Patient Blood Management

Patient Blood Management: A Multimodal Strategy to Improve Outcome by Optimizing, Conserving and Managing Patients’ Own Blood

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Patient Blood Management

PBM is seen as a new paradigm in transfusion medicine

The aim of this workshop is

- to explain the rationals and fundamentals of PBM
- to help to implement this strategy
- to improve patients’ outcome and to reduce costs
Illustration of the benchmarking process

Road Map for Benchmarking

1. Use comparison to identify practice differences*

2. Introduce factors associated with best practices

3. Re-evaluation of performance

Benchmarking is a Continuous Process

*Steps:
  a) Select benchmarking indicator
  b) Identify comparator(s)
  c) Access/retrieve information
  d) Analyze information to identify factors associated with difference in practice

Apelseth et al: Transfusion Medicine Reviews, Vol 0, No 0 (Month), 2011: pp 1-12
Potential uses of benchmarking in transfusion medicine.

Apelseth et al: Transfusion Medicine Reviews, Vol 0, No 0 (Month), 2011: pp 1-12
<table>
<thead>
<tr>
<th>Intervention</th>
<th>Products</th>
<th>Measure</th>
<th>Relative Change, %</th>
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<tbody>
<tr>
<td>Guideline</td>
<td>RBCs</td>
<td>Proportion of patients receiving transfusions</td>
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<td>Patients</td>
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<td>Units/patient</td>
<td>–21 to –62</td>
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<td></td>
<td>FFP</td>
<td>Proportion of patients receiving transfusions</td>
<td>–18</td>
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<tr>
<td></td>
<td>Units</td>
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<td>–91 to –77</td>
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<td>Albumin</td>
<td>Grams</td>
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<tr>
<td></td>
<td>Cryoprecipitate</td>
<td>Units/patient</td>
<td>–44</td>
</tr>
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<td>Audit/feedback</td>
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<td>Regression slope of units/patient per month</td>
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<td>–19 to –62</td>
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<tr>
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<td>FFP</td>
<td>Proportion of patients receiving transfusions</td>
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<td>–15 to –17</td>
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<td>Cryoprecipitate</td>
<td>Units/patient</td>
<td>–44</td>
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<td>Albumin</td>
<td>Grams</td>
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<td>Education</td>
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<tr>
<td></td>
<td>Units/patient</td>
<td></td>
<td>–46 to –77</td>
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</tbody>
</table>
Durability of change in transfusion practice — inappropriate transfusions

Multiple interventions evaluated 3 years after start of interventions: guidelines, education, new transfusion form, prospective audit

RBC Transfusions in Austria

- 5th highest RBC utilization per capita
- Extreme inter-center transfusion variability for matched pa

Potential consequences?

Transfusion culture remains unchanged

Optimal use of blood products
Manual of Optimal Blood Project
Support for safe, clinically effective blood transfusion

Essentials of decision on transfusion
- Assess clinical condition
- Use clinical guidelines
- Inform patient and obtain consent
- Record the decision and rationale

Essentials of ordering blood component
- Identify the patient correctly
- Take blood sample and correctly label the tube
- Complete the request/electronic order form correctly
- Take note of special transfusion requirements
- Send the sample and request form to the Blood Bank
- Communicate with Blood Bank if blood is required urgently

Essentials of monitoring transfused patient
- Monitor patient’s vital signs regularly
- Recognise, diagnose, respond to adverse event
- Record outcome of transfusion
- Assess need for further transfusion

Essentials of administering blood components
- Identify the patient correctly
- Ensure there is a written instruction to transfuse
- Record pretransfusion vital signs
- Check (control) patients blood group if this is normal procedure
- Repeat check of patient identification against component label/documentation
- Inspect component unit/check expiry date
- Set rate of transfusion according to instructions
- Complete all documentation

Essentials of delivery to clinical area
- Component labelling must match patient identifiers
- Record removal of unit from storage location
- Deliver to appropriate person in clinical area
- Maintain correct storage conditions until transfusion

Essentials of pretransfusion testing
- Determine patient’s ABO and RhD type
- Detect clinically significant red cell antibodies
- Select and crossmatch red cell units
- Apply compatibility label
RBC Transfusions in Austria

• 5th highest RBC utilization per capita
• Extreme inter-center transfusion variability for matched pa

Potential consequences?

Transfusion culture remains unchanged
Optimal use of blood products
Patient Blood Management

BBM  EBM
What is patient blood management?

• PBM views a patient’s own blood as a valuable and unique natural resource that should be conserved and managed appropriately.

• PBM employs a patient-specific perioperative multi-disciplinary, multimodal team approach to optimising, conserving and managing patients own blood.

