THE ROLE OF REBOA IN CONTROL OF EXSANGUINATING TORSO HEMORRHAGE

Walter L. Biffl, M.D.

Medical Director, Acute Care Surgery, The Queen’s Medical Center
Professor and Associate Chair for Research, Department of Surgery, JABSOM/University of Hawaii Manoa
THE PROBLEM

Noncompressible Hemorrhage in Chest / Abdomen / Pelvis

Fate of the Patient Depends on:

- Decision Making
- Resources
- Efficacy of Interventions
Use of an Intra-Aortic Balloon Catheter Tamponade for Controlling Intra-Abdominal Hemorrhage in Man
Lieutenant Colonel Carl W. Hughes (Medical Corps, US Army)
Surgery 1954; 36:65

Abstract
An intra-aortic balloon catheter tamponade was utilized in two moribund Korean War casualties with uncontrolled intra-abdominal hemorrhage. Although both patients expired, the catheter was effective in temporarily restoring the blood pressure in one case. The catheter should be further evaluated both experimentally and clinically.
THE SOLUTION – IN EVOLUTION

Lack of familiarity with technique +
Potential mesenteric and spinal ischemia +
Concerns for technical complications +
Unfortunate outcomes

= No widespread adoption
RESUSCITATIVE THORACOTOMY

Line of pericardiectomy
Phrenic nerve

Cross clamp on aorta

THE ROLE OF THORACIC AORTIC OCCLUSION FOR MASSIVE HEMOPERITONEUM

ANNA M. LEDGERWOOD, M.D., MARIS KAZMERS, M.D., AND CHARLES E. LUCAS, M.D.

From the Department of Surgery, Wayne State University School of Medicine, Detroit, Michigan

Outcome of Resuscitative Thoracotomy and Descending Aortic Occlusion Performed in the Operating Room

J. SCOTT MILLIKAN, M.D., AND ERNEST E. MOORE, M.D.
The Role of Intra-aortic Balloon Occlusion in Penetrating Abdominal Trauma

BHUPENDRA K. GUPTA, M.D., SATISH C. KHANEJA, M.D., LUCIO FLORES, M.D., LEWIS EASTLICK, M.D., WAYNE LONGMORE, M.D., AND GERALD W. SHAFTAN, M.D.

**Survival**

Group 1 - No BP in ED  0 / 5 (0%)

Group 2 – Preop Massive Hemoperitoneum  3 / 6 (50%)

Group 3 – Intraop IABO  4 / 10 (40%)
Complications: Three serious complications related to the use of IABO were noted in this group of 21 patients. One patient (#5, Table III), who had multiple attempts at the percutaneous placement of the balloon catheter in the Emergency Department continued to have an ischemic right lower extremity, despite a thrombectomy of the iliofemoral artery which was done 6 hours after initial celiotomy. The catheter exited through the aortic injury in two patients. In the first patient IABO was attempted before celiotomy and aortic exit was recognized by the disappearance of the central aortic pressure tracing in the catheter and a lack of resistance in inflating the balloon; this patient underwent thoracotomy for aortic cross clamping. In the second case, aortic exit occurred during the placement at celiotomy and the catheter was redirected. In the 11 patients in whom a neurologic assessment could be made, there was no instance of spinal cord damage.

In a multicenter cooperative trial involving four different hospitals, there were eight complications in 23 patients. Complications consisted of one instance of paraplegia when there was prolonged balloon inflation time, four instances of the catheter exiting from aortic injuries, and three instances of femoral artery thrombosis. Our initial 14 patients and the three complications formed a part of this trial.
Death on the battlefield (2001–2011): Implications for the future of combat casualty care

For the study interval between October 2001 and June 2011, 4,596 battlefield fatalities were reviewed and analyzed. The stratification of mortality demonstrated that 87.3% of all injury mortality occurred in the pre-MTF environment. Of the pre-MTF deaths, 75.7% (n = 3,040) were classified as nonsurvivable, and 24.3% (n = 976) were deemed potentially survivable (PS). The injury/physiologic focus of PS acute mortality was largely associated with hemorrhage (90.9%). The site of lethal hemorrhage was truncal (67.3%), followed by junctional (19.2%) and peripheral-extremity (13.5%) hemorrhage.
Ruptured Abdominal Aortic Aneurysms: Remote Aortic Occlusion for the General Surgeon

