PERIOPERATIVE ANEMIA
Conflicts of interests

Nothing to declare
Objectives

- Patient blood Management (PBM)
- Anemia – definition and risks
- Causes
- Pathophysiology
- Anemia assessment
- Clinical Management
- Transfusion thresholds
- Point of care testing
- Take home messages
Patient blood management is the timely application of evidence-based medical and surgical concepts designed to maintain hemoglobin concentration, optimize homeostasis and minimize blood loss in an effort to improve patient outcome.

https://www.sabm.org/, accessed on 30.11.19
Patient blood management is the timely application of evidence-based medical and surgical concepts designed to maintain hemoglobin concentration, optimize homeostasis and minimize blood loss in an effort to improve patient outcome.

https://www.sabm.org/, accessed on 30.11.19
PBM – Blood transfusion

- Severe malaria induced anemia in children
- Major trauma with exsanguination
- Major surgery in severely anemic patients without possibility of preoperative anemia correction
- Very severe intra- / postoperative anemia with signs of cardiovascular insufficiency

PBM — Blood transfusion

- Mortality ↑
- Length of hospital stay ↑
- Organ dysfunction ↑
  - Lung injury (TRALI, TACO)
  - Renal impairment
  - Stroke
  - Myocardial infarction
- Infection ↑
- Transfusion reactions
- Tumor growth promotion ↑
- Costs ↑
- Non-Hodgkin lymphoma ↑

PBM key points

Patient Blood Management
A clinical maxim to increase patient safety

- Early detection and treatment of preoperative anaemia in patients undergoing surgery with a high transfusion probability
- Minimizing blood loss and intensified use of blood conserving measures
- Rational and guideline-appropriate use of allogenic blood products
Anemia - WHO

- Haemoglobin concentration of less than 130 g dl\(^{-1}\) for men
- 120 g dl\(^{-1}\) for non-pregnant women.

<table>
<thead>
<tr>
<th></th>
<th>WHO</th>
<th>NCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>Hb &lt; 13 g dl(^{-1})</td>
<td>Hb &lt; 12 g dl(^{-1})</td>
</tr>
<tr>
<td>Female</td>
<td>Hb &lt; 12 g dl(^{-1})</td>
<td>Hb &lt; 11 g dl(^{-1})</td>
</tr>
</tbody>
</table>
Anemia & PBM

Management of anemia
- Monitoring for anemia throughout the course of care
- Managing underlying cause(s) of anemia
- Enhancing physiologic adaptation to anemia (e.g. increasing $O_2$ supply, decreasing demand)
- Supporting hematopoiesis (e.g. Iron, folic acid, ESAs)
- Evidence-based use of transfusion when indicated

Optimization of hemostasis
- Risk assessment (e.g. patient history, coagulopathy)
- Quantitative and qualitative coagulation assessment
- Goal-directed therapy to correct abnormalities, including evidence-based used of plasma and pro-coagulants
- Adjustment of anticoagulants before procedures
- Systemic and topical hemostatic agents

Improved patient outcomes

Interdisciplinary blood conservation modalities
- Continuous assessment of blood loss (amount and rate)
- Quick action to arrest blood loss
- Autologous transfusion techniques (e.g. cell saver, acute, normovolemic hemodilution)
- Minimizing diagnostic blood loss
- Better-planned and less-invasive surgical approaches

Patient-centered decision-making
- Documenting and communicating patient’s preferences
- Incorporating patient values and choices in the care
- Informing patients of risks, benefits and alternatives of treatments and procedures
- Providing patients with all available PBM options
- Attention to patient needs, preferences and concerns

Shander A, Javidroozi M. Curr Opin Anesthesiol 2015
Anemia prevalence

- Up to 60% of surgical population
- 5–78% of patients requiring a surgical intervention

GA Hans, Continuing Education in Anaesthesia, Critical Care & Pain, 2013
Anemia Prevalence, Global, 1990-2013

