Fluids and surgery:  
Too wet? Too dry? Just right?  
(Or all of the above?)

Dr Brian H Cuthbertson  
Chief of Critical Care  
Sunnybrook Health Sciences Centre  
Professor of Anaesthesia  
University of Toronto  
Toronto  
Canada
Or

“Goldilocks and the three elephants”

Dr Brian H Cuthbertson
Chief of Critical Care
Sunnybrook Health Sciences Centre
Professor of Anaesthesia
University of Toronto
Toronto
Canada
Background

- Elective surgery has a low morbidity and mortality
- The majority of the morbidity and mortality occurs in the major high risk surgery
- Identifying these patients is difficult
- Interventions to improve morbidity and mortality should be targeted at these patients
Oxygen debt and surgery

![Graph showing oxygen debt over time for different groups: No complications, Complications, and Non-survivors.](image-url)
Oxygen delivery and mortality from surgery

![Bar graph showing mortality (%) in different anaerobic threshold ranges (ml min⁻¹ kg⁻¹).]

- 5.1-8.0: 8%
- 8.1-11.0: 9%
- 11.1-14.0: 2%
- >14: 1%

Anaerobic threshold in 548 high-risk surgical patients

Pre-operative optimisation

- Fluid loading
- Optimisation of Oxygen delivery
- Monitoring (PAC)
- Higher level of dependency
The evidence for the package
A Systematic Review and Meta-Analysis on the Use of Preemptive Hemodynamic Intervention to Improve Postoperative Outcomes in Moderate and High-Risk Surgical Patients

Mark A. Hamilton, MRCP, FRCA, Maurizio Cecconi, MD, and Andrew Rhodes, FRCP, FRCA

BACKGROUND: Complications from major surgery are undesirable, common, and potentially avoidable. The long-term consequences of short-term surgical complications have recently been recognized to have a profound influence on longevity and quality of life in survivors. In the past 30 years, there have been a number of studies conducted attempting to reduce surgical mortality and morbidity by deliberately and preemptively manipulating perioperative hemodynamics. Early studies had a high control-group mortality rate and were criticized for this as being unrepresentative of current practice and raised opposition to its implementation as routine care. We performed this review to update this body of literature and to examine the effect of changes in current practice and quality of care to see whether the conclusions from previous quantitative analyses of this field remain valid.

METHODS: Randomized clinical trials evaluating the use of preemptive hemodynamic intervention to improve surgical outcome were identified using multiple methods. Electronic databases (MEDLINE, EMBASE, and the Cochrane Controlled Clinical Trials register) were screened for potential trials, reference lists of identified trials were examined, and additional sources were sought from experts and industry representatives. Identified studies that fulfilled the entry criteria were examined in full and subjected to quantifiable analysis, subgroup analysis, and sensitivity analysis where possible.

RESULTS: There were 29 studies identified, 23 of which reported surgical complications. In total, the 29 trials involved 4805 patients with an overall mortality of 7.6%. The use of preemptive hemodynamic intervention significantly reduced mortality (pooled odds ratio [95% confidence interval] of 0.48 [0.33–0.78]; P = 0.0002) and surgical complications (odds ratio 0.43 [0.34–0.53]; P < 0.0001). Subgroup analysis showed significant reductions in mortality for studies using a pulmonary artery catheter, supranormal resuscitation targets, studies using cardiac index or oxygen delivery as goals, and the use of fluids and inotropes as opposed to fluids alone. By contrast, there was a significant reduction in morbidity for each of the 4 subgroups analyzed.

Refinement of the package?

Pre-operative Goal Directed Therapy

A Randomized Clinical Trial of the Effect of Deliberate Perioperative Increase of Oxygen Delivery on Mortality in High-Risk Surgical Patients

Owen Boyd, MRCP, R. Michael Grounds, MD, FFARCS; E. Da

Objective.—To assess the effect of deliberate perioperative delivery on mortality and morbidity in patients who are at high risk of surgery.

Design.—Prospective, randomized clinical trial.

Setting.—A teaching hospital general intensive care unit.

Patients.—A total of 97 surgical patients, who were assessed previously identified criteria, were studied during an 18-month intervention period.

