REBOA for Hemorrhage Control
Old Problem, New Trick?

Michigan Trauma Coalition Membership Meeting
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Division Chief Acute Care Surgery – Spectrum Health
Here’s the Challenge

PATIENT ARRIVES
AIRWAY IS INTACT
BILATERAL BREATH SOUNDS
BP 76/37
Objective

To have a SIMPLE framework for incorporating REBOA into your treatment of the bleeding patient.
The “Golden Hour”

“the first hour after injury will largely determine a critically injured person’s chances for survival”
Precipitous rise in mortality after 30 minutes
Hypotensive GSW: mortality maximum at 15 minutes
Effect of time to operation on mortality for hypotensive patients with gunshot wounds to the torso: The golden 10 minutes

Jonathan P. Meizoso, MD, MSPH, Juliet J. Ray, MD, MSPH, Charles A. Karcutskie, IV, MD, MA, Casey J. Allen, MD, Tanya L. Zakrison, MD, MPH, Gerd D. Pust, MD, Tulay Koru-Sengul, PhD, Enrique Ginzburg, MD, Louis R. Pizano, MD, MBA, Carl I. Schulman, MD, PhD, MSPH, Alan S. Livingstone, MD, Kenneth G. Proctor, PhD, and Nicholas Namias, MD, MBA, Miami, Florida

Overall Mortality: 27%
< 10 min: 20% mortality

> 10 Min Mortality: 45%
> 10 min: 3 x ↑ mortality
“Golden Hour”

“Platinum 10 Minutes”
ED based treatment of the hypotensive patient must be automatic.
What is REBOA?

Mechanism to control non-compressible torso hemorrhage.
History

- 1954: IABO first used in Korean War
- 1970s – 1980s: Resuscitative thoracotomy described by Denver Health and Detroit Receiving
- 1989: IABO vs RT “effective” but revealed high rate of complications with IABO
- 2013: Report of 6 successful cases sparked a renewed interest in REBOA
- 2014: U.S. Military – “REBOA should be considered as an alternative to RT in the setting of extrathoracic blunt or penetrating injury and severe shock”

Biffi et al. JTACS. 2015.
Implementation of resuscitative endovascular balloon occlusion of the aorta as an alternative to resuscitative thoracotomy for noncompressible truncal hemorrhage

Moore et al. JTACS. 2014.
Implementation of resuscitative endovascular balloon occlusion of the aorta as an alternative to resuscitative thoracotomy for noncompressible truncal hemorrhage

Total Number of Patients Undergoing REBOA
N = 24 Patients

REBOA with Vitals Present on ER Admission
N = 17 Patients

+ FAST
ZONE I REBOA
N = 13 Patients

46% Survival

- FAST, + Pelvic Fracture
ZONE III REBOA
N = 4 Patients

75% Survival

REBOA with CPR in Progress on ER Admission
N = 7 Patients*

+ FAST
ZONE I REBOA
N = 6 Patients

0% Survival

- FAST, + Pelvic Fracture
ZONE III REBOA
N = 1 Patients

0% Survival

Scalea et al. JTACS. 2014.
The role of REBOA in the control of exsanguinating torso hemorrhage

Walter L. Biffl, MD, Charles J. Fox, MD, and Ernest E. Moore, MD, Denver, Colorado
Multi-Institutional Studies

The Multi-Institutional Trials Committee is accepting proposals for new multi-center studies and soliciting participation for recently approved studies. Each study is headed by one Coordinating Center, which is primarily responsible for designing the protocol and data collection sheet. After appropriate input and revisions, the studies are posted on the AAST-MIT webpage and interested centers may participate.

Each study is presented with its protocol and data collection sheet. Direct communication with the study PI or the Committee Chairperson is strongly encouraged before participation. The AAST-MIT is looking forward to your enthusiastic support and participation in these and future studies.