• PBM aims to identify patients at risk of anemia and provide a managed plan aimed at reducing or eliminating the need for allogeneic transfusion with an acceptable risk of anemia.
Comprehensive Multimodality Blood Conservation: 100 Consecutive CABG Operations Without Transfusion

Preoperative $\rightarrow$ Intraoperative $\rightarrow$ Postoperative

- YES $\rightarrow$ EPO, Iron, YES $\rightarrow$ Aprotinin
- Hct <36% RCM <1600 cc
- NO $\rightarrow$ Iron NO

- Heparin ASA < 5 days Bleeding Hx

- Minimize crystalloid
- Small volume circuit
- Large volume IAD
- RAP
- Intraoperative salvage
- Optimal surgical technique / hemostasis
- Lowest safe hct (16%)
- Rapid / sustained re-warming

- Shed Mediastinal Blood Reinfusion
- Bleeding Protocol
- Lowest safe HCT transfusion trigger:
  1. < 22% (age < 75)
  2. < 24% (age > 75)
- Minimum safe PLT / Coag Factor guidelines
- Minimum Laboratory Sampling
- Postoperative EPO:
  1. Hct < 24%
  2. Re-op for bleeding
  3. Mechanical ventricular support

Measures to optimize the use of blood components in selected surgical procedures in Austrian hospitals

## Predictors of RBC transfusions

<table>
<thead>
<tr>
<th>Procedure</th>
<th>THR</th>
<th>TKR</th>
<th>CABG</th>
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</thead>
<tbody>
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<td><strong>Independent Variable</strong></td>
<td>Odds ratio (95% CI)</td>
<td>Odds ratio (95% CI)</td>
<td>Odds ratio (95% CI)</td>
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<tr>
<td>Hemoglobin preop.(%)*</td>
<td>0.65 (0.60;0.70)</td>
<td>0.68 (0.63;0.73)</td>
<td>0.69 (0.63;0.75)</td>
</tr>
<tr>
<td>Min. hemoglobin postop.(%)*</td>
<td>1.50 (1.38;1.64)</td>
<td>1.48 (1.35;1.63)</td>
<td>1.52 (1.36;1.70)</td>
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<tr>
<td>Lost RBC volume (%) **</td>
<td>1.82 (1.64;2.01)</td>
<td>1.81 (1.62;2.02)</td>
<td>1.81 (1.58;2.07)</td>
</tr>
<tr>
<td>Center rank‡</td>
<td>1.34 (1.24;1.46)</td>
<td>1.35 (1.25;1.46)</td>
<td>-</td>
</tr>
<tr>
<td>Correctly classified (%)</td>
<td>97.4%</td>
<td>97.2%</td>
<td>97.0%</td>
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</tbody>
</table>

* Percentage of WHO cut-off values
** Percentage of the preoperatively circulating RBC volume
‡ Centers ranked according to the mean perioperative RBC loss
Principle of PBM

1st Pillar: Optimize erythropoiesis
- Detect anemia
- Identify underlying disorder(s) causing anemia
- Manage disorder(s)
- Refer for further evaluation if necessary
- Treat suboptimal iron stores/iron deficiency/anemia of chronic disease/iron-restricted erythropoiesis
- Treat other hematologic deficiencies

Note: Anemia is a contraindication for elective surgery

2nd Pillar: Minimize blood loss & bleeding
- Identify and manage bleeding risk
- Minimizing iatrogenic blood loss
- Procedure planning and rehearsal
- Preoperative autologous blood donation (in selected cases or when patient choice)
- Other

3rd Pillar: Harness & optimize physiological reserve of anaemia
- Assess/optimize patient’s physiological reserve and risk factors
- Compare estimated blood loss with patient-specific tolerable blood loss
- Formulate patient-specific management plan using appropriate blood conservation modalities to minimize blood loss, optimize red cell mass and manage anemia
- Restrictive transfusion thresholds

Preoperative:
- Timing surgery with hematological optimization

Intraoperative:
- Meticulous hemostasis and surgical techniques
- Blood-sparing surgical techniques
- Anesthetic blood conserving strategies
- Autologous blood options
- Pharmacological/hemostatic agents

Postoperative:
- Vigilant monitoring and management of post-operative bleeding
- Avoid secondary hemorrhage
- Rapid warming / maintain normothermia (unless hypothermia specifically indicated)
- Autologous blood salvage
- Minimizing iatrogenic blood loss
- Hemostasis/anticoagulation management
- Prophylaxis of upper GI hemorrhage
- Avoid/treat infections promptly
- Be aware of adverse effects of medication

- Optimize cardiac output
- Optimize ventilation and oxygenation
- Restrictive transfusion thresholds

- Optimize anemia reserve
- Maximize oxygen delivery
- Minimize oxygen consumption
- Avoid/treat infections promptly
- Restrictive transfusion thresholds
Clinician's Transfusion-Trigger Hb

Expected Nadir Hb Patient 1

Blood loss 1,800ml

Pre-op Hb Patient 1

Scenario 1 – Patient treated w/o PBM

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Expected Nadir Hb

Pre-op Hb
Patient 1

Clinician's
Transfusion-Trigger Hb

Blood loss 1,800ml

Scenario 2 – Patient treated w/ PBM

Optimise haemopoiesis

• Fe
• B₁₂
• Folic Acid
• ESAs

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Expected Nadir Hb Patient 1

Pre-op Hb Patient 1

Clinician's Transfusion-Trigger Hb

Blood loss 1,800ml

Blood loss 1,000ml

Scenario 2 – Patient treated w/ PBM

Minimise blood loss & bleeding

- Meticulous surgical hemostasis
- Topical hemostatic agents
- Systemic hemostatic agents
- Anesthesiological techniques
- Normothermia
- Induced hypotension
- etc.