Prevalence (%)

Year

Healthstate
Mild
Moderate
Severe

Mild anemia
Male: Hb 120 - 129 g/L
Female: Hb 110 - 119 g/L

Moderate anemia
Male: Hb 90 - 119 g/L
Female: Hb 80 - 109 g/L

27%
The incidence and importance of anaemia in patients undergoing cardiac surgery in the UK – the first Association of Cardiothoracic Anaesthetists national audit

A. A. Klein, T. J. Collier, M. S. Brar, C. Evans, G. Hallward, S. N. Fletcher, T. Richards, on behalf of the Association of Cardiothoracic Anaesthetists (ACTA)

Anemia - outcome

- Higher mortality - 2 times more likely to die
- Higher transfusion requirements for small haemoglobin changes (10g/dL)
- Longer hospital stays (median 2 days)
- Death linked to severity of anaemia and to gender
Anemia - outcome

- Increase risk of AKI.
- Poorer surgical outcomes.
- Increase perioperative blood transfusion.
- Haematocrit less 39% was associated with an increased risk of 30 day postoperative mortality and cardiac events.

Arora P et al, J Cardiothorac Vasc Anesth 2012
David O et al Anaesth Intensive Care 2013
Klein et al. Anaesthesia June 2016
Pre-op anemia

<table>
<thead>
<tr>
<th>Reference</th>
<th>Year</th>
<th>Anaemia</th>
<th>No anaemia</th>
<th>Weight (%)</th>
<th>Odds ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gruson et al.26</td>
<td>2002</td>
<td>5 of 180</td>
<td>3 of 215</td>
<td>1.8</td>
<td>2.02 (0.48, 8.57)</td>
</tr>
<tr>
<td>Cladeillas et al.22</td>
<td>2006</td>
<td>9 of 42</td>
<td>10 of 159</td>
<td>2.9</td>
<td>4.06 (1.53, 10.79)</td>
</tr>
<tr>
<td>Wu et al.40</td>
<td>2007</td>
<td>86600</td>
<td>33511</td>
<td>5.9</td>
<td>3.62 (3.47, 3.77)</td>
</tr>
<tr>
<td>Bell et al.20</td>
<td>2008</td>
<td>325 of 6143</td>
<td>798 of 30196</td>
<td>5.8</td>
<td>2.06 (1.80, 2.35)</td>
</tr>
<tr>
<td>Beattie et al.19</td>
<td>2009</td>
<td>76 of 3047</td>
<td>24 of 4632</td>
<td>4.8</td>
<td>4.91 (3.10, 7.79)</td>
</tr>
<tr>
<td>Melis et al.20</td>
<td>2009</td>
<td>14 of 197</td>
<td>5 of 216</td>
<td>2.8</td>
<td>3.23 (1.14, 9.14)</td>
</tr>
<tr>
<td>De Santo et al.23</td>
<td>2009</td>
<td>25 of 320</td>
<td>16 of 727</td>
<td>4.1</td>
<td>3.77 (1.98, 7.16)</td>
</tr>
<tr>
<td>Shirzad et al.37</td>
<td>2010</td>
<td>26 of 650</td>
<td>35 of 3782</td>
<td>4.6</td>
<td>4.46 (2.67, 7.46)</td>
</tr>
<tr>
<td>Munoz et al.31</td>
<td>2010</td>
<td>12 of 210</td>
<td>19 of 366</td>
<td>3.7</td>
<td>1.11 (0.53, 2.33)</td>
</tr>
<tr>
<td>Musallam et al.32</td>
<td>2011</td>
<td>3192 of 69229</td>
<td>1240 of 158196</td>
<td>5.9</td>
<td>6.12 (5.73, 6.54)</td>
</tr>
<tr>
<td>Boening et al.21</td>
<td>2011</td>
<td>44 of 185</td>
<td>121 of 3126</td>
