REBOA and the Golden Hour

Joseph M Galante, MD FACS

Disclosures

- None
- American College of Surgeons- Basic Endovascular Skills for Trauma _ BEST

Objectives

- Review concept of the Golden Hour

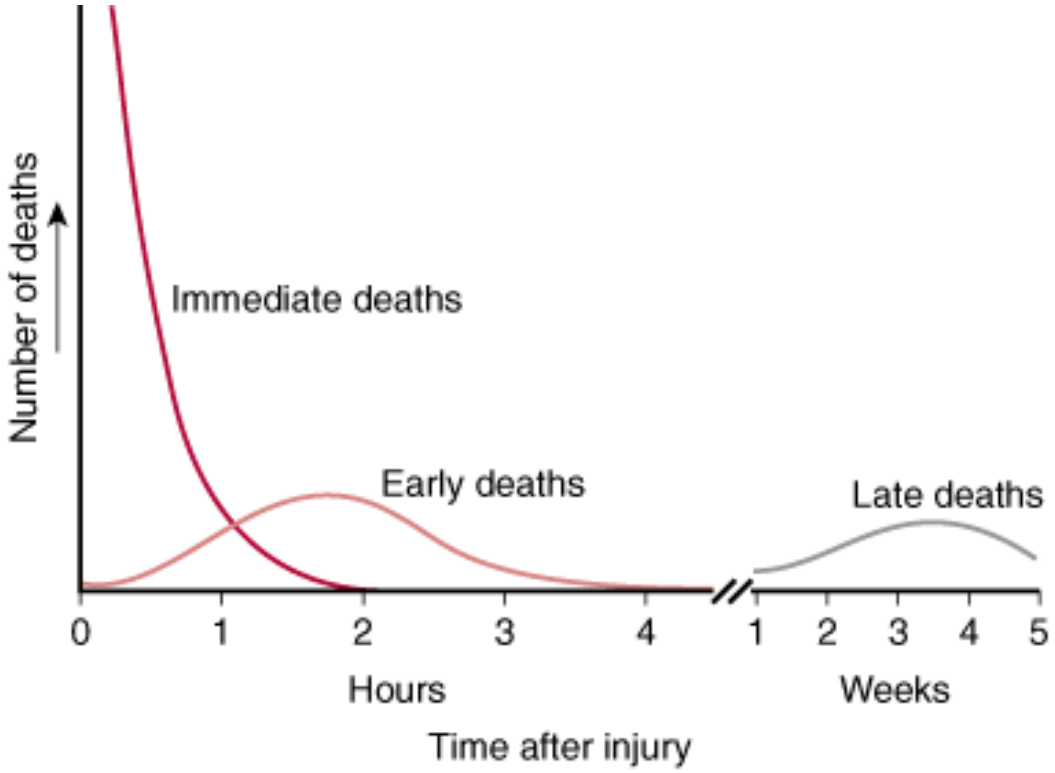
- Strategies for addressing bleeding
- REBOA

Golden Hour

- R. Adams Cowley

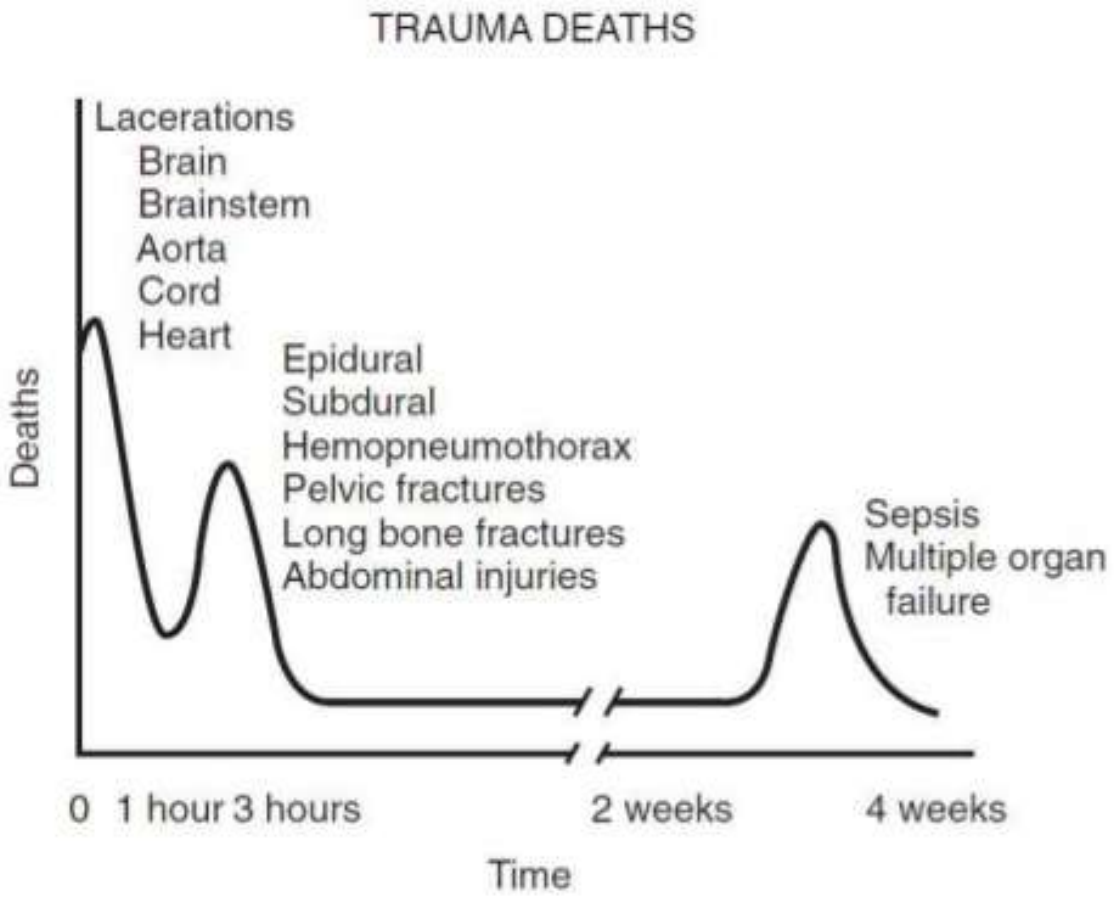
- "There is a golden hour between life and death. If you are critically injured you have less than 60 minutes to survive. You might not die right then; it may be three days or two weeks later -- but something has happened in your body that is irreparable."

Tri-Modal Distribution of Death



Source: Gerard M. Doherty: *CURRENT Diagnosis & Treatment: Surgery, 13th Edition*: http://www.accessmedicine.com

Causes of Death



Trauma deaths have a trimodal distribution. The first death peak (approximately 50%) is within minutes of the injury. The second death peak (approximately 30%) occurs within a few hours to 48 hours. The third death peak occurs within 1 to 4 weeks (approximately 15%) and represents those patients who die from the complications of their injury or treatment. Asensio, 2008.

Military Golden Hour

AAST 2017 PLENARY PAPER

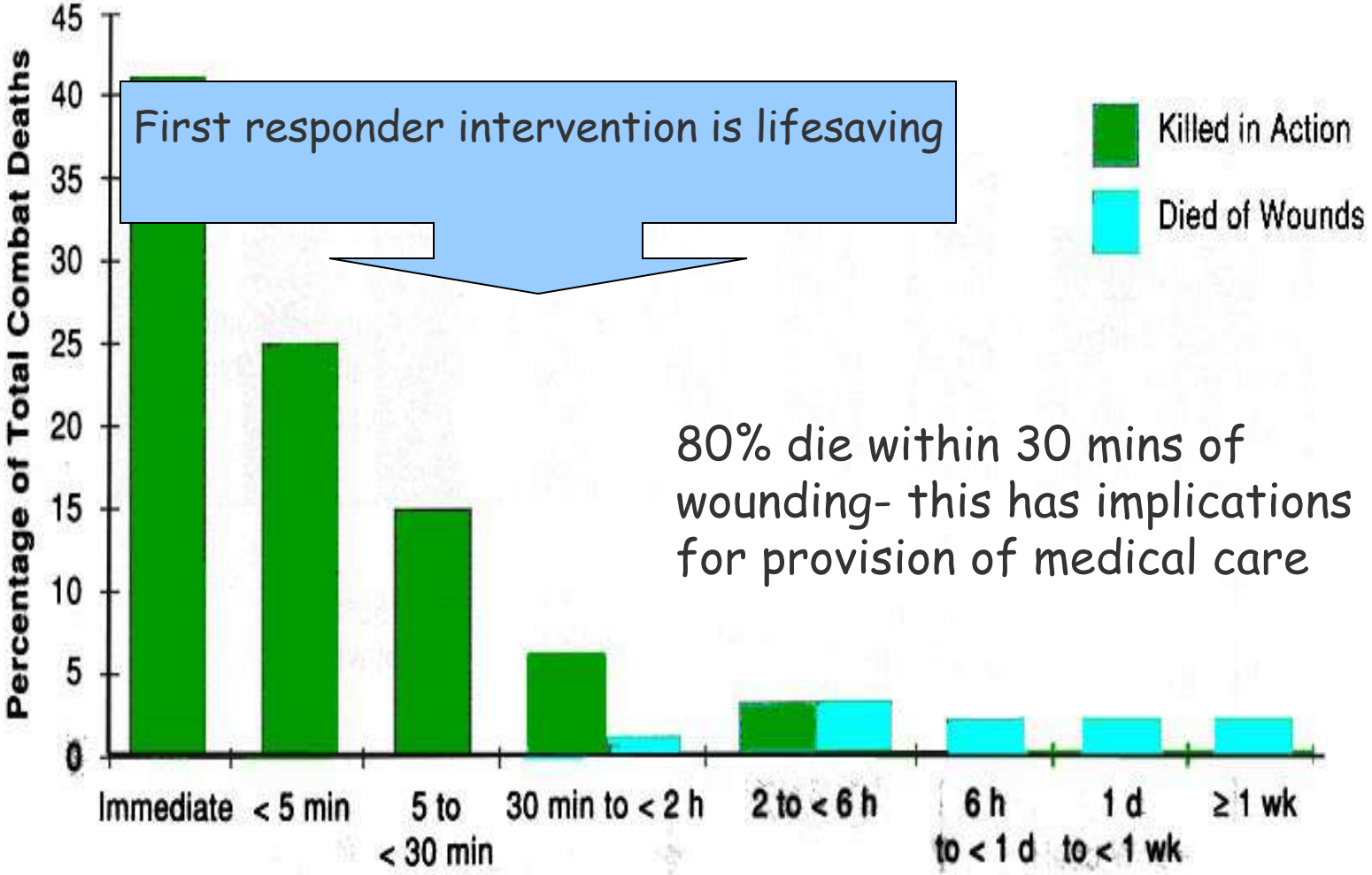
Reexamination of a Battlefield Trauma Golden Hour Policy

