REBOA for Hemorrhage Control
Old Problem, New Trick?

Michigan Trauma Coalition Membership Meeting
Lansing, MI
December 12th, 2019

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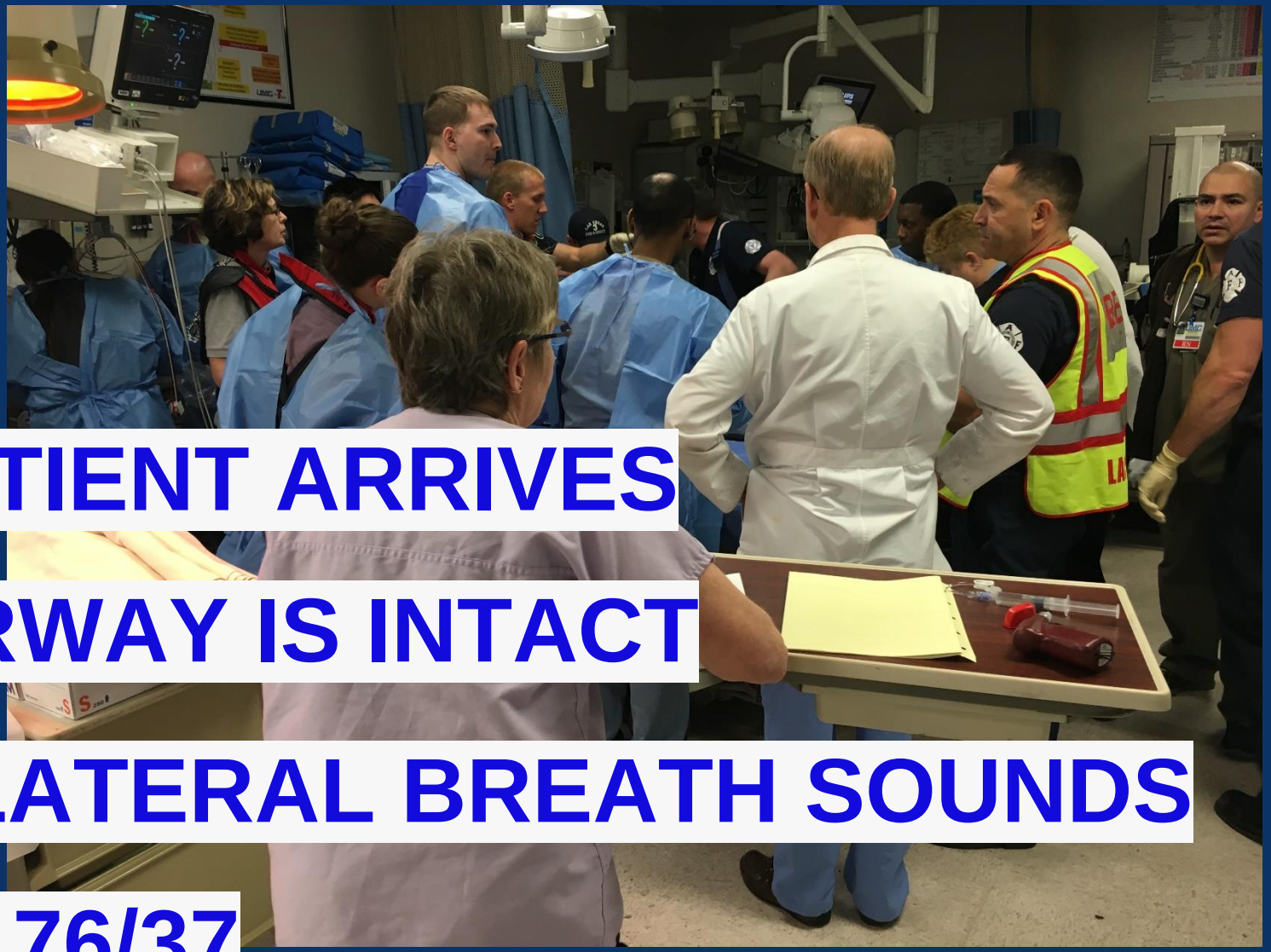
Trauma Medical Director – Butterworth Hospital
Division Chief Acute Care Surgery – Spectrum Health

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"

Time is the enemy: Mortality in trauma patients with hemorrhage from torso injury occurs long before the "golden hour"

A.Q. Alarhayem [a], J.G. Myers [a], D. Dent [a], L. Liao [a], M. Muir [a], D. Mueller [a], S. Nicholson [a], R. Cestero [a], M.C. Johnson [a], R. Stewart [a], Grant O'Keefe [b], B.J. Eastridge [a, *]

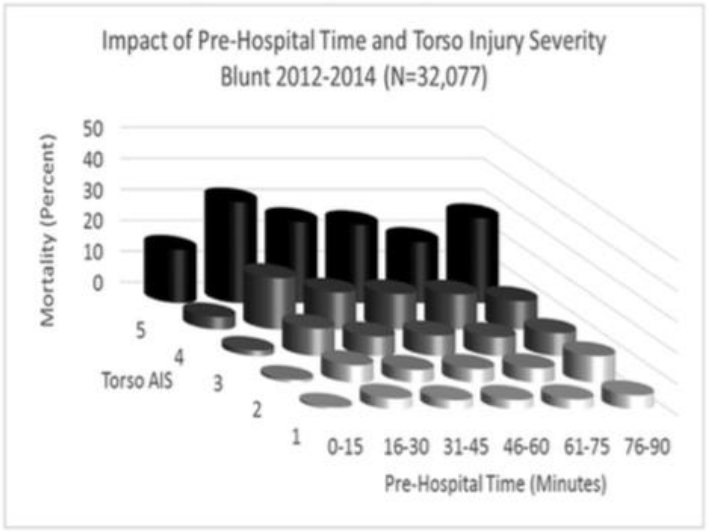


Fig. 2. Mortality Impact of prehospital time and torso injury severity for blunt injury 2012–2014 (N = 32,077).