<td>5.1</td>
<td>7.75 (5.28, 11.38)</td>
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<tr>
<td>Vochteloo et al.38</td>
<td>2011</td>
<td>30 of 536</td>
<td>31 of 726</td>
<td>4.6</td>
<td>1.33 (0.79, 2.22)</td>
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<tr>
<td>Hung et al.38</td>
<td>2011</td>
<td>45 of 1463</td>
<td>13 of 1225</td>
<td>4.2</td>
<td>2.96 (1.59, 5.51)</td>
</tr>
<tr>
<td>Dubiljanin-Raspopovic et al.</td>
<td>2011</td>
<td>19 of 185</td>
<td>12 of 158</td>
<td>3.7</td>
<td>1.39 (0.65, 2.97)</td>
</tr>
<tr>
<td>Greenky et al.25</td>
<td>2012</td>
<td>12 of 2991</td>
<td>21 of 12321</td>
<td>3.9</td>
<td>2.34 (1.15, 4.77)</td>
</tr>
<tr>
<td>Ranucci et al.34</td>
<td>2012</td>
<td>51 of 401</td>
<td>30 of 401</td>
<td>4.8</td>
<td>1.80 (1.12, 2.89)</td>
</tr>
<tr>
<td>Oshin and Torella33</td>
<td>2013</td>
<td>16 of 193</td>
<td>2 of 167</td>
<td>1.8</td>
<td>7.46 (1.69, 32.93)</td>
</tr>
<tr>
<td>Saager et al.35</td>
<td>2013</td>
<td>1288 of 119298</td>
<td>811 of 119298</td>
<td>5.9</td>
<td>1.59 (1.46, 1.74)</td>
</tr>
<tr>
<td>Gupta et al.27</td>
<td>2013</td>
<td>368 of 15272</td>
<td>206 of 16585</td>
<td>5.8</td>
<td>1.96 (1.65, 2.33)</td>
</tr>
<tr>
<td>van Straten et al.38</td>
<td>2013</td>
<td>20 of 351</td>
<td>38 of 1385</td>
<td>4.5</td>
<td>2.14 (1.23, 3.73)</td>
</tr>
<tr>
<td>Secean et al.36</td>
<td>2013</td>
<td>63 of 5879</td>
<td>37 of 18594</td>
<td>5.1</td>
<td>5.43 (3.62, 8.16)</td>
</tr>
<tr>
<td>Jung et al.29</td>
<td>2013</td>
<td>0 of 125</td>
<td>0 of 463</td>
<td>Not estimable</td>
<td></td>
</tr>
<tr>
<td>Zhang et al.41</td>
<td>2013</td>
<td>22 of 432</td>
<td>3 of 223</td>
<td>2.3</td>
<td>3.93 (1.16, 13.29)</td>
</tr>
<tr>
<td>Baron et al.5</td>
<td>2014</td>
<td>656 of 11295</td>
<td>604 of 27439</td>
<td>5.9</td>
<td>2.74 (2.45, 3.07)</td>
</tr>
</tbody>
</table>

Total: 14978 of 371594 | 7430 of 577851 | 100.0 | 2.90 (2.30, 3.68) |

Heterogeneity: $t^2 = 0.24; \chi^2 = 768.79, 22$ d.f., $P < 0.001; I^2 = 97\%$

Test for overall effect: $Z = 8.88, P < 0.001$

Fowler, BJS, 2015
Pre-op anemia

Leichtler, J Am Coll Sur, 2011
Anemia - Transfusion

Munoz, BJA, 2015
Anemia and Transfusion

Karkoutil, Can J Anesth, 2015
Anemia and Transfusion

Anaemia
Blood loss
Transfusion

Pathophysiology

- \( \text{DO} \_2 \)  
- \( \text{CO} \_2 \)  
- \( \text{SpO} \_2 \)  
- \( \text{Hb} \)  
- \( \text{I0p0:003} \)  
- \( \text{PaO} \_2 \)  

\[
\text{DO}_2 = \dot{Q} \times (\text{Hb} \times \text{SaO}_2 \times 1.34 + (\text{PaO}_2 \times 0.003))
\]

Fig. 1. Equation for oxygen delivery.
### Table 2: Impact of anaemia on oxygen delivery.

