Hospital Acquired Anemia

Heather Lachiewicz, M.S.N., R.N.
Department of Nursing

Steven R. Insler, D.O.
Department of Cardiothoracic Anesthesiology and Critical Care Medicine

Heart and Vascular Institute
The Cleveland Clinic Foundation
Cleveland, Ohio 44195
“What is Normal?”

In normal healthy adults:

- Mean hemoglobin values range between 14 g/dL and 15.5 g/dL,
- Corresponds with a hematocrit of 41% to 47%
- Basically HgB x 3 = HCT (calculated value)
What is “Anemia”?  

**Defined:** Reduction in 1 or more of the major red blood cell (RBC) measurements obtained via serum complete blood count (CBC).

- Hemoglobin (HgB), Hematocrit (HCT) or RBC count.
- World Health Organization (WHO)
- US National Health and Nutrition Examination Survey (NHANES III)
- Scripps-Kaiser Database
## Definitions of Anemia

### Various lower limits of Hgb level in defining anemia

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<th>Men (g/dL)</th>
<th>Women (g/dL)</th>
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<tbody>
<tr>
<td><strong>Revised WHO/National Cancer Institute</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
<td>&lt;13</td>
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<tr>
<td><strong>NHANES (National Health and Nutrition Examination Survey) III and Scripps-Kaiser studies</strong>&lt;sup&gt;3&lt;/sup&gt;</td>
<td>White men</td>
<td>White women</td>
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<td>Age 20–59 y &lt;13.7</td>
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<td><strong>Beutler et al,</strong>&lt;sup&gt;3&lt;/sup&gt; 2006</td>
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<td><strong>Jandi,</strong>&lt;sup&gt;4&lt;/sup&gt; 1996</td>
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<td><strong>Lee et al,</strong>&lt;sup&gt;5&lt;/sup&gt; 1998</td>
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<td><strong>Tietz,</strong>&lt;sup&gt;6&lt;/sup&gt; 1995</td>
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<td><strong>Hoffman et al,</strong>&lt;sup&gt;7&lt;/sup&gt; 2004</td>
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<sup>1</sup> Ahmed AK. Hosp Med Clin N Am 2014; e71–e84
<sup>2</sup> Blood 2006; 107(1):1743
<sup>3</sup> J Natl Compr Canc Netw 2008; 6(6):536
RBC and Hemoglobin

Red blood cells contain several hundred thousand hemoglobin molecules, which transport oxygen. Oxygen binds to heme on the hemoglobin molecule.
Pathologic Considerations of Anemia

- Fewer functional RBC/Less Hgb to bind Oxygen
- Less Oxygen means less oxygen available/transported for aerobic metabolism/Energy generation
  - Less oxygen to end organs
- Available oxygen may be unable to meet metabolic oxygen demand.
- Increased cardiopulmonary work
  - Compensate for low oxygen carrying capacity
- Feeling tired/ Short of breath
- Can result in cardiopulmonary arrest
- Associated with poor quality of life, increased hospitalizations and death.
# Direct and Contributing Causes of Anemia

## Direct Causes

<table>
<thead>
<tr>
<th>Cause</th>
<th>Component</th>
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</thead>
<tbody>
<tr>
<td>Poor, insufficient, or abnormal red blood cell production</td>
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<tr>
<td>Excessive red blood cell destruction</td>
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<tr>
<td>Excessive red blood cell loss</td>
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<table>
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<tr>
<th>Knowledge and Behavior</th>
<th>Component</th>
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<tr>
<td>Environment</td>
<td></td>
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<tr>
<td>Lack of access to services</td>
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<tr>
<td>Poverty</td>
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## Component