CPT Zachary M. Arthurs, MD, CPT Vance Y. Sohn, MD, Benjamin W. Starnes, MD, FACS

*aDepartment of Surgery, Madigan Army Medical Center, Fitzsimmons Drive, Building 9040, Tacoma, WA 98431, USA
bDivision of Vascular Surgery, University of Washington, Harborview Medical Center, 325 Ninth Avenue, Seattle, WA 98104, USA
A clinical series of balloon occlusion resuscitation

Megan L. Brenner, Michelle K. McNutt, MD

<table>
<thead>
<tr>
<th>Patient</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tr>
<td>Age, y</td>
<td>62</td>
<td>24</td>
<td>59</td>
<td>25</td>
<td>40</td>
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</tr>
<tr>
<td>Sex</td>
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<td>Male</td>
<td>Male</td>
<td>Male</td>
<td>Male</td>
<td>Female</td>
</tr>
<tr>
<td>Mechanism of injury</td>
<td>MVC</td>
<td>GSW</td>
<td>GSW</td>
<td>MVC</td>
<td>MCC</td>
<td>ATV collision</td>
</tr>
<tr>
<td>Injury Severity Score (ISS)</td>
<td>28</td>
<td>50</td>
<td>9</td>
<td>25</td>
<td>48</td>
<td>43</td>
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<tr>
<td>SBP before REBOA, mm Hg</td>
<td>70</td>
<td>70</td>
<td>0</td>
<td>60</td>
<td>70</td>
<td>85</td>
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<tr>
<td>Cardiac arrest before REBOA</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>SBP after REBOA, mm Hg</td>
<td>135</td>
<td>122</td>
<td>100</td>
<td>110</td>
<td>130</td>
<td>125</td>
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<tr>
<td>Admission base deficit</td>
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<td>4</td>
<td>NA</td>
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<td>14</td>
<td>19</td>
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<td>Time to occlusion, min</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>6</td>
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<td>6</td>
</tr>
<tr>
<td>Time of occlusion, min</td>
<td>12</td>
<td>16</td>
<td>70</td>
<td>60</td>
<td>65</td>
<td>36</td>
</tr>
<tr>
<td>Surgery after REBOA</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Pelvic embolization after REBOA</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Complication of REBOA</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Outcome</td>
<td>Alive</td>
<td>Alive</td>
<td>Alive</td>
<td>Alive</td>
<td>Brain death</td>
<td>Death (care withdrawn)</td>
</tr>
</tbody>
</table>

J Trauma Acute Care Surg 2013; 75:506
Indications for REBOA
n (%) = 244 (18.5%)
Mean ISS (SD) = 51 (21)
Mortality, n (%) = 173 (70.9)

Signs-of-Life En-Route
n = 165
Mean ISS (SD) = 44 (19)
Mortality, n (%) = 95 (57.6%)

- Zone I
- High-grade (AIS
  - Liver/kidney/spleen
  - Mesenteric disruption
  - Named abdominal vessel injury
- Traumatic amputation at/near hip
# Joint Theater Trauma System Clinical Practice Guideline

## Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) for Hemorrhagic Shock

<table>
<thead>
<tr>
<th>Original Release/Approval</th>
<th>16 Jun 2014</th>
<th>Note: This CPG requires an annual review.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reviewed</td>
<td>05 May 2014</td>
<td>Approved: 16 Jun 2014</td>
</tr>
</tbody>
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### Supersedes

- This is a new CPG and must be reviewed in its entirety.

- □ Minor Changes *(or)*
  - □ Significant Changes

- ✗ Changes are substantial and require a thorough reading of this CPG *(or)*
APPENDIX A  TRAUMATIC ARREST ALGORITHM

Trauma with Loss of Vitals

- Blunt
  - Organized Rhythm on EKG or FAST
    - Thoracotomy vs. REBOA I
  - CPR ≤15 min
    - Thoracotomy vs. REBOA I

- Penetrating
  - Neck
    - OR
  - Chest
    - Thoracotomy
  - A/P/E*

Profound Shock Algorithm (Fig 2)

*Abdomen/Pelvis/Extremity; REBOA I = Placement of aortic balloon in the thoracic aorta (2-8 cm above the xyphoid)