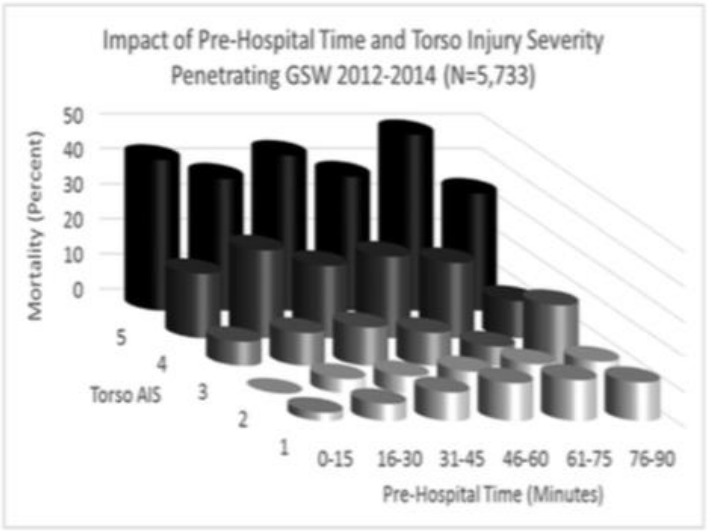
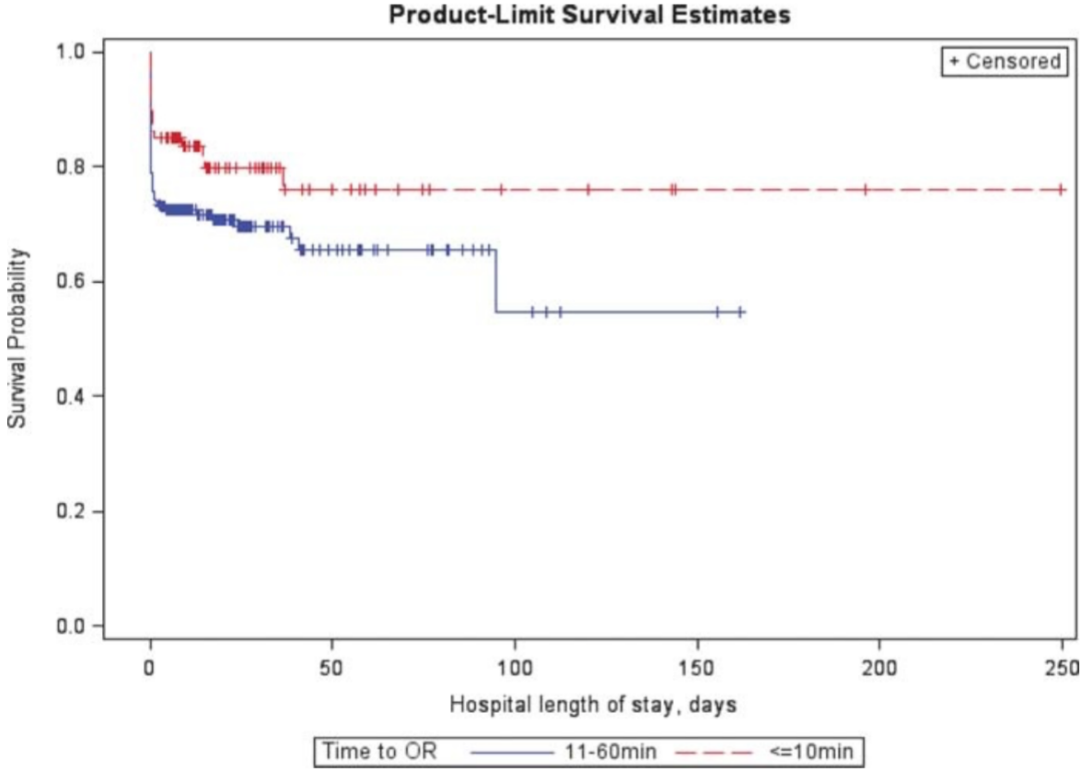


Fig. 3. Mortality Impact of prehospital time and torso injury severity for GSW penetrating injury 2012–2014 (N = 5733).

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

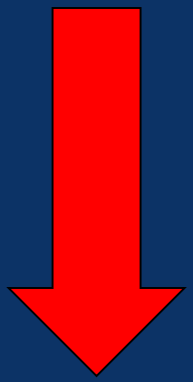
Jonathan P. Meizoso, MD, MSPH, Juliet J. Ray, MD, MSPH, Charles A. Karcutskie, IV, MD, MA, Casey J. Allen, MD, Tanya L. Zakrison, MD, MPH, Gerd D. Pust, MD, Tulay Koru-Sengul, PhD, Enrique Ginzburg, MD, Louis R. Pizano, MD, MBA, Carl I. Schulman, MD, PhD, MSPH, Alan S. Livingstone, MD, Kenneth G. Proctor,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

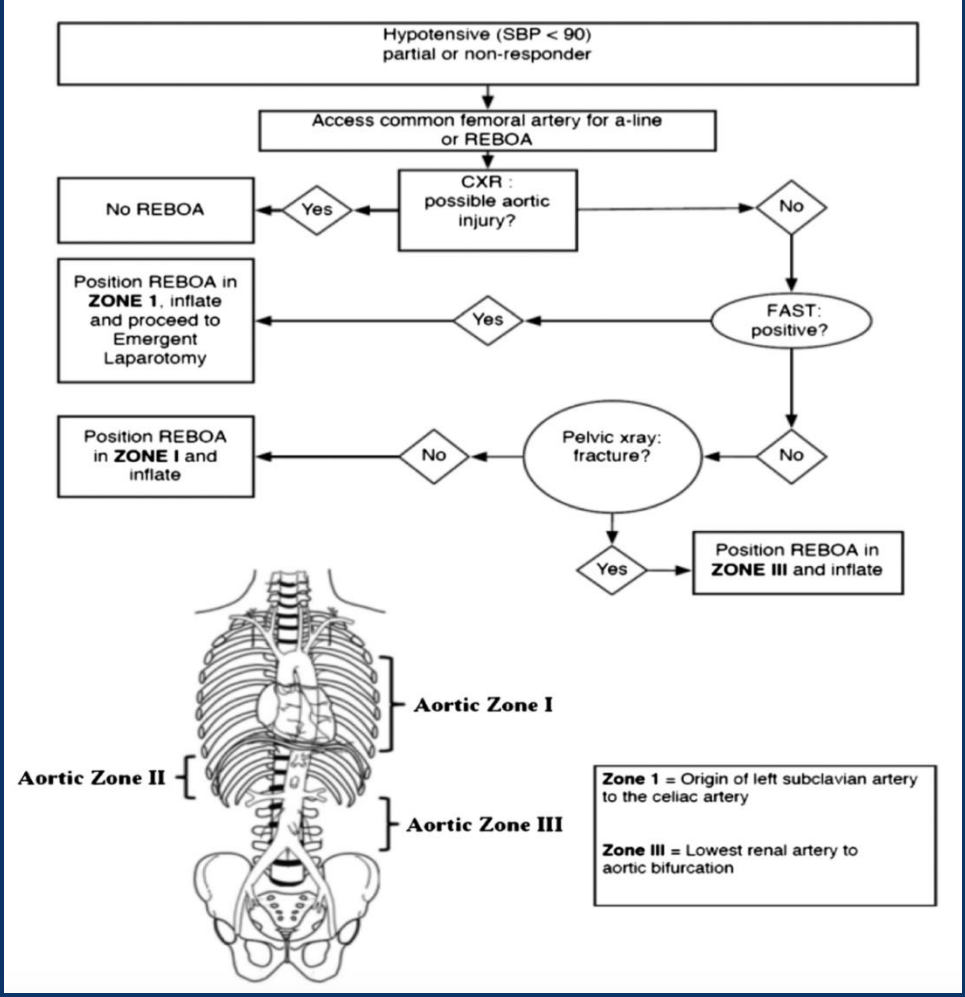
Mechanism to control non-compressible torso hemorrhage.