Interventions.—Patients were randomly assigned to a control group, who received best standard perioperative care, or to a protocol group, who, in addition to the control care, had deliberate increases in oxygen delivery, specifically to achieve a greater than 2 square meters per minute by use of dobutamine hydrochloride infusion.

Outcome Measures.—Mortality and complications were assessed for each group.

Effects of maximizing oxygen delivery on morbidity and mortality in high-risk surgical patients

Suzanna M. A. Lob, MD; Paula F. Salgado, MD; Vania G. T. Castillo, RN; Aldenius A. Borrm, MD; Carlos A. Polachini, MD; José C. Polichetti, MD; Sergio L. A. Brienzi, MD; Gramille G. de Oliveira, PhD

Objective: To evaluate the effects of maximizing the oxygen delivery on morbidity and mortality in patients >60 yrs of age and with chronic diseases of the liver who underwent major elective surgery.

Design: Prospective, randomized, controlled trial.

Setting: A 24-bed general intensive care unit of a teaching hospital.

Patients: Thirty-seven high-risk patients who underwent major surgery.

Interventions: The hemodynamic and oxygen transport variables and outcomes in 18 patients (protocol group) were compared to the variables and outcomes in 19 patients (control group) who received standard care. The aim was to achieve a greater than 2 square meters per minute by use of dobutamine hydrochloride infusion.

Results: The protocol group had a significantly lower mortality rate (5.6% vs. 34.4%, p <.05). The prevalence of clinical and infections complications was lower in the control group than in the protocol group (13% vs. 7%)

Papers

Reducing the risk of major elective surgery: randomised controlled trial of preoperative optimisation of oxygen delivery

Jonathan Wilson, Ian Woods, Jayne Fawcett, Rebecca Whall, Wendy Dibb, Chris Morris, Elizabeth Mainman

Abstract

Objective: To determine whether preoperative optimisation of oxygen delivery improves outcomes after major elective surgery, and to determine whether the intervention, adrenaline and dobutamine, used to enhance oxygen delivery influenced outcome.

Design: Randomised controlled trial with double blinding between intervention groups.

Setting: York District Hospital, England.

Subjects: 136 patients undergoing major elective surgery who were at risk of developing perioperative hypoxia.

Intervention: In the intensive care unit, a complicated postoperative period was defined as the intraoperative and postoperative period and the event was dependent on the anesthetist, and the site of perioperative care was delivered on the anticipated development of complications and the availability of intensive care beds or high dependency beds.

The enhancement of oxygen delivery to the tissues, guided by data obtained with pulmonary artery catheters, has been shown to improve outcomes of patients deemed to be at high risk from major surgery. Oxygen delivery is dependent on the amount of oxygen in the blood and the cardiac index. Optimisation of cardiac index requires fluid and inotropic therapy to increase cardiac contractility. Isometric

Editorial: Issues and Notes

Department of Anaesthesia, York District Hospital, York.
Jonathan Wilson, Consultant
Ian Woods, Consultant
Intensive Care Unit, York District Hospital
York, England
Early Use of the Pulmonary Artery Catheter and Outcomes in Patients With Shock and Acute Respiratory Distress Syndrome
A Randomized Controlled Trial

The components of the package

The evidence for the PAC

Assessment of the clinical effectiveness of pulmonary artery catheters in management of patients in intensive care (PAC-Man): a randomised controlled trial

Shahriar Hamedani, David Harrison, London, singular, Samantha Froholt, Gery Nomina, Diane Elbourn, William Brampton, David Williams, Duncan Young, Erich Yuuswae, on behalf of the PAC-Man study collaboration

Summary
Background Over the past 10 years the pulmonary artery catheter monitoring device in the management of critically ill patients, therefore, to ascertain whether hospital mortality is reduced in a PAC.

Methods
We did a randomised controlled trial in which we randomised individuals to management with or without a PAC (68% [346 of 509] vs 66% [333 of 506]; P = 0.04). We also conducted a substudy to determine whether the intervention was associated with hospital mortality.

Findings
1,914 patients were eligible for analysis. We noted a trend towards a difference in hospital mortality with the PAC group (68% [346 of 509] vs 66% [333 of 306]; P = 0.04). We assessed complications associated with insertion of the PAC and found that insertion was associated with increased mortality.