- Poor dietary intake and/or absorption of iron
- Poor dietary intake and/or absorption of vitamins (A, B-12, folic acid, and possibly B-6, C, and riboflavin) and copper
- Increased need for nutrients due to growth or disease (diarrhea)
- HIV/AIDS
- Other infectious diseases (tuberculosis, malaria)
- Genetic blood diseases (sickle cell disease or trait, thalassemia)
- Malaria
- Hookworm, schistosomiasis
- Bacterial or viral infections (peptic ulcers, gastritis, diarrhea)
- Reproduction (excessive blood loss during menstruation, delivery, and postpartum period; too many pregnancies, shortened postpartum amenorrhea)
- Contraceptive methods (intrauterine devices)
- Poor knowledge among health workers and community members about anemia, iron supplementation, and other anemia prevention and control interventions
- Contamination by heavy metals (lead)
- Low use of antenatal and other services providing iron supplements
- Lack of trained birth attendants to manage bleeding during delivery
- Lack of access to sanitation services that mitigate helminth infestation
- Lack of access to beds to prevent malaria transmission
- Lack of income to buy foods with adequate amounts of absorbable iron or to obtain iron supplements, malaria treatment, insecticide-treated bednets, shoes to prevent helminth infestation, and other preventive commodities or services

Worldwide Distribution of Anemia

Hospital Acquired Anemia (HAA)

- HAA defined as Anemia that develops during hospitalization in patients who had a normal admission HgB level
- Can be categorized as Mild (HgB < 11.0 g/dl), Moderate (HgB 9.1 - 11.0 g/dl) and Severe (HgB < 9.0 g/dl).
- Evidence suggests patients with HAA have increased risk of morbidity and mortality when compared to those who do not have HAA.
Prevalence of HAA

- Not a new problem (1973)

PATIENTS admitted to the coronary and pulmonary care units of the New York Hospital developed mild cases of anemia and reticulocytosis without obvious cause. The purpose of this study was to determine whether these findings could be related to bloodletting for diagnostic studies.

Nosocomial Anemia

Elaine Syster, MD, and James Bernene, MD

Blood loss was measured and serial hematocrit readings and reticulocyte counts were performed on 93 consecutive patients. The mean daily blood loss of 54 ml was accompanied by an observed reticulocyte count of 3.4% over an average of 3.2 days. Hematocrit values in 75 patients with no evidence of bleeding decreased 5.7% during the 20.9 days of hospitalisation. Of the 65 patients not anemic at the time of admission, 26 (40%) became anemic with no obvious cause prior to discharge from the hospital. Bloodletting for diagnostic studies is a significant cause of anemia and reticulocytosis in hospitalized patients.
OBJECTIVE: To determine whether phlebotomy contributes to changes in hemoglobin and hematocrit levels in hospitalized general internal medicine patients.

DESIGN: Retrospective cohort study.

Mean (SD) hemoglobin and hematocrit changes during hospitalization were 7.9 (12.6) g/L (P<0.0001) and 2.1% (3.8%) (P<0.0001), respectively. The mean (SD) volume of phlebotomy during hospital stay was 74.6 (52.1) mL.

CONCLUSIONS: Phlebotomy is highly associated with changes in hemoglobin and hematocrit levels for patients admitted to an internal medicine service and can contribute to anemia.

The CRIT Study: Anemia and blood transfusion in the critically ill—Current clinical practice in the United States*

Howard L. Corwin, MD; Andrew Gettinger, MD; Ronald G. Pearl, MD, PhD; Mitchell P. Fink, MD; Mitchell M. Levy, MD; Edward Abraham, MD; Neil R. MacIntyre, MD; M. Michael Shabot, MD; Mei-Shiang Duh, MPH, ScD; Marc J. Shapiro, MD

Objective: To quantify the incidence of anemia and red blood cell (RBC) transfusion practice in critically ill patients and to examine the relationship of anemia and RBC transfusion to clinical outcomes.

Design: Prospective, multiple center, observational cohort study of intensive care unit (ICU) patients in the United States. Enrollment period was from August 2000 to April 2001. Patients were enrolled within 48 hrs of ICU admission. Patient follow-up was for 30 days, hospital discharge, or death, whichever occurred first.

Setting: A total of 264 ICUs (medical, surgical, or medical-surgical) in 213 hospitals participated in the study.

Patients: A total of 4,992 patients were enrolled in the study.

