Remote Damage Control
Resuscitation: An Overview for Medical Directors and Supervisors

THOR Collaboration
Agenda

• What is Remote Damage Control Resuscitation?

• Putting RDCR into Practice
  – Control Hemorrhage
  – Resuscitate Hemorrhage
  – Adjunctive Measures

• Timing of DCR matters: sooner is better, with decreased mortality benefits
What is RDCR?
Remote

Prehospital (or far-forward/austere) phase of resuscitation
Damage Control:

First, only do the things essential to keeping the ship afloat.

Resuscitation

Emergency treatment to restore:

Circulating volume
Aid oxygen delivery
Replace hemostatic potential

(and a few other things...)

The essentials:

- Hemorrhage control
- Resuscitation
  - TXA
  - WHOLE BLOOD
- Avoid clear fluids
- Plasma (FDP) as a bridge to WB

= RDCR (today in U.S. military)
DCR Definitions

- The initial definition of DCR, by Holcomb and colleagues, states “**DCR addresses the entire lethal triad immediately upon admission to a combat hospital**”.

- **DCR principles** include: compressible hemorrhage control; hypotensive resuscitation; rapid surgical control of bleeding; avoidance of the overuse of crystalloids and colloids, prevention or correction of acidosis, hypothermia, and hypocalcemia; and hemostatic resuscitation (early use of a balanced amount of red blood cells (RBCs), plasma, and platelets).

- **RDCR**: **REMOTE Damage Control Resuscitation** has been defined as the pre-hospital application of Damage Control Resuscitation (DCR) concepts.
  - The term RDCR was first published by Gerhardt and colleagues from the United States Army Institute of Surgical Research and since been promoted by the THOR Network.

Why RDCR?

HEMORRHAGIC SHOCK:

- Low cardiac output →
- Poor tissue perfusion →
- Oxygen debt →
- Acidosis →
- Fibrinolysis/
- Coagulopathy/
- Platelet dysfunction →
- More bleeding →

BLOOD FAILURE

DEATH... IN MINUTES

Need to restore functionality of WB!
Goal of RDCR: Prevent the “Lethal Triad” (i.e. Blood Failure) Close to Point of Injury

The Lethal Triad

- Acidosis
- Hypothermia
- Coagulopathy

Death
DCR, and the case for RDCR

• “Pre-surgical” resuscitation
• Prepping the patient physiologically for best results during surgery
• Preventing complications and shock
• REMOTE DCR = moving the capability of DCR forward closer to the point of injury (POI)
  – It has been applied in the prehospital phase safely
  – It has been shown to decrease mortality if started as soon as possible
Putting RDCR into Practice
Control Hemorrhage

• Core concept inherent in Tactical Combat Casualty Care (TCCC) protocols
  – Validated, universally accepted combat trauma management principles
• Liberal use of tourniquets, hemostatic dressings, junctional tourniquets
• Early and far-forward at the Point of Injury (POI)
  – Self- and Buddy-aid
• Recognition of need for rapid evacuation to surgical care
Updated Fluid Resuscitation Plan
Order of precedence for fluid resuscitation of casualties in hemorrhagic shock

1. Whole blood
2. 1:1:1 plasma:RBCs:platelets
3. 1:1 plasma: RBCs
4. (tie) Plasma (liquid, thawed, dried) or RBCs alone
   ..... 
8. Hextend
9. (tie) Lactated Ringers or Plasma-Lyte A

Butler et al – JSOM 2014
Why WB?

It’s simple!

Don’t make things worse (clear fluids)!

Give the patient what he or she is losing!

Keep it simple (one product)!
Benefits of Low Titer Group O Whole Blood Compared to Blood Components for Blood Failure

• **Efficacy**
  – The cold stored platelets provide improved hemostasis compared to room temperature platelets
  – More concentrated product that contains less anticoagulants and additive solution than an equal amount of components

• **Safety**
  – Reduced risk of hemolysis from the low titer minor incompatible plasma compared to the risk from untitered minor incompatible plasma or platelets
  – Reduced risk of bacterial contamination compared to room temperature stored platelets
  – Impressive safety record with over 1 million units transfused in combat and civilian settings

• **Logistics**
  – Increased access to platelets for both pre-hospital and early in-hospital resuscitations
  – Simplifies and accelerates the provision of all blood components needed to treat hemorrhagic shock
## WB vs. Components: More Concentrated, Simpler