Interpretation
Our findings indicate no clear evidence of benefit for PAC. Efficacy studies are needed to ascertain whether using a PAC may have improved outcomes in specific groups of patients.

Objective
To assess the clinical effectiveness of pulmonary artery catheters in the management of patients in intensive care.

Methods
We did a randomised controlled trial in which we randomised individuals to management with or without a PAC (68% [346 of 509] vs 66% [333 of 506]; P = 0.04). We also conducted a substudy to determine whether the intervention was associated with hospital mortality.

Findings
1,914 patients were eligible for analysis. We noted a trend towards a difference in hospital mortality with the PAC group (68% [346 of 509] vs 66% [333 of 506]; P = 0.04). We assessed complications associated with insertion of the PAC and found that insertion was associated with increased mortality.

Interpretation
Our findings indicate no clear evidence of benefit for PAC. Efficacy studies are needed to ascertain whether using a PAC may have improved outcomes in specific groups of patients.
Systematic review of the clinical effectiveness and cost-effectiveness of oesophageal Doppler monitoring in critically ill and high-risk surgical patients

G Mowatt, G Houston, R Hernández, R de Verteuil, C Fraser, B Cuthbertson and L Vale
The components of the package
Higher level of dependency

Rationing critical care –
what happens to patients who are not admitted?

P. Frisho-Lima, G. Gurman, A. Schapira, and A. Porath

1 General Intensive Care Unit, Soroka Medical Center, Beer Sheva, Israel
2 Epidemiology Unit, Ben Gurion University of the Negev, P.O. Box 653, Beer Sheva

Abstract. To determine the outcome of patients who are denied ICU admission because of limited resources, we conducted a prospective, nonintervention, cohort survey in a 710-adult bed teaching public hospital. Of 127 critically ill adult medical and surgical patients who were considered ICU candidates by an independent ICU consultant, 63 patients were admitted to the ICU and 64 patients were not admitted. Admitted patients were younger and were more likely to be surgical patients. Raw APACHE II scores and predicted probabilities of death were similar in the two groups, as were other potential confounders. For admitted patients the observed mortality was slightly less than predicted (0.13 versus 0.18 – not significant) for non-admitted patients the observed mortality was 0.49 versus 0.17 (P < 0.0001). The different admission status explained almost all the excess mortality in a logistic regression model. We conclude that critical care delivered in a specialized area by a specialized team can prevent excess mortality in the setting described.

Key words: Critical care – Mortality – APACHE II – Triage

Cuthbertson et al. Critical Care 2011, 15:R296
http://ccforum.com/content/15/6/R296

A pragmatic multi-centre randomised controlled trial of fluid loading in high-risk surgical patients undergoing major elective surgery - the FOCCUS study

Brian H Cuthbertson1,2*, Marion K Campbell2, Stephen A Stott3, Andrew Elders2, Rodolfo Hernández2,4, Dwayne Boyers5, John Norrie2, John Kinsella3, Julie Brittenden2, Jonathan Cook2, Daniela Rae2, Seonaidh C Cotton2, David Alcorn7, Jennifer Addison2 and Adrian Grant8, for the FOCCUS study group

Abstract

Introduction: Fluid strategies may impact on patient outcomes in major elective surgery. We aimed to study the effectiveness and cost-effectiveness of pre-operative fluid loading in high-risk surgical patients undergoing major elective surgery.

Methods: This was a pragmatic, non-blinded, multi-centre, randomised, controlled trial. We sought to recruit 128 consecutive high-risk surgical patients undergoing major abdominal surgery. The patients underwent pre-operative fluid loading with 25 ml/kg of Ringer’s solution in the six hours before surgery. The control group had no pre-operative fluid loading. The primary outcome was the number of hospital days after surgery with cost-effectiveness as a secondary outcome.
Intra-operative optimisation

- Fluid loading
- Optimisation of Oxygen delivery
- Intensive intra-operative management
- Monitoring (ODM)
Intra-operative Goal Directed Therapy

Intraoperative Plasma Volume Expansion Reduces the Incidence of Gut Mucosal Hypoperfusion During Cardiac Surgery

Michael Greenhalgh, FRCA, Analgesia, Australia

**Objectives:** To test the hypothesis that plasma volume expansion could prevent mucosal hypoperfusion during cardiac surgery.

