Why?
Anesthesia-related mortality

Perioperative mortality

Financial Disclosures

Air Liquide
Bayer
Biosyn
Edwards
Orion
Prostrakran
Schering
Perioperative Goal Directed Therapy

Why? Perioperative Goal Directed Therapy

Why? Perioperative Goal Directed Therapy

Why? Perioperative Goal Directed Therapy

Why do patients die perioperatively?

Most Common Post-Surgical Complications

Infectious
- Infections
  - Wound
  - Pulmonary
  - Urinary tract
  - Superficial wound
  - Deep wound
  - Organ-space
- Septic shock

Cardiovascular
- Heart failure
- Myocardial infarction
- Hypertension
- Arrhythmias
- Congestive heart failure
- Intracardiac or coronary artery occlusion
- Ventricular or atrial arrhythmias
- Sudden cardiac arrest

Respiratory
- Pneumonia
- Pleural effusion
- Acute respiratory failure
- Ventilator dependence
- Respiratory failure

Gastro-intestinal
- Nausea and vomiting
- Ileus
- Acute bowel obstruction
- Anastomotic leak
- Gastro-intestinal hypertension
- Pancreatitis

Renal
- Renal dysfunction
- Acute renal failure
- Renal insufficiency

Neurological
- Stroke
- Seizures
- Coma
- Altered mental status

Hematological
- Hemorrhage
- Anemia
- Coagulopathy

Other
- Wound dehiscence
- Vascular graft failure

Complication rates depend on the surgical procedure

N = 129,233

<table>
<thead>
<tr>
<th>Surgery</th>
<th>Morbidity rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esophagectomy</td>
<td>55.1</td>
</tr>
<tr>
<td>Pelvic exenteration</td>
<td>45.0</td>
</tr>
<tr>
<td>Pancreatectomy</td>
<td>34.9</td>
</tr>
<tr>
<td>Colectomy</td>
<td>28.9</td>
</tr>
<tr>
<td>Gastroctomy</td>
<td>28.7</td>
</tr>
<tr>
<td>Liver resection</td>
<td>27</td>
</tr>
</tbody>
</table>

Why? Post-Surgical Complications: Frequency

- N = 84,730
- American College of Surgeons National Surgical Quality Improvement Program
- Complication rate: 24.6 - 26.9%
- Major complication rate: 16.2 - 18.2%
- Mortality from major complications: 12.5% - 21.4%

Why? Post-Surgical Complications: Predictability

Successful Implementation of the Department of Veterans Affairs’ General Surgery National Database—N=129,546

Why? Post-Surgical Complications: Predictability

Complication rates depend on the patient

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Odds ratio</th>
</tr>
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<tbody>
<tr>
<td>ASA 4/5 vs 1/2</td>
<td>1.0</td>
</tr>
<tr>
<td>ASA 3 vs 1/2</td>
<td>1.5</td>
</tr>
<tr>
<td>Dyspnea at rest vs. none</td>
<td>1.4</td>
</tr>
<tr>
<td>History of COPD</td>
<td>1.3</td>
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<tr>
<td>Dyspnea with minimal exertion vs. none</td>
<td>1.2</td>
</tr>
</tbody>
</table>

N=129,546

Why? Post-Surgical Complications: Costs

$18,000 average extra cost for treating a patient with one or more post-surgical complications

Why? Post-Surgical Complications: Length of stay

2250 Patients Undergoing General and Vascular Surgery

Table 1. Frequency Distribution of 30-Day Events and Average Length of Stay by General Surgery, American College of Surgeons NSQIP, 2005–2006

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Prevalence</th>
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<th>Average event rate</th>
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<tr>
<td>Cardiac arrest requiring CPR</td>
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<td>2.03</td>
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<tr>
<td>Graft/prosthesis failure</td>
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<tr>
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<td>2.03</td>
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Figure 1. Cumulative length of stay and cumulative cost of postoperative events.