Hb, haemoglobin; CaO₂, arterial blood oxygen content; DO₂, oxygen delivery to tissue; CO, cardiac output.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Hb 15 g dl⁻¹</th>
<th>Hb 7.5 g dl⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspired oxygen (%)</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>PaO₂ (kPa)</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Sats (%)</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>Dissolved oxygen (ml litre⁻¹)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Hb-bound oxygen (ml litre⁻¹)</td>
<td>197</td>
<td>98</td>
</tr>
<tr>
<td>Total CaO₂ (ml litre⁻¹)</td>
<td><strong>200</strong></td>
<td><strong>101</strong></td>
</tr>
<tr>
<td>DO₂ if CO 5 litre min⁻¹ (ml min⁻¹)</td>
<td><strong>1000</strong></td>
<td><strong>505</strong></td>
</tr>
</tbody>
</table>
Fig 1  Effect of anaemia on cardiac index. Derived from data from Roy and colleagues.
Pathophysiology

Fig 2 Haemoglobin–ODC. Temp, temperature; 2,3-DPG, 2,3-diphosphoglycerate.
**Table 3** Causes of imbalance between oxygen supply and demand in the perioperative period

### Reduced oxygen delivery

- Reduction in CO due to hypovolaemia or cardiac depression by drugs, e.g. anaesthetic agents
- Decrease in oxygen saturation due to atelectasis, postoperative pneumonia, thromboembolic event
- Further reduction in haemoglobin as a consequence of surgical blood loss or inhibition of erythropoiesis by the altered cytokine milieu
- Increased affinity of haemoglobin for oxygen due to the leftward shift in the ODC by hypothermia

### Increased oxygen requirements

- Pain
- Fever
- Shivering
- The stress response
Causes

- **Microcytic anaemia:**
  - iron deficiency
  - congenital haemoglobinopathies
  - sideroblastic anaemia
  - Vitamin B6 deficiency

- **Macrocytic anaemia**
  - folate or vitamin B12 deficiency
  - medication
  - alcoholism.

- **Normocytic anaemia**
  - chronic disease, aplastic and sickle cell anaemia,
  - haemolysis,
  - pregnancy,
  - riboflavin, and pyridoxine deficiency.

The most common cause in the surgical population is **iron deficiency***.**

***World Health Organisation 2014

**. Preoperative anaemia Clevenger et al Anaesthesia 2015
Iron deficiency

- Erythrocytes: 2500 mg
- Bone Marrow: 20 mg daily
- RBC Production: 20 mg daily
- Plasma: 4 mg
  - Absorption: 1-2 mg daily
  - Loss: 1-2 mg daily
  - ~ 5 mg daily
- Body Stores: 1000 mg
- Myoglobin & Respiratory Enzymes: 300 mg
Inflammatory diseases

Functional iron
- Bone marrow erythroblasts: ~300 mg
- Erythrocytes: ~1800 mg
- Recycling of heme-iron from senescent erythrocytes by macrophages from reticuloendothelial system (liver, spleen, bone marrow): ~600 mg

Iron transport
- 20–25 mg/day

Iron storage (including macrophages)
- Ferritin: Storage of iron in tissues (~1000 mg in liver)
- Pro-inflammatory cytokines (IL-1, IL-6)
- Hepcidin: (blocks iron supply to plasma)
- Absorption of iron by duodenum: ~1–2 mg/day

Iron delivery to cells
- ATP
- Muscle cells
- Cardiomyocytes
- All cells

Iron-dependent mitochondrial functions:
- Respiratory chain (NADH-dehydrogenase, cytochrome reductase)
- Krebs cycle (succinyl dehydrogenase, aconitase)
Causes

