Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA)
EWS REBOA
Scenario

Current Forward Operations

- Medical and surgical support deployed throughout Combined Joint Operations Area
- Majority of initial care provided at Role 1 or Role 2 level
- Austere environment, limited resources
- Limited options for early control of truncal hemorrhage
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What is REBOA?

**R**esuscitative

**E**ndovascular

**B**alloon

**O**cclusion of the

**A**orta
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What is REBOA?

■ Small catheter with an inflatable balloon near the tip
■ Introduced into femoral artery
■ Advanced into the desired zone of the aorta
■ Inflated to occlude all arterial flow distal to that point
■ Desired effects
  ❑ Control any hemorrhage below the level of the balloon
  ❑ Increase perfusion of critical organs above balloon (heart and brain)
Who Can Place a REBOA?

- Qualified physician who has completed the required training pathway for Operation Inherent Resolve/Operation Resolute Support (OIR/ORS)
  - General surgeon
  - Vascular or cardiothoracic surgeon
  - Emergency medicine at facility with surgical capability
    - Or < 15 min away from surgical capability for Zone 1 occlusion AND whole blood available to resuscitate
    - Or < 30 min away from surgical capability for Zone 3 occlusion AND whole blood available to resuscitate

- Will perform or directly supervise all aspects of placement and balloon/catheter management.
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Recommended Training

- Completion of formal curricula
  - American College of Surgeons (ACS) Basic Endovascular Skills for Trauma (BEST) Course
  - ACS Resuscitation Adjuncts: Prehospital and REBOA (RAPToR)
  - Course Completion of this REBOA presentation
- Review of REBOA video training set (4 videos)
- Review of Joint Trauma System (JTS) REBOA Clinical Practice Guideline (CPG)
- Hands-on with training catheter & simulator (when available)
- Successful completion of REBOA training post-test
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REBOA Catheter

- ER-REBOA catheter™
  (PryTime Medical Inc.)
- FDA approved
- Designed for trauma use
- Now widely adopted at civilian trauma centers
- Initially fielded by Special Ops austere surgical teams
- Planned fielding to all U.S. forward surgical elements in OIR
Important

Two separate items required for a complete REBOA set

1. ER-REBOA catheter

2. Accessory (or “Convenience”) Kit
   - #1 above ONLY contains the catheter
   - #2 provides the 7 French introducer and all other necessary supplies for placing and securing the device
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REBOA Ordering Info

ER-REBOA Catheter
NSN: 6515016580745

Convenience Kit
NSN: 6515016632913
Self-assembled REBOA kit

See REBOA CPG for instructions

Check Prytime Medical website for 7F sheath compatibility

Additional equipment to place with REBOA kit
- Vascular cutdown tray is critical to have available
- Additional micropuncture kit/7F sheath
- .035 guidewire > 20 cm long (to upsize standard femoral art line)
- Injectable contrast
  - Mix with saline for balloon inflation
  - 1/3 contrast and 2/3 saline
Traumatic hemorrhage is categorized as extremity, junctional, or truncal (NCTH)

- Extremity and junctional amenable to tourniquets and hemostatic dressings

For NCTH there has been no effective early intervention

- Rapid transfer to OR, or transport to facility with surgical capability
- High mortality and morbidity

REBOA now fielded to fill this gap in battlefield care
Death on the battlefield (2001–2011): Implications for the future of combat casualty care

Brian J. Eastridge, MD, Robert L. Mabry, MD, Peter Seguin, MD, Joyce Cantrell, MD, Terrill Tops, MD, Paul Uribe, MD, Olga Mallett, Tamara Zubko, Lynne Oetjen-Gerdes, Todd E. Rasmussen, MD, Frank K. Butler, MD, Russell S. Kotwal, MD, John B. Holcomb, MD, Charles Wade, PhD, Howard Champion, MD, Mimi Lawnick, Leon Moores, MD, and Lorne H. Blackbourne, MD

1 in 4 deaths potentially survivable

J Trauma Acute Care Surg, Vol 73, Number 6, Supplement 5
Importance of NCTH on Battlefield

- Extremity 31%
- Axilla/Groin 21%
- Torso 48%

Half of deaths due to NCTH!
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Background

- Initially used in vascular surgery
- Abdominal aortic aneurysm (AAA) repair
- Primarily for contained ruptures
  - Inflow occlusion above AAA
  - Stabilize patient for anesthesia Induction and surgery
- Decrease intraoperative blood loss
- Subsequently adopted for trauma use
REBOA in Combat