Please read the instructions for the AAST MIT Site below. The request form to access the MIT site is below.
Resuscitative endovascular occlusion of the aorta has emerged as a viable alternative to open aortic occlusion in centers that have developed this capability.
ER-REBOA Catheter
Catheter Development

Smaller introducer sheaths for REBOA may be associated with fewer complications

Conclusions

7Fr REBOA catheters can significantly elevate SBP with no access-related complications. Our results suggest that a 7Fr introducer device for REBOA may be a safe and effective alternative to large-bore sheaths, and may remain in place during the post-procedure resuscitative phase without sequelae.
Emergent non-image-guided resuscitative endovascular balloon occlusion of the aorta (REBOA) catheter placement: A cadaver-based study.

Linnebur M¹, Inaba K, Haltmeier T, Rasmussen TE, Smith J, Mendelsberg R, Grabo D, Demetriades D.

Abstract

BACKGROUND: Emergent resuscitative endovascular balloon occlusion of the aorta (REBOA) insertion for critically injured patients in hemorrhagic shock is performed blindly with fluoroscopic imaging confirmation. The aim of this study was to determine a reliable method for initial REBOA catheter insertion with balloon deployment between the left subclavian artery takeoff and the celiac trunk (CT).

METHODS: Human cadaver study. External surface (sternal notch, mid-sternum, xiphoid) and intravascular (left subclavian artery [LSA], and CT) landmarks were measured from standardized left and right common femoral artery puncture sites. The landing zone (LZ, distance between LSA and CT) and margins of safety (distance from distal balloon edge to LSA and proximal balloon edge to CT) were calculated using intravascular landmarks. The probability of balloon deployment in the LZ using external landmarks was compared in univariate analysis using the Fisher exact test.

RESULTS: Ten cadavers were analyzed (seven males; mean body mass index, 19.4 kg/m). Mean (SD) intravascular distances from femoral puncture sites to the LSA and CT were 54.8 (1.9) cm and 32.9 (1.9) cm. The mean (SD) LZ was 21.8 (3.8) cm. Mean (SD) surface distances from femoral puncture sites to the xiphoid, mid-sternum, and sternal notch were 31.8 (3.9) cm, 41.8 (3.3) cm, and 51.8 (3.2) cm. Inserting the catheter to a distance approximated by surface distance from the femoral puncture site to mid-sternum resulted in a 100% likelihood balloon deployment in the LZ for both sides. This was superior to the xiphoid and sternal notch (left site, p = 0.005; right site, p = 0.036; mean of both sites, p = 0.083). Using the mid-sternum landmark, the mean (SD) margins of safety to the LSA and CT were 10.7 (4.3) cm and 3.1 (3.4) cm.

CONCLUSION: When using the use of the mid-sternum landmark for REBOA balloon placement, the likelihood of balloon deployment in the LZ was 100% with an acceptable margin of safety.
Spectrum Algorithm

1. Hypotensive (SBP <90)
   Partial or non-responder

2. Place femoral arterial line.

3. No REBOA
   Yes

4. CXR: possible aortic injury or infrarenal source for hypotension?
   No

5. Position REBOA in ZONE 1, confirm placement, and inflate. Proceed to OR for emergent laparotomy. (Goal: Deflation of balloon in less than 30 minutes)

6. Yes; place 7 Fr. Sheath, Insert REBOA catheter
   No

7. FAST: Positive?
   No

8. Pelvic X-ray: fracture?
   Yes

9. Position REBOA in ZONE II, confirm placement, and inflate. (Goal: deflation of balloon in less than 60 minutes)

10. Yes; place 7 Fr. Sheath, Insert REBOA catheter
    No

11. Trauma Attending decision...

12. Proceed emergently to IR for angiography

13. Unstable patient?

14. Stable patient, complete trauma work-up (CT Scan), transport to ICU
Are you sure the patient is bleeding?

76/37

71/39

66/44

1.8

1.8
Empowered by good information

Are Automated Blood Pressure Measurements Accurate in Trauma Patients?