Hb g/dL

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Expected Nadir Hb  
Pre-op Hb Patient 1

Clinician's Transfusion-Trigger Hb

Blood loss 1,000ml

Scenario 2 – Patient treated w/ PBM

3rd Pillar
Harness & optimise physiological tolerance of anaemia

• Keep pt. normovolemic
• FiO₂ 100%
• Minimising metabolic demand

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Patient Blood Management: The Pragmatic Solution for the Problems with Blood Transfusions


New Blood, Old Blood, or No Blood?
John W. Adamson, M.D.

Patient blood management

Patient blood management is key before elective surgery

Writing in The Lancet, Khalel Musallam and colleagues address an important topic through their analysis of the American College of Surgeons' National Surgical Quality Improvement Program database: namely, what is the prevalence of preoperative anaemia in patients undergoing major non-cardiac surgery and what are the implications? Moreover, by removal of data for allogeneic red-blood-cell transfusions in their analysis (and thus in the absence of treatment for anaemia) the independent and natural course of preoperative anaemia is shown. The main finding of their study was that preoperative anaemia—even to a mild degree—was significantly and independently associated with increased postoperative morbidity and mortality. This association might be aggravated by coexistent perioperative blood loss and (frequently unnecessary) alloeneic transfusions. I believe that Musallam and colleagues' findings could have an enormous effect on health-care systems worldwide because preoperative diagnosis and treatment of anaemia (apart from transfusions of red blood cells) has almost never been undertaken routinely before surgery.1

Anaemia is a serious but easily treatable condition. Treatment is less costly than is transfusion and would possibly improve outcomes, not only by increased tolerance of perioperative blood loss and avoidance of allogeneic transfusions but also through elimination of the risk of anaemia by maintaining increased physiological haemoglobin values throughout the perioperative period.1

Because of the nature of Musallam and colleagues' retrospective observational study,1 the cause of anaemia was not assessed. However, about a third of patients with anaemia probably would have had nutritional deficiencies, a third probably would have had chronic disease, and a third would have had anaemia from an unknown cause.1 Moreover, diagnostic and interventional blood loss might have had an additional role in the rates of anaemia reported.

Because of the prevalence, treatability, and negative outcomes of preoperative anaemia, preservation and improvement of preoperative red-blood-cell mass is essential as one of the three pillars of the new patient blood management strategy,1 which lasts for the entire perioperative period and has a patient-specific perioperative multidisciplinary and multifaceted team approach.
Patient Blood Management (Teil 1)
Individuelles Behandlungskonzept zur Reduktion und Vermeidung von Anämie, Blutverlust und Transfusionen

Der Beitrag ist im Rahmen der 2. Österreichischen Benchmark-Studie entstanden, die vom Fonds der Bundesgesundheitsagentur finanziert wurde.

Hans Gombotz • Axel Hofmann • Peter Rehak • Johann Kurz

Engfäule zu vermeiden. Geht man in Mitteleuropa von derzeitigen Verhältnissen aus, werden durch Verzögerung des Bluttransfusionsmanagements und durch fortlaufende Überprüfung der Verbraucher häufig der Bluttransfusionssaldo gesteigert [9, 10]. Derzeit erhalten Patienten

> zwischen 0–19 Lebensjahr 1,7
> über 80 Jahre etwa 236,8 g Hämoglobin/pro Jahr


Historische Entwicklung: Die Lipidversorgung im Zentrum der zentralen Behandlung von Transfusion von Blutprodukten und Komponenten wie z.B.

> erhöht eingeschränkte Volumenverabreichung (VCD)
> Transfusionssensor (TRASI)

> und werden anlagernder Intensiv- und Spitalaufnahme sowie einer erhöhten Mortalität.


> Diese Probleme der Bluttransfusion sind durch den Risikos einer vorbestehenden oder neu auftretenden Anämie und des Risikos eine Bluttransfusion zur Gegenüberstellung [6–8].

Die richtungsweisende Bluttransfusion ist mit erhöhten Infektkosten und Infektkomplikationen, transformativer Volumenverabreichung (VCD) oder therapeutischer Lungentransfusion (TRASI) sowie einer erheblichen Leitfähigkeit verbunden.

