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Review Article

REVIEW ARTICLE

Perioperative goal-directed therapy with uncalibrated pulse contour methods: impact on fluid management and postoperative outcome

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Abstract

Previous meta-analyses suggest that perioperative goal-directed therapy (GDT) is useful to decrease postoperative morbidity. Most GDT studies analysed were done with pulmonary artery catheters, oesophageal Doppler and calibrated pulse contour methods. Uncalibrated pulse contour (uPC) techniques are an appealing alternative but their accuracy has been questioned. The effects of GDT on fluid management (volumes and volume variability) remain unclear. We performed a meta-analysis of randomized controlled trials investigating the effects of GDT with uPC methods on postoperative outcome. The primary endpoint was postoperative morbidity. Fluid volumes and fluid volume variability (standard deviation/mean) over the GDT period were also studied. Nineteen studies met the inclusion criteria (2159 patients). Postoperative morbidity was reduced with GDT (OR 0.46, 95% CI 0.30–0.70, $P<0.001$). The volume of colloids was higher [weighted mean difference (WMD) +345 ml, 95% CI 148–541 ml, $P<0.001$] and the volume of crystalloids was lower (WMD –429 ml, 95% CI –634 to –224 ml, $P<0.01$) in the GDT group than in the control group. However, the total volume of fluid (WMD –220 ml, 95% CI –590 to 150 ml, $P=0.25$) and the variability of fluid volume (34% *vs* 33%, $P=0.98$) were not affected by GDT. The use of GDT with uPC techniques was associated with a decrease in postoperative morbidity. It was not associated with an increase in total fluid volume nor with a decrease in fluid volume variability.

Key words: cardiac output; general surgery; haemodynamics

Many studies suggest that perioperative goal-directed therapy (GDT) is useful to decrease postoperative morbidity, hospital length of stay and hospital costs.[1–3] As a result, in patients undergoing major surgery, the use of GDT is now recommended by several guidelines and consensus statements from international experts.[4–7] The first perioperative GDT studies were done 20–30 yr ago with the pulmonary artery catheter.[8–10] Then, other studies followed where haemodynamic parameters were derived from the oesophageal Doppler[11 12] or from calibrated pulse contour methods.[13 14] Uncalibrated pulse contour (uPC) methods are relatively new in the GDT arsenal since they became available only a decade ago.[15] They are quick to set up, easy to use, not operator dependent, not affected by electrocautery and are increasingly used for haemodynamic monitoring during major surgery.[16] However, their accuracy and precision have been questioned when compared with clinical

reference methods, such as thermodilution and echocardiography.[17–20] Whether uPC techniques can be useful to guide haemodynamic therapy and improve post-surgical outcome has been investigated by several randomized controlled trials (RCTs) yielding conflicting results.

Both insufficient and excessive fluid administration are associated with an increase in postoperative complications.[21 22] Optimizing haemodynamic parameters such as stroke volume and cardiac output with fluid may result, at least in theory, in excessive fluid administration. In addition, recent studies have reported a very large variability in the volume of fluid administered to surgical patients during the perioperative period.[22 23] By analogy with manufacturing and the Six Sigma concept, it has been suggested that variability of clinical practices is the enemy of quality of care,[24] and that the beneficial effects of GDT may be related to the harmonization of fluid management.[25 26] Therefore, we performed a meta-analysis of RCTs to clarify the impact of GDT with uPC methods on postoperative morbidity, on fluid volume and on fluid volume variability.

Methods

Eligibility criteria

According to Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA), studies were searched using the following eligibility criteria.[27] Participants were adult (age 18 yr or over) patients undergoing elective or emergency surgery. Studies involving mixed population of critically ill or non-surgical patients were excluded. The intervention was defined as GDT with uPC methods. RCTs comparing the effects of GDT *vs* standard or usual fluid management were considered for analysis. No language (i.e. article in English), publication date or publication status restrictions were imposed when selecting the studies to be analysed. Primary outcome measure was post-surgical morbidity, defined as the proportion of patients developing one or more post-surgical complications. Post-surgical infectious, cardiac, respiratory, renal and abdominal complications, as well as hospital length of stay and mortality, were assessed as secondary outcome variables. Abdominal complications included both gastro-intestinal and liver complications. The volume of crystalloids and of colloids, as well as the total volume of fluid received during the GDT period were also analysed.

Information sources

Various search strategies were performed to retrieve relevant studies by using MEDLINE, the Cochrane Library and EMBASE databases (last update January, 2016). No date restriction was applied for MEDLINE and The Cochrane Library databases whereas the search was limited to 2006–16 for the EMBASE database. Additional trials were searched in the DARE database and the reference lists of previously published reviews and retrieved articles.

Search

We used the following terms to search for studies: randomized controlled trial, controlled clinical trial, goal directed, goal oriented, goal target, cardiac output, cardiac index, oxygen delivery, oxygen consumption, cardiac volume, stroke volume, fluid therapy, fluid loading, fluid administration, optimization, optimisation, pulse pressure variation, pleth variability index, stroke volume variation, systolic pressure variation (see Supplementary data S1 for details regarding the search strategy).

Study selection

Two investigators (N.B., M.T.G.) first examined each title and abstract to identify potentially relevant articles. The eligibility of the retrieved full-text articles was independently determined by two investigators (N.B., F.M.). The analysis was limited to trials done with uPC methods.

Data collection process

Data were independently collected by two investigators (M.T.G., F.M.) with any discrepancy resolved by re-inspection of the original article. To avoid transcription errors, the data were inputted into statistical software and re-checked by a third investigator (N.B.).

Data items

Data abstraction included type of surgery, number of patients, type of uPC method, GDT protocol end-points, postoperative morbidity, complications, mortality and hospital length of stay. The volume of colloid and crystalloid solutions administered during the GDT period was also collected. When information was not found in original manuscripts, authors were contacted to maximize the number of data available for analysis.

Risk of bias in individual studies

A domain-based evaluation, as proposed by the Cochrane Collaboration,[28] was used to evaluate the methodological quality of RCTs. This is a two-part tool, addressing seven specific domains (sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting and 'other issues') that are strongly associated with bias reduction.[29 30] Each domain in the tool includes one or more specific entries in a 'Risk of bias' table. Within each entry, the first part of the tool describes what is reported in the study, in sufficient detail to support a judgment about the risk of bias. The second part of the tool assigns a judgment relating to the risk of bias for that entry. This is achieved by assigning a judgment of 'Low risk', 'High risk' or 'Unclear risk' of bias. After each domain was completed, a 'Risk of bias summary' table was generated. The green ⊕ symbol plus indicates low risk of bias, the red minus ⊖ symbol indicates high risk of bias and the white colour indicates unclear risk of bias. For each study, the total number of green plus symbols was calculated: trials with five or six green plus symbols were considered as having an overall low risk of bias. With regard to blinding, studies in which the outcome variables were collected by investigators not aware of the GDT strategy were considered adequately masked.

Summary measures and planned method of analysis

Meta-analytic techniques (analysis software RevMan, version 5.3 Cochrane Collaboration, Oxford, England, UK) were used to combine studies using Odds Ratios (OR) and 95% confidence intervals (CI) for dichotomous variables, and weighted mean difference (WMD) and 95% CI for continuous variables. A statistical difference between groups was considered to occur if the pooled 95% CI did not include 1 for the OR. An OR <1 favoured GDT when compared with standard haemodynamic treatment. Two-sided