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”*

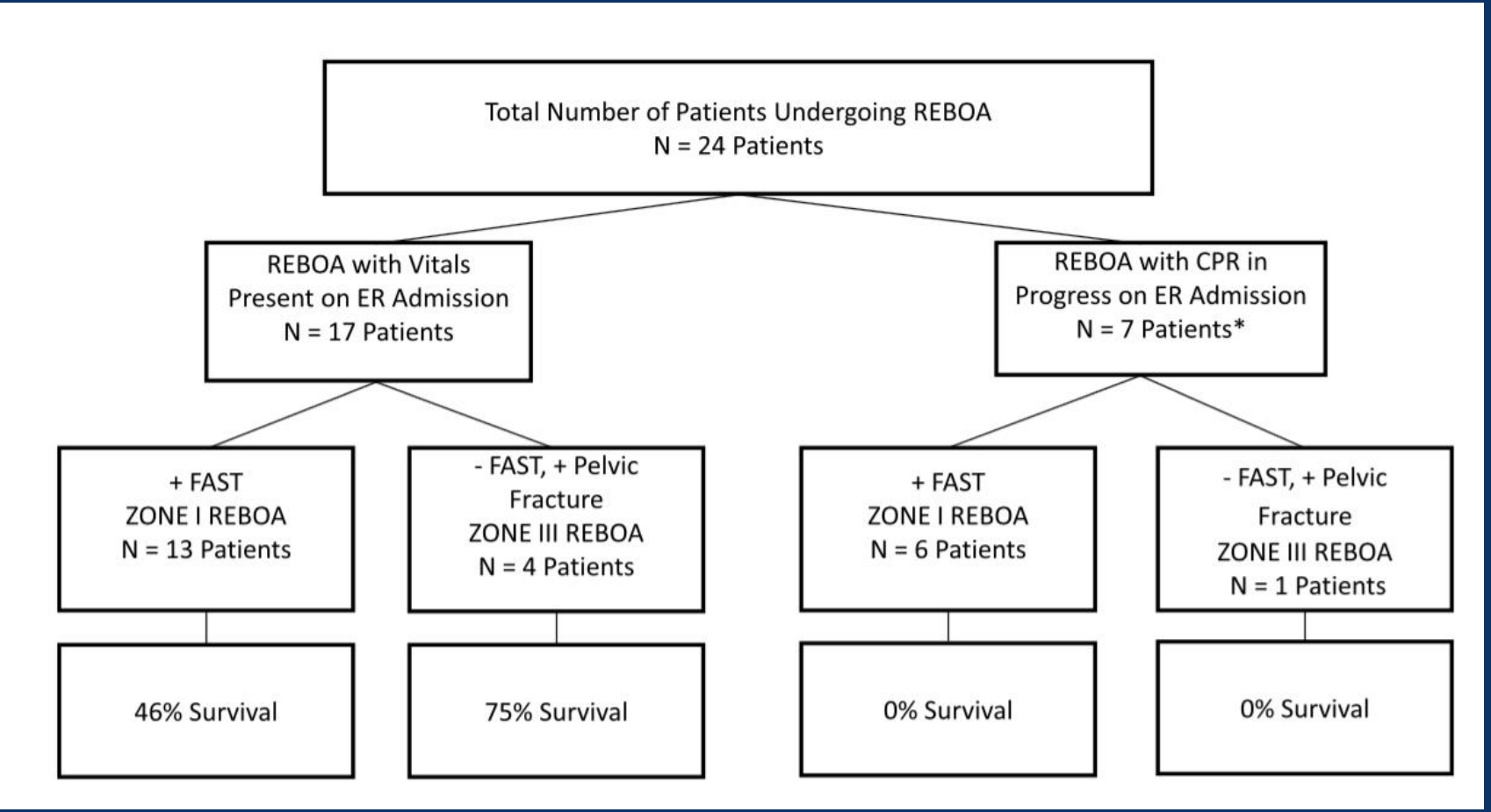
Biffl et al. JTACS. 2015.

Implementation of resuscitative endovascular balloon occlusion of the aorta as an alternative to resuscitative thoracotomy for noncompressible truncal hemorrhage



Moore et al. JTACS. 2014.

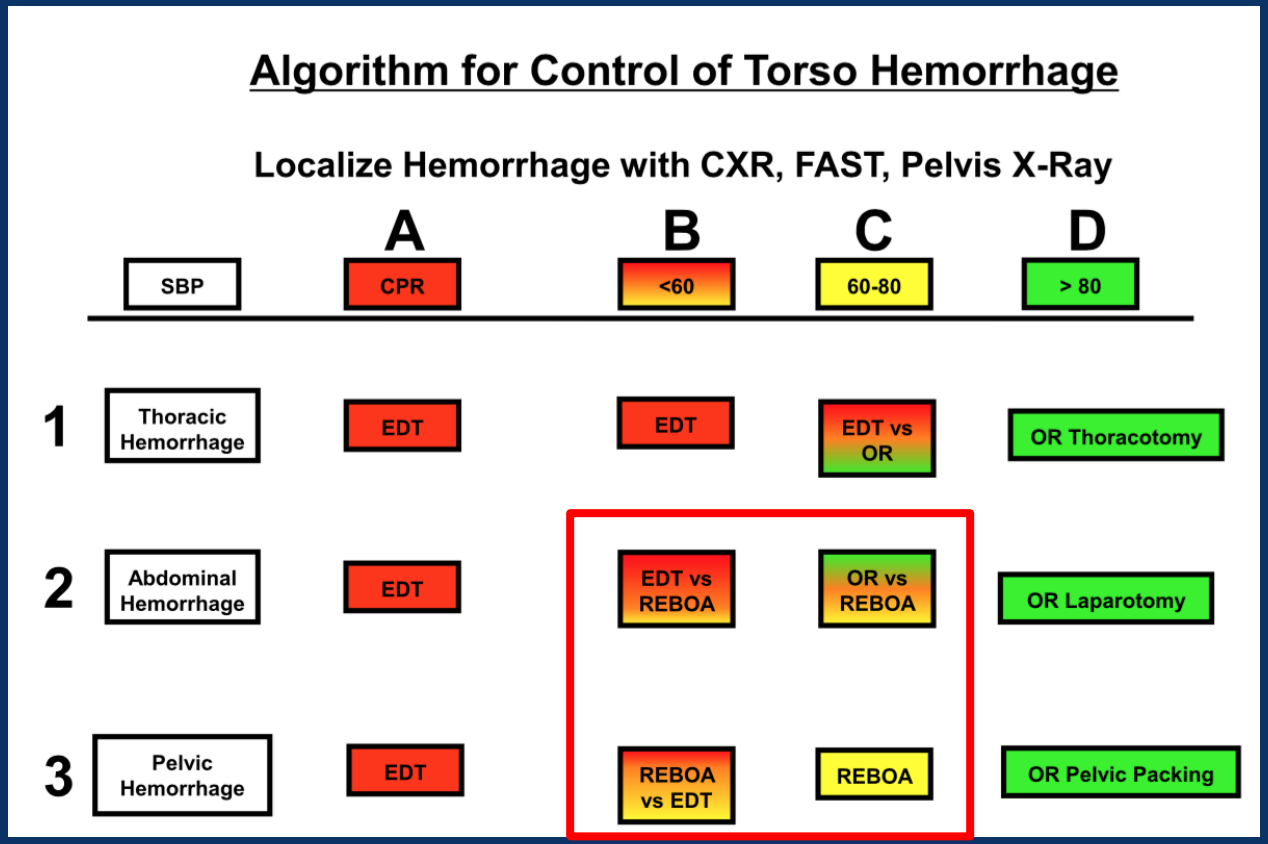
Implementation of resuscitative endovascular balloon occlusion of the aorta as an alternative to resuscitative thoracotomy for noncompressible truncal hemorrhage



Scalea et al. JTACS. 2014.