<table>
<thead>
<tr>
<th></th>
<th>WB 4°C</th>
<th>Components (1:1:1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hgb</strong></td>
<td>12-13</td>
<td>9</td>
</tr>
<tr>
<td><strong>HCT</strong></td>
<td>35-37</td>
<td>28</td>
</tr>
<tr>
<td><strong>PLT</strong></td>
<td>138-165</td>
<td>90-120</td>
</tr>
<tr>
<td><strong>Fibrinogen, Factors</strong></td>
<td>Normal @ baseline, FVIII ≥ 50% d7</td>
<td>All 62% dilution @ baseline, plus loss FVIII</td>
</tr>
<tr>
<td><strong>TEG</strong></td>
<td>Nearly normal d21</td>
<td>Reduced vs. WB</td>
</tr>
<tr>
<td><strong>PLT aggregation</strong></td>
<td>≥ 50% baseline d7-10</td>
<td>Nearly complete loss d5 in RT-PLT</td>
</tr>
<tr>
<td><strong>Practical aspects (4L)</strong></td>
<td>8 bags, one storage mode (8 U, 4000 ml)</td>
<td>13 bags, three storage modes (6:6:1, 4150 ml)</td>
</tr>
</tbody>
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Anti-coagulants and Additives

1:1:1 Component Therapy:

- 6 x RBC (AS-5) 6 x 120 ml = 720ml
- 6 x FFP 6 x 50 ml = 300ml
- 1 x aPLT 1 x 35 ml = 35ml

Total = 1055ml

Whole Blood x 6 Units:

- 6 x 63ml = 378ml

Total: 378ml

3 times the volume of anticoagulant & additives in reconstituted whole blood from components (1:1:1) compared to whole blood!

Spinella PC, J Trauma. 2009;66:S69-76
Whole Blood Recent Combat Data

Fresh whole blood use by forward surgical teams in Afghanistan is associated with improved survival compared to component therapy without platelets


Warm Fresh Whole Blood Is Independently Associated With Improved Survival for Patients With Combat-Related Traumatic Injuries

Philip C. Spinella, MD, Jeremy G. Perkins, MD, Kurt W. Grathwohl, MD, Alec C. Beekley, MD, and John B. Holcomb, MD

Comparison of platelet transfusion as fresh whole blood versus apheresis platelets for massively transfused combat trauma patients

Adjunctive DCR Measures

- TXA administration
- Calcium administration
- Trending vital signs/monitoring
  - Consider monitoring urine output
  - Consider measuring point of care labs (lactate)
- Nursing care
- Warming/maintaining body temperature of the patient
- Wound care/antibiotics
- Pain control
Tranexamic Acid Summary

- CRASH-2: 20,211 patients, 274 hospitals, 40 countries
- Tranexamic acid is the only drug to have a demonstrated mortality benefit in trauma.
- Timing of administration appears to be critical in trauma (use only within 3 hours of injury). Overall safety profile is very reassuring.
- Only available dosing guidance provided by CRASH-2 (1gm load over 10 minutes, then 1gm over 8 hours).
- Tranexamic acid is no longer patent-protected. DoD formulary cost is $39.12 for a 1gm vial (about $80 total for the CRASH-2 regimen).
Calcium Supplementation

**CALCIUM**: hypoCa → long QTc, decreased cardiac output, coagulopathy, seizures, etc.

97.4% of trauma MTP patients hypocalemic (<1.12mmol/L)

50-70% severe (<0.8-0.9mmol/L)
→ More coagulopathy
→ More blood transfused
→ Double mortality (49% vs. 24%)
→ Calcium replacement after 4U, but never resolved (still <1.12mmol/L)

One unit of citrated blood product can drop iCa

Give 2g CaCl or 6gm Ca gluconate EARLY (<4 U transfused)

Timing of RDCR
Time to Death: KIA/DOW
Golden Hour is too late to start DCR...

Number of KIA and DOW Deaths by Time Increment (AFG)
N=457

Must start resuscitation pre-hospital: Remote DCR (RDCR)!

RDCR: immediately if not sooner!

Rapid Pre- or In-Hospital Transfusion

*34 min from injury

### Adjusted Cox Models for 24 hour Survival

- Transfusion started within 13* vs. >13 minutes after MEDEVAC take-off from POI
- Among survivors past minute 13, transfusion started >13-20 vs. >20 minutes after take-off

**20-fold Early Survival Benefit**

Even after excluding 49/60 KIAs for contraindications, HR=0.17, p=0.035

**6-fold Early Survival Benefit**

**No Survival Benefit**

Increasing duration of shock is not helpful.

Think BLS. How many minutes before myocardium and brain die?
Golden Hour is too late…

NEED BLOOD at POI

Number of KIA and DOW Deaths by Time Increment
N=457

- KIA
- DOW

JTS 2016.
RDCR Summary

- Hemorrhage and injury cause **acute blood failure** or **hemovascular dysfunction** (leading to the “lethal triad”).

- DCR treats drivers of blood failure simultaneously with blood/blood products (and TXA).

- DCR is most effective if **started immediately**: RDCR.

- Risk/benefit of products should be considered in light of exsanguination mortality.

- Simplicity is a virtue: **LTOWB**.

- Push the **capability** forward to save lives close to POI.