65,788 patients (1980–2000) preoperative evaluation anemia definition WHO

Kuller, Anästhesist, 2001
Full glass

Intraoperative blood loss

.............same blood loss
Clinical approach

Management of severe perioperative bleeding: guidelines from the European Society of Anaesthesiology

First update 2016

Anemia management

monitoring for anaemia throughout the course of care

correction of underlying causes(s) of anaemia

supporting haematopoiesis (e.g. iron, folic acid, ESAs)
Have a plan

We recommend the application of intervention algorithms incorporating predefined triggers and targets based on .... monitoring to guide individualized ... intervention ....

(1C)
Assessment

- Medical history
- Full blood count
Alternative approach

Fig 3 Suggested algorithm for the aetiological diagnosis of preoperative anaemia. U&E, urea and electrolytes; LFTs, liver function tests; LDH, lactate dehydrogenase; AED, anti-epileptic drugs.
## Chronic disease vs. Iron deficiency

<table>
<thead>
<tr>
<th></th>
<th>Iron deficiency anemia (IDA)</th>
<th>Anemia of chronic disease (ACD)</th>
<th>Anemia of mixed origin (AMO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serum ferritin</td>
<td>↓</td>
<td>N or ↑</td>
<td>N</td>
</tr>
<tr>
<td>Serum iron</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Transferrin</td>
<td>↑</td>
<td>↓ or N</td>
<td>↓</td>
</tr>
<tr>
<td>Transferrin saturation</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Mean corpuscular volume</td>
<td>↓</td>
<td>↓ or N</td>
<td>↓ or N</td>
</tr>
<tr>
<td>Iron-binding capacity</td>
<td>↑</td>
<td>↓</td>
<td>↓ to low N</td>
</tr>
<tr>
<td>Serum transferrin receptor</td>
<td>↑</td>
<td>N</td>
<td>↑ or N</td>
</tr>
<tr>
<td>Serum transferrin receptor index</td>
<td>High (&gt;2)</td>
<td>Low (&lt;1)</td>
<td>High (&gt;2)</td>
</tr>
<tr>
<td>C-reactive protein</td>
<td>N</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Erythropoietin</td>
<td>↑</td>
<td>N or slightly ↑</td>
<td>↑ or N</td>
</tr>
<tr>
<td>Cytokine levels</td>
<td>N</td>
<td>↑</td>
<td>↑</td>
</tr>
</tbody>
</table>
Preoperative anaemia in adults and children appears to be a strong predictor for perioperative transfusion across various types of conditions and surgeries and may be associated with adverse events.

We recommend that patients at risk of bleeding are assessed for anaemia 3 to 8 weeks before surgery.
We recommend that patients at risk of bleeding are assessed for anaemia 3 to 8 weeks before surgery. 1C

If anaemia is present, we recommend identifying the cause (iron deficiency, renal insufficiency or inflammation). 1C
ESA - guidelines

- Treat iron deficiency

*We recommend treating iron deficiency with iron supplementation.* 1B

*We recommend the use of intravenous iron in preference to oral iron.* 1C
IV: earlier and more robust recovery of Hb

Lin DM, Lin ES, Tran MH.
Efficacy and safety of erythropoietin and intravenous iron in perioperative blood management: a systematic review.

Leahy MF, Roberts H, Mukhtar SA, et al.
A pragmatic approach to embedding patient blood management in a tertiary hospital.
If other causes of anaemia have been excluded or treated, we suggest erythropoietin-stimulating agents. 2B
ESAs’s efficacy

increase in Hb + reduced RBC requirements

Alsaleh K, Alotaibi GS, Almodaimegh HS, et al.
The use of preoperative erythropoiesis-stimulating agents (ESAs) in patients who underwent knee or hip arthroplasty: a meta-analysis of randomized clinical trials.