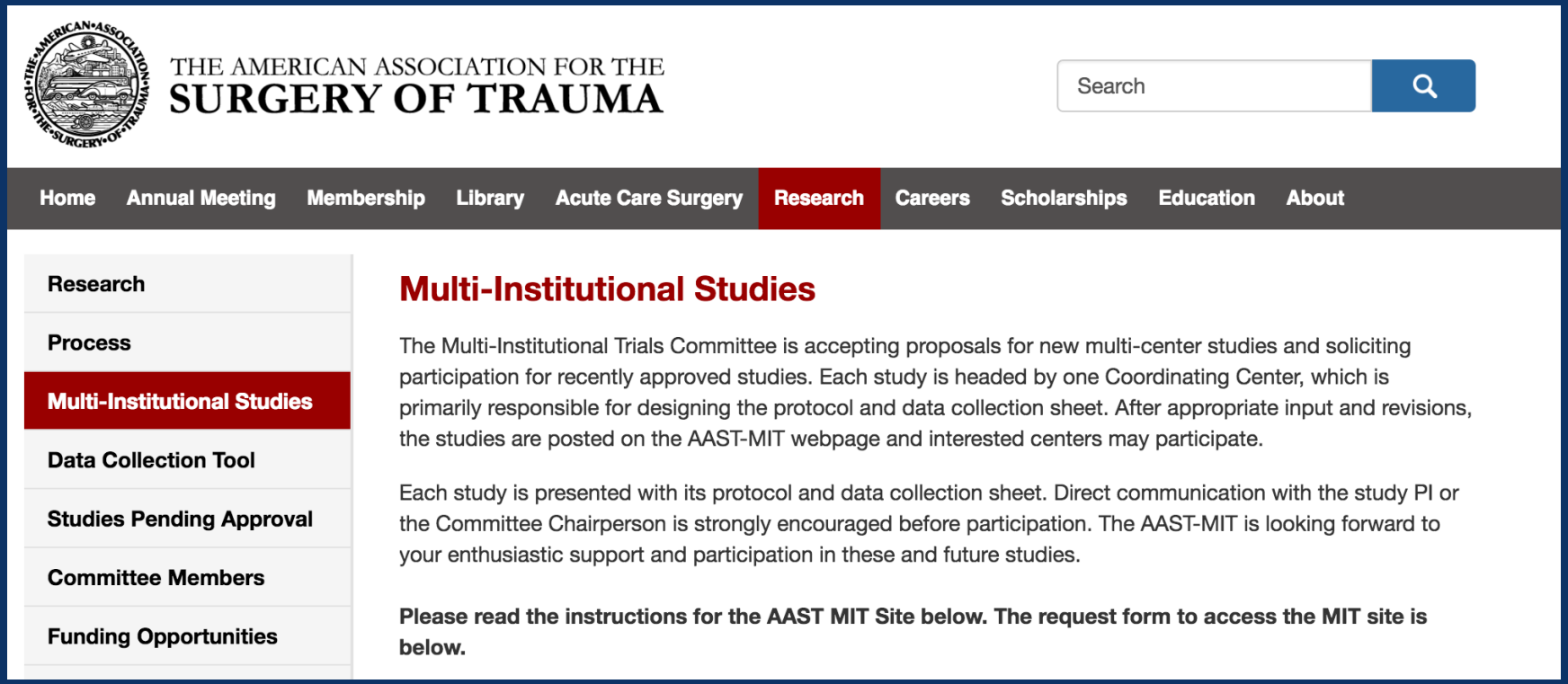
The role of REBOA in the control of exsanguinating torso hemorrhage

Walter L. Biffl, MD, Charles J. Fox, MD, *and* **Ernest E. Moore, MD,** *Denver, Colorado*



Biffl et al. JTACS. 2015.

AAST AORTA Study

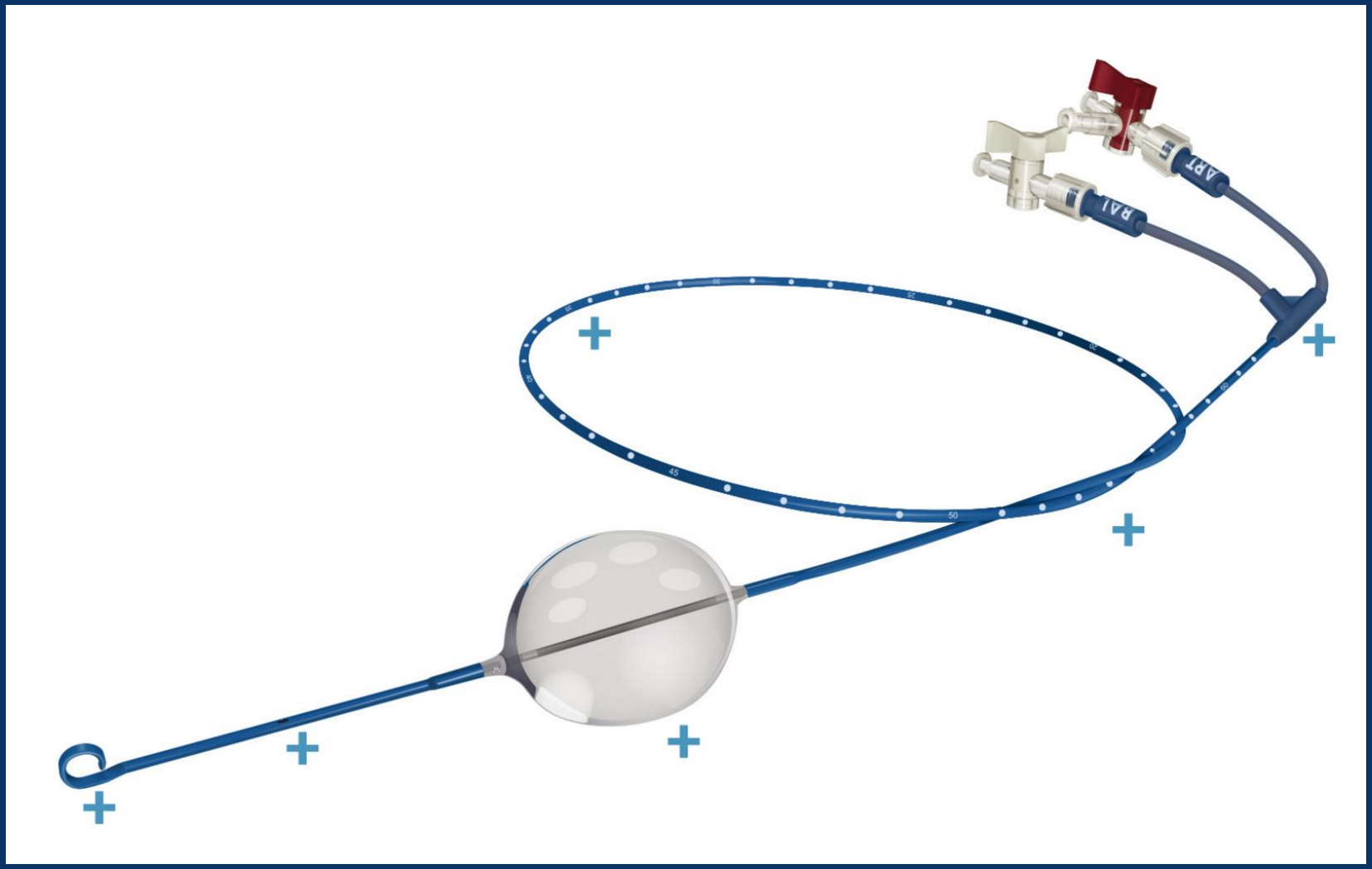


The AAST prospective Aortic Occlusion for Resuscitation in Trauma and Acute Care Surgery (AORTA) registry: Data on contemporary utilization and outcomes of aortic occlusion and resuscitative balloon occlusion of the aorta (REBOA)

Resuscitative endovascular occlusion of the aorta has emerged as a viable alternative to open aortic occlusion in centers that have developed this capability.