Das Modell „Patient Blood Management“

Multidisziplinär: Patient Blood Management (PBM) ist ein multidisziplinäres, evidenzbasiertes Behandlungsmittel, das zum Ziel hat, durch

> saubere Übertragung von Transfusionen
> Vermeidung von Blutverlust und Transfusionen

Zusammenfassend: Verfügbar (auch online), Verständigung von Angiogenese und Phlebologie (auch online)

Patient Blood Management
A 68-Year-Old Woman Contemplating Autologous Blood Donation Before Elective Surgery

Lynne Uhl, MD, Discussant

Dr Tess: Ms C is a 68-year-old woman who presented with progressive right knee pain and swelling. She first developed pain and swelling in her right knee in 2003 and was diagnosed as having osteoarthritis. She underwent arthroscopy and bursectomy in 2006, but in the last few years, she has experienced worsening of her pain as well as significant physical limitations. Joint injections with steroids have resulted in little improvement, and now she is planning to undergo knee replacement surgery in 8 weeks.

Ms C's medical history includes osteoarthritis, hypertension, hyperthyroidism, hypercholesterolemia, and uterine fibroids in addition to the arthroscopy in 2006. Her medications include hydrochlorothiazide, levothyroxine, simvastatin, and aspirin. She has no known drug allergies.

On examination, Ms C is a healthy-appearing woman with normal vital signs. Her physical examination results were normal except for pain on palpation of her medial right knee, an antalgic gait, and difficulty with toe and heel walking due to pain. A routine complete blood cell count revealed a white blood cell count of 7900/µL, hemoglobin level of 15.1 g/dL, mean corpuscular volume of 88.8 fl, and blood cell (RBC) dias.

Globally, more than 81 million units of red blood cells are transfused annually. Of the 15 million red blood cell components transfused annually in the United States, approximately 40% are transfused to patients undergoing elective surgical procedures. Because of concerns about limited blood availability as well as risks of transfusion-related adverse events, blood products should be used judiciously. Using the case of Ms C, a 68-year-old woman considering autologous blood donation prior to knee replacement surgery, the concept of patient blood management is discussed. This approach entails a complete evaluation of the patient in the preoperative period to assess for bleeding risks and anemia, with a goal to optimize a patient’s condition prior to surgery; use of various strategies in the operative period to mitigate the need for allogeneic blood transfusion; and meticulous postoperative care to again avoid the need for blood transfusion.
WHA63.12 adopted by resolution May 21, 2010:

„Bearing in mind that patient blood management means that before surgery every reasonable measure should be taken to optimize the patient’s own blood volume, to minimize the patient’s blood loss and to harness and optimize the patient-specific physiological tolerance of anaemia following WHO’s guide for optimal clinical use (three pillars of patient blood management)“
Meeting of the Advisory Committee on Blood Safety and Availability

On June 8, 2011, the Committee will be asked to review and comment on WHA 63.12 regarding the availability, safety and quality of blood products. [http://apps.who.int/gb/ebwha/pdf_files/WHA63/A63_R12-en.pdf](http://apps.who.int/gb/ebwha/pdf_files/WHA63/A63_R12-en.pdf) Specifically the Committee will be asked to review the current status of safe and rational use of blood products in patient blood management and assess the current status in the U.S.
Australia

The review of the 2001 NHMRC/ASBT Clinical Practice Guidelines for the Use of Blood Components is being undertaken with funding and project management provided by the National Blood Authority (NBA) on behalf of all governments. The NBA has facilitated the formulation of a Steering Committee, Expert Working Group, and Clinical/Consumer Reference Groups.

NHMRC Guidelines Development:

Module 1 - Critical Bleeding/Massive Transfusion
Module 2 - Peri operative
Module 3 - Medical
Module 4 - Intensive Care
Module 5 - Obstetric
Module 6 - Paediatric/Neonates

Tut etwas Blut immer gut?

Ärzte kritisieren den verschwenderischen Umgang mit Blutkonserven, die längst nicht nur für Notfallpatienten verwendet werden. Dabei ist die Übertragung nicht ohne Risiko.

Von Nicola von Lutterotti


Rationale for PBM

- Blood supply issues
- Cost of blood
- Transfusion practice variability
- Transfusion safety and effectiveness
Rationale for PBM

- Blood supply issues
- Cost of blood
- Transfusion practice variability
- Transfusion safety and effectiveness
Blood supply issues

Red cell transfusion and age of population

% pts. and age

Units transfused/1000 inhabitants

Source: Compiled from WA Tomorrow
Impact of the Ageing Population on Blood Demand

- The 70- to 80-year-olds have an eightfold higher RBC consumption than 20- to 40-year-olds.

