Bleeding post-op Cardiothoracic Surgery

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Disclosures

None
Objectives

Mechanisms of bleeding in CVT surgery

Predictors of bleeding

Approach to the severely bleeding patient

Use of transfusion protocols to improve patient outcomes
Background

Transfusion in CVT surgery is common
  • 30 to 40% receive RBC units

  • 1/3 of elective CAGB procedures require allogeneic blood product support

  • Consumes ~20% U.S. blood supply
Massive Transfusion: Winnipeg, Canada

- Cardiothoracic Surgery: 34%
- GI hemorrhage: 20%
- Trauma: 15%
- Vascular Surgery: 12%
- Other surgery: 3%
- Obstetrical: 22%
Major Bleeding, Transfusions, and Anemia: The Deadly Triad of Cardiac Surgery

Marco Ranucci, MD, FESC, Ekaterina Baryshnikova, BD,

• Turns out...bleeding is bad
• Worse when transfused
• Highly associated with:
  – Death
  – Thrombosis
# CVT Surgery: Mechanisms of bleeding

## Dilutional
- Pump Prime
- Cell Salvage
- Crystalloid / Colloid

## Consumption

## Hypothermia

## Acidosis

## Thrombocytonia & Platelet Dysfunction
- ‘Pump platelet’

## Medications

## Hyperfibrinolytic state

(inherited coagulation defects)
CVT Surgery: Mechanisms of bleeding

Dilutional
- Pump Prime
- Cell Salvage
- Crystalloid / Colloid
## CVT Surgery: Mechanisms of bleeding

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<th>Dilutional</th>
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| Acidosis                     | (inherited coagulation defects)       |
CVT Surgery: Mechanisms of bleeding

- Platelet activation / degranulation
- Reduced Coagulation enzyme activity
- Increased fibrinolysis
- NO change in INR/aPTT

Hypothermia
CVT Surgery: Mechanisms of bleeding

Acidosis

pH: 7.4 to 7.0
70% reduction in the activation of the prothrombinase complex
CVT Surgery: Mechanisms of bleeding

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CVT Surgery: Mechanisms of bleeding

Hyperfibrinolytic state

Ischemic Reperfusion injury

Release of TPA from endothelial surface

Presence of in situ thrombus formation (aka mediastinal clot)
Predictors of bleeding

**Patient factors**
- Age > 65 years
- Female gender
- Weight < 77 kg
- Multiple comorbidities

**Medications**
- Antiplatelet agents
- Anticoagulants
- Thrombolytics

**Preoperative laboratory values**
- Pre-op anemia (<135 g/L)
- Pre-op thrombocytopenia (<150x10⁹)
- Increased creatinine

**Surgical factors**
- Surgeon
- Non-elective surgery
- Previous cardiac surgery
- Combined procedures
- Prolonged CBP time (>2 hours)
- Hypothermic circulatory arrest
‘Surgical’ Bleeding / need for re-operation

1. 500 mL of fresh bleeding in first hour
   400 mL per hour for 2 hours
   300 mL per hour for 3 hours

2. > 1,000 mL of bleeding in the first 4 hours

2. Sudden massive bleeding

3. Signs of cardiac tamponade
The Papworth postoperative blood loss chart
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Approach to bleeding CVT patient

Maintain tissue oxygenation

Adequate circulating volume

Achieve hemostasis

Prevent coagulopathy
Component Therapies and Targets

Red Blood Cells

- Tissue Oxygenation (over-rated)
- Intravascular volume
- Under appreciated hemostatic function
- Target in bleeding: 100 g/L
Component Therapies and Targets

Platelets

- Necessary for $1^0$ hemostasis
- Number irrelevant if dysfunctional
  - CPB circuit
  - Medications
  - Hypothermia (reversible)
- Target in bleeding: 50-70 x10$^9$/L
Component Therapies and Targets

Frozen plasma

• Contains 100% concentration of all coagulation factors

• Lots of fibrinogen
  • 2-4 g/L

• Target in bleeding: < 1.5
Component Therapies and Targets

Cryoprecipitate

- Fibrinogen
- (Factor VIII, vWF, XIII)
- Rarely indicated
- Target in bleeding: 1 g/L

* Consider in isolated hyperfibrinolysis
Can extra protamine eliminate heparin rebound following cardiopulmonary bypass surgery?

Kevin H. T. Teoh, MD


- Double blind placebo controlled RCT  n= 300
- Protamine 25 mg/hr x 6 hours vs. saline
- Protamine eliminated heparin rebound
- Modest reductions in bleeding
- No difference in transfusion
Hemostatic monitoring during bleeding

Options

• Hemoglobin
• Platelet
• aPTT/INR
• Fibrinogen

• Thromboelastography
• Gut instinct
Thromboelastography (TEG/ROTEM)

- TEG Developed in 1948
- Assesses the viscoelastic properties of whole blood
**ROTEM**

Viscoelastic hemostatic assays in cardiac surgery

VHA has routinely been used in cardiac surgery for more than 25 years, and since the first reports in 1987
An audit of red cell and blood product use after the institution of thromboelastometry in a cardiac intensive care unit

L. Anderson,* I. Quasim,* R. Soutar,† M. Steven,* A. Macfie* and W. Korte‡ *Department of Anaesthesia, †Department of Haematology, Western Infirmary, Glasgow, UK, and ‡Institute for Clinical Chemistry and Haematology, Kantonsspital, St Gallen, Switzerland

- 990 patient before-and-after study
- 7% reduction in proportion receiving RBCs
- 4% reduction in proportion receiving FFP
- 5% reduction in proportion receiving Platelets
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Survival of trauma patients after massive red blood cell transfusion using a high or low red blood cell to plasma transfusion ratio*