Use of an Intra-aortic Balloon Catheter Tamponade for Controlling Intra-abdominal Hemorrhage in Man
LTC Carl W. Hughes, MC, USA. Vol. 36, Issue 1, P65-68, July 01, 1954

- 2 casualties in Korea, 1954
- Restored hemodynamics
- Later died of injuries
A Modern Case Series of REBOA in an Out-of-Hospital, Combat Casualty Care Setting
Manley JD, Mitchell BJ, DuBose JJ, Rasmussen TE, JSOM, 2017

- 4 REBOA’s in an austere environment 2016
  Hemoperitoneum and class IV shock
- Ultrasound guidance for access
- Blind positioning of REBOA
- 2 performed by GS, 2 performed by EM
- All patients survived to Role 2
- No complications
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Successful REBOA Utilization

2 key components to success: Patient selection and technical skills

Must be meticulous in both to use REBOA effectively

Patient selection

- **Blunt Trauma**
  - Severe Chest Injury?**
    - Yes → No REBOA
    - No → Abdominal FAST Positive
  - Abdominal FAST Positive
    - Yes → Consider Zone I REBOA, Emergent Laparotomy
    - No → Pelvic Fx?
      - Yes → Consider Zone III REBOA
      - No → EWS

- **Penetrating**
  - Neck
    - REBOA not indicated, Operating room
  - Chest
    - REBOA not indicated, Consider thoracotomy
  - A/P/J
    - Consider Zone I REBOA
  - Extremity
    - Tourniquet, Resuscitate
Technical skills
Patient Selection: Two Primary Scenarios

1. Hemodynamically unstable patient
   - Abdominal and/or pelvic hemorrhage
   - No identified thoracic or neck bleeding
   - Non-responder or temporary responder to resuscitation

2. Patient in traumatic arrest
   - Suspected abdominal/pelvic hemorrhage
   - No suspected or identified thoracic hemorrhage/aortic injury or obvious injury of neck vasculature
   - Some sign of life present (EKG or ultrasound)
Unstable patient or arrest with proven/suspected bleeding

- Penetrating wounds to abdomen or pelvis
- Blunt trauma with positive Focused Assessment with Sonography for Trauma (FAST)
- Distended abdomen c/w large volume hemoperitoneum
- Pelvic fracture on exam and/or x-ray
- Positive diagnostic peritoneal aspirate (DPA)*
- Complex femoral junctional injuries or proximal leg amputations with ongoing hemorrhage not amenable to direct control

*DPA typically performed if persistent hypotension, suspected abdominal source, but FAST exam is negative.
Contraindications to REBOA

- Major thoracic hemorrhage/injury that could be worsened with REBOA
  - Hemothorax, aortic injury, cardiac injury, vascular injury of neck

- Ruling out major thoracic pathology/bleeding prior to REBOA*
  - Chest x-ray is optimal study if available
  - Thoracic ultrasound (evaluation for hemothorax)
  - Pericardial view on FAST exam
  - Bilateral chest tubes - particularly for pulseless electrical activity (PEA) arrest
  - Physical exam (auscultation, percussion, signs of tamponade)

*DPA typically performed if persistent hypotension, suspected abdominal source, but FAST exam is negative.
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Patient Selection

Algorithm in REBOA for Hemorrhagic Shock CPG

1. Palpable carotid pulse?
   - Yes
     - ATLS Protocols:
       - Intubation
       - Volume infusion
       - Rapid assessment for hemorrhage
       - Organized CKG rhythm or cardiac contraction on ultrasound?
         - Yes
           - Blunt Trauma
         - No
           - Penetrating Trauma
   - No
     - Blunt trauma?
       - Yes
         - CPR <15 minutes
       - No
         - Penetrating trauma?
           - Yes
             - Thoracotomy vs Zone 1 REBOA
           - No
             - A/P/I
               - Thoracotomy vs Zone 1 REBOA

   - Clinical response?
     - Yes
     - Blunt trauma?
       - Yes
         - CPR <15 minutes
       - No
         - Penetrating trauma?
           - Yes
             - Thoracotomy vs Zone 1 REBOA
           - No
             - A/P/I
               - Thoracotomy vs Zone 1 REBOA
     - No
       - Penetrating trauma?
         - Yes
           - Thoracotomy vs Zone 1 REBOA
         - No
           - A/P/I
             - Thoracotomy vs Zone 1 REBOA

2. If SBP < 90, see REBOA for Profound Shock Algorithm
   - Yes
     - Consider Thoracotomy vs REBOA if reversible cause suspected. Otherwise declare patient dead.
   - No
     - Blunt Trauma
     - Penetrating Trauma

