THE BLOOD INTERFACE IN CARDIOVASCULAR SURGERY

THE KNOWN AND UNKNOWN
BLOOD INTERFACE IN CARDIOVASCULAR SURGERY

John H. Gibbon, MD.

Gibbon-IBM heart-lung machine model II

Figure 1. The Dodrill-GMR heart pump.

1962 Texas Heart Institute founded by Denton A. Cooley, MD.
1968 First successful heart transplantation in the United States.
1969 First implantation in the world of an artificial heart in a human.
1975 First study funded by the National Heart, Lung, and Blood Institute of an implantable left ventricular assist device (LVAD) for post-cardiotomy support.
1976 First accredited School of Perfusion Technology in the United States.
1978 First bridge-to-transplant with an LVAD.
1981 Second implantation in the world of an artificial heart in a human.
1986 First implant of the HeartMate pneumatically powered LVAD, as a bridge to transplant.
1990 First cases of MAZE surgery performed at St. Luke’s Episcopal Hospital for atrial fibrillation.
1991 First patient in the world left the hospital with an electric, portable, battery-powered LVAD.
1999 Implantation of the AbiCor total artificial heart.
2000 First site for clinical trials of the Jarvik 2000, a miniature, axial flow left ventricular assist device.
2001 100,000th open heart operation performed.
2006 1,000th heart transplant performed.
2011 First successful implantation of a continuous-flow total artificial heart in a human.
2012 THI founder Dr. Denton A. Cooley publishes his memoirs, 100,000 Hearts, highlighting many historical firsts.
The Blood Interface in Cardiovascular Surgery: The Known and Unknown

Arthur Bracey, MD

Gulf Coast Regional Blood Center
1400 La Concha Lane, Houston, Texas 77054
Daily mean nadir hemoglobin levels in subgroups of patients with nadir postoperative Hb between 8 and 9 g/dL.

Outcome measures

Transfusion protocol Hb8

Transfusion incidence in subgroups of patients by lowest Hb during postoperative period

Transfusion incidence in postoperative period

Transfusion protocol Hb8

RBC Transfusion Guideline for Physicians

Transfusion protocol Hb8

Transfusion protocol Hb8

Transfusion protocol Hb8
CVRR Resuscitation Algorithm

- All pump patients will have lactate and ScvO₂ measured on ICU admission
- Hemodynamically unstable patients (category a) will be treated according CVRR Resuscitation algorithm
- Hemodynamically stable patients (category b) with elevated lactate ≥ 18 and ScvO₂ < 70% will trigger intervention for treatment of occult hypoperfusion according to CVRR Resuscitation algorithm
- Response to therapy will be monitored by:
  a. ScvO₂ drawn 1 hour post intervention (continue intervention if ScvO₂ remains < 70% after bolus or RBC transfusion x 2.
  b. Lactate drawn 18±2 hours after initial specimen

Category b1

From: Transfusion Requirements After Cardiac Surgery: The TRACS Randomized Controlled Trial

Time zero was just after randomization (12 hours before surgery). Hazard ratio, 1.28 (95% confidence interval, 0.60-2.73) (P = .99) for restrictive strategy vs liberal strategy.

Transfusion protocol Hb8
Duration of mechanical ventilation in patients with postoperative Hb between 8 - 9

Transfusion Protocol Hb 8
Self-assessment of fatigue

Bracey A. Transfusion 1999; 39:1070

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BLOOD STORAGE

- RECESS (Steiner) – CVS complex case population (redo, multiple procedure)
  - primary outcome – MODS
  - secondary outcome discharge death, oxygenation, endorgan function troponin, creatinine
  - randomize to < 8-10 days vs >21 days
  - screen 7200 to get 800 in each arm
  - physiologic substudy will address O2 delivery, deformability/flow

