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Clinical Practice

Randomized controlled trial of stroke volume optimization during elective major abdominal surgery in patients stratified by aerobic fitness

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Abstract

Background: The benefits of stroke volume optimization during surgery are unclear, with recent data not replicating the positive effects of earlier studies.

Methods: This was a randomized controlled trial of standard fluid therapy with or without supplementary blinded intraoperative stroke volume optimization in 220 patients having major elective rectal resection or cystectomy with ileal conduit. All patients were treated using a contemporary enhanced recovery pathway. Interventional fluid challenges used Gelofusine (B Braun, Germany), guided by stoke volume variability measured by LiDCO*rapid* (LiDCO, UK). Participants were stratified by aerobic fitness (characterized by preoperative cardiopulmonary exercise test), surgical specialty, and intended surgical approach (open or laparoscopic). The primary outcome was the prevalence of moderate or severe complications on day 5 after surgery, defined using the postoperative morbidity survey (POMS) criteria.

Results: Patients received ~13 ml kg^{-1} h^{-1} of i.v. fluids during surgery. The intervention group received an additional mean (SD) 956 (896) ml Gelofusine. There were no statistically significant differences between groups in any primary or secondary end point. A positive POMS on postoperative day 5 was noted in 54 of 111 control subjects (48.6%) and 55 of 109 participants in the intervention group [50.5%; adjusted odds ratio 0.90 (95% confidence interval 0.52–1.57), *P*=0.717]. Mean (SD) hospital length of stay was 9.6 (6.8) days in the control group and 11.8 (11.5) days in the intervention group (adjusted difference −2.1 (−4.6 to 0.3) days, *P*=0.091). There was no statistical interaction between stroke volume optimization and aerobic fitness in terms of rate of complications or length of stay.

Conclusions: Algorithm-driven stroke volume optimization is of no benefit when superimposed on a liberal baseline fluid regimen in patients having elective major abdominal surgery, when stratified to minimize differences in fitness and surgical approach between groups.

Clinical trial registration: ISRCTN21597243.

Key words: colorectal surgery; exercise test; fluid therapy; haemodynamics; postoperative complications

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Editor's key points

- Perioperative goal-directed fluid therapy is considered beneficial, but recent data are conflicting; the benefits may depend on the type of surgery and individual physical fitness.
- This study examined the effects of stroke volume optimization in patients undergoing major colonic surgery or cystectomy, under an enhanced recovery care programme.
- Patients were stratified and allocated according to aerobic fitness and type and technique of surgery to minimize confounding factors.
- Fluid regimens in both groups were liberal, but there were no significant differences in postoperative complications or other outcomes.
- These data do not support the widespread routine use of intraoperative cardiac output monitoring in major elective surgery.

Over the past four decades, goal-directed fluid therapy (GDT) has largely been associated with improved clinical outcomes in high-risk perioperative patients.[1–4] Stroke volume optimization (SVO), defined as the endeavour to titrate i.v. fluids to achieve an ideal target stroke volume throughout surgery,[5] has shown few or no benefits in patients undergoing elective major abdominal surgery in more recent studies.[6–9] Contemporary perioperative management may have minimized the effect of SVO. Alternatively, benefits may apply only to patients who are genuinely 'high risk', such as on the basis of decreased aerobic fitness.

We previously reported a single-centre trial where patients having major elective colorectal surgery were randomized to intraoperative fluid therapy with or without supplementary SVO guided by oesophageal Doppler.[7] There was no evidence of a significant benefit of the intervention on patients' time to discharge readiness or length of hospital stay and some evidence of a detrimental effect on these outcomes in a prospectively defined subgroup of aerobically 'fit' patients. Our interpretation was that the intervention algorithm, based solely on a consideration of stroke volume with no stopping threshold to limit further fluid administration, was perhaps aimed at stroke volume maximization rather than optimization and may therefore have promoted a fluid excess, particularly in fit patients. Adverse outcomes may also have been associated with the use of starch-based colloid solutions for fluid challenges. Starch-based colloids have since been withdrawn from such use in the UK.[10]

Moreover, there is a high likelihood of confounding in small randomized trials. For example, in most of the prominent GDT studies in colorectal surgery to date[7 11 12] an imbalance between groups in the proportion of rectal resections (operations associated with a longer overall length of stay than colonic resections)[13] is apparent. This may contribute to seemingly inferior outcomes in one group, in a manner that has little to do with the fluid therapy intervention.