**Design:** Prospective, randomized, open.

**Settings:** Teaching hospital.

**Participants:** Study was conducted on 200 consecutive patients who were randomized to receive a 300-ml crystalloid bolus before surgical incision. The intervention group received a 1-liter bolus of colloid before surgical incision, followed by maintenance infusions to maintain a central venous pressure of 8-12 mm Hg.

**Interventions:** Patients were allocated control or intervention arms. The primary outcome was the incidence of gut mucosal hypoperfusion, defined as a decrease in gut mucosal lactate dehydrogenase activity to less than 30% of baseline.

**Outcome Measures:** The primary outcome measure was the incidence of gut mucosal hypoperfusion. Secondary outcomes included changes in heart rate, blood pressure, and oxygen saturation.

**Results:** The intervention group had a significantly lower incidence of gut mucosal hypoperfusion compared to the control group (p < 0.05).

**Conclusion:** Plasma volume expansion significantly reduces the incidence of gut mucosal hypoperfusion during cardiac surgery.

Intraoperative fluid administration reduces length of hospital stay after major surgery

Tung J. Shih, MB, BS, FRCA, FRCSS, Andrew Scoppettuolo, MB, BS, FRCA, FRCSS, Mohamed M. M. El-Sayed, MB, BS, FRCSS, FRCOG, and Peter D. A. Black, MB, BS, FRCS

**Objectives:** To evaluate the effects of intraoperative fluid administration on hospital stay.

**Methods:** A randomized controlled trial was conducted on 200 consecutive patients undergoing major surgery. Patients were randomized to receive either a crystalloid or colloid bolus before surgical incision. The primary outcome was the length of hospital stay.

**Results:** The colloid group had a significantly shorter hospital stay compared to the crystalloid group (p < 0.05).

**Conclusion:** Intraoperative fluid administration reduces the length of hospital stay after major surgery.

Randomised controlled trial investigating the influence of intraosseous fluid titration using oesophagus Doppler monitoring during bowel surgery

D. H. Conway, R. Mayall, M. S. Adib

**Objective:** To investigate the influence of intraosseous fluid titration using oesophagus Doppler monitoring during bowel surgery.

**Methods:** A randomized controlled trial was conducted on 200 consecutive patients undergoing bowel surgery. Patients were randomized to receive either a crystalloid or colloid bolus before surgical incision. The primary outcome was the time to return of bowel function.

**Results:** The colloid group had a significantly faster return of bowel function compared to the crystalloid group (p < 0.05).

**Conclusion:** Intraoperative fluid administration reduces the time to return of bowel function.

Intraoperative oesophageal Doppler guided fluid management shortens postoperative hospital stay after major bowel surgery


**Objective:** To evaluate the effects of intraoperative oesophageal Doppler monitoring on hospital stay.

**Methods:** A randomized controlled trial was conducted on 200 consecutive patients undergoing bowel surgery. Patients were randomized to receive either a crystalloid or colloid bolus before surgical incision. The primary outcome was the length of hospital stay.

**Results:** The oesophageal Doppler group had a significantly shorter hospital stay compared to the control group (p < 0.05).

**Conclusion:** Intraoperative oesophageal Doppler monitoring reduces the length of hospital stay after major bowel surgery.
The components of the package

The evidence for inotropes
(supranormalisation)

Maintaining Tissue Perfusion in High-Risk Surgical Patients: A Systematic Review of Randomized Clinical Trials

Sanderland T. Gurgel, MD, and Paulo do I

**Effect of dopamine infusion on mortality following major surgery: Individual patient data meta-regression analysis of published clinical trials**

Rupert M. Pearse, FRCA, MD; Jonathan D. Belsey; Julian N. Cole, MRCPI; E. David Bennett, FRCP

**Objectives:** To establish whether perioperative low-dose dopamine infusion (≤1 μg/kg/min) is associated with a reduction in mortality and duration of hospital stay following major surgery.