RECESS – MODS SCORE

Clinical components of the multiple organ dysfunction score

<table>
<thead>
<tr>
<th>Organ system</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Respiratory (PaO2/FiO2)</td>
<td>&gt;300</td>
<td>226-300</td>
<td>151-225</td>
<td>76-150</td>
<td>≤ 75</td>
</tr>
<tr>
<td>Renal (creatinine)</td>
<td>≤100</td>
<td>101-200</td>
<td>201-350</td>
<td>351-500</td>
<td>&gt;500</td>
</tr>
<tr>
<td>Hepatic (bilirubin)</td>
<td>≤20</td>
<td>21-60</td>
<td>61-120</td>
<td>121-240</td>
<td>≥240</td>
</tr>
<tr>
<td>CV (PAR) (HR x CV/PWP)</td>
<td>≤10.0</td>
<td>10.1-15.0</td>
<td>15.1-20.0</td>
<td>20.1-30.0</td>
<td>&gt;30.0</td>
</tr>
<tr>
<td>Heme (plat ct)</td>
<td>&gt; 120</td>
<td>81-120</td>
<td>51-80</td>
<td>21-50</td>
<td>≤20</td>
</tr>
<tr>
<td>Neuro (Glasgow Coma Score)</td>
<td>15</td>
<td>13-14</td>
<td>10-12</td>
<td>7-9</td>
<td>≤6</td>
</tr>
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Harker L. Blood 1980 56: 824-834

BLOOD INTERFACE IN CARDIOVASCULAR SURGERY

Platelet Ultrastructure - Activation


Normal Hemostasis: Pivotal role of TF/VIIa

Mortality Associated with Platelet Transfusion (Panel A) and Antifibrinolytic Therapy (Panel B) among Patients Who Received Aspirin and Patients Who Did Not.

BLOOD INTERFACE IN CARDIOVASCULAR SURGERY


Randomized trials –
1. Increased chest tube output 200-400 ml.
2. Increased RBC transfusion 0.5 – 1 RBC unit.

Goldman (1991) 351 Increased Increased Increased
Sethi (1990) 772 Increased Increased Increased
Goldman (1988) 555 Increased Not Inc. Increased
Kallis (1994) 100 Increased Increased Increased
Ferraris (1988) 34 Increased Increased Increased
Kawande (1987) 36 Increased Increased Increased

BLOOD INTERFACE IN CARDIOVASCULAR SURGERY


Relationship between 24-h postoperative chest tube output and time to surgery after last clopidogrel dose in patients with clopidogrel exposure (n = 59)

BLOOD INTERFACE IN CARDIOVASCULAR SURGERY

- Platelet function assays
  1. Platelet aggregation
  2. PFA-100
  3. VerifyNow
  4. Thromboelastograph (TEG)
  5. Platelet works
  6. Flow cytometry P-selectin (research)
  7. Cone and plate(let) analyzer (research)
  8. Thrombovision T-Guide (trial phase)
  9. VASP Phosphorylation (flow-research)

PLATELET FUNCTION ASSAYS

- Gold standard
- Technically difficult
- Agonists: ADP, epinephrine, collagen, arachidonic acid, ristocetin
- Advantages: graphs dynamics of aggregation
Interindividual variability in platelet response to clopidogrel after stenting


Proposed mechanisms for interindividual variability in platelet inhibition in response to clopidogrel


Frequency distribution of platelet inhibition after cessation of daily clopidogrel therapy

Transfusion Triggers – Transfusion Algorithms

Platelet Function Before CPB in the Prospective Groups

CABG after Receipt of Clopidogrel

Incidence of Reduced Platelet Function (ADP aggregation - normal function >70%)
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**PLATELET FUNCTION ASSAYS**

**MICROVASCULAR BLEEDING MANAGEMENT using TEG algorithm**

- **TREATMENT**
  - TEG
  - PROTHROMINE
  - PLATELETS
  - FFP
  - AMICAR
  - CRYO

**Microvascular bleeding management using algorithm based on TEG results**

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<td>36 ± 142</td>
<td>217 ± 463*</td>
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<td>PLAT vol. (ml)</td>
<td>34 ± 94</td>
<td>83 ± 160</td>
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<td>22/53(42%)</td>
<td>31/52(60%)</td>
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<tr>
<td>FFP incidence</td>
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*p<.05  *p<.01

**PLATELET FUNCTION ASSAYS**

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**BLOOD INTERFACE IN CARDIOVASCULAR SURGERY**

- **Unresolved questions**
  1. What is the lowest tolerable hemoglobin? Is there a better measure of oxygen supply?
  2. How best can one assess the coagulation system – pre, during and post surgery? Is there a role for platelet function assessment?
  3. Are further design enhancements drug therapies possible to decrease inflammation, avoid coagulation activation?

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  - G. Laine
  - D. Codd
  - L. Chen
  - N. Nussmeier
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  - J. Moulds

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**Perioperative blood management**

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**Bill T. Teague Lectureship**

**May 14, 2014**

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