, Austria) (26, 27).
But since the actual purpose of monitors is to guide therapy, studies are needed to determine if a non-invasive haemodynamic monitor coupled with an interventional protocol effects patients' outcome. Some have already been conducted and the results seem promising (28).

CONCLUSION

Despite producing proof of ongoing usefulness of GDT strategies in the light of protocolised patient care is becoming challenging, they undoubtedly have their place in optimising individual's haemodynamics, tissue perfusion and, in turn, reducing morbidity and perhaps, mortality (9,16–18).
As recently suggested in a consensus, the ideal haemodynamic monitor should provide accurate and reproducible measurements of relevant variables that can be interpreted, should be readily available and easy to use, operator-independent, have a rapid response time, be harmless, cost-effective and should help guide therapy (29). Newer non-invasive technologies fulfil many of the abovementioned properties. Further validation, especially in outcome studies, and probably some technological improvements are needed before they can be definitely recommended for clinical use. However, they definitely seem to be a useful haemodynamic tool for patients who would otherwise not be included in GDT protocols due to lack of appropriate monitoring, like those undergoing hip-replacement procedures (28).

CONFLICTS OF INTEREST

National representatives of Edwards Lifesciences and LiDCO.

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