Jeffrey T. Howard, PhD, Russ S. Kotwal, MD, Alexis R. Santos-Lazada, PhD, Matthew J. Martin, MD, *and* Zsolt T. Stockinger, MD, *Fort Sam Houston, Texas*

- Reduction in mortality is associated with early treatment capabilities and rapid transport

The platinum ten minutes

US Army Vietnam



80% die within 30 mins of wounding- this has implications for provision of medical care

Hemorrhage Control

Spectrum Hemorrhage Control

Hemorrhage Control

- Compressible hemorrhage
- Non-compressible hemorrhage
- Junctional

Non-Compressible Hemorrhage

Options for Hemorrhage Control

- Remove bleeding organ
- Pack (apply pressure)
- Stop inflow (Clamp aorta) – Thoracotomy
- REBOA

Rhee PM, et al – *JACS*, 2000

First author	Location	Journal	Year	Years in review	Total survivors*	EDTs performed	Survival rate (%)
Branney45	Denver	J Trauma	1998	23	41	950	4.3
Bleetman50	UK	Injury	1996	2.5	1	18	5.6
Brown51	Indiana	Am Surg	1996	7.5	4	160	2.5
Velmahos52	Johannesburg	Arch Surg	1995	12.5	43	846	5.1
Mazzorana40	Oakland	Am Surg	1994	6	10	273	3.7
Durham53	Houston	J Trauma	1992	6	32	387	8.3
Lorenz54	San Francisco	J Trauma	1992	10.5	40	424	9.4
Boyd41	Youngstown	J Trauma	1992	4	2	28	7.1
Esposito48	Seattle	J Trauma	1991	4	2	112	1.8
Ivatury55	Bronx	J Trauma	1991	6	17	163	10.4
Lewis56	Cape Town	Injury	1991	2	8	45	17.8
Ordog57	Los Angeles	J Emerg Med	1987	6	5	80	6.3
Feliciano58	Houston	Am J Surg	1986	7	25	333	7.5
Schwab59	Norfolk	Am Surg	1986	2	14	51	27.5
Brautigan60	Detroit	Am J Emerg Med	1985	2	4	32	12.5
Danne43	Washington, DC	J Trauma	1984	2	10	89	11.2
Vij44	Detroit	Surgery	1983	2	5	63	7.9
Shimazu61	Baltimore	J Trauma	1983	5	5	153	3.3
Flynn42	Houston	Ann Emerg Med	1982	1	4	33	12.1
Harnar62	Seattle	Am J Surg	1981	2	5	64	7.8
Baker47	San Francisco	J Trauma	1980	7	33	168	19.6
Oparah63	Los Angeles	J Thorac Cardiovasc	1979	5	2	14	14.3
MacDonald64	Long Beach	JACEP	1978	4.5	2	28	7.1
Mattox65	Houston	JACEP	1974	3	27	106	25.5
Total					341	4, 620	7.4

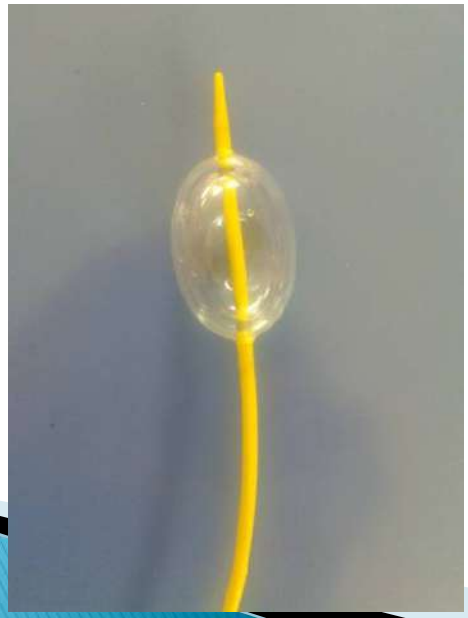
Total survivors were those that were alive at discharge from the hospital.
EDT, emergency department thoracotomy.

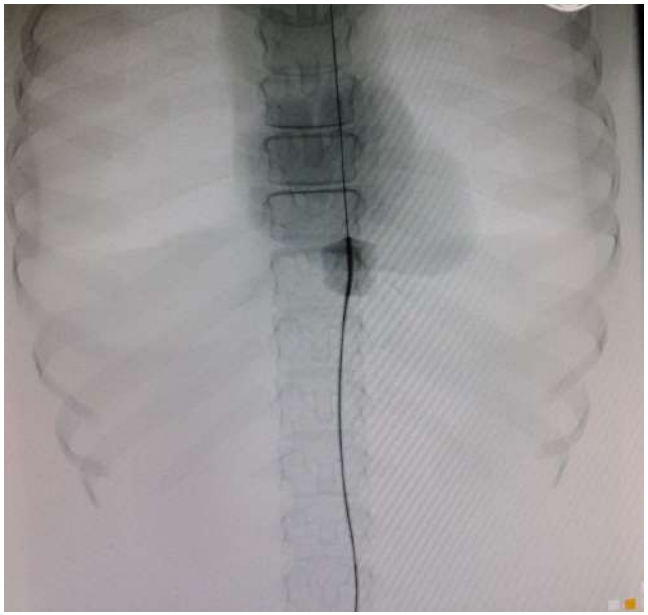
Overall survival 7.4%

Alternative

- REBOA
- Resuscitative Endovascular Balloon Occlusion of the Aorta

- “Internal aortic clamp”





REBOA for Trauma – History

- Hughes CW. *Use of intra-aortic balloon catheter tamponade for controlling intra-abdominal hemorrhage in man.* Surgery 1954;36(1):65-8

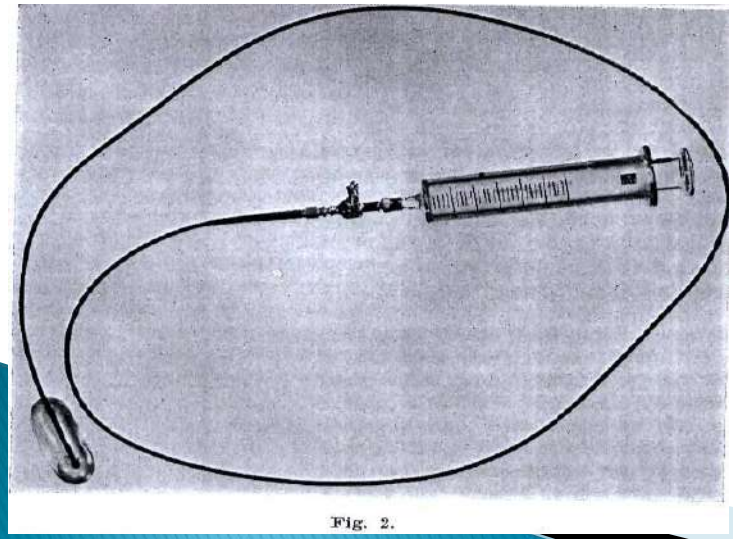


Fig. 2.

