Goal-directed haemodynamic therapy in cardiac surgery

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Background

The concept of goal-directed haemodynamic optimisation was developed in the late 70s and early 80s of the last century by the surgeon W C Shoemaker. Observational studies showed that high-risk surgical patients that did not survive after major non-cardiac surgery were characterised by the inability to adapt oxygen delivery to the perioperatively increased oxygen demand. He suggested improving patients’ outcomes by optimising the cardiac index and oxygen delivery to the haemodynamic levels observed in survivors. Stimulated by Shoemaker’s ideas, he and various other researchers performed prospective studies that clearly supported this concept.

Significantly, these studies also revealed that patients with established organ failure did not benefit from this optimisation approach. It is not astonishing then that studies in critically ill patients with sepsis and multi-organ dysfunction, haemodynamically treated to the specific goals suggested by Shoemaker, either experienced no or even detrimental effects in contrast to the perioperative field. Unfortunately, the misconception to transfer Shoemaker’s “early, perioperative, goal-directed haemodynamic optimisation” concept to the treatment of patients with established organ dysfunction, provided the basis for many emotional discussions which almost led to abandonment of the concept. Nonetheless, in line with previous meta-analytic data, the most recent meta-analysis on this topic clearly shows the clinical usefulness of pre-emptive haemodynamic optimisation in surgical patients with a moderate or high morbidity and mortality risk.

Unfortunately, most of these studies were performed in patients undergoing non-cardiac surgery; and only a few studies – focused on less than 1 000 patients overall - have addressed the effects of haemodynamic optimisation in patients undergoing cardiac surgery. However, data gathered during large observational studies in cardiothoracic patients revealed that patients with a poor outcome present a haemodynamic pattern that is comparable to the observations by Shoemaker and colleagues in non-cardiac population. Arterial hypotension, low oxygen delivery, low cardiac stroke volume, a low mixed venous oxygen saturation, high cardiac filling pressures, and high lactate levels are all associated with increased postoperative morbidity and mortality. This suggests that, besides maintaining arterial blood pressure in the preoperative range, improving cardiac performance by optimising filling and stroke volume, as well as optimising the ratio between oxygen delivery and demand, will be important goals for the haemodynamic management of cardiac surgical patients.

Optimising arterial blood pressure

Gold et al compared the effects of a mean arterial blood pressure of 80 to 100 mmHg during CPB in comparison with a MAP of 50 to 60 mmHg in 248 CABG patients with preserved left ventricular function. They observed a significant decrease in the combined endpoints of cardiac and neurological morbidity. Unfortunately, the haemodynamic approach was only limited to the period of CPB and may therefore not necessarily be transferred to the whole perioperative period. However, a post hoc study focusing on the effects of blood pressure optimisation in patients with different degrees of aortic atheromatous disease revealed that patients with high-grade disease benefited from higher blood pressure levels in terms of reduction in neurological complications.
Fluid optimisation

Mythen et al showed that intraoperative esophageal Doppler-guided stroke volume optimisation by colloidal fluids improved splanchnic perfusion and reduced postoperative complications and length of hospital stay in comparison with a conventionally treated group. Additionally, patients in the intervention group were treated with lower doses of diuretics, suggesting that this optimisation also had beneficial effects on kidney function. Comparably, McKendry et al used esophageal Doppler-guided stroke volume optimisation in a study including 174 cardiac surgical patients in the postoperative period. In contrast to Mythen et al, these investigators aimed for a fixed stroke volume index (> 35 ml/m²) and were only partially successful in achieving the predefined goal. This may explain that the authors observed only a trend towards reduction in complications (p = 0.08). Nonetheless, length of hospital stay was significantly reduced from nine days in the control to seven days in the protocol group.

Optimising the ratio between oxygen delivery and demand

Poloenen et al investigated the effects of a goal-directed haemodynamic approach targeting a mixed venous oxygen saturation (SvO₂) > 70% and a plasma lactate < 2 mmol/l within the first eight hours after ICU admission in 403 cardiac surgery patients. The control treatment consisted of fluid loading aimed at a pulmonary artery occlusion pressure between 12 to 18 mmHg, a haemoglobin of greater than 100 g/l, maintaining arterial perfusion pressure between 70 to 90 mmHg by use of vasopressors (dopamine and noradrenaline) or sodium nitroprusside, and inotropic therapy with dobutamine, if the cardiac index was below 2.5 l/min/m² respectively. In the protocol group, dobutamine was additionally titrated to achieve the haemodynamic targets of a SvO₂ > 70% and a lactate < 2 mmol/l at eight hours postoperatively. Although 42.9% of patients in the protocol group (control-group: 57.9%) did not achieve the haemodynamic targets at eight hours postoperatively, this therapeutic strategy was associated with a significant reduction in the number of patients with organ failure at hospital discharge (control: 5.6%; protocol: 1.0%) and length of hospital stay (control: eight days; protocol: seven days).

Combined strategies

Goepfert et al retrospectively analysed the effects of fluid optimisation aimed at achieving a global enddiastolic volume index higher than 640 ml/m², a cardiac index higher than 2.5 l/m² and a mean arterial pressure between 70 to 90 mmHg in comparison with a historical control group. Patients in the intervention received more fluids and less vasopressors and inotropes. Only minor effects on clinical outcomes (faster “fit for discharge” from ICU) were observed.

Smetkin et al analysed the effects of guiding intra- and postoperative haemodynamics by intrathoracic blood volume, cardiac index and central venous oxygen saturation in comparison with standard treatment in 40 patients undergoing off-pump coronary artery bypass grafting (OPCAB) and observed a decreased time until ‘fit for ICU discharge’ and a reduction in hospital stay length.

Conclusions

The accumulated evidence derived from this specific surgical population may be considered moderate in terms of patients who have been studied in prospective trials. Keep in mind the scientific basis derived from patients undergoing non-cardiac surgery - supported by three meta-analyses. It is therefore not reasonable to doubt that patients undergoing cardiac surgery do not benefit from pre-emptive, goal-directed haemodynamic optimisation.

The available evidence suggests that this should ideally be accomplished by optimising fluid status (ideally guided by stroke volume optimisation) and adapting oxygen delivery to demand (guided by venous oximetry). The results of the most recent meta-analysis on this issue provide strong arguments that, in general, this may most effectively be achieved by using a pulmonary artery catheter. However, until prospective trials comparing different monitoring and treatment modalities in cardiac surgical patients become available, the choice of monitoring should be based on the experience in the specific centre.

References available on request