Dubose et al. JTACS. 2016.

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.

Teeter et al. JTACS. 2016

Catheter Placement

J Trauma Acute Care Surg. 2016 Sep;81(3):453-7. doi: 10.1097/TA.0000000000001106.

Emergent non-image-guided resuscitative endovascular balloon occlusion of the aorta (REBOA) catheter placement: A cadaver-based study.

Linnebur M[1], Inaba K, Haltmeier T, Rasmussen TE, Smith J, Mendelsberg R, Grabo D, Demetriades D.

Author information

Abstract

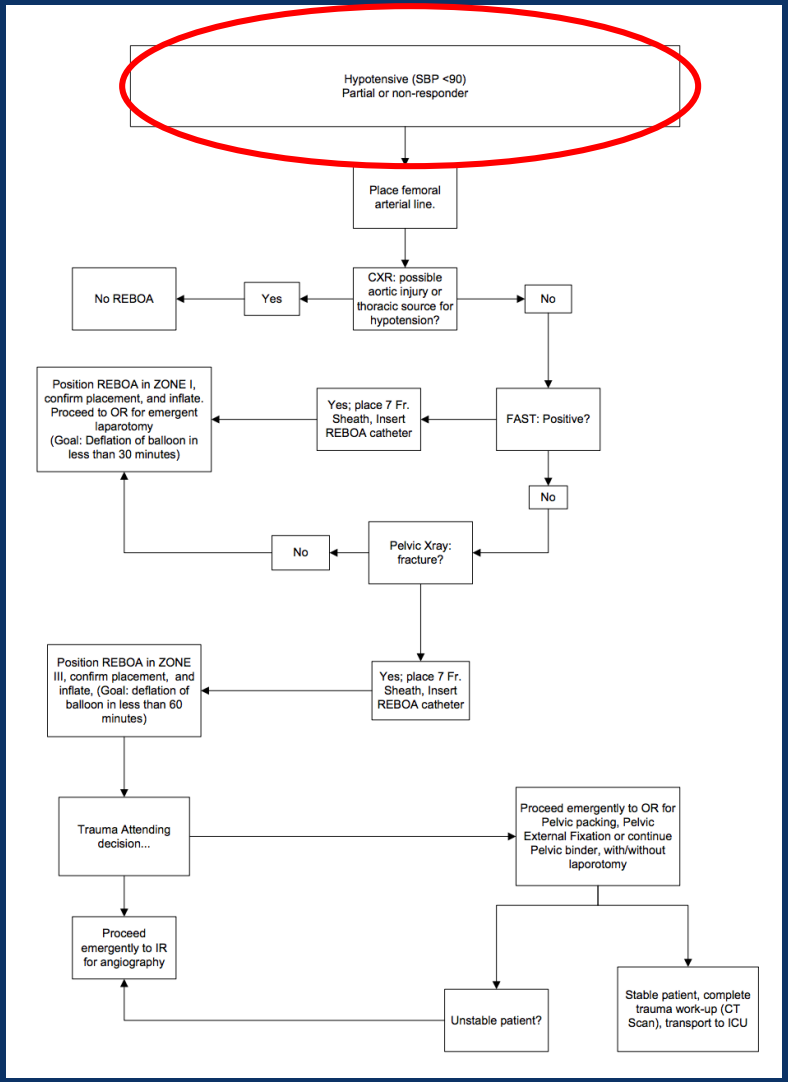
BACKGROUND: Emergent resuscitative endovascular balloon occlusion of the aorta (REBOA) insertion for critically injured patients in hemorrhagic shock is performed blindly with fluoroscopic imaging confirmation. The aim of this study was to determine a reliable method for initial REBOA catheter insertion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



Are you sure the patient is bleeding?

76/37

71/39

66/44

Empowered by good information

The Journal of **TRAUMA®** *Injury, Infection, and Critical Care*

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

BP Group	No.	Manual BP	Automatic BP	ISS	BD	IV Fluid (L)	Blood (mL)
1 (≤90 mm Hg)	92	80 ± 2	106 ± 6*	29.9 ± 3.5	–5.4 ± 1	3.7 ± 0.5	593 ± 310
2 (91–110 mm Hg)	119	103 ± 1	119 ± 4*	24.6 ± 2.9#	–2.7 ± 1#	2.7 ± 0.4+	161 ± 65#
3 (>110 mm Hg)	177	135 ± 3	138 ± 3	18.2 ± 1.7@	–1.6 ± 1#	2.3 ± 0.3#	72 ± 31#

IV, intravenous.

* $p < 0.0001$ vs. manual BP; # $p < 0.0001$; @ $p < 0.001$; + $p < 0.01$ vs. group 1 (BP ≤ 90 mm Hg).

Journal of Clinical Nursing

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

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[c] *Radiology 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*
[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 1
Demographic and clinical characteristics fAC-CVC: Femoral Arterial Catheter and Central Venous Catheter.

	fAC-CVC(−) n = 446	fAC-CVC (+) n = 243	p
Age (y)	38 (17)	37 (16)	0.39
Sex Ratio M/F (% male)	367/79 (82%)	179/64 (74%)	0.01
BMI (kg/m^2)			0.06
ISS			<0.001
ISS > 15 n (%)			<0.001
AIS head			<0.001
IGS 2			<0.001
GCS ≤ 8 n (%)			<0.001
Mortality n (%)	32 (7%)	56 (23%)	<0.001
Time spent in trauma bay (min)	30 [20;40]	45 [40;60]	<0.001