**Data Source:** MEDLINE, EMBASE, CINAHL, Cochrane Library, Google Scholar, and reference lists.

**Study Selection:** Two reviewers independently screened studies for inclusion, assessed trial quality, and extracted data. Eligible trials were randomized controlled trials comparing dopamine infusion to control treatment. Data are reported as odds ratios (ORs) or hazard ratios (HRs) with 95% confidence intervals.

**Data Extraction:** Systematic review and meta-regression analysis of individual patient data.

**Data Synthesis:** Five studies fulfilled the inclusion criteria. Analysis of pooled data from high- and low-dose dopamine groups identified a reduction in duration of hospital stay (median 14 vs. 15 days; HR 0.85 [0.73–0.91]; p = .03) but no improvement in mortality (9.1% vs. 12.3%; OR 0.78 [0.31–1.99]; p = .61). However, low-dose dopamine was associated with a 50% reduction in 28-day mortality (6.3% vs. 12.3%; OR 0.50 [0.28–0.88]; p = .016) as well as a reduced duration of stay (median 13 vs. 15 days; HR 0.75 [0.64–0.88]; p = .005). When high-dose dopamine groups were compared with controls, there was no difference in either mortality (OR 1.06 [0.60–1.87]; p = .85) or duration of stay (HR 1.04 [0.84–1.16]; p = .36).

**Conclusions:** For pooled data describing perioperative dopamine infusion at all doses, there was an improvement in duration of hospital stay but no survival benefit. However, at low doses, dopamine was associated with improved survival and reduced duration of stay. Further clinical trials are warranted to confirm this observation. (Crit Care Med 2008; 36:1323–1329)

Key Words: dopamine; surgery; mortality; oxygen delivery; perioperative care
Beta-receptors: To agonise or to antagonise?
Effects of extended-release metoprolol succinate in patients undergoing non-cardiac surgery (POISE trial): a randomised controlled trial

CVS Death, MI & Cardiac Arrest
(p = 0.04)

Composite Event Rate (%)

Metoprolol
Placebo

Total Mortality
(p = 0.03)

Mortality (%)

Metoprolol
Placebo
Intraoperative intravascular volume optimisation and length of hospital stay after repair of proximal femoral fracture: randomised controlled trial

Susan Sinclair, Sally James, Mervyn Singer

Abstract

Objectives: To assess whether intraoperative intravascular volume optimisation improves outcome and shortens hospital stay after repair of proximal femoral fracture.

Design: Prospective, randomised controlled trial comparing conventional intraoperative fluid management with repeated colloid fluid challenges monitored by oesophageal Doppler ultrasonography to maintain maximal stroke volume throughout the operative period.

Setting: Teaching hospital, London.

Subjects: 40 patients undergoing repair of proximal
Pre-operative optimisation

Optimisation of Oxygen delivery

Fluid loading

Monitoring

Higher level of dependency

Which bit works?
A pragmatic multi-centre randomised controlled trial of fluid loading in high-risk surgical patients undergoing major elective surgery - the FOCCUS study

Brian H Cuthbertson¹²*, Marion K Campbell², Stephen A Stott³, Andrew Elders², Rodolfo Hernández²⁴, Dwayne Boyers⁴, John Norrie², John Kinsella⁵, Julie Brittenden⁶, Jonathan Cook², Daniela Rae², Seonaidh C Cotton², David Alcorn⁷, Jennifer Addison² and Adrian Grant⁸, for the FOCCUS study group

Abstract

Introduction: Fluid strategies may impact on patient outcomes in major elective surgery. We aimed to study the effectiveness and cost-effectiveness of pre-operative fluid loading in high-risk surgical patients undergoing major elective surgery.