- **What can we translate from modern approach**

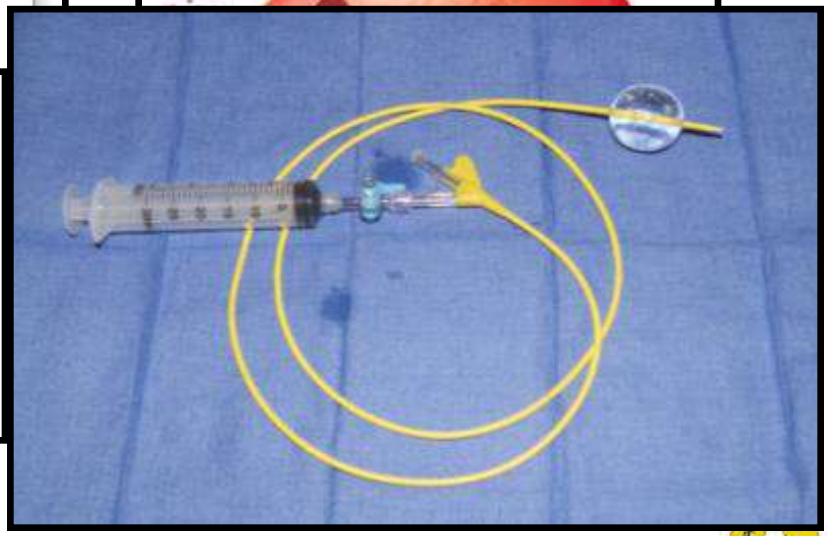
ORIGINAL ARTICLES

10 Years of Emergency Endovascular Aneurysm Repair for Ruptured Abdominal Aortoiliac Aneurysms: Lessons Learned

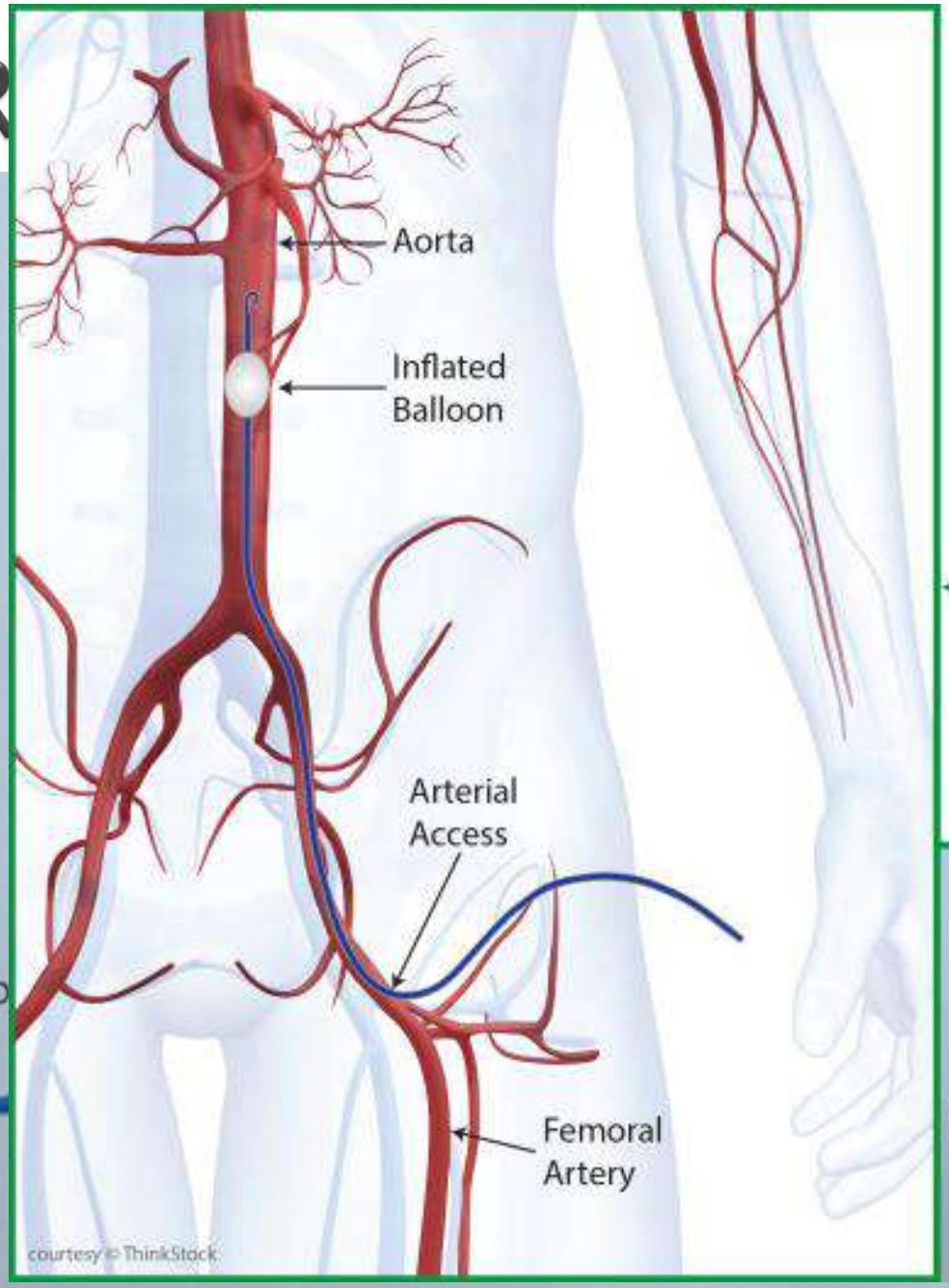
Dieter Mayer, MD, Thomas Pfammatter, MD,† Zoran Rancic, PhD,* Lukas Hechelhammer, MD,† Markus Wilhelm, MD,* Frank J. Veith, MD,‡ and Mario Lachat, MD**

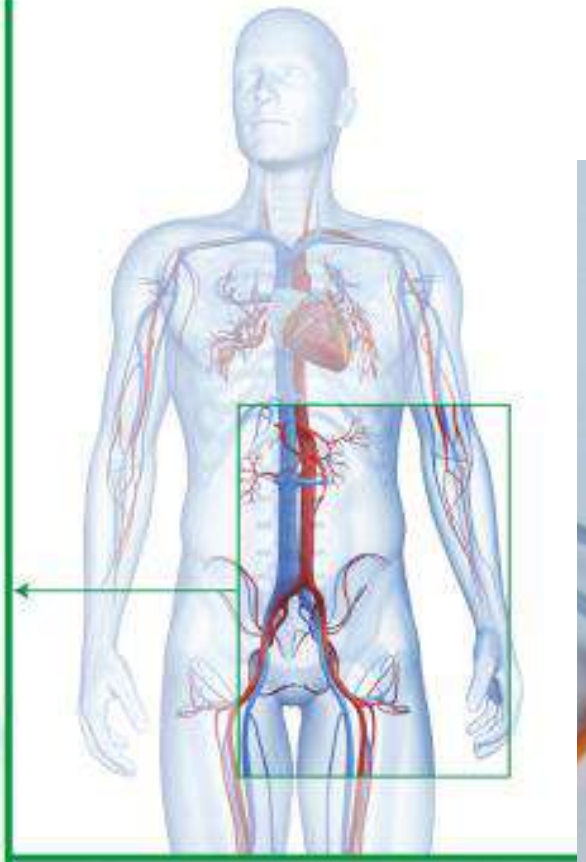
Conclusion: In this 102 patient contemporary series of cEVAR for RAAA, endografting proved to be safe with a 30-day mortality of 13%. Key components of this favorable outcome result were adequate preoperative diagnostic imaging, hypotensive hemostasis, selective transfemoral supraceliac aortic balloon occlusion, predominantly local anesthesia, detection and treatment of ACS, and attention to logistics. Widespread adoption of these treatment components is recommended.