Fig. 2. RBC usage per capita by age in Finland 2002 to 2006. Current annual RBC usage in Finland is 50 units per 1000 inhabitants.
Rationale for PBM

- Blood supply issues
- **Cost of blood**
- Transfusion practice variability
- Transfusion safety and effectiveness
Activity Based Cost of Transfusion from a Provider’s Perspective

The cost of blood transfusion in Western Europe as estimated from six studies

<table>
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<th>Year of data</th>
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Ivo Abraham and Diana Sun

TRANSFUSION **,**, **,** **,
Cost of transfusion outcome
Frequency and outcomes of blood products transfusion across procedures and clinical conditions warranting inpatient care: an analysis of the 2004 healthcare cost and utilization project nationwide inpatient sample database.

- Retrospective cohort study of all hospitalisations in the US in 2004 (n=38.66 million) to assess in-hospital outcomes associated with blood transfusion.
- 5.8% (2.33 million) transfused
- After adjustment for age, gender, comorbidities, admission type or DRG transfusion associated with:
  - 1.7 increased odds of death (P<0.0001)
  - 1.9 increased odds of infection (P<0.0001)
  - 2.5 days longer LOS
  - $17,194 higher charges (P<0.0001)

$40.1 billion more charges for txed pts!

Rationale for PBM

• Blood supply issues
• Cost of blood
  • Transfusion practice variability
  • Transfusion safety and effectiveness
Variation in Use of Blood Transfusion in Coronary Artery Bypass Graft Surgery

Elliott Bennett-Guerrero; Yue Zhao; Sean M. O'Brien; et al.


http://jama.ama-assn.org/cgi/content/full/304/14/1568

Observed Variation in Hospital-Specific Transfusion Rates for Primary Isolated CABG Surgery With Cardiopulmonary Bypass During 2008 (N=798 Sites)
Measures to optimize the use of blood components in selected surgical procedures in Austrian hospitals

RBC loss (%) and % patients transfused in THR and TKR

Practice against guidelines/literature
(WA-Blood Project)


Absolute hemoglobin values in females were significantly lower throughout the perioperative course, whereby relative hemoglobin values were nearly identical before surgery but considerably higher on postoperative day 5 (p<0.001)
Rationale for PBM

• Blood supply issues
• Cost of blood
• Transfusion practice variability
• Transfusion safety and effectiveness
Source of swine flu discovered!!
Pathogens – Costly Fear

The AUSTRALIAN RED CROSS discarded 33,600 liters of donated blood as the result of fears that it was contaminated with dengue fever following an outbreak of the disease in northern Queensland in late 2009 and 2010, according to a report in the *Sunday Herald Sun*.

That loss ... accounted for about 7% of its overall blood supply.
Ansteckungsweg über das Blut können Bluttransfusionen Alzheimer übertragen?

Alzheimerforscher haben Hinweise darauf gefunden, dass die Demenzerkrankung via Bluttransfusionen übertragen werden könnte. Unklar ist, in welcher Konzentration die mutmaßlichen Erreger ansteckend sein könnten.

Amerikanischen Neurowissenschaftlern soll es in einem Tierversuch gelungen sein, Alzheimer auf dem Blutweg von einer kranken Maus auf eine gesunde zu übertragen. Die Ergebnisse wurden allerdings noch nicht in einem seriösen Fachblatt veröffentlicht. Der Molekularbiologe Christian Haass von der Universität München sagte FOCUS, es könnte möglich sein, dass die Ansteckung über Eiweißmoleküle im Blut verlaufe. ... Allerdings sei eine Altersbegrenzung für Blutspender „vielleicht sinnvoll“.

Risks of Blood Transfusion
Overview of SHOT reports (366) 1996-1998

- Incorrect blood/component transfused (191)
- Acute transfusion reaction (55)
- Delayed transfusion reaction (51)
- Graft versus host disease (8)
- Acute lung injury (27)
- Post transfusion purpura (22)
- Transfusion transmitted infections (12)
A Multicenter, Randomized, Controlled Clinical Trial
of Transfusion Requirements in Critical Care
(Complications during ICU-stay)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Restrictive (n=418)</th>
<th>Liberal (n=420)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac</td>
<td>55 (13.2%)</td>
<td>88 (21.0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pulmonary</td>
<td>106 (25.4%)</td>
<td>122 (29.0%)</td>
<td>0.22</td>
</tr>
<tr>
<td>Infectious</td>
<td>42 (10.0%)</td>
<td>50 (11.9%)</td>
<td>0.38</td>
</tr>
<tr>
<td>Gastrointestinal</td>
<td>13 (3.1%)</td>
<td>19 (4.5%)</td>
<td>0.28</td>
</tr>
<tr>
<td>Neurologic</td>
<td>25 (6.0%)</td>
<td>33 (7.9%)</td>
<td>0.28</td>
</tr>
<tr>
<td>Shock</td>
<td>67 (16%)</td>
<td>55 (13.1%)</td>
<td>0.23</td>
</tr>
<tr>
<td>Any</td>
<td>205 (49.0%)</td>
<td>228 (54.3%)</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Hebert P.C. et al: NEJM 340, 409-17, 1999
Table 2. Frequencies of Composite Infection and Ischemic Outcomes