Likewise, most of these studies[6 7 9 11 12] used length of hospital stay or time to discharge readiness as their primary outcomes. These factors are reliant on subjective clinical judgements, patient motivation, and social factors, and are thus relatively weak as study end points. Complication rate is perhaps more clinically relevant.

The aim of this study was to investigate the effects of intraoperative SVO on postoperative outcomes in patients stratified according to aerobic fitness and type of surgery in order to minimize the effects of these factors between groups.

Methods

This was a prospective parallel-arm double-blind randomized controlled trial conducted at Derriford Hospital, Plymouth, UK. The clinical trial was approved by the Cornwall and Plymouth Research Ethics Committee (reference: 10/H0203/68), adopted by National Institute of Healthcare Research (UKCRN ID: 10093), and registered at http://www.isrctn.org (trial identifier: ISRCTN21597243).

Participant recruitment and randomization

All patients undergoing elective rectal resection and cystectomy at our hospital are routinely offered preoperative cardiopulmonary exercise testing (CPET) to facilitate informed consent about perioperative risk and to assist planning of perioperative care. Incremental submaximal workload CPET is performed on a stationary bicycle (Zan; nSpire, Longmont, CO, USA), according to a standard procedure as previously reported.[7]

Consecutive eligible patients were provided with written information at the time of CPET and invited to participate in the trial. Potential participants were risk stratified as aerobically fit or unfit primarily on the basis of weight-indexed oxygen consumption at anaerobic threshold >10.9 or <11.0 ml O_2 kg^{-1} min^{-1}, but ultimately depending on classification of fitness by an objective clinician experienced in interpreting CPET. Therefore, patients in whom anaerobic threshold could not be identified were also eligible for the trial and were included in the unfit group.[14]

Exclusion criteria were as follows: recent acute myocardial infarction, unstable angina, uncontrolled arrhythmias causing symptoms or haemodynamic compromise, syncope, active endocarditis, acute myocarditis or pericarditis, symptomatic severe aortic stenosis, uncontrolled heart failure, acute pulmonary embolus or pulmonary infarction, thrombosis of lower extremities, suspected dissecting aneurysm, uncontrolled asthma, pulmonary oedema, oxygen saturation <85% at rest, respiratory failure, or acute non-cardiopulmonary disorder that might affect exercise performance or be aggravated by exercise (e.g. infection, acute renal failure, thyrotoxicosis).

Written informed consent to participate in the trial was obtained at the time of admission for surgery. Participants were allocated via a secure Web-based dynamic randomization system, computer generated by the UK Clinical Research Collaboration-registered Peninsula Clinical Trials Unit (PenCTU) in conjunction with an independent statistician. They were allocated in a 1:1 ratio to either the control group or SVO group, using a minimization-based method including the stratification factors of aerobic fitness (fit or unfit), type of surgery (rectal or cystectomy), and planned surgical approach (open or laparoscopic). Apart from the investigator, all perioperative medical and nursing personnel were blinded to fluid therapy group allocation.

Perioperative care

Perioperative surgical care was conducted in line with an enhanced recovery pathway that has been in use at our hospital since 2009 (Supplementary data, Appendix S1). The majority of patients were admitted on the day of surgery; they received mechanical bowel preparation at the discretion of the surgeon. All patients received general anaesthesia, conducted at the discretion of the consultant anaesthetist. Likewise, thoracic