Lin DM, Lin ES, Tran MH.
Efficacy and safety of erythropoietin and intravenous iron in perioperative blood management: a systematic review.
ESAs’s efficacy

effective in knee and hip arthroplasty with preoperative Hb 10-13 g/dl without iron deficiency or after iron supplementation


If autologous blood donation is performed, we suggest treatment with iron and/or erythropoietin-stimulating agents to avoid preoperative anaemia and increased overall transfusion rates. 2C
We recommend preoperative autologous blood donation in procedures involving special groups of patients (e.g. rare blood types, special antibody constellation) or at the express wish of the patient if there is a high transfusion probability.
In patients with preoperative anaemia, we recommend the use of combined therapy with intravenous iron and erythropoietin along with a restrictive transfusion policy. 1C
Iron + ESA’s

effective in knee and hip arthroplasty with preoperative Hb 12 or 13 g/dl:

✓ fewer transfusions
✓ shorter LOS
✓ less readmission

Kotze A, Carter LA, Scally AJ.
Effect of a patient blood management programme on preoperative anaemia, transfusion rate, and outcome after primary hip or knee arthroplasty: a quality improvement cycle.
Iron + ESA’s + Folate (3-4 weeks)

in anaemic patients refusing allogeneic transfusions


Iron + ESAs + Folate + B12

modifying the risk of anaemia on RBC transfusions

In non-cancer patients with preoperative anaemia scheduled for elective major surgery, we recommend postponing surgery until anaemia has been corrected. 1C
In patients who are anaemic following surgery, we suggest the use of intravenous iron. 2C
Post-op Iron

effective in knee and hip arthroplasty, especially in case of anaemia:
✓ fewer transfusions
✓ cost neutral


IV iron

dose of isomaltoside \text{[mg iron]} = \\
\text{body weight [kg]} \times (\text{target} - \text{current Hb}) \text{[g/dl]} \times 2.4 \\
+ \text{iron for iron stores [mg iron]}

\text{short infusion in 100-250 ml NaCl 0.9\% over 30 min (-10 mg/kg) or 60 min (10-20 mg/kg)}
Iron + ESA’s + B12 + Folate

Pragmatic approach „global correction“

1 g isomaltosid IV

+ 40,000 U erythropoietin alpha s.c.

+ 1 mg/day vitamin B12 p.o.

+ 5 mg/day folate p.o.
ESA guidelines

We recommend a target haemoglobin concentration of 7 to 9 g dl\(^{-1}\) during active bleeding. 1C
## Post-op transfusion trigger

<table>
<thead>
<tr>
<th>Hb level (g/dl)</th>
<th>Clinical criteria:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ability to compensate anaemia?</td>
</tr>
<tr>
<td></td>
<td>signs of hypoxia?</td>
</tr>
<tr>
<td></td>
<td>risk factors: comorbidity?</td>
</tr>
<tr>
<td></td>
<td>relevant postOP bleeding?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decision for pRBC transfusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 6</td>
</tr>
<tr>
<td>yes (1-2 pRBCs)</td>
</tr>
</tbody>
</table>

| 6 - 8                          |
| compensation adequate          |
| no risk factors                |
| no relevant postOP bleeding    |

| 6 - 8                          |
| compensation reduced           |
| e.g. ST-segment dynamics, tachycardia |
| > 80 bpm, hypotension, lactate acidosis |
| risk factors present:         |
| e.g. CHD, cardiac failure, stroke, renal dysfunction |

| yes                           |

| 8 - 10                        |
| compensation adequate         |

| no                            |

| > 10                          |
| compensation reduced:         |
| e.g. ST-segment dynamics, tachycardia |
| > 80 bpm, hypotension, lactate acidosis |

| yes                           |

| no                            |

**Tab.: Vereinfachter Algorithmus zur Indikationsstellung einer Erythrozytenkonzentrat-(EK-)Transfusion postoperativ auf der Normalstation.**
Post-op anemia