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

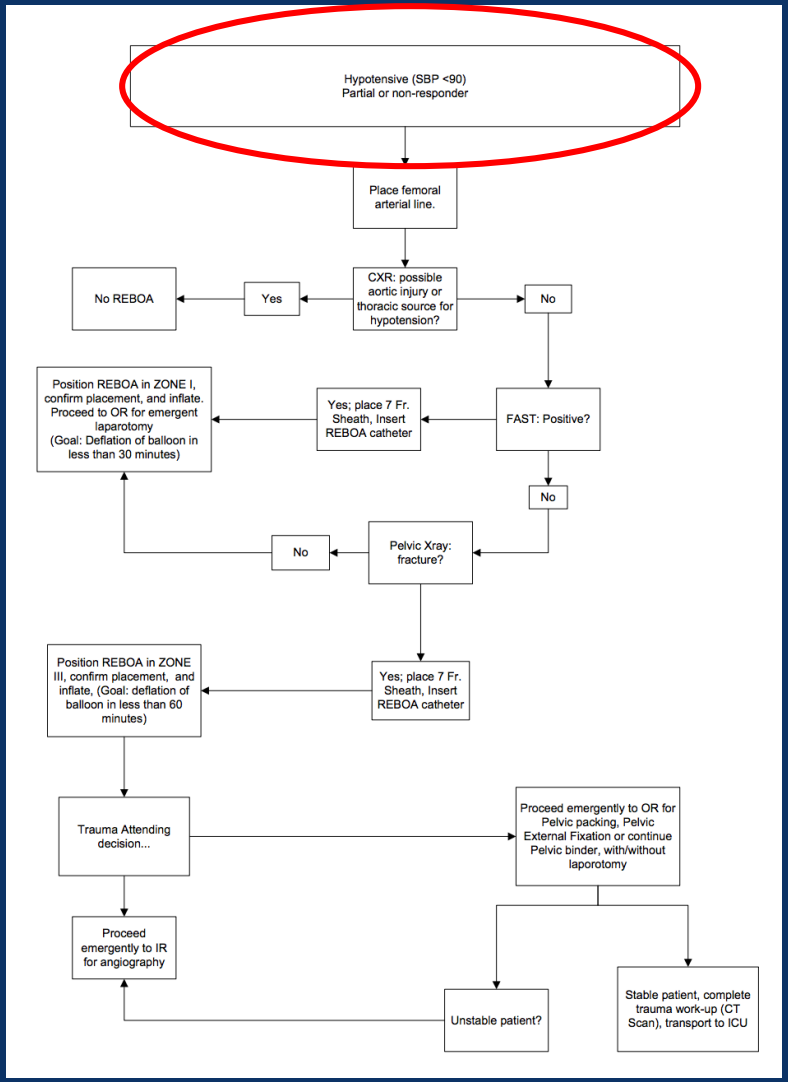
Extremities

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



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.**

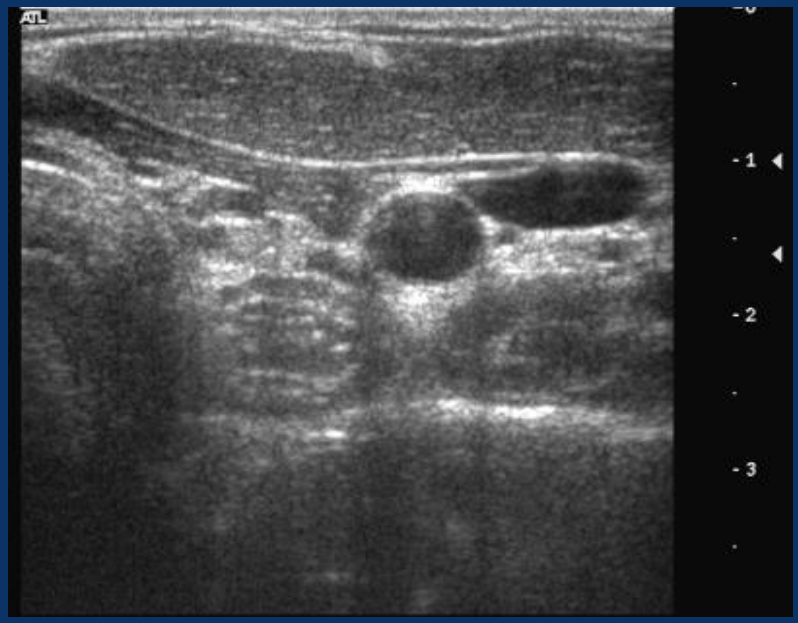
Exclusion Criteria

- 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



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7 French Sheath upsize

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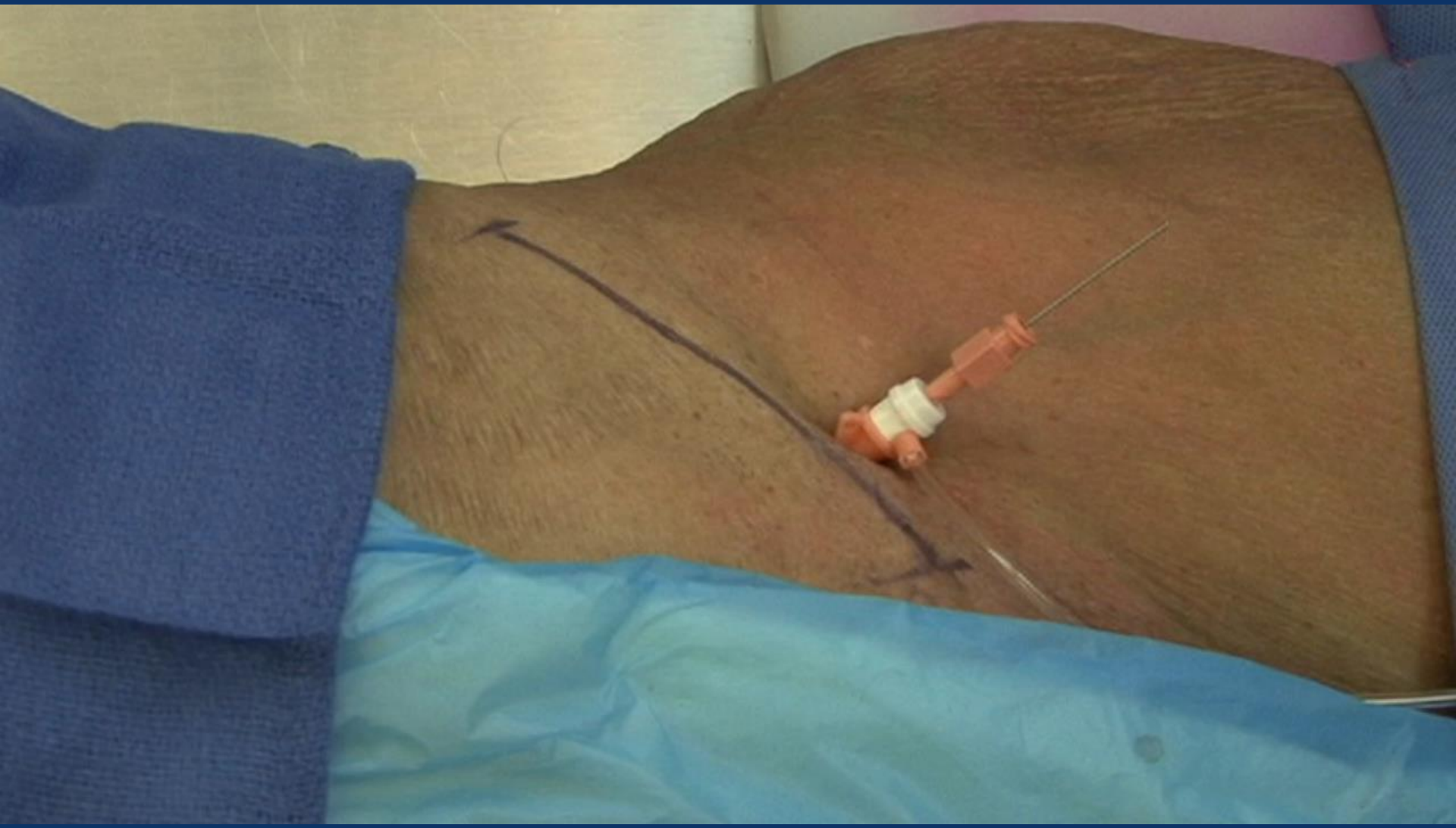