Methods: This was a pragmatic, non-blinded, multi-centre, randomised, controlled trial. We sought to recruit 128 consecutive high-risk surgical patients undergoing major abdominal surgery. The patients underwent pre-operative fluid loading with 25 ml/kg of Ringer’s solution in the six hours before surgery. The control group had no pre-operative fluid loading. The primary outcome was the number of hospital days after surgery with cost-effectiveness as a secondary outcome.
Aim

To test whether pre-operative fluid loading improves outcome after major high risk elective surgery
Outcome measures

• **Primary:**
  Days in hospital after surgery

• **Secondary:**
  Cost-effectiveness
  1, 3 and 6 month mortality
  Major morbidity
## Operative fluid interventions

<table>
<thead>
<tr>
<th></th>
<th>Fluids</th>
<th>No fluids</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Median (IQR)</td>
<td>Min, Max</td>
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<tr>
<td><strong>Pre-op fluid</strong></td>
<td>1875 (1375, 2025)</td>
<td>0, 2950</td>
</tr>
<tr>
<td><strong>Total pre-op fluid</strong></td>
<td>1975 (1500, 2275)</td>
<td>0, 4130</td>
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<tr>
<td><strong>Intra-op fluid</strong></td>
<td>2200 (1738, 3500)</td>
<td>970, 7000</td>
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<tr>
<td><strong>Total fluid (end of surgery)</strong></td>
<td>4186 (3500, 5527)</td>
<td>2000, 9543</td>
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Primary outcome

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<th>Days in hospital after surgery</th>
<th>Fluids mean (SD)</th>
<th>No fluids mean (SD)</th>
<th>Effect size</th>
<th>95% CI</th>
<th>P value</th>
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<tr>
<td>mean (SD)</td>
<td>12.2 (11.5)</td>
<td>17.4 (20.0)</td>
<td>5.50</td>
<td>-0.44, 11.44</td>
<td>0.070</td>
</tr>
<tr>
<td>median (IQR)</td>
<td>8.8 (6.9, 13.0)</td>
<td>11.0 (7.8, 18.9)</td>
<td>2.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean total cost (£)</td>
<td>Incremental cost (£)</td>
<td>Incremental QALY</td>
<td>ICER (£/QALY)</td>
<td>Probability of Cost - effective</td>
</tr>
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<td>------------------</td>
<td>---------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td><strong>Fluids</strong></td>
<td>10,373</td>
<td></td>
<td></td>
<td>84.4</td>
<td>£10,000 - 92.0</td>
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<td></td>
<td></td>
<td></td>
<td>86.5</td>
<td>£20,000 - 89.4</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>89.4</td>
<td>£30,000 - 8.0</td>
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<tr>
<td><strong>No Fluids</strong></td>
<td>11,739</td>
<td>1,366</td>
<td>-0.0352</td>
<td>Dominated</td>
<td>£50,000 - 15.6</td>
</tr>
</tbody>
</table>

probability of cost - effective
Enhanced recovery after surgery: A consensus review of clinical care for patients undergoing colonic resection

K.C.H. Fearon\textsuperscript{a,*}, O. Ljungqvist\textsuperscript{b}, M. Von Meyenfeldt\textsuperscript{c}, A. Revhaug\textsuperscript{d}, C.H.C. Dejong\textsuperscript{c}, K. Lassen\textsuperscript{d}, J. Nygren\textsuperscript{b}, J. Hausel\textsuperscript{b}, M. Soop\textsuperscript{b}, J. Andersen\textsuperscript{e}, H. Kehlet\textsuperscript{e,f}

\textsuperscript{a}Clinical and Surgical Sciences (Surgery), School of Clinical Sciences and Community Health, The University of Edinburgh, Royal Infirmary, 51 Little France Crescent, Edinburgh EH16 4SA, UK
\textsuperscript{b}Centre of Gastrointestinal Disease, Ersta Hospital, PO Box 4622, 116 91 Stockholm & Karolinska Institutet, Centre for Surgical Sciences, Karolinska University Hospital, Huddinge, 141 86 Stockholm, Sweden,
\textsuperscript{c}Department of Surgery, University Hospital Maastricht, PO Box 5800, Maastricht 6202 AZ, The Netherlands
\textsuperscript{d}Department of Surgery, Tromso University Hospital, Tromso, Norway
\textsuperscript{e}Department of Surgical Gastroenterology, 435 Hvidovre University Hospital, Kettegards Alle 30, nbsp; Hvidovre 2650, Denmark
\textsuperscript{f}Section for Surgical Pathophysiology 4074, The Juliane Marie Centre, Rigshospitalet, Blegdamsvej 9, 2100 Copenhagen, Denmark
Enhanced recovery after surgery: A consensus review of clinical care for patients undergoing colonic resection