APPENDIX B  ALGORITHM FOR THE MANAGEMENT OF PROFOUND SHOCK

SBP <90 with Transient or No Response
CPR pre-hospital with ROSC

- Blunt
  - Cardiac or Aortic Injury?
    - Yes
      - No REBOA
    - No + FAST
      - Yes
        - Consider REBOA I
    - No Pelvic Fx
      - Yes
        - Consider REBOA III

- Penetrating
  - Neck
    - No REBOA
  - Chest
    - No REBOA
  - A/P/E*
    - Consider REBOA I

*Abdomen/Pelvis/Extremity; ROSC, Return of Spontaneous Circulation; REBOA I = Placement of aortic balloon in the thoracic aorta (2-8 cm above the xyphoid); REBOA III = Placement of aortic balloon directly above the aortic bifurcation (1-2 cm above the umbilicus)
Simple device is saving lives

EXCLUSIVE Cathy O'Leary Medical Editor

Friday, 6 February 2015 4:45PM

Lifesaver: Trauma surgeon Dieter Weber with the device. Picture: Ian Munro/The West Australian
### Table 1: Clinical Characteristics

<table>
<thead>
<tr>
<th>Patient</th>
<th>Age</th>
<th>Sex</th>
<th>Mechanism</th>
<th>ISS</th>
<th>Liver injury</th>
<th>Splenic injury</th>
<th>FAST scan</th>
<th>Renal injury</th>
<th>Retroperitoneal hemorrhage</th>
<th>Pelvic fracture</th>
<th>Femoral fracture</th>
<th>SBP before REBOA, mm Hg</th>
<th>SBP after REBOA, mm Hg</th>
<th>PRBC within 24 h, mL/U</th>
<th>FFP within 24 hours, mL/U</th>
<th>PC within 24 hours, mL/U</th>
<th>FFP/PRBC ≥ 1, U</th>
<th>Total occlusion time, min</th>
<th>REBOA-related complications</th>
<th>Additional operative management</th>
<th>28-d outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>58</td>
<td>Male</td>
<td>Blunt</td>
<td>75</td>
<td>Grade II</td>
<td>—</td>
<td>Positive</td>
<td>Grade IV</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>80</td>
<td>90</td>
<td>6,000 mL/50 U</td>
<td>5,400 mL/60 U</td>
<td>1,000 mL/50 U</td>
<td>Yes</td>
<td>97</td>
<td>No</td>
<td>No</td>
<td>Dead</td>
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<tr>
<td>2</td>
<td>79</td>
<td>Male</td>
<td>Blunt</td>
<td>59</td>
<td>Grade IV</td>
<td>Grade IV</td>
<td>Positive</td>
<td>—</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>80</td>
<td>130</td>
<td>3,600 mL/30 U</td>
<td>6,300 mL/70 U</td>
<td>1,200 mL/60 U</td>
<td>Yes</td>
<td>74</td>
<td>No</td>
<td>No</td>
<td>Alive</td>
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<tr>
<td>3</td>
<td>64</td>
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<td>Blunt</td>
<td>50</td>
<td>Grade V</td>
<td>—</td>
<td>Positive</td>
<td>Grade IV</td>
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<td>99</td>
<td>139</td>
<td>2,400 mL/20 U</td>
<td>900 mL/10 U</td>
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<td>Yes</td>
<td>85</td>
<td>No</td>
<td>No</td>
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<td>4</td>
<td>69</td>
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<td>25</td>
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<td>—</td>
<td>Positive</td>
<td>Grade IV</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>74</td>
<td>135</td>
<td>6,240 mL/52 U</td>
<td>4,050 mL/45 U</td>
<td>600 mL/30 U</td>
<td>Yes</td>
<td>85</td>
<td>No</td>
<td>No</td>
<td>Alive</td>
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<tr>
<td>5</td>
<td>55</td>
<td>Male</td>
<td>Blunt</td>
<td>48</td>
<td>Grade IV</td>
<td>—</td>
<td>Positive</td>
<td>Grade III</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>84</td>
<td>92</td>
<td>3,600 mL/30 U</td>
<td>2,700 mL/30 U</td>
<td>200 mL/10 U</td>
<td>Yes</td>
<td>150</td>
<td>No</td>
<td>No</td>
<td>Alive</td>
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<tr>
<td>6</td>
<td>46</td>
<td>Male</td>
<td>Blunt</td>
<td>54</td>
<td>Grade IV</td>
<td>—</td>
<td>Positive</td>
<td>Grade IV</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>71</td>
<td>190</td>
<td>2,640 mL/22 U</td>
<td>2,700 mL/30 U</td>
<td>200 mL/10 U</td>
<td>Yes</td>
<td>43</td>
<td>No</td>
<td>No</td>
<td>Alive</td>
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<tr>
<td>7</td>
<td>64</td>
<td>Male</td>
<td>Blunt</td>
<td>41</td>
<td>Grade III</td>
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<td>Positive</td>
<td>Grade III</td>
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<td>No</td>
<td>No</td>
<td>78</td>
<td>153</td>
<td>1,200 mL/10 U</td>
<td>1,800 mL/20 U</td>
<td>250 mL/15 U</td>
<td>Yes</td>
<td>33</td>
<td>No</td>
<td>No</td>
<td>Alive</td>
</tr>
</tbody>
</table>