To be consider

- haemolysis due to, e.g. hypotonic solutions, sepsis, incompatible transfusion
- clinically apparent or occult blood loss from or into the gastro-intestinal tract
- inappropriately low erythropoietin synthesis and secretion due to stress-related inflammation
- diminished responsiveness of erythroid precursor cell to erythropoietin due to inflammation and/or decreased availability of iron (iron sequestration)
- nutritional deficiencies (e.g., vitamin B₁₂, folic acid) and pharmacological interactions
- haemodilution due to (excessive) fluid administration
Post-op

volume monitoring
Restrictive vs. Liberal

Liberal or Restrictive Transfusion after Cardiac Surgery

- PRT in 2007 patients undergoing cardiac surgery and having a postop. Hb < 9.0 g/dL
- Hb transfusion trigger: 7.5 g/dL vs. 9.0 g/dL
- Primary outcome = 3 months composite of
  - Serious infection / Ischemic event
  - Myocardial infarction / AKI
  - Infarction of the gut

Restrictive vs. Liberal

**Primary composite outcome**

HR = 1.09, 95% CI (0.93, 1.27), p = 0.29
Restrictive vs. Liberal Red-Cell Transfusion for Cardiac Surgery

- PRT in 5243 patients undergoing cardiac surgery on CPB having a EuroSCORE ≥ 6
- Hb transfusion trigger: <7.5 g/dL vs. <9.5 g/dL OR / ICU and <8.5 g/dL on the regular ward
- Primary outcome = 28 days composite of Death / MI / Stroke / new renal failure with dialysis
- Secondary outcomes
  ➞ RBC transfusions
  ➞ Clinical outcomes

This article was published on November 12, 2017, at NEJM.org.
### Table 3. Primary and Secondary Outcomes in the Per-Protocol Population.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Restrictive Threshold (N = 2430)</th>
<th>Liberal Threshold (N = 2430)</th>
<th>Odds Ratio or Hazard Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary outcome</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Composite-outcome event — no./total no. (%)</td>
<td>276/2428 (11.4)</td>
<td>303/2429 (12.5)</td>
<td>0.90 (0.76–1.07)</td>
</tr>
<tr>
<td>Death — no./total no. (%)</td>
<td>74/2427 (3.0)</td>
<td>87/2429 (3.6)</td>
<td>0.85 (0.62–1.16)</td>
</tr>
<tr>
<td>Stroke — no./total no. (%)</td>
<td>45/2428 (1.9)</td>
<td>49/2429 (2.0)</td>
<td>0.92 (0.61–1.38)</td>
</tr>
<tr>
<td>Myocardial infarction — no./total no. (%)</td>
<td>144/2428 (5.9)</td>
<td>144/2429 (5.9)</td>
<td>1.00 (0.79–1.27)</td>
</tr>
<tr>
<td>New-onset renal failure with dialysis — no./total no. (%)</td>
<td>61/2428 (2.5)</td>
<td>72/2429 (3.0)</td>
<td>0.84 (0.60–1.19)</td>
</tr>
</tbody>
</table>

### Table 2. Transfusion Outcomes in the Per-Protocol Population.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Restrictive Threshold (N = 2430)</th>
<th>Liberal Threshold (N = 2430)</th>
<th>Odds Ratio or Rate Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red-cell transfusions after randomization</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥1 Unit of red cells — no. (%)</td>
<td>1271 (52.3)</td>
<td>1765 (72.6)</td>
<td>0.41 (0.37–0.47)</td>
</tr>
<tr>
<td>No. of units of red cells transfused</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>2</td>
<td>3</td>
<td>0.85 (0.82–0.88)*</td>
</tr>
</tbody>
</table>
Transfusion Threshold of 7 g per Deciliter — The New Normal
Paul C. Hébert, M.D., and Jeffrey L. Carson, M.D.