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Not Transfused</th>
<th>Transfused</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>n</td>
</tr>
<tr>
<td>Infection*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nadir hematocrit &lt; 21</td>
<td>52</td>
<td>1</td>
</tr>
<tr>
<td>Nadir hematocrit ≥ 21 and &lt; 24</td>
<td>390</td>
<td>16</td>
</tr>
<tr>
<td>Nadir hematocrit ≥ 24 and &lt; 27</td>
<td>1176</td>
<td>42</td>
</tr>
<tr>
<td>Nadir hematocrit ≥ 27</td>
<td>2056</td>
<td>82</td>
</tr>
<tr>
<td>Ischemia†</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nadir hematocrit &lt; 21</td>
<td>52</td>
<td>1</td>
</tr>
<tr>
<td>Nadir hematocrit ≥ 21 and &lt; 24</td>
<td>390</td>
<td>13</td>
</tr>
<tr>
<td>Nadir hematocrit ≥ 24 and &lt; 27</td>
<td>1175</td>
<td>40</td>
</tr>
<tr>
<td>Nadir hematocrit ≥ 27</td>
<td>2053</td>
<td>72</td>
</tr>
</tbody>
</table>

Intraoperative Transfusion of 1 U to 2 U Packed Red Blood Cells Is Associated with Increased 30-Day Mortality, Surgical-Site Infection, Pneumonia, and Sepsis in General Surgery Patients

Propensity and risk adjusted odds ratios (95% CI) for 30-day mortality and morbidity by level of intraoperative transfusion. Both morbidity and mortality risks were substantially increased after only 1 U RBC transfusion intraoperatively and continued to increase with increasing units. Circles, mortality; squares, morbidity.

Intraoperative Transfusion of Small Amounts of Blood Heralds Worse Postoperative Outcome in Patients Having Noncardiac Thoracic Operations

8728 nonvascular thoracic operations in patients from 173 hospitals. Of these, 7875 (90.2%) did not receive intraoperative transfusions.
## Association of RBC transfusions with mortality and morbidity in critically ill in observational studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Design</th>
<th>Number</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ciesla, 2005&lt;sup&gt;13&lt;/sup&gt;</td>
<td>Trauma</td>
<td>Prospective cohort</td>
<td>1,344</td>
<td>Increased multiorgan failure</td>
</tr>
<tr>
<td>Gong, 2005&lt;sup&gt;106&lt;/sup&gt;</td>
<td>ICU patients</td>
<td>Prospective cohort</td>
<td>688</td>
<td>Increased risk of ARDS&lt;sup&gt;*&lt;/sup&gt;</td>
</tr>
<tr>
<td>Lebron, 2005&lt;sup&gt;109&lt;/sup&gt;</td>
<td>Liver transplant</td>
<td>Retrospective cohort</td>
<td>241</td>
<td>Increased early postoperative renal failure</td>
</tr>
<tr>
<td>Shorr, 2005&lt;sup&gt;107&lt;/sup&gt;</td>
<td>ICU patients</td>
<td>Prospective cohort</td>
<td>3,502</td>
<td>Increased ICU acquired bacteremia</td>
</tr>
<tr>
<td>Silverboard, 2005&lt;sup&gt;,112&lt;/sup&gt;</td>
<td>Trauma</td>
<td>Prospective cohort</td>
<td>102</td>
<td>Increased risk of ARDS</td>
</tr>
<tr>
<td>Smith, 2004&lt;sup&gt;108&lt;/sup&gt;</td>
<td>Subarachnoid hemorrhage</td>
<td>Prospective cohort</td>
<td>441</td>
<td>Worse outcome with intraoperative transfusions</td>
</tr>
<tr>
<td>Vincent, 2004&lt;sup&gt;5&lt;/sup&gt;</td>
<td>ICU patients</td>
<td>Prospective cohort</td>
<td>1,136</td>
<td>Increased ICU, hospital and 28-day mortality</td>
</tr>
<tr>
<td>Leal-Noval, 2003&lt;sup&gt;104&lt;/sup&gt;</td>
<td>Cardiac surgery</td>
<td>Prospective cohort</td>
<td>103</td>
<td>Increased organ dysfunction</td>
</tr>
<tr>
<td>Malone, 2003&lt;sup&gt;95&lt;/sup&gt;</td>
<td>Trauma</td>
<td>Prospective cohort</td>
<td>15,534</td>
<td>Increased ICU LOS, mechanical ventilation, and pneumonia</td>
</tr>
<tr>
<td>Chelemor, 2002&lt;sup&gt;100&lt;/sup&gt;</td>
<td>CABG</td>
<td>Prospective cohort</td>
<td>533</td>
<td>Increased mortality</td>
</tr>
<tr>
<td>Claridge, 2002&lt;sup&gt;110&lt;/sup&gt;</td>
<td>Trauma</td>
<td>Prospective cohort</td>
<td>1,593</td>
<td>Increased bacterial infections</td>
</tr>
<tr>
<td>Corwin, 2002&lt;sup&gt;4&lt;/sup&gt;</td>
<td>ICU</td>
<td>Prospective cohort</td>
<td>4,892</td>
<td>Increased infection</td>
</tr>
<tr>
<td>Taylor, 2002&lt;sup&gt;95&lt;/sup&gt;</td>
<td>ICU</td>
<td>Retrospective cohort</td>
<td>1,717</td>
<td>Increased ICU and hospital LOS</td>
</tr>
<tr>
<td>Vamvakas, 2002&lt;sup&gt;111&lt;/sup&gt;</td>
<td>Cardiac surgery</td>
<td>Retrospective cohort</td>
<td>416</td>
<td>Increased complications</td>
</tr>
<tr>
<td>Leal-Noval, 2001&lt;sup&gt;96&lt;/sup&gt;</td>
<td>Cardiac surgery</td>
<td>Prospective cohort</td>
<td>738</td>
<td>Increased nosocomial infections, ICU LOS, and mortality</td>
</tr>
<tr>
<td>Chang, 2000&lt;sup&gt;97&lt;/sup&gt;</td>
<td>Colorectal surgery</td>
<td>Retrospective cohort</td>
<td>282</td>
<td>Increased postoperative ventilation associated with volume of RBC supernatant</td>
</tr>
<tr>
<td>Carson, 1999&lt;sup&gt;101&lt;/sup&gt;</td>
<td>Hip fracture</td>
<td>Retrospective cohort</td>
<td>9,598</td>
<td>Increased postoperative infection</td>
</tr>
<tr>
<td>Offner, 1999&lt;sup&gt;105&lt;/sup&gt;</td>
<td>Trauma</td>
<td>Prospective cohort</td>
<td>61</td>
<td>Increased mortality</td>
</tr>
<tr>
<td>Vamvakas, 1999&lt;sup&gt;103&lt;/sup&gt;</td>
<td>Cardiac surgery</td>
<td>Retrospective cohort</td>
<td>416</td>
<td>Increased risk of serious bacterial infection and pneumonia</td>
</tr>
<tr>
<td>Carson, 1998&lt;sup&gt;141&lt;/sup&gt;</td>
<td>Hip fracture</td>
<td>Retrospective cohort</td>
<td>513</td>
<td>Increased multiorgan failure</td>
</tr>
<tr>
<td>Moore, 1997&lt;sup&gt;102&lt;/sup&gt;</td>
<td>Trauma</td>
<td>Prospective cohort</td>
<td>698</td>
<td>Increased mortality</td>
</tr>
</tbody>
</table>

