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FOCUS ON: ENHANCED RECOVERY

Targeted fluid administration for major surgery

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SUMMARY

Targeted Fluid Adminstration (TFA) is a technique using less invasive cardiac output monitors to guide individualised intra-operative fluid therapy. Typically, the anaesthetist administers boluses of approximately 200–250 ml of colloid solution whilst measuring changes in stroke volume or another measure of fluid responsiveness, such as stroke volume variation. When the stroke volume measurements indicate that the cardiovascular system is no longer fluid responsive, the patient is assumed to be close to the upper flat phase of the Frank–Starling Curve. Research using TFA suggests that post-operative complications such as ileus and length of hospital stay are reduced when fluid therapy is managed in this way. Most of the positive evidence for TFA has been achieved using the oesophageal Doppler (CardioQ, Deltex Medical, Chichester UK), although other cardiac output monitors are available, there are few clinical outcome studies that justify their use in routine practice. Widespread adoption of TFA for patients undergoing major surgery will help achieve the goals of enhanced recovery.

1. Introduction

Adequate tissue perfusion during the peri-operative period is a key determinant of post-operative outcomes, complications, length of stay and even survival. Standard cardiovascular monitors available to the anaesthetist include pulse, non-invasive blood pressure and urine output in addition to clinical observation. These physiological observations are not rapid or sensitive indicators of hypovolaemia: it is possible to have a 15% reduction in circulating volume without any effect on heart rate or blood pressure. Similarly urine output is assessed over at least 1 h before any effect of fluid resuscitation can be interpreted. Unfortunately standard monitoring does not detect occult hypovolaemia or respond to large fluid shifts rapidly. This prevents the anaesthetist from giving fluids to treat hypovolaemia and provide optimal perfusion conditions. More invasive estimates of cardiac pre-load such as central venous pressure and pulmonary artery pressure have been advocated as peri-operative monitors. Extensive investigation of invasive pressure monitoring has consistently demonstrated that these devices poorly predict the response of the cardiovascular system to changes such as fluid challenge, fluid loss, changes in PEEP or changes in patient position.[1–3] Furthermore pressure-based monitoring is invasive, time consuming, expensive and associated with significant clinical complications.

Studies in very high risk surgical patients have demonstrated that targeting oxygen delivery using the pulmonary artery catheter to guide fluid and vasoactive drugs could improve post-operative patient outcomes.[4,5] However the benefits suggested by these promising early studies failed to materialise when repeated in larger multi-centric randomised controlled trials.[6,7] The use of the pulmonary artery catheter during major surgery has diminished as a result of the published evidence and the emergence of less invasive monitoring systems.

Less invasive cardiac output monitors have been developed in response to the desire of anaesthetists to offer optimal tissue perfusion using blood flow based monitors to guide fluid and drug therapy. In order to gain widespread acceptability, these monitors have demonstrated reliability and validity in estimating cardiac output and other cardiovascular parameters. They also need to be user friendly, suitable for the theatre environment, minimally invasive and cost effective. These monitors can then be integrated into a technique of 'Targeted Fluid Administration' (TFA): a pro-active, individualised approach to intravenous fluid therapy. Crucially, peri-operative techniques such as TFA should optimise tissue perfusion and improve the post-operative experience for patients undergoing major surgery.

In this article, we will review the various monitors, fluids and drugs which can be used to apply TFA for major surgical patients.

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2. Fluid therapy during major surgery: achieving a balance in unknown quantities

Major surgery presents a number of significant challenges to the anaesthetist such as producing adequate ventilation, oxygenation, hypnosis, muscle relaxation and pain relief (nociception) both during and after surgery. All these require a careful balance of the beneficial and unwanted effects of drugs and mechanical interventions during surgery which itself involves significant tissue damage over a prolonged period of time. Perhaps the most controversial area of anaesthetic management is intravenous fluid therapy where advocates of liberal or restrictive administration techniques; different fluid formulations and various vasoactive drugs can all claim to have supporting evidence. Below we will outline the challenge and propose a rational fluid replacement technique, which is practical and associated with improved patient outcomes. We believe that this technique should be fully integrated into Enhanced Recovery Services.

2.1. Measuring tissue perfusion

One of the greatest challenges during and after major surgery is maintaining adequate tissue perfusion to allow optimal delivery of oxygen and nutrients whilst helping eliminate metabolic waste products. Optimal tissue perfusion has been shown to reduce excessive pro-inflammatory states and hence complications following surgery. Adequate perfusion is very difficult to measure at the tissue beds in routine clinical practice, and so the anaesthetist must rely on surrogate cardiovascular markers such as blood pressure, stroke volume and cardiac output.