Measurements and Main Results: The mean hemoglobin level at baseline was 11.0 ± 2.4 g/dL. Hemoglobin level decreased throughout the duration of the study. Overall, 44% of patients received one or more RBC units while in the ICU (mean, 4.6 ± 4.9 units). The mean pretransfusion hemoglobin was 8.6 ± 1.7 g/dL. The mean time to first ICU transfusion was 2.3 ± 3.7 days. More RBC transfusions were given in study week 1; however, in subsequent weeks, subjects received one to two RBC units per week while in the ICU. The number of RBC transfusions a patient received during the study was independently associated with longer ICU and hospital lengths of stay and an increase in mortality. Patients who received transfusions also had more total complications and were more likely to experience a complication. Baseline hemoglobin was related to the number of RBC transfusions, but it was not an independent predictor of length of stay or mortality. However, a nadir hemoglobin level of <9 g/dL was a predictor of increased mortality and length of stay.

Conclusions: Anemia is common in the critically ill and results in a large number of RBC transfusions. Transfusion practice has changed little during the past decade. The number of RBC units transfused is an independent predictor of worse clinical outcomes.

(Crit Care Med 2004; 32:39–52)

Key Words: anemia; blood transfusion; transfusion practice; transfusion risks
CRIT STUDY: 2004

- 284 ICU’s in 213 US Hospitals
- 4,892 patients
- Mean Baseline HgB 11.0 +/- 2.4 g/d
- Overall 44% received an average of ~4.6 units PRBC
  - Mean Pre-transfusion HgB was 8.6
- Mean time to first transfusion in ICU was 2.3 days/then ~1-2 U/week
- Conclusion: the number of transfusions of Packed red blood cells was an independent predictor of longer ICU and hospital LOS and mortality.
The most common cause of major blood loss

Defined as a loss of $>\ = 20\%$ of total blood volume.

- Cardiovascular procedures
- Liver transplantation
- Hepatic resections
- Major orthopedic procedures e.g. hip & knee replacement/spine surgery
- Craniofacial
- Major Urologic Malignancy
- Trauma

European Journal of Anaesthesiology 2009, 26:722-729
Hospital-Acquired Anemia: Prevalence, Outcomes, and Healthcare Implications

Colleen G. Koch, MD1,2, Lian Li, PhD3, Zhiyuan Sun, MS3, Eric D. Hixson, PhD3, Anne Tang, MS3, Shannon C. Phillips, MD3, Eugene H. Blackstone, MD2,3, J. Michael Henderson, MD4

1Department of Cardiothoracic Anesthesia, Heart and Vascular Institute, Cleveland Clinic, Cleveland, Ohio; 2Quality and Patient Safety Institute, Cleveland Clinic, Cleveland, Ohio; 3Department of Quantitative Health Sciences, Research Institute, Cleveland Clinic, Cleveland, Ohio; 4Business Intelligence, Medical Operations, Cleveland Clinic, Cleveland, Ohio; 5Department of Thoracic and Cardiovascular Surgery, Heart and Vascular Institute, Cleveland Clinic, Cleveland, Ohio; 6Department of General Surgery, Digestive Disease Institute, Cleveland Clinic, Cleveland, Ohio.

BACKGROUND: Evidence suggests that patients with normal hemoglobin (Hgb) levels on hospital admission who subsequently develop hospital-acquired anemia (HAA) may be at risk for adverse outcomes. Our objectives were to (1) determine the prevalence of HAA and (2) examine whether HAA is associated with increased mortality, length of stay (LOS), and total hospital charges.

METHODS: The population consisted of 417,301 adult hospitalizations from January 1, 2008 to August 31, 2011, in an academic medical center and 9 community hospitals. Patients with anemia on admission, and hospitals in the health system without available laboratory data were excluded; 186,447 hospitalizations were included in the analysis. Demographics, comorbidities, and outcomes were retrieved from administrative data; Hgb values were taken from the electronic medical record. Regression modeling was used to examine the association between demographics, comorbidity, hospitalization type, and HAA variables (mild: Hgb >11 and <12 g/dL for women, and >11 and <13 g/dL for men; moderate: Hgb 9.1 to <11.0 g/dL; severe: Hgb ≤9.0 g/dL) on mortality, LOS, and hospital charges.