* ARDS = acute respiratory distress syndrome.

Adverse Blood Transfusion Outcomes: Establishing Causation

James P. Isbister, Aryeh Shander, Donat R. Spahn, Jochen Erhard, Shannon L. Farmer, and Axel Hofmann

The transfusion of allogeneic red blood cells (RBCs) and other blood components is ingrained in modern medical practice. The rationale for administering transfusions is based on key assumptions that efficacy is established and risks are acceptable and minimized. Despite the cliché that, “the blood supply is safer than ever,” data about risks and lack of efficacy of RBC transfusions in several clinical settings have steadily accumulated. Frequentist statisticians and clinicians demand evidence from randomized clinical trials (RCTs); however, causation for the recognized serious hazards of allogeneic transfusion has never been established in this manner. On the other hand, the preponderance of evidence implicating RBC transfusions in adverse clinical outcomes related to immunomodulation and the storage lesion comes from observational studies, and a broad and critical analysis to evaluate causation is overdue. It is suggested in several circumstances that this cannot wait for the design, execution, and conduct of rigorous RCTs. We begin by examining the nature and definition of causation with relevant examples from transfusion medicine. Deductive deterministic methods may be applied to most of the well-accepted and understood serious hazards of transfusion, with modified Koch’s postulates being fulfilled in most circumstances. On the other hand, when several possible interacting risk factors exist and RBC transfusions are associated with adverse clinical outcomes, establishing causation requires inferential probabilistic methodology. In the latter circumstances, the case for RBC transfusions being causal for adverse clinical outcomes can be strengthened by applying modified Bradford Hill criteria to the plethora of existing observational studies. This being the case, a greater precautionary approach to RBC transfusion is necessary and equipoise that justifying RCTs may become problematic.