James W. Davis, MD, FACS, Ivan C. Davis, MS, Lynn D. Bennink, BSN, John F. Bilello, MD, FACS, Krista L. Kaups, MD, FACS, and Steven N. Parks, MD, FACS
Automated or Manual BP?

### Table 2: Blood Pressure Group, Injury Scores, Base Deficit, and Fluid Resuscitation

<table>
<thead>
<tr>
<th>BP Group</th>
<th>No.</th>
<th>Manual BP</th>
<th>Automatic BP</th>
<th>ISS</th>
<th>BD</th>
<th>IV Fluid (L)</th>
<th>Blood (mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (≤90 mm Hg)</td>
<td>92</td>
<td>80 ± 2</td>
<td>106 ± 6*</td>
<td>29.9 ± 3.5</td>
<td>−5.4 ± 1</td>
<td>3.7 ± 0.5</td>
<td>593 ± 310</td>
</tr>
<tr>
<td>2 (91–110 mm Hg)</td>
<td>119</td>
<td>103 ± 1</td>
<td>119 ± 4*</td>
<td>24.6 ± 2.9*</td>
<td>−2.7 ± 1*</td>
<td>2.7 ± 0.4†</td>
<td>161 ± 65*</td>
</tr>
<tr>
<td>3 (&gt;110 mm Hg)</td>
<td>177</td>
<td>135 ± 3</td>
<td>138 ± 3</td>
<td>18.2 ± 1.7@</td>
<td>−1.6 ± 1@</td>
<td>2.3 ± 0.3@</td>
<td>72 ± 31@</td>
</tr>
</tbody>
</table>

IV, intravenous.

* p < 0.0001 vs. manual BP; † p < 0.0001; ‡ p < 0.001; †† p < 0.01 vs. group 1 (BP ≤ 90 mm Hg).

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**REVIEW**

A systematic review of variability and reliability of manual and automated blood pressure readings

**Conclusions.** There are situations where the substitution of oscillometric for auscultatory devices could have particularly serious repercussions for the patient, such as when the patient is either hypertensive or hypotensive. However, further research is required on the use of aneroid sphygmomanometers as a replacement for mercury devices.
Human Over Machine
What about the arterial line?
Empowered by good information....but at a cost

Femoral arterial and central venous catheters in the trauma resuscitation room

S.R. Hamada\textsuperscript{a,*}, M. Fromentin\textsuperscript{b}, M. Ronot\textsuperscript{c}, T. Gauss\textsuperscript{d}, A. Harrois\textsuperscript{a}, J. Duranteau\textsuperscript{a}, C. Paugam-Burtz\textsuperscript{d}

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\textsuperscript{d} Anaesthesia and Critical Care Department, AP-HP, Hôpital Beaujon, Hôpitaux Universitaires Paris Nord Val de Seine, Université Paris Diderot, 100 rue du Général Leclerc, Clichy, Paris 7, 92110, France

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographic and clinical characteristics fAC-CVC: Femoral Arterial Catheter and Central Venous Catheter.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>fAC-CVC(−) n = 446</td>
</tr>
<tr>
<td>Age (y)</td>
<td>38 (17)</td>
</tr>
<tr>
<td>Sex Ratio M/F (% male)</td>
<td>367/79 (82%)</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td>0.06</td>
</tr>
<tr>
<td>ISS</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>ISS &gt; 15 n (%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>AIS head</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>IGS 2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>GCS ≤ 8 n (%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mortality n (%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Time spent in trauma bay (min)</td>
<td>30 [20;40]</td>
</tr>
</tbody>
</table>

30 vs 45 mins
Time is of the Essence

“Platinum 10 Minutes”
Where is the $%*@ blood?
The Blood Loss Can’t Hide...