RESULTS: Among 186,447 hospitalizations, 139,807 patients (74%) developed HAA; mild, 40,828 (29%); moderate, 57,184 (41%); and severe, 41,795 (30%). Risk-adjusted odds ratios and 95% confidence intervals for in-hospital mortality with HAA were: mild, 1.0 (0.88–1.17; P = 0.8); moderate, 1.51 (1.33–1.71; P < 0.001); and severe, 3.26 (2.90–3.72; P < 0.001). Risk-adjusted relative mean LOS and hospital charges relative to no HAA were higher with HAA: LOS: mild, 1.08 (1.08–1.10; P < 0.001); moderate, 1.28 (1.26–1.29; P < 0.001); severe, 1.88 (1.86–1.89; P < 0.001). Hospital charges: mild, 1.66 (1.66–1.67; P < 0.001); moderate, 1.18 (1.17–1.19; P < 0.001); severe, 1.80 (1.79–1.82; P < 0.001).


Retrospective analysis of 188,447 hospitalizations across the Cleveland Clinic Health System

Increased risk of mortality in patients with moderate (9.1-11 g/dl HgB) to severe (<9.0 g/dl HgB) HAA.

Increased LOS and Hospital resource use in all categories HAA
What are the causes of HAA?
The etiology of HAA is multifactorial

- Phlebotomy has consistently been implicated as one of the major causative factors in developing hospital acquired anemia.

- Repeated phlebotomy procedures may cause:
  - ICU patients lose 25-40 ml blood/day
  - ICU patients with arterial catheters lose approximately 900 mL blood during their ICU stay

- Diagnostic blood loss - Salisbury study
Diagnostic Blood Loss From Phlebotomy and Hospital-Acquired Anemia During Acute Myocardial Infarction

Adam C. Salisbury, MD, MSc; Kimberly J. Reid, MS; Karen P. Alexander, MD; Frederich A. Masoudi, MD, MSPH; Sue-Min Lui, PhD, MS, MBA; Paul S. Chan, MD, MSc; Richard G. Bach, MD; Tracy Y. Wang, MD, MHS, MSc; John A. Speris, MD, MPH; Mikhail Restorff, MD

Background: Hospital-acquired anemia (HAA) during acute myocardial infarction (AMI) is associated with higher mortality and worse health status and often develops in the absence of recognized bleeding. The extent to which diagnostic phlebotomy, a modifiable process of care, contributes to HAA is unknown.

Methods: We studied 17,676 patients with AMI from 57 US hospitals included in a contemporary AMI database from January 1, 2000, through December 31, 2008, who were not anemic at admission but developed moderate to severe HAA (in which the hemoglobin level declined from normal to <11 g/dL), a degree of HAA that has been shown to be prognostically important. Patients' total diagnostic blood loss was calculated by multiplying the number and types of blood tubes drawn by the standard volume for each tube type. Hierarchical modified Poisson regression was used to test the association between phlebotomy and moderate to severe HAA, after adjusting for site and potential confounders.

Results: Moderate to severe HAA developed in 3,531 patients (20%). The mean (SD) phlebotomy volume was higher in patients with HAA (173.8 [130.3] mL) vs those without HAA (83.5 [52.0] mL; P < .001). There was significant variation in the mean diagnostic blood loss across hospitals (moderate to severe HAA: range, 119.1-246.0 mL; mild HAA or no HAA: 53.0-110.1 mL). For every 30 mL of blood drawn, the risk of moderate to severe HAA increased by 18% (relative risk [RR], 1.18; 99% confidence interval [CI], 1.13-1.22). This was only modestly attenuated after multivariable adjustment (RR, 1.13; 99% CI, 1.12-1.18).

Conclusions: Blood loss from greater use of phlebotomy is independently associated with the development of HAA. These findings suggest that HAA may be preventable by implementing strategies to limit blood loss from laboratory testing.