FFP, fresh frozen plasma; PC, platelet concentrate; PRBC, packed red blood cell; SBP, systolic blood pressure.
Traumatic intra-abdominal hemorrhage control: Has current technology tipped the balance toward a role for prehospital intervention?

Muzzafer Chaudery, MRCS, James Clark, MRCS, Mark H. Wilson, FRCS, Duncan Bew, FRCS, Guang-Zhong Yang, PhD, and Ara Darzi, FRS, London, United Kingdom
CONCLUSION: REBOA treatment is associated with higher mortality compared with similarly ill trauma patients who did not receive a REBOA. The higher observed mortality among REBOA-treated patients may signal “last ditch” efforts for severity not otherwise identified in the trauma registry. (J Trauma Acute Care Surg. 2015;78: 721–728. Copyright © 2015 Wolters Kluwer

Evaluation of the safety and feasibility of resuscitative endovascular balloon occlusion of the aorta

J Trauma Acute Care Surg 2015; 78:897

Nobuyuki Saito, MD, Hisashi Matsumoto, MD, PhD, Takanori Yagi, MD, Yoshiaki Hara, MD, Kazuyuki Hayashida, MD, Tomokazu Motomura, MD, Kazuki Mashiko, MD, Hiroaki Iida, MD, Hiroyuki Yokota, MD, PhD, and Yukiko Wagatsuma, MD, MPH, DrPH, Inzai, Japan

Aortic occlusion was shorter in survivors than in deaths (21 minutes vs. 35 minutes, p = 0.05). The mean systolic blood pressure was significantly increased by REBOA (from 53.1 [21] mm Hg to 98.0 [26.6] mm Hg, p < 0.01). There were three cases with complications (12.5%), one external iliac artery injury and two lower limb ischemias in which lower limb amputation was necessary in all cases. Acute kidney injury developed in all three cases, but failure was not persistent.

REBOA seems to be feasible for trauma resuscitation and may improve survivorship. However, the serious complication of lower limb ischemia warrants more research on its safety. (J Trauma Acute Care Surg. 2015;78: 897–904. Copyright © 2015 Wolters Kluwer
- Is It Safe?
- Can it Replace RT?
- Does it Make Sense?
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

J Trauma Acute Care Surg 2015; 78:1054
Algorithm for Control of Torso Hemorrhage

Localize Hemorrhage with CXR, FAST, Pelvis X-Ray

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
<tr>
<td></td>
<td>SBP</td>
<td>CPR</td>
<td>&lt;60</td>
<td>&gt;80</td>
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</table>

1. Thoracic Hemorrhage
   - EDT
   - EDT vs OR
   - OR Thoracotomy

2. Abdominal Hemorrhage
   - EDT
   - EDT vs REBOA
   - OR vs REBOA
   - OR Laparotomy

3. Pelvic Hemorrhage
   - EDT
   - REBOA vs EDT
   - REBOA
   - OR Pelvic Packing

Biffl et al. J Trauma Acute Care Surg 2015; 78:1054
<table>
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<tr>
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<th>% Pre-Arrest Blood Flow</th>
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<tr>
<td></td>
<td>Closed</td>
</tr>
<tr>
<td>Cerebral Cortex Perfusion</td>
<td>10%</td>
</tr>
<tr>
<td>Cardiac Output</td>
<td>25%</td>
</tr>
</tbody>
</table>