Chest
Abdomen
Pelvis
Retroperitoneum
Extremities
Scene
Bottom line…don’t think too hard

- Determine if patient is actually hypotensive
- Hemorrhagic shock until proven otherwise
- Listen to EMS
- Consider each compartment as a source of bleeding
- Perform thorough physical exam
- Supplement with ED based imaging (XR and FAST)
Spectrum Algorithm

Hypotensive (SBP <90)
Partial or non-responder

Place femoral arterial line.

No REBOA

CXR: possible aortic injury or thoracic source for hypotension?

Yes

Position REBOA in ZONE I, confirm placement, and inflate. Proceed to OR for emergent laparotomy.
(Goal: Deflation of balloon in less than 30 minutes)

No

Pelvic X-ray: fracture?

Yes, place 7 Fr.
Sheath, Insert REBOA catheter

No

Position REBOA in ZONE II, confirm placement, and inflate. (Goal: deflation of balloon in less than 60 minutes)

Yes, place 7 Fr.
Sheath, Insert REBOA catheter

Proced with chest tube placement, PCC, and OR for emergent laparotomy

Trauma Attending decision...

Proceed emergently to IR for angiography

Unstable patient?

Stable patient, complete trauma work-up (CT Scan), transport to ICU

FAST: Positive?

Yes

No

Inclusion Criteria

- Greater than or equal to 18 years old
- Hypotensive (SBP < 90) and partial/non-responder to resuscitation
- Truncal hemorrhage (abdomen or pelvis)
- Penetrating extremity injury

Reserved for sick patients in hemorrhagic shock, not responsive to traditional therapy.
Exclusion Criteria

- Pulseless patient (ED thoracotomy)
- Hemorrhage from above diaphragm
- Cardiac injury
- Penetrating thoracic injury
- Widened mediastinum
- Traumatic brain injury

- CXR, Pelvis XR, FAST should be completed prior to placement
Ultrasound Guided Access

- Safe vascular access can be obtained without imaging, but...
- Reduce risk of vascular injury with more precise vessel entry
- Recognize variant anatomy
- Select puncture site precisely
- Obtain access in pulseless arteries

Slide courtesy of medical device company
Slide courtesy of medical device company
Slide courtesy of medical device company
7 French Sheath upsize
Slide courtesy of medical device company
Device depth measurement

Zone 1 measurement

Zone 3 measurement

Slide courtesy of medical device company
Balloon flush

Slide courtesy of medical device company
Secure Catheter

Slide courtesy of medical device company
Aortic Occlusion Time

- Decide on a course of action and move towards it expeditiously

- How long can the balloon stay up?
  - 30 minutes for Zone 1
  - 60 minutes for Zone 3
After all this…still hypotensive

- ED is transition between the scene and definitive care
- Facilitate transition to area able to most quickly terminate source of bleeding
  - OR
  - IR
Lower your standards: Resuscitating to Hypotension

- Hypotensive resuscitation: Restrictive approach to resuscitation
- Keep pressure high enough to perfuse organs
- Keep pressure low enough to limit bleeding
- Avoid “popping the clot”
- Goal SBP 80 - 90 mm HG
Technology gone wrong
Complications

- Gut ischemia
- Reperfusion syndrome
- Spinal ischemia
- Increased intracranial pressure
- Aortic injury (syringe change)
- Femoral artery injury
- Death
Better Science Coming?

WELCOME TO UK-REBOA TRIAL WEBSITE

The UK-REBOA (Resuscitative Endovascular Balloon Occlusion of the Aorta) Trial
PRACTICE
**PI EVERY CASE**

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**PI BUTTERWORTH ADULT TRAuma CRITIQUE WORKSHEET**

**RESUSCITATIVE ENDOVASCULAR BALLOON OCCLUSION of the AORTA (REBOA)**

<table>
<thead>
<tr>
<th>Pt. Name:</th>
<th>Patient Arrival Date &amp; Time:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pt DOB:</td>
<td>Level of Activation:</td>
</tr>
<tr>
<td>Age:</td>
<td>Criteria for Level Med:</td>
</tr>
<tr>
<td>MRN:</td>
<td>Trauma Surgeon:</td>
</tr>
<tr>
<td>TBI:</td>
<td></td>
</tr>
</tbody>
</table>