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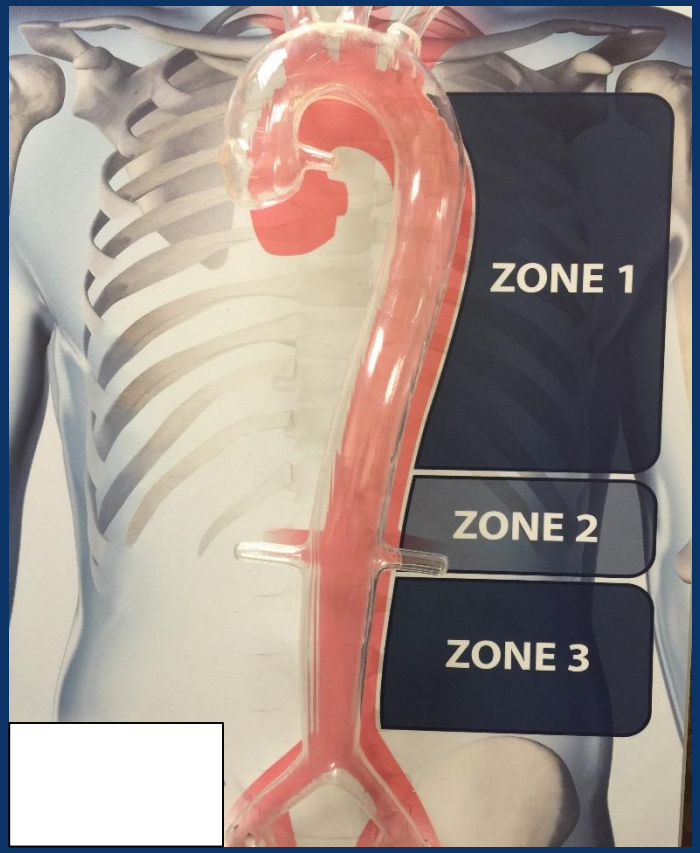
Device depth measurement



Zone 1 measurement

Zone 3 measurement

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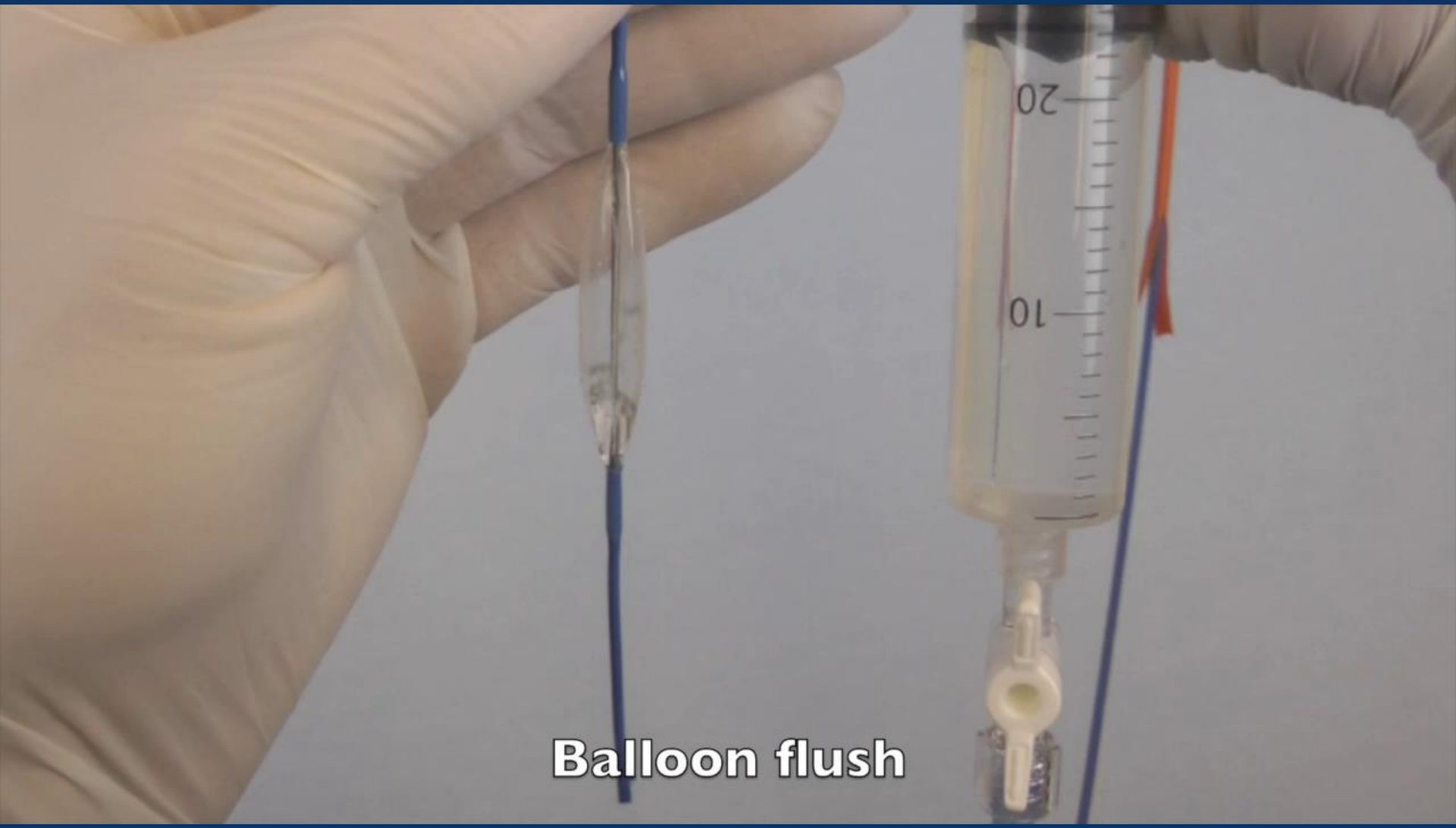