Anita Rajasekhar, MD; Rob Gowing, MD, MSc, FRCSC; Ryan Zarychanski, MD, MSc, FRCPC; Donald M. Arnold, MD, MSc; Wendy Lim, MD, MSc, FRCPC; Mark A. Crowther, MD, MSc, FRCPC; Richard Lottenberg, MD

- Systematic review of the literature
  - 11 published cohort and case-control studies
- Civilian and military trauma
- 10/11 studies reported decreased mortality associated with an increased FFP:RBC ratio

- Only 1 study attempted to control for survival bias
- No RCTs identified
Predefined Massive Transfusion Protocols are Associated With a Reduction in Organ Failure and Postinjury Complications

Bryan A. Cotton, MD, Brigham K. Au, BS, Timothy C. Nunez, MD, Oliver L. Gunter, MD, Amy M. Robertson, MD, and Pampee P. Young, MD, PhD


<table>
<thead>
<tr>
<th></th>
<th>Pre-TEP (n = 141)</th>
<th>TEP (n = 125)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>24-h survival (%)</td>
<td>61</td>
<td>69</td>
<td>0.185</td>
</tr>
<tr>
<td>30-d survival (%)</td>
<td>37.6</td>
<td>56.8</td>
<td>0.001</td>
</tr>
<tr>
<td>Hospital length of stay, d (±SD)</td>
<td>16.4 (±20.1)</td>
<td>12.0 (±12.1)</td>
<td>0.049</td>
</tr>
<tr>
<td>ICU length of stay, d (±SD)</td>
<td>6.6 (±9.4)</td>
<td>5.0 (±8.3)</td>
<td>0.239</td>
</tr>
<tr>
<td>Ventilator days, d (±SD)</td>
<td>8.2 (±9.7)</td>
<td>5.7 (±7.2)</td>
<td>0.017</td>
</tr>
<tr>
<td>IO blood products, units (±SD)</td>
<td>11.0 U (±SD)</td>
<td>14.7 U (±SD)</td>
<td>0.001</td>
</tr>
<tr>
<td>IO crystalloid, L (±SD)</td>
<td>7.0 L (±SD)</td>
<td>4.8 L (±SD)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>24-h blood products (±SD)</td>
<td>38.7 U (±SD)</td>
<td>31.2 U (±SD)</td>
<td>0.050</td>
</tr>
</tbody>
</table>

SD, standard deviation; IO, intraoperative.
Exsanguination protocol improves survival after major hepatic trauma

Victor Zaydfudim\textsuperscript{a, *}, William D. Dutton\textsuperscript{a}, Irene D. Feurer\textsuperscript{a,b}, Brigham K. Au\textsuperscript{a},
C. Wright Pinson\textsuperscript{a}, Bryan A. Cotton\textsuperscript{c,d}

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<thead>
<tr>
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<th>Pre-TEP ($n = 39$)</th>
<th>TEP ($n = 36$)</th>
<th>$p$-Value</th>
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<tr>
<td>Intra-operative mortality\textsuperscript{a}</td>
<td>13 (33)</td>
<td>8 (22)</td>
<td>0.28</td>
</tr>
<tr>
<td>24-h mortality\textsuperscript{a}</td>
<td>19 (49)</td>
<td>13 (36)</td>
<td>0.27</td>
</tr>
<tr>
<td>30-day mortality\textsuperscript{a}</td>
<td>27 (69)</td>
<td>17 (47)</td>
<td>0.05</td>
</tr>
<tr>
<td>Intra-operative pRBC\textsuperscript{b}</td>
<td>12 (8–16)</td>
<td>12.5 (7.5–20.5)</td>
<td>0.78</td>
</tr>
<tr>
<td>Intra-operative FFP\textsuperscript{b}</td>
<td>4 (3–7)</td>
<td>8 (4–12)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Intra-operative platelets\textsuperscript{b}</td>
<td>1 (0–2)</td>
<td>2 (1–4)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Intra-operative crystalloid (L)\textsuperscript{b}</td>
<td>6 (4–10)</td>
<td>4 (2.5–6)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>24-h pRBC\textsuperscript{b}</td>
<td>19 (14–26)</td>
<td>16 (10–24)</td>
<td>0.20</td>
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<tr>
<td>24-h FFP\textsuperscript{b}</td>
<td>10 (5–20)</td>
<td>10 (8–14.5)</td>
<td>0.72</td>
</tr>
<tr>
<td>24-h platelets\textsuperscript{b}</td>
<td>5 (2–14)</td>
<td>3 (1.5–5.5)</td>
<td>0.06</td>
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Transfusion protocols NOT in trauma

• Communication
• Processes of care
• Safe ratios of blood components

• Increased waste?
• Unproven outcomes
Pharmacologic measures

• Tranexamic acid
• DDVAP
• Vlla
• Fibrinogen concentrates
Effects of Fibrinogen Concentrate as First-line Therapy during Major Aortic Replacement Surgery

A Randomized, Placebo-controlled Trial

- Single centre, double blind RCT, aortic surgery. N=61
- Treatment of coagulopathic bleeding
- Dosing guided by ROTEM

- Fewer allogeneic blood components in patients receiving fibrinogen (median, 2 vs. 13 U; $P < 0.001$)
- Total avoidance of transfusion was achieved in 13 (45%) of 29 patients receiving fibrinogen
Fibrinogen concentrate in bleeding

- 6 RCTs; 248 patients
- All – unclear or high risk of bias
- 12 ongoing trials!

- Reduced incidence of allogeneic transfusion
  - 5 studies; 207 patients
  - (RR 0.47, 95% CI 0.31 to 0.72)
Fibrinogen: Unanswered questions

- Who should receive?
- When to give?
- What dose?
- What outcomes?
- What about safety?
- Cost effectiveness?
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Questions...?