We believe it has become abundantly clear that a transfusion threshold of 7 g per deciliter should become the new normal, recommended in all critically ill patients, including those with severe sepsis and septic shock. To speed up adoption, we should ensure that clinical practice

Point of care testing

Point of care testing
Rotem analizisi

<table>
<thead>
<tr>
<th></th>
<th>CT (s)</th>
<th>CFT (s)</th>
<th>Amplitudinea după CT (mm)</th>
<th>MCF* (mm)</th>
<th>Indicele de liză a trombului (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>10 min. A10</td>
<td>20 min. A20</td>
<td></td>
</tr>
<tr>
<td>INTEM</td>
<td>100-240</td>
<td>30-110</td>
<td>44-66</td>
<td>50-71</td>
<td>50-72</td>
</tr>
<tr>
<td>EXTEM</td>
<td>38-79</td>
<td>34-159</td>
<td>43-65</td>
<td>50-71</td>
<td>50-72</td>
</tr>
<tr>
<td>HEPTEM</td>
<td>100-240</td>
<td>30-110</td>
<td></td>
<td>50-72</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100-240**</td>
<td>30-110</td>
<td></td>
<td>50-72</td>
<td></td>
</tr>
<tr>
<td>FIBTEM</td>
<td></td>
<td></td>
<td>7-23</td>
<td>8-24</td>
<td>9-25***</td>
</tr>
<tr>
<td>APTEM</td>
<td>38-79</td>
<td>34-159</td>
<td></td>
<td>50-72</td>
<td></td>
</tr>
</tbody>
</table>
## Conventional test vs. Rotem

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>ROTEM®</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBC % transfused (%)</td>
<td>98</td>
<td>84</td>
<td>0.031</td>
</tr>
<tr>
<td>RBC units / patient</td>
<td>5</td>
<td>3</td>
<td>0.001</td>
</tr>
<tr>
<td>FFP % transfused (%)</td>
<td>80</td>
<td>40</td>
<td>0.001</td>
</tr>
<tr>
<td>FFP units / patient</td>
<td>5</td>
<td>0</td>
<td>0.001</td>
</tr>
<tr>
<td>PC % transfused (%)</td>
<td>66</td>
<td>56</td>
<td>0.412</td>
</tr>
<tr>
<td>PC units / patient</td>
<td>2</td>
<td>2</td>
<td>0.010</td>
</tr>
<tr>
<td>Fibrinogen % administered (%)</td>
<td>60</td>
<td>64</td>
<td>0.837</td>
</tr>
<tr>
<td>Fibrinogen units / patient</td>
<td>2</td>
<td>2</td>
<td>0.481</td>
</tr>
<tr>
<td>PCC % administered (%)</td>
<td>52</td>
<td>44</td>
<td>0.433</td>
</tr>
<tr>
<td>rFVIIa % administered (%)</td>
<td>24</td>
<td>2</td>
<td>0.002</td>
</tr>
<tr>
<td>Cost of hemotherapy (Euro)</td>
<td>3109</td>
<td>1658</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Conventional test vs. Rotem

Active bleeding

Stop bleeding

Perfusion
Stop hemorrhage

- Keep patient alive
  - permissive hypotension
  - limit fluid infusion (dilution)

- Stop hemorrhage
  - early surgery, damage control

- Maintain coagulation competence
  - target coagulopathy
Disease coagulopathy?

FIBRINOLYSIS
Disease coagulopathy

- Antifibrinolitic: TxA
  - 1.0 gr. i.v. over 10 min.
  - if necessary after 30 min 1.0 gr. i.v./10 min
  - first 3 hours

- Co-factors: Ca++, Ph, Temperature control
Take home messages

- Anaemia and allogenic blood transfusion are independent risk factors for poor postoperative outcomes: morbidity and mortality.
- One-third of patients are found to be anaemic on pre-assessment.
- PBM is a concept with the goal of avoiding unnecessary blood transfusions to improve patient outcomes and safety.
- Iron deficiency requires iron supplementation.