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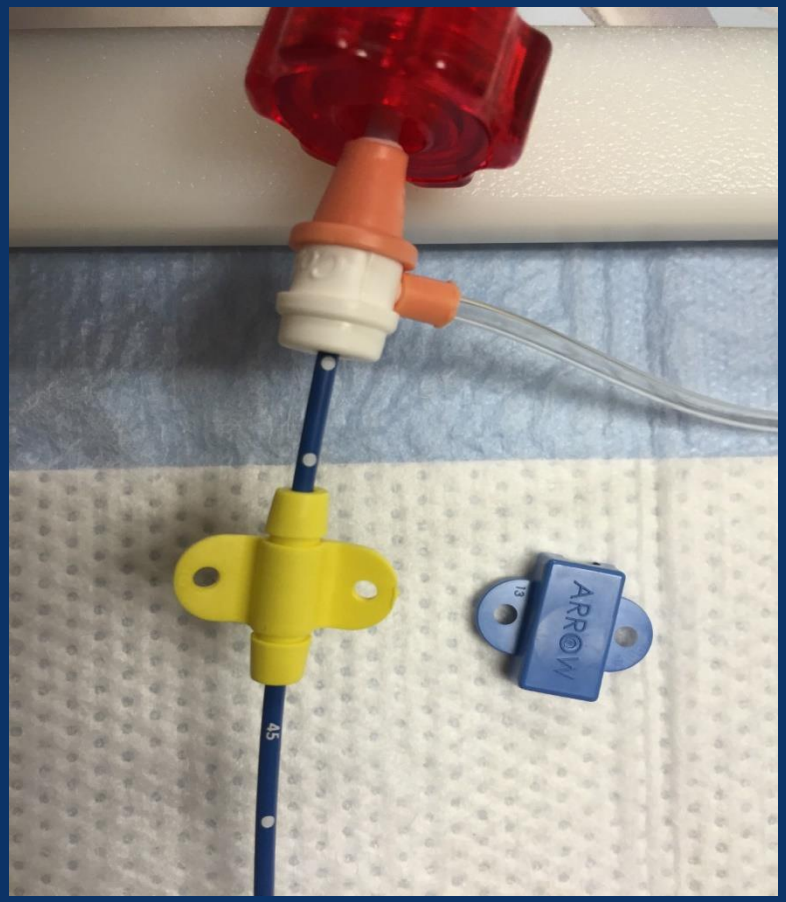
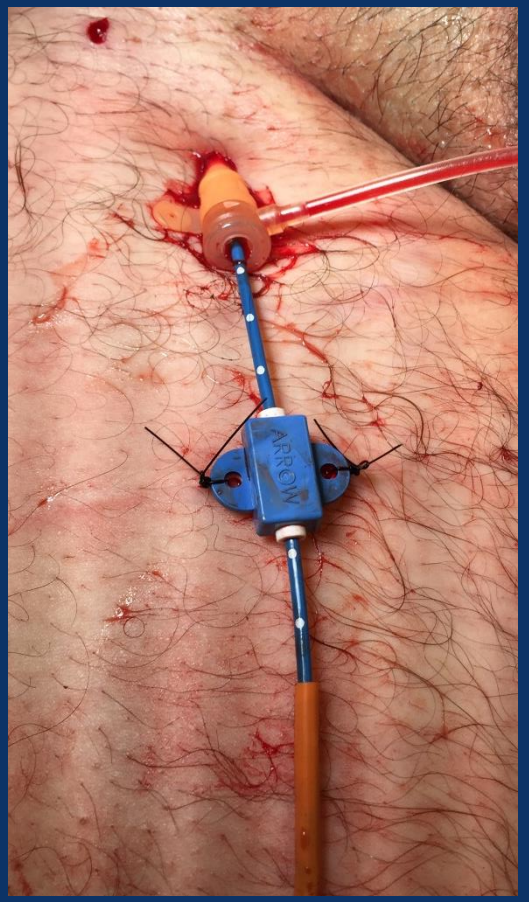
Secure Catheter





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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

Slide courtesy of medical device company

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

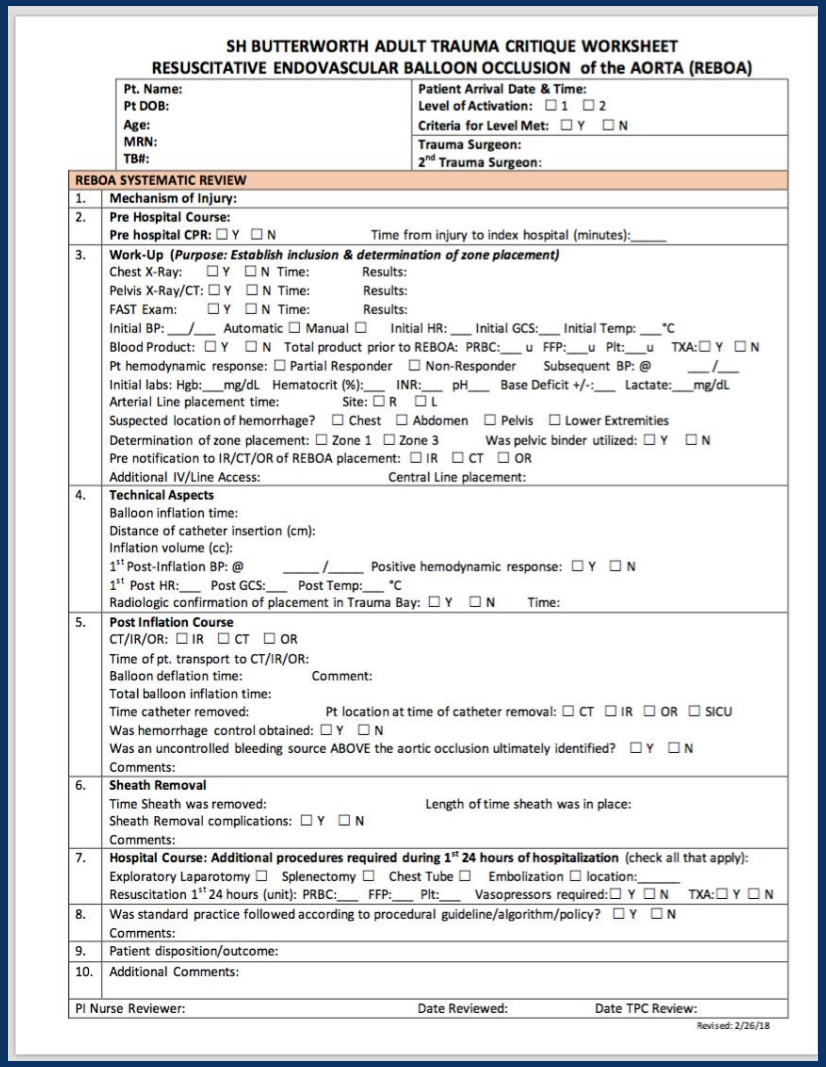
Complications

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

Better Science Coming?

PRACTICE

PI EVERY CASE



SH BUTTERWORTH ADULT TRAUMA CRITIQUE WORKSHEET
RESUSCITATIVE ENDOVASCULAR BALLOON OCCLUSION of the AORTA (REBOA)

Pt. Name: **Pt DOB:** **Age:** **MRN:** **TB#:**	**Patient Arrival Date & Time:** **Level of Activation:** ☐ 1 ☐ 2 **Criteria for Level Met:** ☐ Y ☐ N **Trauma Surgeon:** **2nd Trauma Surgeon:**

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/CT: ☐ Y ☐ N Time: Results:
   FAST Exam: ☐ Y ☐ N Time: Results:
   Initial BP: ___/___ Automatic ☐ Manual ☐ Initial HR: ___ Initial GCS:___ Initial Temp: ___ °C
   Blood Product: ☐ Y ☐ N Total product prior to REBOA: PRBC:___ u FFP:___u Plt:___u TXA:☐ Y ☐ N
   Pt hemodynamic response: ☐ Partial Responder ☐ Non-Responder Subsequent BP: @ ___/___
   Initial labs: Hgb:___mg/dL Hematocrit (%):___ INR:___ pH___ 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 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: @ _____/_____ Positive hemodynamic response: ☐ Y ☐ N
   1st Post HR:___ Post GCS:___ 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
   Comments:
6. **Sheath Removal**
   Time Sheath was removed: Length of time sheath was in place:
   Sheath Removal complications: ☐ Y ☐ N
   Comments:
7. **Hospital Course: Additional procedures required during 1st 24 hours of hospitalization** (check all that apply):
   Exploratory Laparotomy ☐ Splenectomy ☐ Chest Tube ☐ Embolization ☐ location:_____
   Resuscitation 1st 24 hours (unit): PRBC:___ FFP:___ Plt:___ Vasopressors required:☐ Y ☐ N TXA:☐ Y ☐ N
8. Was standard practice followed according to procedural guideline/algorithm/policy? ☐ Y ☐ N
   Comments:
9. Patient disposition/outcome:
10. Additional Comments:

PI Nurse Reviewer: Date Reviewed: Date TPC Review:

Revised: 2/26/18

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