Arch Intern Med. Published online August 8, 2011. doi:10.1001/archinternmed.2011.361
The etiology of HAA is multifactorial

- GI blood loss
- Surgical procedures
- Coagulopathies
- Pathogen-associated hemolysis
- Hypoadrenalism
- Nutritional deficiencies
- RBC production in critically ill patients is often abnormal.
  - Decreased production erythropoietin (EPO)/ May be immune mediated. Il-1, TNF.
  - Impaired bone marrow response to EPO
  - Reduced RBC survival.
  - Sepsis Syndrome/ Low serum Fe/TIBC. Do bacteria require Fe for growth and survival? Does human host attempt to deprive pathogen of Fe?
  - Possible immunologic stimuli:
    “Anemia of immune activation” may have evolved as a protective mechanism against foreign antigens.

HAA and Outcome

\[ \text{CaO}_2 = (\text{Hb} \times 1.39 \times \text{SaO}_2) + (\text{PaO}_2 \times 0.003) \]

- CaO2 - arterial oxygen concentration
- Hb - Hemoglobin
- SaO2 - Arterial Oxygen saturation
- 1.39 ml O2 - amount oxygen each gram Hb can carry
- PaO2 - arterial oxygen tension
- 0.003 solubility coefficient of oxygen

\[ \text{CO} = \text{HR} \times \text{SV} \]

- HR - Heart Rate
- SV - Stroke Volume (EDV-ESV ~70 ml/beat)

\[ \text{DO}_2 = \text{CO} \times \text{CaO}_2 \times 10 \]

- DO2 - Oxygen delivery
HAA and Outcome

Decreased O2 carrying capacity

- Increased HR and increased CO
- Increased Oxygen extraction and decreased oxygen delivery to tissues
- Shift of oxyhemoglobin disassociation curve to the right
- Eventual decreased CO
  - Promote arrhythmia
  - Exacerbate myocardial ischemia
  - Increase sympathetic tone
  - Exacerbate shock in setting of compromised ventricular function
- Leads to Poor hospital and Post discharge outcomes

- 2909 AMI patients identified from the multi-center TRIUMPH registry (Translational Research Investigating Underlying Disparities in AMI Patients)
- At discharge 1321 (45.4%) had HAA/ 348 (26.3%) had moderate to severe anemia (HgB:9.1-11 g/dl)
- After adjustment for GRACE score and bleeding, patients with moderate-severe HAA had higher mortality (HR 1.82 (95% CI 1.11-2.98) vs. no HAA), as well as poorer health status at 1-year.
Who is at Risk?

- Almost every patient admitted to the hospital
- Those anemic at admission have higher risk for worsening anemia
- The longer a patient stays the greater the risk
- Increasing severity of illness correlates with worsening anemia
- Age older than 65 years
- Malnutrition
Management of HAA

Investigate the Cause of Anemia?

- Increased RBC destruction?
  - Inherited or Acquired hemolytic anemias
- Decreased Production?
  - Lack of nutrients
  - Bone marrow disorders
  - Bone marrow suppression
  - Low levels trophic hormones that stimulate RBC production
  - Anemia of inflammation
- Blood Loss?
  - Obvious bleeding
  - Occult bleeding
  - Induced/phlebotomy
  - Underappreciated
Management of HAA

Detailed History of symptoms or medical conditions that cause anemia?
- Is anemia recently Acquired? In-Hospital?
- Appropriate Diagnostic Imaging or Endoscopic Studies

Physical Examination
- Tachycardia, orthostatic hypotension, fever, dyspnea
- Jaundice
- Pallor
- Petechial/Ecchymoses
- Hepatomegaly, splenomegaly, lymphadenopathy
- Occult blood
- Neutropenia
Management of HAA

- Laboratory Evaluation for HAA
  - Serum Ferritin
    - Functional vs. Absolute Iron deficiency anemia
    - Functional: sufficient Fe, but d/t EPO, phlebotomies, blood loss, unable to deliver Fe d/t rapid turnover of RBC
    - Absolute: RBC produced without adequate Fe.
  - Serum Fe
  - Serum Transferrin Saturation (%)
  - Nutritional status: Vitamin B12/Folate
  - Reticulocyte count: Absolute and immature (%)
  - Complete Blood Count with differential
  - Complete metabolic Panel
  - Coagulation panel, haptoglobin
HAA MANAGEMENT