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2250 Patients Undergoing General and Vascular Surgery

Figure 1. Cumulative length of stay and cumulative cost of postoperative events.
Postoperative complications: Most significant independent risk factor for readmission

Any post-surgical complication increases the risk of readmission by a factor of four

[odds ratio: 4.20; 95% CI: 2.89-6.13]

Why?

Post-Surgical Complications: Re-Admission

• Perioperative mortality/morbidity is still inacceptably high
  - Complications are not exceptions
  - Complications are costly
  - Complications are responsible for prolonged LOS and readmissions
  - Complications affect long-term survival

Why?

Post-Surgical Complications: Long-term survival

Relationship between Intraoperative Mean Arterial Pressure and Clinical Outcomes after Noncardiac Surgery

Toward an Empirical Definition of Hypotension

MAP <55 mmHg

- Auto-cardiac pacing
- Cardiac arrest
- Microthrombosis

Analysis times (days)

Final mortality day 1
Final mortality day 8
No POMS-defined mortality

Perioperative Goal-Directed Therapy
Post-Surgical Complications: How to avoid?

Identification of the target zone: Trial and error?

Identification of the target zone: Fixed volume regimen?
The importance of flow

\[ DO_2 = CO \cdot cO_2 \]

\[ = HR \cdot SV \cdot cO_2 \]
Perioperative Goal-Directed Therapy

Identification of the target zone: The Frank Starling Curve

- Normal ventricular function
- Decreased ventricular function
- CVP

Identification of the target zone: Stroke volume optimization

- Normovolemia is achieved when the individual patient is no longer volume-responsive.
- Further volume fails to improve SV.

Identification of the target zone: Stroke volume optimization - Laparoscopy

- Brandstrup B. et al. Which goal for fluid therapy during colorectal surgery is followed by the best outcome: near-maximal stroke volume or zero fluid balance?

Identification of the target zone: Ventilation induced arterial pressure variations

- Bentzer J. et al. Will This Hemodynamically Unstable Patient Respond to a Bolus of Intravenous Fluids? JAMA. 2016;316(12):1298-1309
Perioperative Goal Directed Therapy

Identification of the target zone: Ventilation induced arterial pressure variations

- SVV/PPV - Limitations
  - SOS
    - Spontaneous ventilation
    - Open chest-conditions
    - Sustained cardiac arrhythmias
  - Low tidal volumes
  - High respiratory rate
  - PHTRV dysfunction
  - Vasoconstriction
  - Children
  - High IAP (IAH, laparoscopy)
  - Many of these limitations are not present in the OR
    - Alternative: Passive leg raising

Identification of the target zone: Diagnostic accuracy

Salzwedel C. et al. Perioperative goal-directed hemodynamic therapy based on radial arterial pulse pressure variation and continuous cardiac index trending reduces postoperative complications after major abdominal surgery: a multi-center, prospective, randomized study. Critical Care 2013, 17:R191

Bentzer J. et al. Will This Hemodynamically Unstable Patient Respond to a Bolus of Intravenous Fluids? JAMA. 2016;316(12):1298-1309
Identification of the target zone: How to measure SV?

Identification of the target zone: How to measure SV?

And so what?

PGDT: Mortality

N = 734

N = 106

Survival from randomization

Survival from 28 days post randomization

Survival analysis from randomization

Outcome data described as median survival in days together with the HR and its 95% confidence interval

Table 1

No complication Complication HR 95% CI

Protocol Control HR 95% CI

More details of the original study can be found in the Intensive Care Med (2010) 36:1327–1332.
PGDT: Morbidity

N = 3024

Perioperative cardiac output–guided hemodynamic therapy based on radial arterial pulse pressure variation and continuous cardiac index trending reduces postoperative complications after major abdominal surgery: a multi-center, prospective, randomized study.

PGDT: Not only volume!