Blood Flow in the Cerebral Cortex During Cardiac Resuscitation in Dogs

Regional cerebral cortical blood flow (rCCBF) in 15 large dogs was determined using the double thermistor dilution method during standard closed-chest massage (CCM), CCM with an epinephrine infusion at 30 µg/kg/min (CCM + Epi), and open-chest cardiac massage (OCCM). As a percentage of prearrest flow values, the rCCBF was 9.8% with CCM, 35% with CCM + Epi, and 156% with OCCM. The rCCBF was reduced significantly with CCM (P < .005) and CCM + Epi (P < .01). OCCM generated flows indistinguishable from prearrest values. The use of high-dose epinephrine significantly increased the rCCBF during CCM. The implications for intact neurologic resuscitation of these reductions in rCCBF with CCM are important. [Jackson RE, Joyce K, Danosi SF, White BC, Vigor D, Hoehner TJ: Blood flow in the cerebral cortex during cardiac resuscitation in dogs. Ann Emerg Med September 1984 (Part 1);13:657-659.]

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-arrest cc/min/g</th>
<th>Resuscitation cc/min/g</th>
<th>Pre-arrest (%)</th>
<th>P Value</th>
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</thead>
<tbody>
<tr>
<td>CCM</td>
<td>0.69 ± 0.24</td>
<td>0.06 ± 0.02</td>
<td>9.8 ± 3.4</td>
<td>&lt; .005</td>
</tr>
<tr>
<td>CCM + Epi</td>
<td>0.49 ± 0.16</td>
<td>0.15 ± 0.09</td>
<td>36.1 ± 22.3</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>OCCM</td>
<td>0.53 ± 0.16</td>
<td>0.83 ± 0.42</td>
<td>156.6 ± 79.2</td>
<td>&gt; .05</td>
</tr>
</tbody>
</table>

From the Section of Emergency Medicine, Department of Surgery, Wayne University School of Medicine, and the Section of Emergency Medicine, Michigan State University, East Lansing, Michigan.

Raymond E Jackson, MD
Kathleen Joyce, MD
Steve F Danosi, MD
Detroit
Blaine C White, MD, FACEP
East Lansing, Michigan
David Vigor
Thomas J Hoehner
Detroit
We conclude that CCCPR does not augment arterial pressure in the clinical situations associated with decreased LVEDV and is unlikely to provide organ perfusion for trauma victims.
Open chest cardiac massage offers no benefit over closed chest compressions in patients with traumatic cardiac arrest

Matthew J. Bradley, MD, Brandon W. Bonds, MD, Luke Chang, Shiming Yang, PhD, Peter Hu, PhD, Hsiao-chi Li, MS, Megan L. Brenner, MD, Thomas M. Scalea, MD, and Deborah M. Stein, MD, MPH, Baltimore, Maryland

Observational Study Traumatic Arrest
Measured ROSC and ETCO2

Although thoracotomy is necessary for the emergent surgical repair of thoracic injury, we found no sufficient evidence showing significant improvement in ROSC with OCCM. So far, it lacks evidence showing that OCCM could provide a physiologic advantage in improving CO as measured by ETCO2 when compared with equivalent periods of CCC. With newer endovascular techniques for aortic occlusion, thoracotomy solely for performing OCCM may not provide any benefit to the patient over CCC.
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
The AAST prospective Aortic Occlusion for Resuscitation in Trauma and Acute Care Surgery (AORTA) registry: Data on contemporary utilization and outcomes of aortic occlusion and resuscitative balloon occlusion of the aorta (REBOA)

Joseph J. DuBose, MD, Thomas M. Scalea, MD, Megan Brenner, MD, Dimitra Skiada, MD, Kenji Inaba, MD, Jeremy Cannon, MD, Laura Moore, MD, John Holcomb, MD, David Turay, MD, Cassra N. Arbabi, MD, Andrew Kirkpatrick, MD, James Xiao, MD, David Skarupa, MD, Nathaniel Poulin, MD, and the AAST AORTA Study Group, Davis, California