(*Ann Surg* 2009;249: 510–515)



R

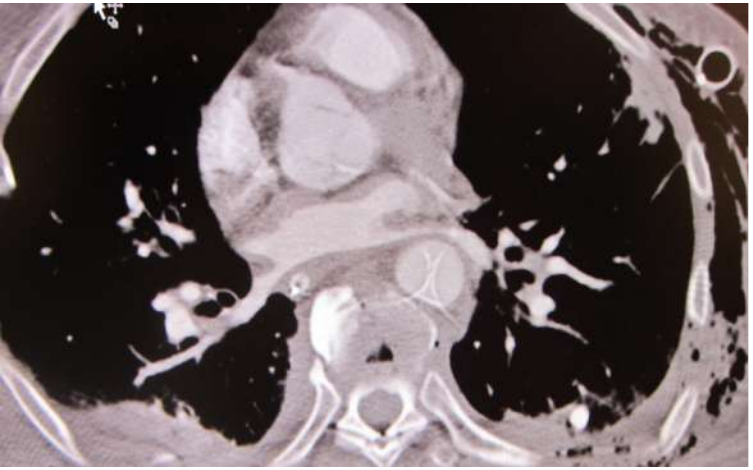

Aorta
Inflated Balloon
Arterial Access
Femoral Artery
courtesy © ThinkStock



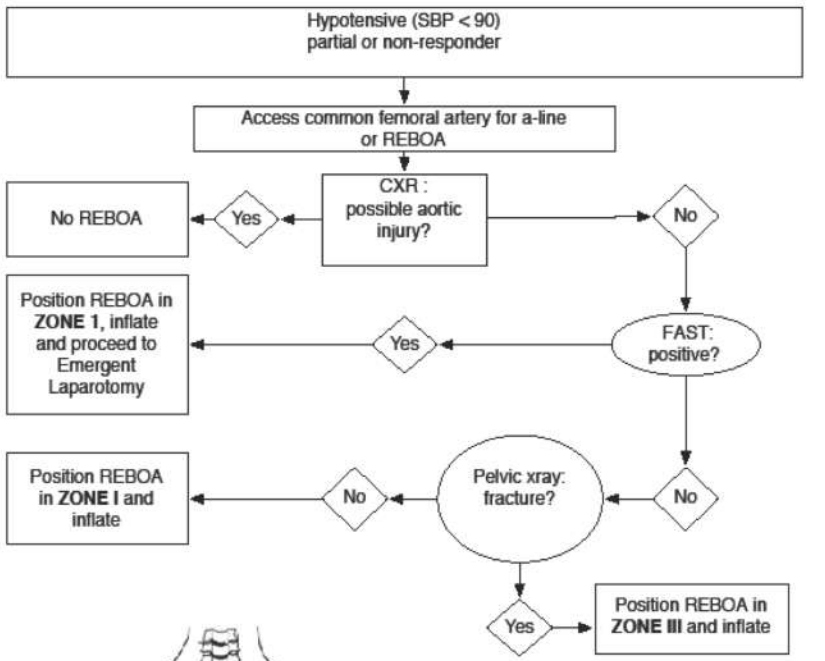

ER-REBOA™ CATHETER

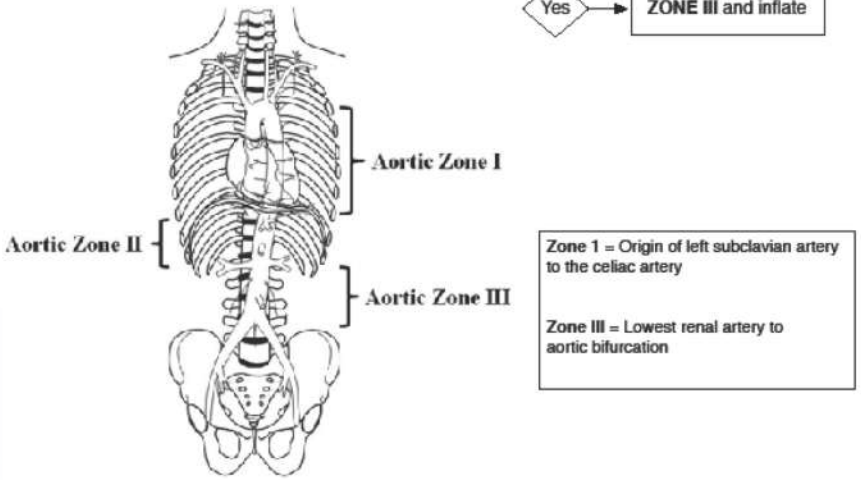
P-tip

REBOA



Proposed Technique for REBOA





PROCEDURES & TECHNIQUES

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

Temporary occlusion of the aorta as an operative method to increase proximal or central perfusion to the heart and brain in the setting of shock is not new.[1] Resuscitative aortic occlusion with a balloon was reported as early as the Korean War and has been described in more recent publications.[2–5] Despite potential advantages over thoracotomy with aortic clamping, resuscitative endovascular balloon occlusion of the aorta (REBOA) for trauma has not been widely adopted. Broader application of this procedure may have lagged because of latent technology, a poorly understood skill set, or anticipated ineffectiveness of the technique. However, the recent evolution of endovascular technology and its clear benefit in managing vascular disease such as ruptured abdominal aortic aneurysm suggest that a reappraisal of this technique for trauma is needed. The objective of this report is to provide a technical description of REBOA.

To simplify, this maneuver can be considered in the following five steps each with specific procedural considerations (Table 1):

1. Arterial access
2. Balloon selection and positioning
3. Balloon inflation
4. Balloon deflation
5. Sheath removal

STEP 1: ARTERIAL ACCESS AND POSITIONING OF INITIAL SHEATH

Establishing Arterial Access

At this time, access to the arterial circulation for REBOA for trauma should be obtained through the femoral artery. At the completion of this initial step, a 10- to 15-cm-long sheath will be positioned in the femoral and external iliac artery. Access to the femoral artery can be obtained using one of three techniques: percutaneous, open exposure (i.e., cut down), or exchange over a guidewire from an existing femoral arterial line. Percutaneous access is now commonly accomplished under ultrasound guidance using the same probe applied for the focused abdominal sonography for trauma or focused assessment with sonography for trauma examination. In this scenario, a straight or linear array transducer is superior to a curvilinear transducer. Ultrasound or direct surgical identification of the femoral artery lateral to the vein is especially important in the hypotensive patient without a palpable pulse. Once identified, the artery should be entered at a 45-degree angle with a hollow 18-gauge needle through which a 0.035-inch wire can be passed. After the wire has been passed into the artery, the needle is removed and a small incision made at the interface of the wire and the skin. Next the sheath is placed over the wire into the artery. It is important that any time a sheath is passed over a wire into the arterial system, the sheath's internal dilator is firmly in place to allow a smooth reverse taper from the wire to the diameter of the sheath. Once the dilator and sheath have been advanced over the wire through the skin into the artery, the dilator is removed leaving the sheath as a working port through which other maneuvers can be accomplished. To avoid bleeding from the side port of the sheath after the dilator is removed, it is important that the operator assure that the stopcock is in the "off" position to the patient.

Selection and Positioning of Initial Sheath

Sheaths are measured as French (Fr) (1Fr = 0.333 mm) and are sized based on their internal diameter. Common initial sheaths are 5 Fr to 8 Fr and come in lengths from 8 cm to 15 cm. As long as the operator is confident that the femoral artery has been accessed and the 0.035-inch starter wire passes without resistance, placement of this short sheath can be accomplished without fluoroscopic guidance. As noted, the initial sheath can also be placed after removing an existing arterial line over a wire (i.e., "rewiring"). This maneuver is accomplished by placing a wire greater than 2× the length of the catheter to be removed over the wire lumen allowing the catheter to be removed over the wire while maintaining arterial access. After a larger opening is created at the wire/skin interface, the short working sheath with its internal dilator in position can be inserted over this wire as previously described.