Treatment: Non-Pharmacologic versus Pharmacologic

NON-Pharmacologic

- Minimize Blood Loss
  - Reduce Blood Draws
  - Bundle blood draws to minimize waste
  - Eliminate unnecessary procedures
  - Hold anticoagulation if suspect bleeding source
  - Stop active bleeding
  - Use micro or pediatric tubes to reduce blood volume
  - Reduce waste associated with in-line arterial catheters
HAA MANAGEMENT

- Pharmacologic
  - Replace unrecognized nutritional deficiency
    - Multivitamins
    - Folate/ Vit C
    - Erythropoietin
      - Demonstrated to improve survival and HgB when used w/other blood conservation techniques in GI bleeds, trauma, CT surgery, burns, orthopedic surgery, general surgery.
        - Pharmacotherapy 2008; 28(11):1383-90
        - Lancet 1993; 341:1228-32
  - IV/PO Iron
  - Transfusion of Red Blood Cells (RBC)
Transfusion

• Consider transfusion when:
  • HgB level $\leq 7$ g/dl
  • Evidence of end organ ischemia?
  • Symptomatic with higher levels HgB
  • SBP $< 70-80$ mmHg
  • Tachycardia HR $> 110$ BPM (not corrected by volume)
  • Evidence of end organ ischemia (cardiac, pulm, renal, neuro)
  • Acute coronary syndrome with HgB $< 8$ g/dl and any 2 of the following: angina, new ECG changes, or abnormal enzymes
  • Acute massive blood loss of greater than or equal to 30% blood volume not corrected by volume replacement.
  • Non-elective pre-surgery HgB level less than or equal to 7 g/dl, with anticipated blood loss more than 750 cc.

Transfusion RBC

- RBC transport oxygen and carbon dioxide
- RBC improve oxygen delivery (and CO2) removal at the micro-circulatory level
- Only transfuse for clear indication of inadequate perfusion, or symptomatic and critical deficit in oxygen carrying capacity.
  - Oxygen Content
  - Oxygen delivery
  - Oxygen uptake
- Consider the RBC transfusion paradox
RBC Transfusion Paradox

- Anemia is associated with poor outcome
- RBC transfusion corrects anemia
- But....
  - Transfusion doesn’t correct the adverse effects of anemia
  - Transfusion itself associated with poor outcome.

- Why? Consider risks of blood transfusion
Risks of RBC transfusion

- Mis-transfusion - Human Error
- Reactions - Acute and delayed
- Transfusion transmitted disease
- TRALI - transfusion related acute lung injury
- TACO - Transfusion associated circulatory overload
- TRIM - Transfusion related immune modulation
- Blood storage lesion
TRIM: Transfusion Related Immune Modulation

- Transfused allogeneic blood results in an infusion of large amounts of foreign cells, antigens and NON-leukocyte derived biological response modifiers.
- Temporary suppression of the immune system
- Dose-response relationship
  - Increased infection risk
  - Increased mortality risk
  - Increased length of stay

HAA and Outcome

- Spahn DR. Anemia and patient blood management in hip and knee surgery: a systematic review of the literature. Anesthesiology 2010; 113:482-495
  - 49 publications examining postoperative anemia and clinical outcome in patients undergoing hip (THA)/knee surgery (TKA) and hip fracture surgery.
  - Pre and postoperative anemia is highly prevalent 51% THA/TKA and 87% hip fracture surgery.
  - Anemia associated with significant adverse clinical outcomes and increased need for allogeneic transfusion rates. Leads to decreased physical functioning, increased infection rates, increased LOS, and increased mortality
  - Increased rate of autologous blood transfusion (risk factor for poor clinical outcomes).
Blood Storage Lesion