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Observational Studies by Outcome
n > 10,000

Σn = 335,306

Adverse outcome Mixed
Inappropriate use of blood products

- Overtransfusion
  - Risk of unnecessary transfusions
    - Mortality
    - Morbidity
  - Increased costs
- Undertransfusion
  - Risk of anemia
    - Mortality
    - Morbidity
- Transfusion process per se
  - Mortality
  - Morbidity

Increased costs
Mortality
Morbidity
Risk of Mortality and Morbidity

Anemia with CVD

Anemia without CVD

Transfusion

From “Blood loss“ to “Less blood“

Risk of anemia + Risk of blood loss + Risk of transfusion = ?????
Components of PBM

- Evaluation of the actual blood usage (data management)
- Optimising blood ordering schedules
- Increasing tolerance of anemia
- 3 pillar strategy
  - Optimising preoperative red cell mass
  - Minimising perioperative blood loss
  - Reducing transfusion trigger
Components of PBM

• Evaluation of the actual blood usage (data management)
• Optimising blood ordering schedules
• Increasing tolerance of anemia
• 3 pillar strategy
  – Optimising preoperative red cell mass
  – Minimising perioperative blood loss
  – Reducing transfusion trigger
Data Management

Total units transfused per year

Example from EMMC USA Total units transfused by year
### Data Management

#### Pre & Post txn Hb

**Centre # 1 ICU**

<table>
<thead>
<tr>
<th>Pre txn Hb</th>
<th>Post txn Hb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>78</td>
</tr>
<tr>
<td>Median</td>
<td>74</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Units txd</th>
<th>Post txn Hb rise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.3</td>
</tr>
<tr>
<td>Median</td>
<td>2</td>
</tr>
</tbody>
</table>

**Centre # 2 ICU**

<table>
<thead>
<tr>
<th>Pre txn Hb</th>
<th>Post txn Hb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>86</td>
</tr>
<tr>
<td>Median</td>
<td>79</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Units txd</th>
<th>Post txn Hb rise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>3.4</td>
</tr>
<tr>
<td>Median</td>
<td>2</td>
</tr>
</tbody>
</table>
Data Management

RBC transfusion rate and outcomes

Column chart without data table

RBC transfusion rate and outcomes
Continuous benchmarking – a cost-effective PBM tool
Principal Diagnoses w/ +200 RBCs Transfused – Western Australia Metro 2010
(32 of 1,055 Principal Diagnoses w/ RBC Txns)

12,386 RBC Units
Components of PBM

• Evaluation of the actual blood usage (data management)

• **Optimising blood ordering schedules**

• Increasing tolerance of anemia

• 3 pillar strategy
  – Optimising preoperative red cell mass
  – Minimising perioperative blood loss
  – Reducing transfusion trigger
Vergleich: Bereitstellung EK

EK pro Tausend PatientInnen

<table>
<thead>
<tr>
<th>Erhebung 1</th>
<th>Erhebung 2*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verabreicht, nicht bereitgestellt</td>
<td>11,3%</td>
</tr>
<tr>
<td>bereitgestellt und nicht verabreicht</td>
<td>60,2%</td>
</tr>
<tr>
<td>bereitgestellt und verabreicht</td>
<td>28,5%</td>
</tr>
</tbody>
</table>

* ohne ReOP
Quantity of Type and Screens, Crossmatches and RBC Transfused

CTR Rate Crossmatch vs. Transfusions

Goal at least 1,8:1
### MSBOS
Maximum Blood Ordering Schedule

<table>
<thead>
<tr>
<th>Authors</th>
<th>Type of surgery</th>
<th>CTR before</th>
<th>CTR after</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rogers et al. 2006</td>
<td>Orthopedics</td>
<td>3.21 : 1</td>
<td>1.62 : 1</td>
</tr>
<tr>
<td>Mehra et al. 2004</td>
<td>Knee replacement</td>
<td>4.90 : 1</td>
<td>1.70 : 1</td>
</tr>
<tr>
<td>Foley et al. 2003</td>
<td>Gynecology</td>
<td>2.25 : 1</td>
<td>1.71 : 1</td>
</tr>
<tr>
<td>Richardson et al. 1998</td>
<td>Various</td>
<td>1.80 : 1</td>
<td>1.80 : 1</td>
</tr>
</tbody>
</table>

1.7: 1 = reduction of ....€

Thalia Palmer, BS, Joyce A. Wahr, MD, Michael O’Reilly, MD, and Mary Lou V.H. Greenfield, MPH, MS

Department of Anesthesiology, University of Michigan Health System, Ann Arbor

Anesth Analg 2003;96:369–75
Data Management

Single RBC unit txns vs total units txd

Example from EMMC USA
Significant reduction of red blood cell transfusion requirements by changing from a double-unit to a single-unit transfusion policy in patients receiving intensive chemotherapy or stem cell transplantation.

**Figure 1.** Reduction of RBC units per therapy and transfusion-free time. The box plots display medians, interquartile ranges, and 95% confidence intervals. The double RBC-unit period is represented in light gray and the single-unit period in dark gray. (A) Changing the transfusion policy led to a 25% reduction of the transfused RBC units per therapy cycle ($P=0.003$). (B) Normalization to one aplasia day resulted in a 24% reduction of the RBC transfusions in the single-unit period ($P<0.001$). (C) The mean time between two transfusions was 20% longer in the double-unit period ($P<0.001$).