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From the US Army Institute of Surgical Research (A.S., T.E.R.), Fort Sam Houston, San Antonio, Texas; Academic Department of Military Surgery and Trauma (A.S.), Royal Centre for Defence Medicine, Birmingham, United Kingdom; Section of Vascular Surgery (J.L.E.), Department of Surgery, University of Michigan Health System, Ann Arbor, Michigan; and The Norman M. Rich Department of Surgery (T.E.R.), F. Edward Hebert School of Medicine, Uniformed Services University of the Health Sciences, Bethesda, Maryland.
The viewpoints expressed in this manuscript are those of the authors and do not reflect the official position of the United States Air Force or Department of Defense.
Address for reprints: Todd E. Rasmussen, MD, FACS, US Army Institute of Surgical Research, 3400 Rawley E. Chambers Suite B, Fort Sam Houston, TX 78234; email: todd.rasmussen@amedd.army.mil.
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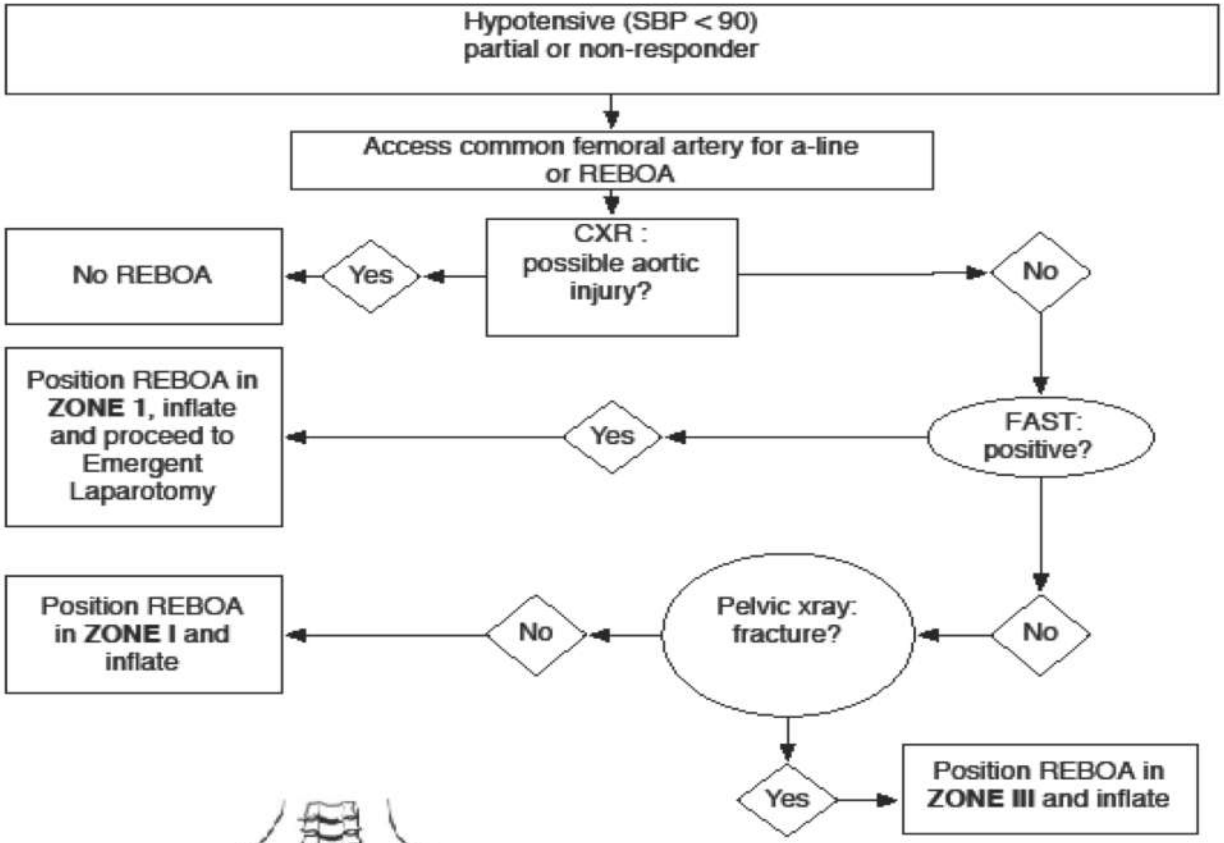
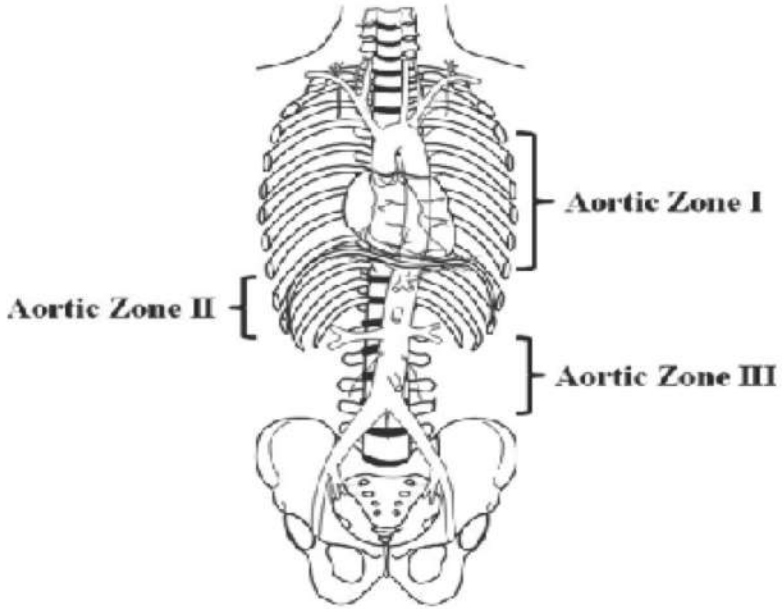




Zone 1 = Origin of left subclavian artery to the celiac artery

Zone III = Lowest renal artery to aortic bifurcation

AAST Multi-institutional Trials

Aortic Occlusion for Resuscitation in Trauma and Acute Care Surgery (AORTA)

- A prospective observational study of the Endovascular Skills in Trauma and Resuscitative Surgery

http://www.aast.org/Research/MultiInstitutionalStudies.aspx

The AAST Prospective Aortic Occlusion for Resuscitation in Trauma and Acute Care Surgery (AORTA) Registry

J. Dubose et al. AAST 2015 podium

- REBOA n=46, EDT n=68
- Groin cutdown 50% of REBOAs
- 65% imaging use
- No difference in AO time (6-7mins) REBOA vs EDT
- 87% REBOAs placed by ACS
- No difference in survival
- Complications:
  - PSA (1), thromboemboli (2)
  - no limb ischemia

Implementation of REBOA as an alternative to resuscitative thoracotomy for noncompressible truncal hemorrhage

24 REBOA, 72 EDT

- No difference in demographics, ISS, MOI, admission VS
- Survival: EDT=9.75%, REBOA=37.5%, p=0.003
- ICU deaths: Early death from hemorrhage
  - EDT 71.4%, REBOA 0%

- Dispo:
  - 77.8% of REBOA survivors were discharged home
  - 71.5% of RT survivors were discharged to Rehab/SNF

REBOA Compared to EDT

ORIGINAL SCIENTIFIC ARTICLES

Resuscitative Endovascular Balloon Occlusion of the Aorta and Resuscitative Thoracotomy in Select Patients with Hemorrhagic Shock: Early Results from the American Association for the Surgery of Trauma's Aortic Occlusion in Resuscitation for Trauma and Acute Care Surgery Registry

Megan Brenner, MD, FACS, Kenji Inaba, MD, FACS, Alberto Aiolfi, MD, Joseph DuBose, MD, FACS, Timothy Fabian, MD, FACS, Tiffany Bee, MD, FACS, John B Holcomb, MD, FACS, Laura Moore, MD, FACS, David Skarupa, MD, FACS, Thomas M Scalea, MD, FACS, for the AAST AORTA Study Group

- REBOA can confer survival benefit or thoracotomy

REBOA technique – 12 (Fr)

Materials

femoral arterial line kit, sterile drapes, mayo stand, saline/contrast

REBOA bag:

1. Amplatz Super Stiff wire 260cm, 0.035" (Boston Scientific)
2. 12Fr sheath (Cook Medical)
3. CODA 32mm balloon catheter (Cook Medical)
4. 30cc syringe
5. sterile marker and stickers
6. (micropuncture kit, Cook Medical)

REBOA technique

1. Access the common femoral artery 2 cm below the inguinal ligament using the femoral a-line kit.

2. Advance Amplatz wire into a-line catheter to proximal Zone 1
(external landmark: below 2nd rib space). A CXR MUST be obtained to confirm wire placement.

3 Exchange a-line catheter for a 12 Fr sheath, upsizing if necessary.

4. Advance sheath proximal common iliac artery and remove dilator.

5. Advance balloon to distal Zone 1, or distal Zone 3, and inflate to moderate resistance.

6. Observe changes in hemodynamics while continuing resuscitation and diagnosis / treatment of hemorrhagic source as indicated.

7. Secure sheath, balloon, and wire for transport to definitive care.

8. Once need for occlusion has passed, remove balloon, sheath, wire, and verbalize repair of artery as indicated.

ER-REBOA technique

Materials:

femoral arterial line kit, sterile drapes, mayo stand, saline/contrast, 7 Fr sheath, ER-REBOA catheter

- 1. Access common femoral artery
- 2. Place 7 (Fr) sheath
- 3. Measure REBOA Catheter
- 4. Insert and inflate balloon

REBOA technique

Pearls

The success of this procedure is based on *common femoral artery access*

1. External landmarks
2. Optional use of US
3. Needle entry and cannulation

REBOA technique

Pitfalls

1. Access
2. Sheath exchange
3. Resistance during insertion
4. Wire/sheath/balloon displacement and correction

Transfer to definitive care

REBOA removal

Balloon deflation : discuss with anesthesia!
(physiologic consequences = removal of aortic cross-clamp)

Requires groin cutdown and arterial repair in OR

- May require repair with patch
- Watch for dissection flaps
- Distal fogarty embolectomy if back bleeding