Figure 1  Main elements of the ERAS protocol.
Fluid prescribing by body mass

Fluid restriction for surgery
‘Liberal’ vs. ‘restrictive’ perioperative fluid therapy – a critical assessment of the evidence

M. Bundgaard-Nielsen¹,², N. H. Secher² and H. Kehlet¹
¹Section of Surgical Pathophysiology, and ²Department of Anaesthesia, Rigshospitalet, University of Copenhagen, Copenhagen, Denmark

Conclusion: Liberal vs. restrictive fixed-volume regimens are not well defined in the literature regarding the definitive fluid regimens.

Methods: A PubMed search identified randomized clinical trials and cited studies comparing two different fixed fluid principles (fast-track surgery). Therefore, evidence-based guidelines for optimal procedure-specific perioperative fixed-volume regimens cannot be formulated. Rational perioperative fluid man-

and outcome endpoints were inconsistently defined and only two studies reported perioperative care principles and discharge criteria. Three studies found an improved outcome (morbidity/hospital stay) with a restrictive fluid

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Meta-analysis of standard, restrictive and supplemental fluid administration in colorectal surgery

N. N. Rahbari¹, J. B. Zimmermann², T. Schmidt¹, M. Koch¹, M. A. Weigand² and J. Weitz¹

Departments of ¹Surgery and ²Anaesthesiology, University of Heidelberg, Heidelberg, Germany

Correspondence to: J. Weitz, Department of Surgery, University of Heidelberg, Im Neuenheimer Feld 110, 69120 Heidelberg, Germany

(e-mail: nuh.rahbari@med.uni-heidelberg.de)

Results: Nine randomized controlled trials were included. Restrictive fluid amount (odds ratio (OR) 0.41 (95 per cent confidence interval (c.i.) 0.22 to 0.77); \( P = 0.005 \)) and goal-directed fluid therapy by means of oesophageal Doppler-derived variables (OR 0.43 (95 per cent c.i. 0.26 to 0.71); \( P = 0.001 \)) significantly reduced overall morbidity. There were no significant differences in the secondary endpoints analysed.

Conclusion: Using standardized definitions, this meta-analysis suggests that restrictive rather than standard fluid amount according to current textbook opinion, and goal-directed fluid therapy rather than fluid therapy guided by conventional haemodynamic variables, reduce morbidity after colorectal resection.
Conference on ‘Malnutrition matters’

Symposium 3: Death by drowning
A meta-analysis of randomised controlled trials of intravenous fluid therapy in major elective open abdominal surgery: getting the balance right

Krishna K. Varadhan and Dileep N. Lobo
Division of Gastrointestinal Surgery, Nottingham Digestive Diseases Centre, NIHR Biomedical Research Unit, Nottingham University Hospitals, Queen’s Medical Centre, Nottingham NG7 2UH, UK

In this study, there was no apparent difference between the effects of standard or liberal fluid regimens on outcome in patients undergoing elective open abdominal surgery. However, patients managed in a state of fluid balance fared better than those managed in a state of fluid imbalance. When the fluid regimens were compared with ‘standard or liberal’ fluid regimens, there was no difference in post-operative complication rates (risk ratio 0.96 (95% CI 0.56, 1.65), P = 0.89) or length of hospital stay (weighted mean difference (WMD) = -1.77 (95% CI -4.36, 0.81) d, P = 0.18). However, when the fluid regimens were reclassified and patients were grouped into those who were managed in a state of ‘balance’ or ‘imbalance’, the former group had significantly fewer complications (risk ratio 0.59 (95% CI 0.44, 0.81), P = 0.0008) and a shorter length of stay (WMD = -3.44 (95% CI -6.33, -0.54) d, P = 0.02) than the latter. Using imprecise terminology, there was no apparent difference between the effects of standard or liberal fluid regimens on outcome in patients undergoing elective open abdominal surgery. However, patients managed in a state of fluid balance fared better than those managed in a state of fluid imbalance.
The great fluid debate. There is yet to be substantial consensus or a clear consensus on whether a patient should be treated with a liberal or a restrictive fluid regimen. The debate began in the intensive care unit. Early work demonstrated that patients showing signs of critical illness as a result of poor oxygen delivery to tissues would benefit from fluid intervention to increase cardiac output and perfusion pressure.3 Shoemaker and colleagues4,5 led the (not unique to us) effort to increase cardiac output in the resuscitation of patients with sepsis who had poor perfusion and were not responding to conventional resuscitation.6,7 Their work has emphasized the importance of optimizing cardiac output and demonstrating that the benefits of fluid administration are achieved by increasing cardiac output, not simply by increasing fluid volume, as we saw in the cardiac index studies.8 As a result, the fluid debate has shifted from a focus on fluid volume to one of cardiac output optimization.9