2.2. Measuring fluid status

Although fluid losses during surgery are to be anticipated, the state of hydration before and during surgery is unknown and measuring blood volume directly, whilst possible in principle, is invasive and sufficiently complex to prohibit use in day-to-day practice. Measuring fluid loss relies on careful measurement of surgical swabs and crude estimation of evaporative and other insensible losses of perhaps up to 1 mL/kg/h. Fluid overload is equally difficult to assess yet is associated with complications related to excessive tissue oedema such as ileus and respiratory distress. Again the anaesthetist has to rely on surrogate markers to assess volume status yet commonly adopted pressure-based surrogates: pulmonary capillary wedge pressure and central venous pressure, consistently fail to predict fluid responsiveness.[1–3,8] Dynamic surrogate measures of fluid responsiveness such as stroke volume variation, pulse pressure variation and to a lesser extent corrected flow time have all been shown to be superior to pressure-based surrogates.[9,10]

3. Targeted fluid administration

'Targeted Fluid Administration' is a technique that utilises less invasive cardiac output monitors such as oesophageal Doppler to guide fluid boluses with the intention of maximising stroke volume (Fig. 1). These devices also display flow based surrogates of volume status. Whilst there is no proof that maximised stroke volume is equivalent to either optimal tissue perfusion or euvolaemia, it is clear that this technique particularly when instituted in a timely manner at the start of anaesthesia is associated with a reduction in the production of pro-inflammatory cytokines.[11] Whilst these are merely surrogate markers, using this technique has reduced postoperative complications leading to enhanced recovery and a reduction in length of hospital stay for patients undergoing major surgery in a number of randomised controlled trials.[12,13]

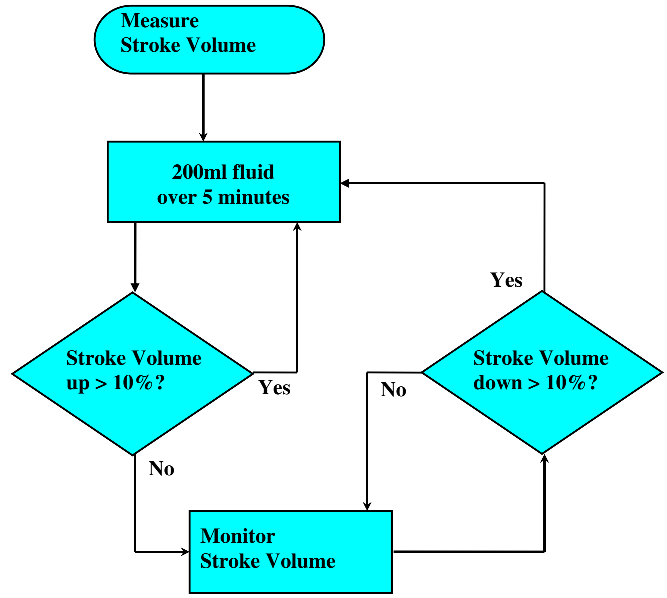

Fig. 1. Targeted Fluid Administration. Clinical Algorithm.

4. Using cardiac output monitoring to guide intravenous fluid

Targeted Fluid Administration has been demonstrated most reliably with less invasive cardiac output monitors. Of these, the oesophageal Doppler is the most popular device, used in 7 randomised controlled trials; quality improvement projects and routine clinical practice around the world. For the purpose of this review article, we will concentrate on the use of the oesophageal Doppler.

5. Oesophageal Doppler monitoring (ODM)

ODM measures the velocity of blood flowing down the descending aorta with each heartbeat. This is achieved by careful placement of a soft, flexible probe in the mid-oesophagus via the nose or mouth. The probe tip is gently manoeuvred until the ultrasound beam is directed at the descending aorta. The Doppler shift principle then allows measurement of blood velocity in the aorta. This is can be represented by a typical triangular waveform (Fig. 2) and characteristic sound. By integrating the velocity waveform to derive the average velocity and making assumptions about aortic cross- sectional area (based on weight, height and age)

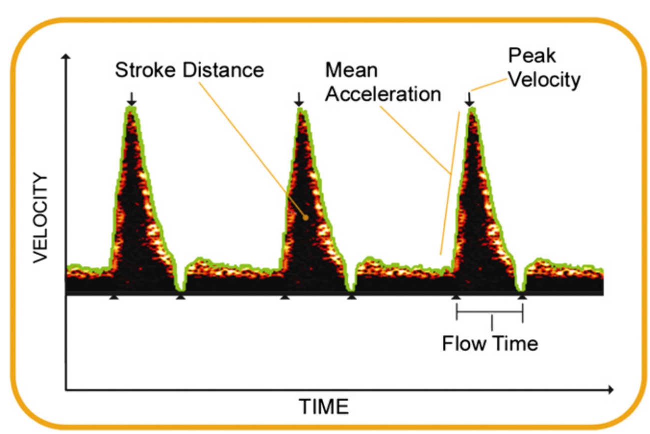

Fig. 2. The characteristic waveform of oesophageal Doppler representing the velocity change over time of blood pulsating in the descending aorta.