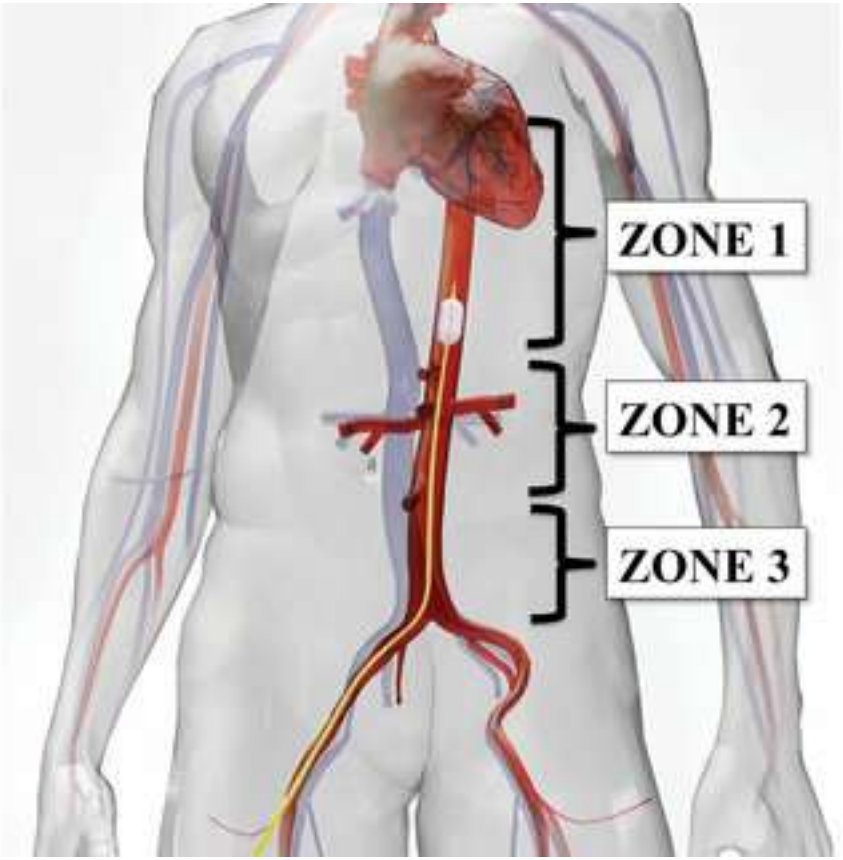
REBOA removal

- Ensure inflow is adequate
- Check pulse above and below repair, and pedal pulses before completing case
- Role for Vascular Surgery consultation

Simple Principle

- Internal aortic occlusion
- All or nothing

Reperfusion



Survival of severe blunt trauma patients treated with resuscitative endovascular balloon occlusion of the aorta compared with propensity score-adjusted untreated patients

Tatsuya Norii, MD, Cameron Crandall, MD, *and* **Yusuke Terasaka, MD,** *Albuquerque, New Mexico*

BACKGROUND: Despite a growing call for use of resuscitative endovascular balloon occlusion of the aorta (REBOA) for critically uncontrolled hemorrhagic shock, there is limited evidence of treatment efficacy. We compared the mortality between patients who received a REBOA with those who did not, adjusting for the likelihood of treatment and injury severity, to measure efficacy.

METHODS: We analyzed observational prospective data from the Japan Trauma Data Bank (2004–2011) to compare the mortality between adult patients who received a REBOA with those who did not. To adjust for potential treatment bias, we calculated the likelihood of REBOA treatment via a propensity score (PS) using available pretreatment variables (vital signs, age, sex, as well as anatomic and physiologic injury severity) and matched treated patients to up to five similar PS untreated patients. We compared survival to discharge between treated and untreated groups using conditional logistic regression and Cox proportional hazards regression.

RESULTS: Of 45,153 patients who met inclusion, 452 patients (1.0%) received REBOA placement. These patients were seriously injured (median Injury Severity Score [ISS], 35) and had high mortality (76%). Patients who did not receive a REBOA had significantly lower injury severity (median ISS, 13; $p < 0.0001$) and lower mortality (16%). After matching REBOA patients with controls with similar PSs for treatment, the crude conditional odds ratio of survival by REBOA treatment was 0.30 (95% confidence interval, 0.23–0.40).

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.

LEVEL OF EVIDENCE: Epidemiologic study, level III; therapeutic study, level IV.

KEY WORDS: Balloon occlusion; resuscitation/method; trauma centers; blunt trauma; aortic diseases/therapy.

Norii et al. – J Trauma, 2015

- 452 REBOA patients – severe blunt trauma
  - Propensity Score Matching (N = 45,153)
  - Crude conditional odds ratio of survival by REBOA treatment was 0.30 (95% CI interval, 0.23–0.40)

Norii et al. – J Trauma, 2015

- "REBOA treatment associated with higher mortality compared to similarly ill trauma patients who did not receive REBOA. The higher observed mortality among REBOA-related patients may signal "last ditch" efforts for severity not otherwise identified in the trauma registry"

Japan
Evaluation of the safety and feasibility of REBOA

Saito et al. JTACS May 2015 - Volume 78 - Issue 5 - p 897–904

N = 24 REBOA patients

Results:

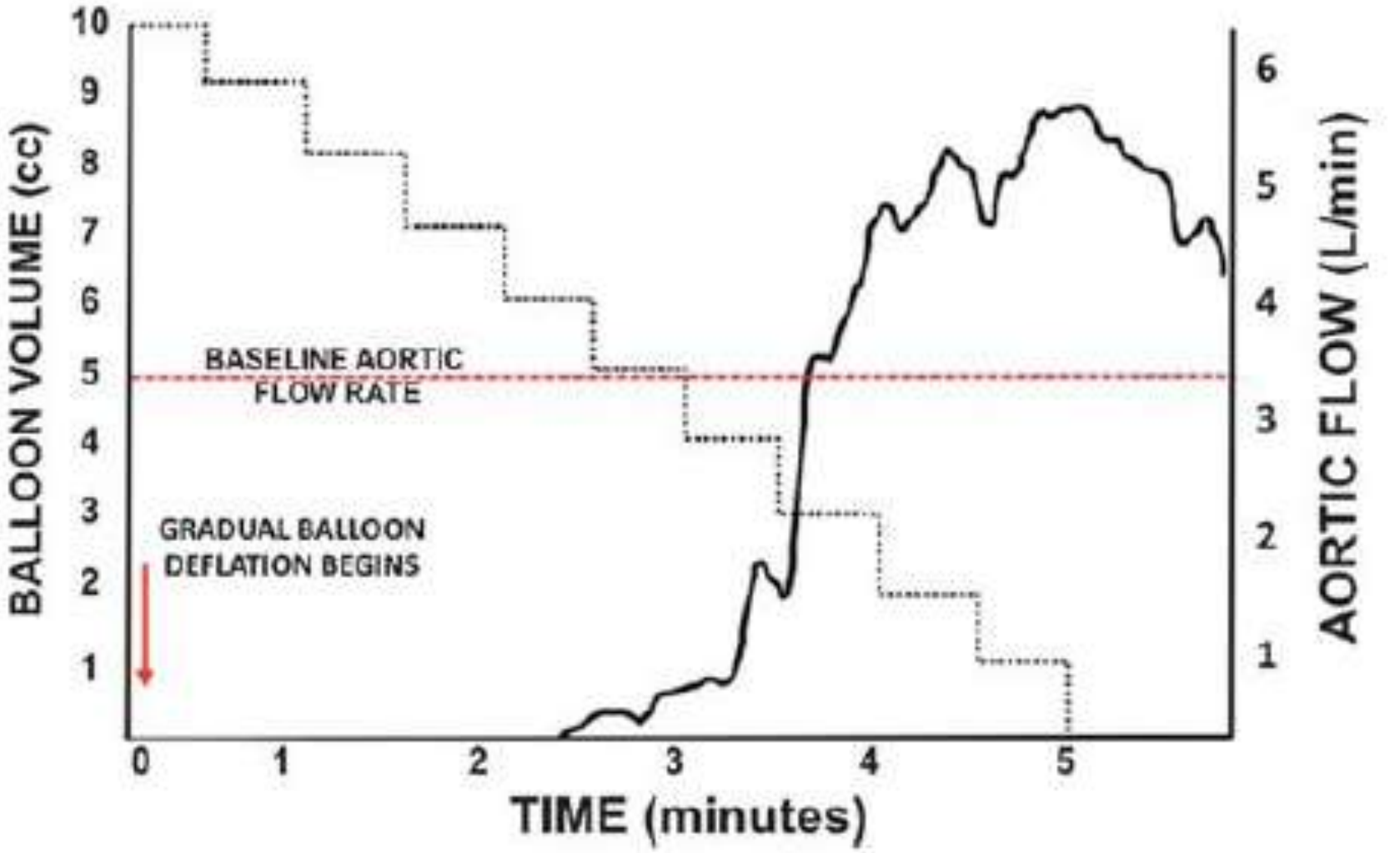
- blunt injury, mean ISS 47
- 10 deaths (42%), balloon could not be deflated in 5
- median *duration of aortic occlusion was shorter in survivors* than non- (21 minutes vs. 35 minutes)
- mean *systolic blood pressure was significantly increased*
- 3 cases with complications, 1 EIA, 2 ischemia…

lower limb amputation was necessary in all cases

Conclusion:

- REBOA seems to be feasible

B

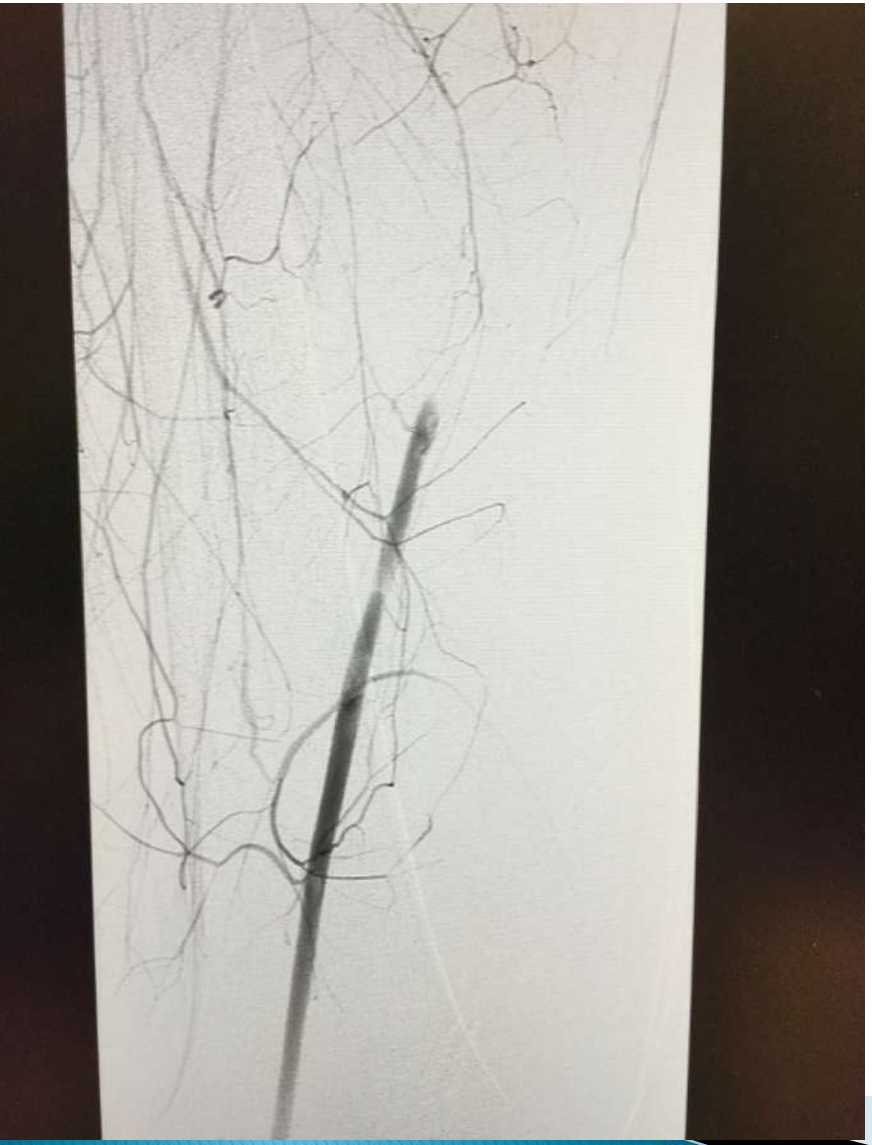


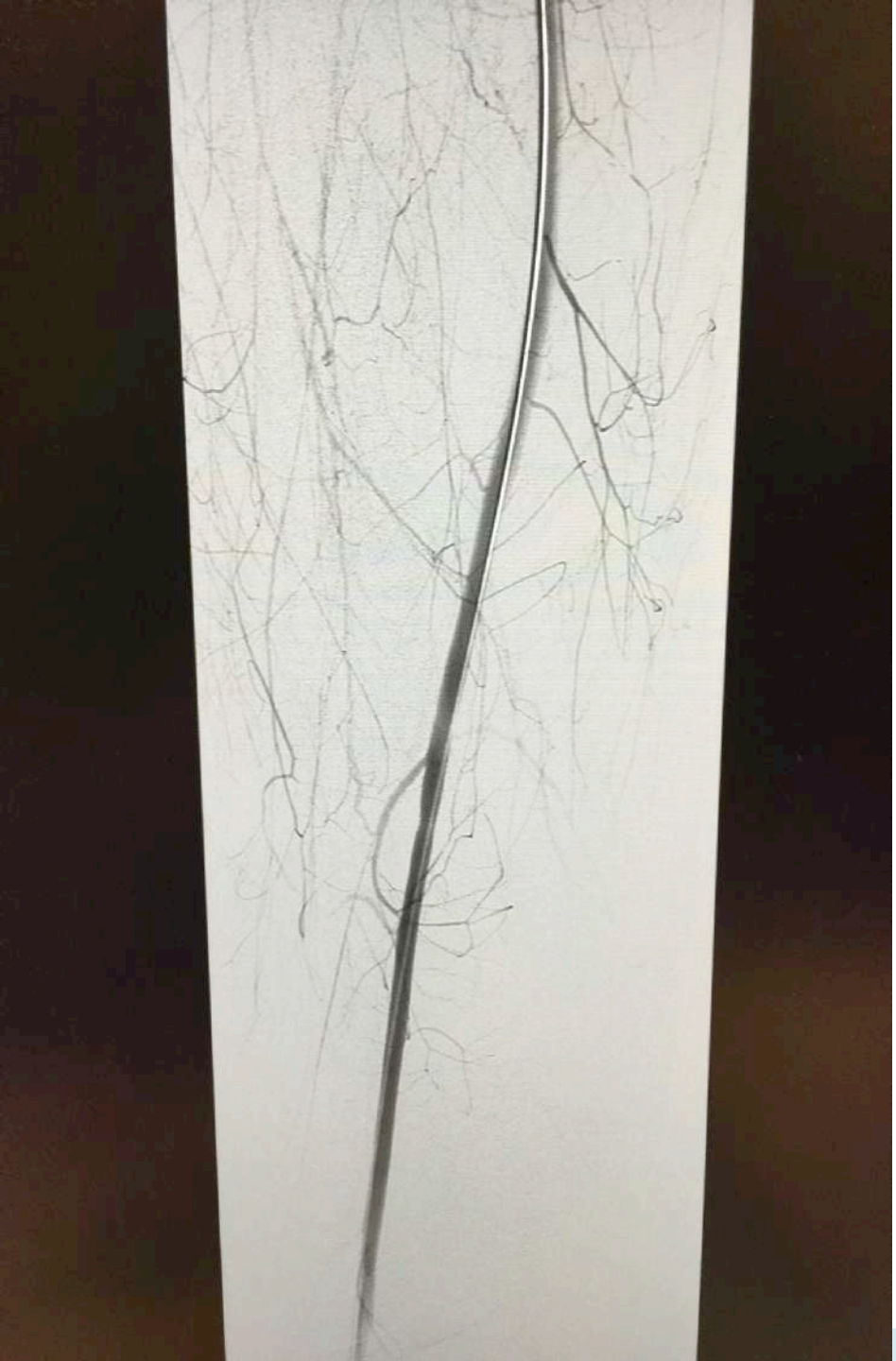
P-REBOA. (*B*) Proximal and distal blood pressures from a single ER-REBOA catheter placed through a 7 Fr sheath.