Aortic occlusion for resuscitation after trauma remains a dramatic but crucial tool in the care of profoundly hypotensive patients after injury. Contemporary survival rates seem to have improved compared to historical controls, and good neurologic outcomes among survivors can be achieved. Resuscitative endovascular balloon occlusion of the aorta has emerged as a viable alternative to open AO in centers that have developed this capability, with similar outcomes to open AO techniques based on limited early data. Ongoing maturation of the AAST AORTA database is required to determine the impact of REBOA use.
RT vs REBOA, $p<.05$

- Transfer from OSF; Blunt vs Penetrating; Chest AIS; Field Intubation
- Median SBP, HR (0,0 vs 50, 85)
- Temperature
- Resident/Fellow (43% vs 4%)
- Post-Occlusion SBP (69 vs 90); Sustained SBP $>90$ (28% vs 51%)
- Mortality 84% vs 72%
- DC Dispo Home 12% vs 9%

Dubose et al. J Trauma Acute Care Surg 2016 EPub
A systematic review of the use of resuscitative endovascular balloon occlusion of the aorta in the management of hemorrhagic shock

Jonathan James Morrison, MD, PhD, Richard E. Galgon, MD, MS, Jan Olaf Jansen, FRCS, FFICM, Jeremy W. Cannon, MD, SM, Todd Erik Rasmussen, MD,

<table>
<thead>
<tr>
<th>Ref</th>
<th>Year</th>
<th>n</th>
<th>Weight</th>
<th>Mean SBP Rise (95% CI)</th>
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<td>34</td>
<td>1989</td>
<td>16</td>
<td>16.3%</td>
<td>51 (33 – 68)</td>
</tr>
<tr>
<td>14</td>
<td>2010</td>
<td>13</td>
<td>7.1%</td>
<td>70 (41 – 99)</td>
</tr>
<tr>
<td>45</td>
<td>2012</td>
<td>6</td>
<td>20.4%</td>
<td>37 (23 – 51)</td>
</tr>
<tr>
<td>13</td>
<td>2013</td>
<td>6</td>
<td>8.7%</td>
<td>61 (35 – 87)</td>
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<tr>
<td>22</td>
<td>2015</td>
<td>7</td>
<td>8.3%</td>
<td>52 (25 – 79)</td>
</tr>
<tr>
<td>19</td>
<td>2015</td>
<td>14</td>
<td>39.2%</td>
<td>57 (51 – 63)</td>
</tr>
</tbody>
</table>

**Overall Effect**

53 (44 – 61)

Model: p < 0.001
Heterogeneity: $I^2 = 35.5$

Abbreviations: SBP – Systolic Blood Pressure; CI – Confidence Interval

Forrest Plot

Rise in SBP / mmHg
Resuscitative endovascular balloon occlusion of the aorta might be dangerous in patients with severe torso trauma: A propensity score analysis

Junichi Inoue, MD, Atsushi Shiraishi, MD, PhD, Ayako Yoshiyuki, MD, Koichi Haruta, MD, Hiroki Matsui, MPH, and Yasuhiro Otomo, MD, PhD, Tokyo, Japan

- REBOA Used in Japan Since 1990s
- Surgery / Embolization for Torso Hemorrhage
- 625 Pts Each Group
### Table 1: Adjusted and Unadjusted Comparison of Mortality Rates

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>Adjusted for REBOA</th>
<th>Unadjusted for REBOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall subjects</td>
<td>6.5 [10.9, 22.0]</td>
<td>16.5 [10.9, 22.0]</td>
</tr>
<tr>
<td>With REBOA</td>
<td>4.3 [3.3, 5.5]</td>
<td>6.5 [10.9, 22.0]</td>
</tr>
<tr>
<td>Without REBOA</td>
<td>11.9 [10.9, 22.0]</td>
<td>16.5 [10.9, 22.0]</td>
</tr>
</tbody>
</table>

### Figures

**Figure 4:** Subgroup analysis of mean differences in inhospital mortality rates in association with REBOA. REBOA = Rapid Exsanguination Blood Flow Occlusion Adjunct.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Adjusted for REBOA</th>
<th>Unadjusted for REBOA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury Type</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blunt Trauma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Penetrating Trauma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glasgow Coma Scale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic Blood Pressure, mmHg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount of REBOA per institute per year</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Door to primary surgery time, minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIS Abdomen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIS Pelvis and Lower Extremities</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AIS Chest</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Notes

- REBOA = Rapid Exsanguination Blood Flow Occlusion Adjunct
- AIS = Abbreviated Injury Scale
- N = Number of subjects