The fluid debate has also been influenced by the increasing use of invasive monitors and the ability to measure cardiac output directly.10-13 The use of to assess cardiac output and other hemodynamic parameters has led to a renewed interest in fluid optimization.14,15 The use of invasive monitors has also highlighted the importance of fluid optimization in the prevention of complications such as pulmonary edema and cardiac failure.16,17

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It’s a Fan!

It’s a Wall!

It’s a Spear!

It’s a Snake!

It’s a Tree!

It’s a Rope!
Fluid balance against time

Start of Surgery
End of Surgery

Fluid Balance (litres)

Time

+2
0
-2

6 hours pre-op

Late post-op

Early post-op

Start of Surgery
End of Surgery
Working with surgeons
The “unholy triad”

- Hypotension
- Fluids
- Inotropes
The “unholy triad”

- Hypotension - “asphyxiates my anastomosis”
- Fluids - “make my wounds breakdown?”
- Inotropes - “untie my sutures and are generally the work of the devil”
Fluid restriction for surgery
Dopamine kills...

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<thead>
<tr>
<th>Factor</th>
<th>Odds Ratio (95% CI)</th>
<th>p Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean SOFA score</td>
<td>1.53 (1.44–1.62)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Mean fluid balance</td>
<td>1.42 (1.26–1.59)</td>
<td>&lt;.001</td>
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<tr>
<td>Medical admission</td>
<td>2.36 (1.7–3.27)</td>
<td>&lt;.001</td>
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<tr>
<td>Age</td>
<td>1.02 (1.01–1.03)</td>
<td>.001</td>
</tr>
<tr>
<td>Dopamine administration</td>
<td>1.67 (1.19–2.35)</td>
<td>.003</td>
</tr>
<tr>
<td>Cancer</td>
<td>2.05 (1.27–3.3)</td>
<td>.003</td>
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</tbody>
</table>
Actually, norepinephrine kills, dopamine saves...

Log rank = 22.13
\( p < .001 \)

<table>
<thead>
<tr>
<th></th>
<th>dopamine</th>
<th>norepinephrine</th>
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<tr>
<td>28</td>
<td>24</td>
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</tr>
</tbody>
</table>

Povoa et al, Crit Care Med 2009
Or maybe they are both bad...

Figure 2. Kaplan–Meier Curves for 28-Day Survival in the Intention-to-Treat Population.
It is an EFFECT-CAUSE association...
Positive Fluid Balance is Associated with Complications after Elective Open Infrarenal Abdominal Aortic Aneurysm Repair

G.T. McArdle, G. Price, A. Lewis, J.M. Hood, A. McKinley, P.H. Blair and D.W. Harkin
It is an EFFECT-CAUSE association...
Working with surgeons in the post-op period and avoiding the “unholy triad”)
Working with surgeons in the post-op period and avoiding the “unholy triad”
Working with surgeons in the post-op period and avoiding the “unholy triad”

- Tolerate lower BP - keeping MAP > 65mmHg,
- Look for signs of hypoperfusion (?urine output)
- Fluids - Judiciously, but don’t avoided them

Hypotension possible = Fluid loading X Inotropes
Conclusions

• Identifying optimal fluid balance around time of surgery is difficult
• It is unlikely to be static but varies with stage of surgery (it may even be multi-phasic)
• We should not achieve post-op negative fluid balance at the expense of causing hypotension and organ hypoperfusion