Biochemical, Structural, Enzymatic, Morphologic and Functional Deterioration

- RBC’s age rapidly outside of the body despite refrigeration
- ATP (high energy molecule) declines
- RBC shape changes - stiffer, poor deformability
  - loss of membrane lipids, altered shape, osmotic fragility
- 2,3 DPG is undetectable at 1 week storage
  - 12-24 hours post transfusion to regenerate
  - Transfused blood can bind oxygen but does not offload well.
- Free hemoglobin (from RBC breakdown) scavenges NO, leads to microcirculatory vasoconstriction

Duration of Red-Cell Storage and Complications after Cardiac Surgery

Colleen Gorman Koch, M.D., Liang Li, Ph.D., Daniel I. Sessler, M.D., Priscilla Figueroa, M.D., Gerald A. Hoeltge, M.D., Tomislav Mihaljevic, M.D., and Eugene H. Blackstone, M.D.

ABSTRACT

BACKGROUND
Stored red cells undergo progressive structural and functional changes over time. We tested the hypothesis that serious complications and mortality after cardiac surgery are increased when transfused red cells are stored for more than 2 weeks.

METHODS
We examined data from patients given red-cell transfusions during coronary-artery bypass grafting, heart-valve surgery, or both between June 30, 1998, and January 30, 2006. A total of 2672 patients received 8892 units of blood that had been stored for 14 days or less (“newer blood”), and 3130 patients received 10,782 units of blood that had been stored for more than 14 days (“older blood”). Multivariable logistic regression with propensity-score methods was used to examine the effect of the duration of storage on outcomes. Survival was estimated by the Kaplan-Meier method and Blackstone’s decomposition method.

RESULTS
The median duration of storage was 11 days for newer blood and 20 days for older blood. Patients who were given older units had higher rates of in-hospital mortality (2.2% vs. 1.7%, P=0.004), intubation beyond 72 hours (5.7% vs. 5.6%, P=0.003), renal failure (2.7% vs. 1.6%, P=0.003), and sepsis or septicemia (4.0% vs. 2.8%, P=0.01). A composite of complications was more common in patients given older blood (25.4% vs. 22.4%, P=0.001). Similarly, older blood was associated with an increase in the risk-adjusted rate of the composite outcome (P=0.03). At 1 year, mortality was significantly less in patients given newer blood (7.4% vs. 11.0%, P<0.001).

CONCLUSIONS
In patients undergoing cardiac surgery, transfusion of red cells that had been stored for more than 2 weeks was associated with a significantly increased risk of postoperative complications as well as reduced short-term and long-term survival.
Duration of RBC storage and Complications after Cardiac Surgery

- Cardiac Surgery Patients June 1998 - January 2006
- 2,872 Patients received 8,802 units PRBC stored ≤14 days
- 3,130 received 10,758 units PRBC stored >15 days

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<th>≤14 days</th>
<th>&gt;15 days</th>
<th>P</th>
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<tr>
<td>In-Hospital Mortality</td>
<td>1.7%</td>
<td>2.8%</td>
<td>0.0004</td>
</tr>
<tr>
<td>Prolonged Ventilation</td>
<td>5.6%</td>
<td>9.7%</td>
<td>0.001</td>
</tr>
<tr>
<td>Renal Failure</td>
<td>1.6%</td>
<td>2.7%</td>
<td>0.003</td>
</tr>
<tr>
<td>1 year mortality</td>
<td>7%</td>
<td>11%</td>
<td>0.001</td>
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THINK.

Think Before Transfusing
Restrictive Trigger: 7-9 g/dl Hgb
Liberal Trigger 10-12 g/dl Hgb

Impact of More Restrictive Blood Transfusion Strategies on Clinical Outcomes: A Meta-analysis and Systematic Review

Shelley R. Sipneter, MD, Jacob S. Buckley, MD, Saurav Chattarjee, MD

*Stanford University School of Medicine, Stanford, Calif. †Brown University, Providence, RI; ‡St Luke’s—Roosevelt Hospital Center, New York, NY.