---

**Table Note:**

- All values are presented as median (IQR).
- P values for interaction are given for categorical variables.
CONSIDERATIONS

- Availability of resources (OR, equipment)
- Distance from definitive care
- Skill set
- Complication profile (RT vs REBOA)
- Time
- Cost / Resource Utilization
# Algorithm for Control of Torso Hemorrhage

Localize Hemorrhage with CXR, FAST, Pelvis X-Ray

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SBP</td>
<td>CPR</td>
<td>&lt;60</td>
<td>&gt; 80</td>
</tr>
<tr>
<td></td>
<td>EDT</td>
<td>EDT</td>
<td>EDT vs OR</td>
<td>OR Thoracotomy</td>
</tr>
<tr>
<td>2</td>
<td>Thoric Hemorrhage</td>
<td>EDT</td>
<td>EDT vs REBOA</td>
<td>OR vs REBOA</td>
</tr>
<tr>
<td></td>
<td>OR Laparotomy</td>
<td>EDT vs REBOA</td>
<td>REBOA</td>
<td>OR Pelvic Packing</td>
</tr>
<tr>
<td>3</td>
<td>Pelvic Hemorrhage</td>
<td>EDT</td>
<td>REBOA vs EDT</td>
<td>REBOA</td>
</tr>
</tbody>
</table>

Biffl et al. J Trauma Acute Care Surg 2015; 78:1054
DHMC Algorithm: Management of Patient with Unstable Pelvic Fractures and Severe Hemorrhagic Shock

ATLS Primary Survey
CXR, FAST, Pelvis X-Ray
Massive Transfusion Protocol

ED REBOA*

OR Pelvic Packing, Pelvic External Fixation
Laparotomy as Indicated

Stable

Unstable

OR Pelvic Angiography

CT Scan Head, C-Spine, Chest, Abdomen, Pelvis

*Zone I if FAST (+)
Zone III if FAST (-)

Biffl et al. J Trauma Acute Care Surg 2015; 78:1054
CURRENT AREAS OF INTEREST

- **Simulators for Training** (Brenner et al; Keller et al)
- **Smaller Diameter Sheaths** (Teeter et al; Taylor et al)
- **Adjuncts to Insertion**
- **Fluoroscopy-Free / Fixed Distance** (Scott et al; Sokol et al; Pezy et al; Linnebur et al)
- **Ultrasound / Microbubbles** (Chaudery et al)
- **Partial Occlusion** (Johnson et al; Russo et al)
- **Prehospital Use** (Sadek et al)
Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) as an Adjunct for Hemorrhagic Shock

Adam Stannard, MRCS, Jonathan L. Eliason, MD, and Todd E. Rasmussen, MD

**PROCEDURES & TECHNIQUES**

**STEP 1: ARTERIAL ACCESS AND POSITIONING OF INITIAL SHEATH**

**STEP 2: SELECTION AND POSITIONING OF THE BALLOON**

**STEP 3: INFLATION OF THE BALLOON AND SECURING OF THE APPARATUS**

**STEP 4: DEFLATION OF THE BALLOON**

**STEP 5: REMOVAL OF THE BALLOON AND SHEATH**

**TABLE 2. Examples of Endovascular Tools (Wires, Sheaths, and Balloons) Used To Accomplish REBOA**

<table>
<thead>
<tr>
<th>Description</th>
<th>Size</th>
<th>Length (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wire Amplatz Stiff Wire Guide (Cook Medical)</td>
<td>0.035 inch</td>
<td>260</td>
</tr>
<tr>
<td>Sheaths Initial (starter)</td>
<td>5–6 Fr</td>
<td>8–15</td>
</tr>
<tr>
<td>Delivery and support</td>
<td>12–14 Fr</td>
<td>45–60</td>
</tr>
<tr>
<td>Balloons Coda balloon (Cook Medical)</td>
<td>14 Fr (32–40 mm diameter)</td>
<td>120</td>
</tr>
<tr>
<td>Reliant (Medtronic)</td>
<td>12 Fr (10–46 mm diameter)</td>
<td>100</td>
</tr>
<tr>
<td>Berenstein (Boston Scientific)</td>
<td>6 Fr (11.5 mm diameter)</td>
<td>80</td>
</tr>
</tbody>
</table>