3. Organized CKG rhythm or cardiac contraction on ultrasound?
   - Yes
     - Blunt Trauma
   - No
     - Penetrating Trauma

4. CPR <15 minutes
   - Yes
     - Thoracotomy vs Zone 1 REBOA
   - No
     - A/P/I
       - Thoracotomy vs Zone 1 REBOA

5. Penetrating trauma?
   - Yes
     - Thoracotomy vs Zone 1 REBOA
   - No
     - A/P/I
       - Thoracotomy vs Zone 1 REBOA

6. A/P/I
   - Thoracotomy vs Zone 1 REBOA

7. Penetrating Neck
   - Operating Room
8. Penetrating Chest
   - Thoracotomy
9. Penetrating Extremity
   - Tourniquet, Resuscitate

NO REBOA

- Penetrating Neck
- Penetrating Chest
- Penetrating Extremity
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Patient Selection: Key Points

■ Rapid identification of potential candidate with bleeding below the diaphragm and no major bleeding injuries above the diaphragm.

■ Early placement of femoral access in any potential candidate, preferably prior to decompensation or arrest.

■ Immediate availability of surgeon and OR team to perform exploration and definitive hemorrhage control.
Technique

- Review the four REBOA training videos for details of the ER-REBOA device and placement (total = 22 minutes)
  - ER-REBOA catheter and convenience kit familiarization video
  - ER-REBOA “Best Practices” video
  - “How I Do It” videos, part 1 and part 2
    - Part 1: https://www.youtube.com/watch?v=-U7MkU3eA7E
    - Part 2: https://www.youtube.com/watch?v=DZ5LCEt7PBk

- Review the technique description in the REBOA JTS CPG.
EWS Introduction

REBOA Placement

Site for CFA Access
Introduction

Femoral Access Techniques

Real-time ultrasound guidance is optimal if available

Palpation/Landmarks

Open groin cut down
REBOA Placement

Technique

- Femoral artery access with 7 French introducer sheath
  - Introducer sheath and all supplies contained in the ER-REBOA Convenience Kit
  - Palpate both femoral arteries; use stronger pulse side.
- ALWAYS confirm arterial placement and not in vein.
- Sheath can be used as arterial line if REBOA not immediately needed.
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REBOA Placement

Technique

- Desired site of placement is common femoral artery, NOT superficial femoral.
- Site of needle stick should be at or right below inguinal ligament.
- If difficulty passing wire, abort and try the other side.
- Team should be simultaneously setting up arterial line set.
- X-ray tech ready for post-placement films (if available).
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Aortic Zones for REBOA

- **Zone 1**
  - Descending thoracic aorta
  - Most commonly utilized

- **Zone 3**
  - Distal abdominal aorta
  - Less commonly used
  - Isolated pelvic hemorrhage

- **Zone 2** not utilized
Selection

- **Zone 1** placement will occlude flow to entire abdomen and lower body.
  - Should have efficacy for all sites of potential abdominal/pelvic bleeding.

- **Zone 3** will occlude flow to pelvis and legs, but maintain or even increase flow to abdominal organs.
  - Utilized for strongly suspected or proven pelvic or junctional hemorrhage, and no suspicion of abdominal hemorrhage.
  - Patient should have negative FAST exam and/or DPA.
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Aortic Zone for REBOA

Targeting Correct Aortic Zone

- Placement under real-time fluoro guidance optimal
  - But not available or practical for most deployed MTFs

- External landmarks should be routinely utilized
  - Distance from inguinal ligament/sheath to sternal notch = Zone 1
    - ER-REBOA: place p-tip just below sternal notch and measure to access site
  - From inguinal ligament/sheath to xiphoid process = Zone 3
    - ER-REBOA: place p-tip just below the xiphoid and measure to access site
  - Measure using catheter and note distance for both zones

- For most adults within average size range
  - Can use 46 cm for Zone 1 and 27 cm for Zone 3
Confirm Placement and Efficacy

- Inflate balloon slowly and watch tracing from arterial line port.
- Should see immediate increase in pressure with occlusion (see image).
- Loss of contralateral femoral pulse
  - May be only initial confirmation possible in austere setting
- Decrease or cessation of bleeding (if visible)
- Max balloon inflation is 24 cc
- Use “3 to 8, don’t over-inflate” mnemonic
  - 3 cc will occlude average size aorta in Zone 3
  - 8 cc will occlude average size aorta in Zone 1
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X-ray for REBOA Position