ABSTRACT

BACKGROUND: There is accumulating evidence that restricting blood transfusions improves outcomes, with newer trials showing greater benefit from more restrictive strategies. We systematically evaluated the impact of various transfusion triggers on clinical outcomes.

METHODS: The MEDLINE database was searched from 1966 to April 2013 to find randomized trials evaluating a restrictive hemoglobin transfusion trigger of <7 g/dL compared with a more liberal trigger. Two investigators independently extracted data from the trials. Outcomes evaluated included mortality, acute coronary syndrome, pulmonary edema, infections, rebleeding, number of patients transfused, and units of blood transfused per patient. Extracted data also included information on study setting, design, participant characteristics, and risk for bias of the included trials. A secondary analysis evaluated trials using less restrictive transfusion triggers, and a systematic review of observational studies evaluated more restrictive triggers.

RESULTS: In the primary analysis, pooled results from 3 trials with 2364 participants showed that a restrictive hemoglobin transfusion trigger of <7 g/dL resulted in reduced in-hospital mortality (RR 0.74; confidence interval [CI] 0.60–0.92), total mortality (RR 0.86; CI 0.65–0.98), rebleeding (RR 0.64; CI 0.45–0.90), acute coronary syndrome (RR 0.44; CI 0.22–0.90), pulmonary edema (RR 0.48; CI 0.33–0.72), and bacterial infections (RR 0.85; CI 0.75–1.00), compared with a more liberal strategy. The number needed to treat with a restrictive strategy to prevent 1 death was 33. Pooled data from randomized trials with less restrictive transfusion strategies showed no significant effect on outcomes.

CONCLUSIONS: In patients with critical illness or blood, restricting blood transfusions by using a hemoglobin trigger of <7 g/dL significantly reduces cardiac events, rebleeding, bacterial infections, and total mortality. A less restrictive transfusion strategy was not effective.
• Primary analysis, pooled results from 3 trials, 2,364 patients: Adult and Peds Critical Care, Acute GI bleeding

• Evaluated trials using a restrictive hemoglobin transfusion trigger < 7g/dl

• Concluded: Restrictive HgB triggers significantly reduces the incidence of cardiac events, re-bleeding, bacterial infection and total mortality
Prevention of HAA

- Early recognition of anemia before planned or unplanned hospitalizations
  - Regular checkups and lab work including CBC

- On Hospital Admission at risk patients or those with pre-existing anemia should be identified and optimized (if possible)

- General approaches to Prevent HAA
  - Identify high risk patients
  - Assess Fe stores once anemia identified and treat if appropriate
    - Fe deficient vs. Functional Fe deficiency
  - Use smaller, or pediatric tubes for blood draws
  - Use in-line reinfusion if appropriate
  - Reduce wasted blood after blood draws/ arterial line placement site
  - Limit unwarranted procedures
  - Bundle tests to limit waste
  - Reduce unneeded arterial blood draws
  - Identify coagulopathy and bleeding risk patients
  - Use stress ulcer prophylaxis where appropriate
  - Consider Fe replacement and use of EPO
Nursing Advocacy

- Frequency of labs
- Attention to patient
  - vital signs
  - Physical assessment skills
  - laboratory results
- Attention to blood wastage
Conclusion:

- Anemia can be categorized as severe (hemoglobin [Hgb] level <9 g/dL), moderate (Hgb 9.1-11.0 g/dL), and mild (Hgb >11.0 g/dL).
- Hospital-acquired anemia (HAA) is prevalent in the intensive care unit, after major surgery as well as on the wards.
- Every patient admitted to hospital at risk of developing HAA.
- Causes of HAA: blood draws, erythropoietin (EPO) suppression caused by increase in inflammatory markers from acute illness, and down-regulation of iron.
- HAA recognition and treatment affect patient outcomes.
- Prevention and management of HAA demand a team approach and a culture that supports recognition and reduction of unnecessary laboratory testing and procedures.
- Pharmacologic treatment continues to evolve, and evidence-based use of intravenous iron and EPO may have a role in supporting erythropoiesis to help prevent transfusion.
- Exercise caution when considering blood transfusion.