**REBOA SYSTEMATIC REVIEW**

1. Mechanism of Injury:

2. Pre Hospital Course:
   - Pre hospital CPR: ☐ Y ☐ N
   - Time from injury to index hospital (minutes): __________

3. Work-Up (Purpose: Establish inclusion & determination of zone placement)
   - Chest X-Ray: ☐ Y ☐ N Time: Results:
   - Pelvis X-Ray: ☐ Y ☐ N Time: Results:
   - FAST Exam: ☐ Y ☐ N Time: Results:
   - Blood Product: ☐ Y ☐ N Total product prior to REBOA: PRBC: __ u FFP: __ u PTh: __ u TXA: __ Y ☐ N
   - Pt hemodynamic response: ☐ Partial Responder ☐ Non-Responder ☐ Subsequent BP: ☐ Initial labs: Hgb: __mg/dl Hematocrit (%): __ INR: __ pCO2 Base deficit: __/ __ Lactate: __mg/dl
   - Arterial Line placement time: Site: ☐ R ☐ L
   - Suspected location of hemorrhage: ☐ Chest ☐ Abdomen ☐ Pelvis ☐ Lower Extremities
   - Determination of zone placement: ☐ Zone 1 ☐ Zone 2 ☐ Zone 3
   - Was pelvic binder utilized: ☐ Y ☐ N
   - Pre notification to IR/CT/OR of REBOA placement: ☐ IR ☐ CT ☐ OR
   - Additional IV/Line Access: ☐ Central Line placement:

4. Technical Aspects
   - Balloon inflation time:
   - Distance of catheter insertion (cm):
   - Inflation volume (cc):
   - 1st Post-Inflation BP: ☐ Y ☐ N
   - 1st Post HR: __ Post Temp: __°C
   - Radiologic confirmation of placement in Trauma Bay: ☐ Y ☐ N
   - Time:

5. Post Inflation Course
   - CT/IR/OR: ☐ IR ☐ CT ☐ OR
   - Time of pt. transport to CT/IR/OR:
   - Balloon deflation time:
   - Comment:
   - Total balloon inflation time:
   - Time catheter removed:
   - Pt location at time of catheter removal: ☐ CT ☐ IR ☐ OR ☐ SICU
   - Was hemorrhage control obtained: ☐ Y ☐ N
   - Was an uncontrolled bleeding source ABOVE the aortic occlusion ultimately identified? ☐ Y ☐ N

6. Sheath Removal
   - Time Sheath was removed:
   - Length of time sheath was in place:
   - Sheath Removal complications: ☐ Y ☐ N

7. Hospital Course: Additional procedures required during 1st 24 hours of hospitalization (check all that apply):
   - Exploratory Laparotomy ☐ Splenectomy ☐ Chest Tube ☐ Embolization ☐ Vascular Access
   - Resuscitation 1st 24 hours (unit): PRBC: __ FFP: __ PTh: __ Vasopressors required: ☐ Y ☐ N TXA: ☐ Y ☐ N

8. Was standard practice followed according to procedural guideline/algorithm/policy? ☐ Y ☐ N

9. Patient disposition/outcome:

10. Additional Comments:

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Pl Nurse Reviewer: __________ Date Reviewed: __________ Date TPC Review: __________
Summary

- Patients die quickly from hemorrhage
- Determine if patient is hypotensive
- Identify the general region of bleeding
- Replace the blood loss
- REBOA can be used as a bridge to bleeding control
- Facilitate transfer to definitive control of hemorrhage
- PRACTICE, PRACTICE, PRACTICE
- Objectively assess (PI) every case
THANK YOU FOR BEING
All in, all the time