Table 2. Subgroup Analysis for Mortality

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>No. of studies</th>
<th>No. of patients</th>
<th>Control group mortality</th>
<th>Protocol group mortality</th>
<th>Odds ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>21</td>
<td>3511</td>
<td>183/1657 (11%)</td>
<td>13/280 (5%)</td>
<td>0.29 (0.18–0.47)*</td>
</tr>
<tr>
<td>Supranormal</td>
<td>3</td>
<td>4105</td>
<td>135/2039 (7%)</td>
<td>28/448 (6%)</td>
<td>0.47 (0.29–0.76)*</td>
</tr>
<tr>
<td>Other</td>
<td>19</td>
<td>3350</td>
<td>208/2035 (10%)</td>
<td>17/198 (9%)</td>
<td>0.35 (0.19–0.65)*</td>
</tr>
</tbody>
</table>

PGDT: Safety

N = 2129

Cardiac complications associated with goal-directed therapy in high-risk surgical patients: a meta-analysis.

PGDT: Length of stay

Systematic review and meta-analysis of enhanced recovery programmes in surgical patients

Standardised mean difference: -1.14 days (95% CI: -1.45 to -0.83)
**PGDT: Costs**

Tackling the economic burden of post-surgical complications: would perioperative goal-directed fluid therapy help?

<table>
<thead>
<tr>
<th></th>
<th>Patients with complications</th>
<th>Patients without complications</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-hospital mortality</td>
<td>12.4%</td>
<td>1.4%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hospital LOS</td>
<td>20.5 ± 20.1 d</td>
<td>8.1 ± 7.1 d</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Direct costs</td>
<td>$47,284 ± 49,170</td>
<td>$17,408 ± 15,612</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*With PGDT:*
- projected decrease of complications by 8.0 - 9.3%
- gross costs savings of $43 M - $73 M for the study population
- gross costs savings of $169 - $570 per patient

**PGDT: Guidelines**

**NHS Guidelines**

National Institute for Health and Clinical Excellence

"The CardioQ-OBD should be considered for use in patients undergoing major or high-risk surgery or other surgical patients in whom a clinician would consider using invasive cardiovascular monitoring. This will include patients undergoing major or high-risk surgery or high-risk patients undergoing intermediate-risk surgery."

Intraoperative fluid management

**Recommendation 13**

In patients undergoing some forms of orthopaedic and abdominal surgery, perioperative treatment with intravenous fluid to achieve an optimal value of stroke volume should be used where possible as this may reduce postoperative complication rates and duration of hospital stay.

Orthopaedic surgery: Evidence level 1b

Abdominal surgery: Evidence level 1a

**Recommendation 14**

 Patients undergoing non-elective major abdominal or orthopaedic surgery should receive intravenous fluid to achieve an optimal value of stroke volume during and for the first eight hours after surgery. This may be supplemented by a low dose dopexamine infusion.

Evidence level 1b

**PGDT: Guidelines**

Perioperative goal directed therapy: Consensus statement from the enhanced recovery partnership

The Enhanced Recovery Partnership recommends that all Anaesthetists caring for patients undergoing intermediate or major surgery should have cardiac output measuring technologies immediately available and be trained to use them.

The use of intra-operative fluid management technologies are recommended from the outset in the following types of cases:
- Major surgery with a 30-day mortality rate of >1%
- Major surgery with a predicted blood loss of greater than 500 ml.
- Major intra-abdominal surgery.
- Intermediate surgery (30-day mortality>5.5%) in high-risk patients (age>80 years, history of LVF, MI, CVA or peripheral arterial disease).
- Unexpected blood loss and/or fluid loss requiring >12 litres of fluid replacement.
- Patients with ongoing evidence of hypovolaemia and/or tissue hypoperfusion (e.g. persistent lactic acidosis).
Perioperative Goal-Directed Therapy

Perioperative hemodynamic optimization: Summary

- Perioperative mortality/morbidity is still inacceptably high
- Complications are not exceptions
- Complications are costly
- Complications are responsible for prolonged LOS and readmissions
- Complications affect long-term survival

Improvement in outcome requires a bundle of therapeutic measures

Perioperative Goal-Directed Therapy
- is a key element
- optimizes fluid status in the individual patient using SV-measurements
- reduces morbidity and hospital LOS
- can be focused on high-risk patients (which are easy to identify)
- requires a treatment protocol
- re-imbursement?
- implementation?

Thank you very much for your attention