Complications

- Device malfunction
- Arterial Injury

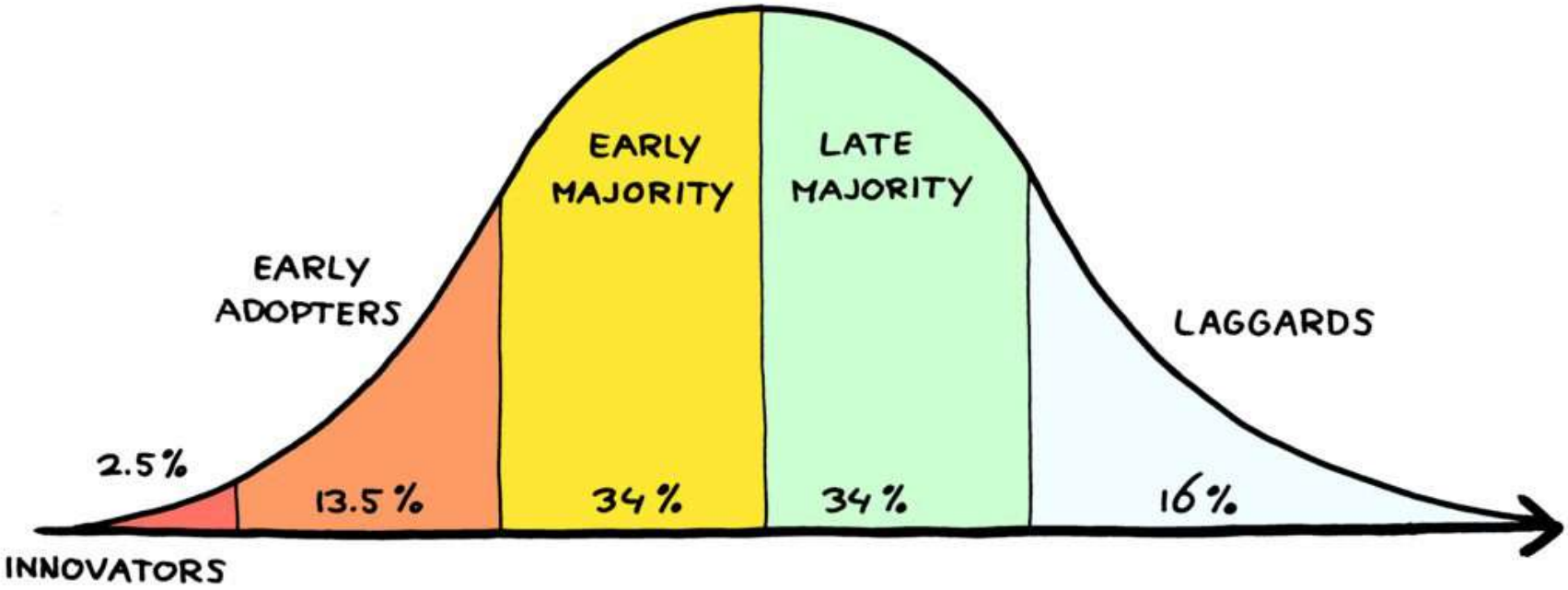
Complications



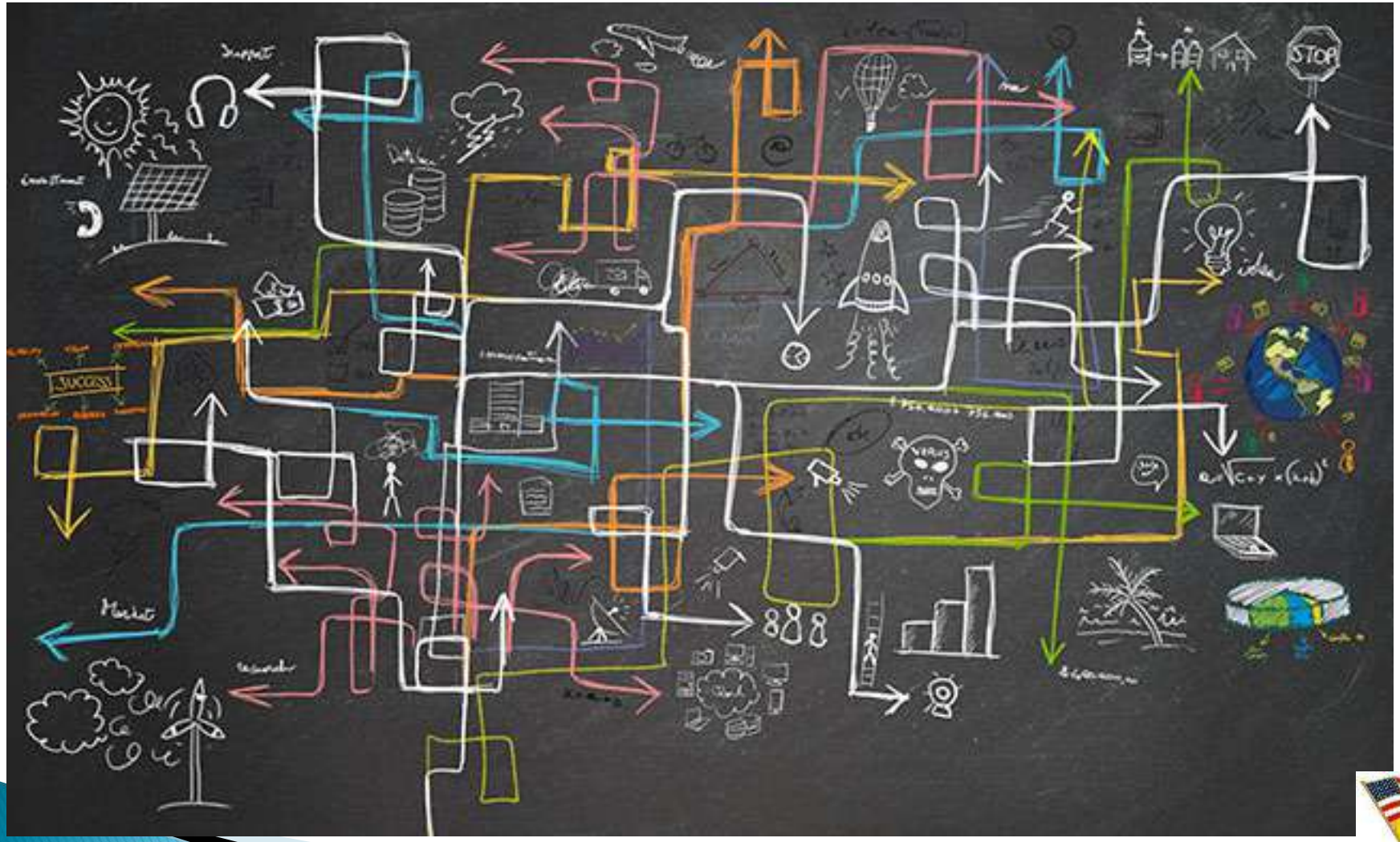


Post Status Angiojet thromboembolectomy

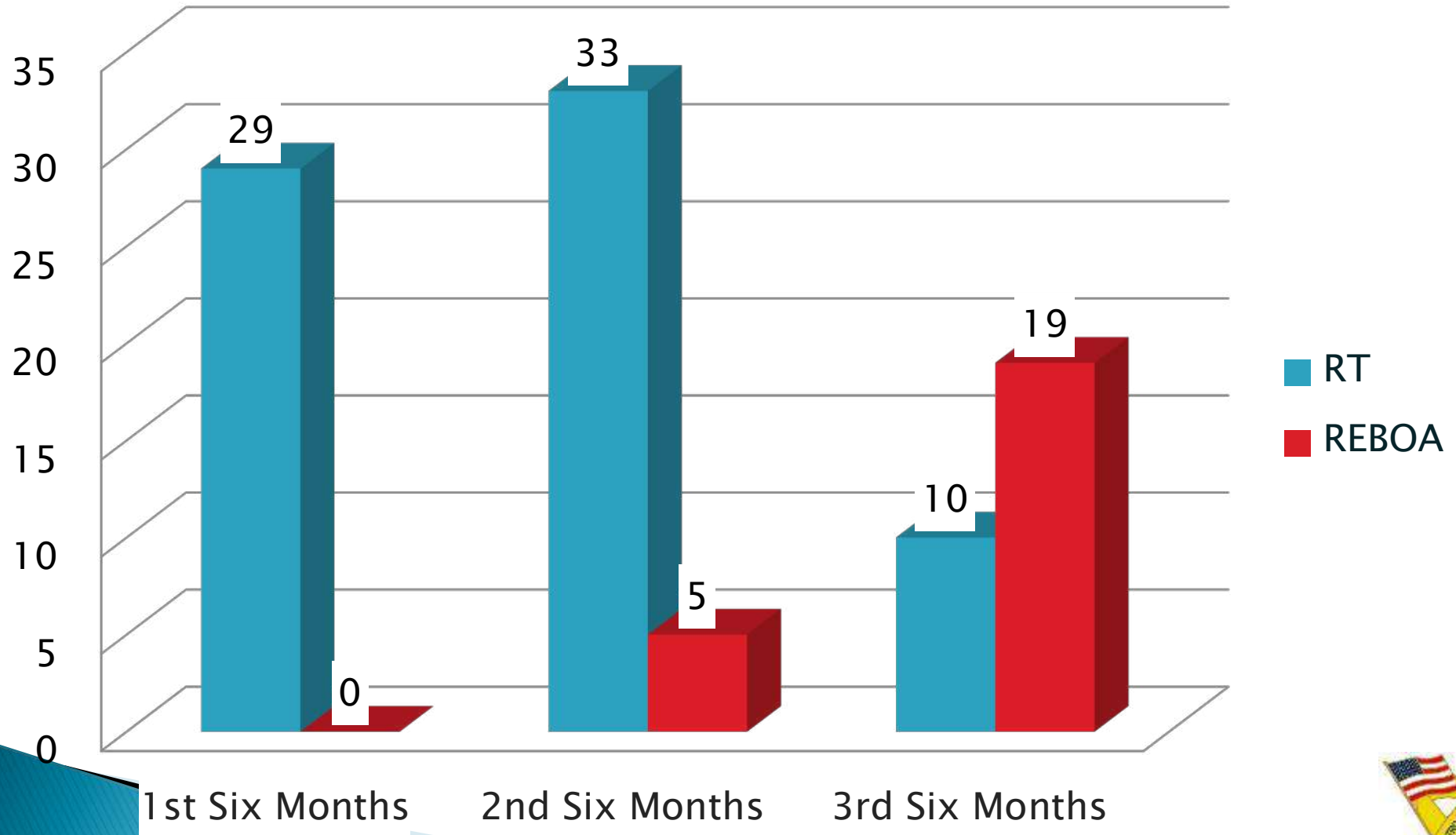
Diffusion of Innovation



Systematic Process



Number of RT and REBOA cases



Look to Future

- Automated control for partial REBOA
- Wire-free devices
- Fluoroscopy free
- Monitoring/infusion/occlusion capability

Summary

- Golden Hour
- Bleeding needs to stop
- Multiple methods
- REBOA offers less invasive alternative

Conclusion

- REBOA has advantages and disadvantages
- Non-operative tool for Non-compressible hemorrhage
- DATA AND NEW TECHNOLOGY WILL BE THE DIFFERENCE