Zone 1

Zone 3
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Balloon Inflation

“3 to 8, don’t overinflate”

<table>
<thead>
<tr>
<th>Balloon Diameter</th>
<th>Inflation Volume</th>
</tr>
</thead>
<tbody>
<tr>
<td>15 mm</td>
<td>5 cc</td>
</tr>
<tr>
<td>20 mm</td>
<td>8 cc</td>
</tr>
<tr>
<td>25 mm</td>
<td>13 cc</td>
</tr>
<tr>
<td>30 mm</td>
<td>20 cc</td>
</tr>
<tr>
<td>32 mm</td>
<td>24 cc</td>
</tr>
</tbody>
</table>
Secure the Catheter. **Will migrate out if unsecured.**
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Catheter Placement

Secure the Catheter

If open cutdown performed, it is critical to secure both the sheath and the REBOA catheter.

- Suture sheath to fascia.
- Suture catheter fastener clip to skin.
**MEFIIS: Acronym for Placement**

- **M**easure balloon distance (for Zone 1 and Zone 3 placement)
- **E**vacuate balloon
- **F**lush the arterial line
- **I**nsert the catheter
- **I**nflate the balloon
- **S**ecure the catheter
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Duration

Duration of Tolerable REBOA?
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Ischemia/Reperfusion

REBOA Creates Ischemia/Reperfusion Injury

- Tolerable 30-60 minutes
- Longer than 1 hour
  - Unlikely to survive
  - < 30 min desired

- Less I/R injury created
- Longer occlusion times tolerable
  - 4-6 hours recorded
  - < 60 min preferred

Zone 1

Zone 3
REBOA is NOT a therapeutic intervention!
- It is a bridge to provide stability for transport to definitive control of hemorrhage
- Typically either operative intervention or angioembolization
- In deployed environment, almost always will be OR
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Balloon Deflation

Time for Balloon Deflation

- Communicate to team before deflating.
- Rapid reperfusion can be fatal.
  - hypotension, acidosis, hyperkalemia
- Optimize intravascular volume.
- Have bicarb and calcium ready.
  Consider giving prior to deflation
- SLOW, controlled deflation
  - particularly for Zone 1 REBOA
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Balloon Removal

- Deflate balloon fully
- Cut sutures
- Withdraw through sheath
- Make decision
  - Remove sheath
  - Leave in place
### EWS REBOA

**Introducer Sheath**

<table>
<thead>
<tr>
<th>Remove Sheath</th>
<th>Leave Sheath</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding controlled</td>
<td>Damage-control setting</td>
</tr>
<tr>
<td>Minimal risk re-bleed</td>
<td>Risk of re-bleeding</td>
</tr>
<tr>
<td>NOT coagulopathic</td>
<td>Coagulopathic, hypothemic</td>
</tr>
<tr>
<td>Able to be observed closely</td>
<td>Need for rapid transfer</td>
</tr>
<tr>
<td>No need for arterial line or access</td>
<td>Need for arterial line or access</td>
</tr>
</tbody>
</table>

*Default option if placed at Role 1 or Role 2 level is to leave sheath in place. Can be removed at next echelon when patient fully resuscitated.*
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Sheath Removal

■ If sheath was placed percutaneously:
  □ Pull sheath and apply immediate direct pressure.
  □ Hold for 30 minutes and then release and observe.
  □ Reapply if any signs of bleeding or hematoma forming.

■ If sheath was placed via open cutdown:
  □ Remove sheath and close arteriotomy

■ Percutaneous closure devices are an option if available.
Always assess limb right after sheath removal
- Pulse/Doppler checks and assessment of leg/foot perfusion
- Completion angiogram of leg is an option

CONTINUE serial exams postoperatively
- Q1H vascular checks x 24 hours

If evidence of access site thrombosis
- Immediate angiography or operative exploration
- Catheter embolectomy
- Primary re-closure or patch angioplasty

Groin hematomas common
Completion of formal curricula
- ACS BEST Course
- ACS RAPToR Course

Completion of this REBOA presentation

Review of REBOA video training set (4 videos)

Review of JTS REBOA CPG

Hands-on with training catheter and simulator (when available)

Successful completion of REBOA training post-test
Each unit or element with REBOA capability will identify at least one “REBOA champion.”

Responsibilities include:

- Providing familiarization training to entire team.
- Ensuring proper storage and utilization.
- Coordinating re-order/re-supply as needed.
- Left seat/right seat training of replacement.
- Submission of data on any REBOA use per JTS CPG.