

Case Report

REBOA for Refractory Pelvic Hemorrhage: Preventing Mortality in Potentially Survivable Death after Trauma

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Abstract

REBOA has been recently adopted for trauma patients with refractory hypotension or in traumatic arrest from hemorrhage below the diaphragm. REBOA has shown improved physiologic parameters, coronary and cerebral blood flow, and survival in hemorrhage models. The National Trauma Care System (NTCS) goal to achieve zero preventable deaths after injury may benefit with advances in REBOA. Non-compressible hemorrhages have been found to contribute significantly to the potentially survivable combat deaths in the wars in Iraq and Afghanistan and REBOA has indications for use in non-compressible hemorrhage below the diaphragm. Recognition that indications for REBOA are present in potentially survivable deaths after injury is the driving force behind its evolution and in alignment with the goals of the NTCS. This case report is an example of REBOA use, by a military trauma surgeon working in the civilian setting, on a patient in refractory hemorrhagic shock secondary to blunt trauma and pelvic hemorrhage with a positive outcome.

ABBREVIATIONS

ACS: American College of Surgeons; AO: Aortic Occlusion; AORTA: Aortic Occlusion for Resuscitation in Trauma and Acute Care Surgery; CT: Computed Tomography; CXR: Resuscitative Balloon Occlusion of the Aorta; DoD: Department of Defense; EDT: Emergency Department Thoracotomy; FAST: Focused Assessment with Sonography in Trauma; FFP: Fresh Frozen Plasma; HR: Heart Rate; ICU: Intensive Care Unit; NTCS: National Trauma Care System; PRBC: Packed Red Blood Cells; REBOA: Resuscitative Balloon Occlusion of the Aorta; SBP: Systolic Blood Pressure; XR: X-ray

INTRODUCTION

REBOA has been recently adopted for trauma patients with refractory hypotension or in traumatic arrest from hemorrhage below the diaphragm [1-3]. Operative intervention or catheter-based radiologic techniques with ongoing resuscitation remain the standard means of achieving hemostasis in hemorrhagic shock. In translational studies REBOA, as an adjunct to resuscitation, provides temporary aortic occlusion above the site of hemorrhage in an attempt to improve physiological parameters, cerebral and coronary perfusion, and survival long

enough to achieve appropriate resuscitation and definitive hemostasis [4,5].

Significant numbers of potentially survivable combat deaths in Operation Iraqi Freedom and Operation Enduring Freedom have been found to be the result of truncal, junctional and extremity hemorrhage [6]. Truncal hemorrhage below the diaphragm, non-compressible junctional hemorrhage, and lower extremity hemorrhage causing refractory hypotension or traumatic arrest in the right clinical scenario are indications for REBOA. The driving force behind the evolution of REBOA is the recognition that potentially survivable deaths are significant in a patient population whom REBOA may have prevented mortality.

The state-side use of REBOA, continued analysis of clinical data, and dedicated training may translate into a decrease in potentially survivable death on the battlefield. We present a case of hemorrhagic shock secondary to severe blunt trauma where REBOA is performed by an active duty surgeon in civilian practice and continue with a discussion about the evolution of REBOA.

CASE PRESENTATION

A 63-year-old male pedestrian was struck by motor vehicle at high speed. Prehospital paramedic reported unresponsiveness

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Submitted: 25 November 2016

Accepted: 20 February 2017

Published: 23 February 2017

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Keywords

- REBOA
- Pelvic fracture
- Hemorrhage
- Hemorrhagic shock
- Refractory hemorrhagic shock
- Refractory pelvic hemorrhage
- Preventable mortality
- Potentially survivable injury
- Preventable death after injury
- National trauma care system

and hypotension en route and the patient's airway was secured via endotracheal intubation. The patient arrived in the resuscitation area hypotensive (SBP 53) and tachycardic (HR 123) without any external signs of hemorrhage. Common femoral arterial access with a 5 Fr catheter was obtained for hemodynamic monitoring and a venous catheter was placed for resuscitation. The abdominal FAST exam was negative. CXR demonstrated bilateral rib fractures with small bilateral pneumothoraces without evidence of aortic injury. Bilateral tube thoracostomy was performed with minimal output and no improvement in hemodynamics. Pelvic XR demonstrated left superior and inferior rami fractures and bilateral widening of the sacroiliac joints consistent with AP compression injury. Resuscitation with 4 units of PRBC and 4 units of FFP occurred within 12 minutes of arrival without significant hemodynamic response.

Due to severe hemorrhage secondary to the pelvic fracture and lack of hemodynamic response to resuscitation, REBOA was performed. The common femoral arterial line was upsized to a 12 Fr sheath. An Amplatz Super Stiff guidewire was inserted and imaging performed. A Coda 32mm balloon catheter was inserted over the guidewire and inflated in the distal abdominal aorta, or Zone 3. The patient's hemodynamic response was immediate (SBP 118, HR 92).

The balloon catheter was secured and the patient taken to CT scan while one additional unit of PRBC and FFP were infused. CT scan demonstrated pelvic fracture and hematoma and the inflated balloon in Zone 3. The patient was transferred to the IR suite, the balloon deflated over 5 minutes and angioembolization was performed. The patient proceeded to the operating room where the 12 Fr sheath was removed, the arteriotomy repaired, and pelvic fixation performed. Post-operatively the patient was transferred to the trauma ICU in stable condition and discharged neurologically intact on post-operative day 11.

DISCUSSION

The casualties of war in Afghanistan and Iraq [6], acting as a catalyst for innovation, ignited renewed joint military-civilian partnership to eliminate preventable mortality in trauma [7]. Wartime successes in prehospital transport from combat injury to definitive care have had positive impacts on combat survival, yet preventable mortality remains [8]. The Combat Casualty Care Research Program is supporting advancement in REBOA for use in prolonged field care [9]. The Aortic Occlusion for Resuscitation in Trauma and Acute Care Surgery (AORTA) registry, a prospective observational study, began in 2013 [1]. The AORTA registry is a military-civilian collaboration, investigating duration of aortic occlusion (AO) during REBOA and emergency department thoracotomy (EDT), in order to define outcomes, practice patterns and predictors of success in modern AO. The American College of Surgeons reaffirmed their commitment to collaboration with the Department of Defense (DoD) and the Military Health System and their joint military-civilian partnership in 2014 [10]. The Joint Theater Trauma System Clinical Practice Guidelines on REBOA for Hemorrhagic Shock were approved in the same year [11]. A smaller REBOA catheter compatible with a 7Fr sheath, with support from the DoD [12], was approved by the Food and Drug Administration in late 2015 [13]. This military-civilian partnership, in their

shared recognition that potentially survivable injuries may have been prevented with REBOA and in their combined commitment to eliminate preventable mortality, is fueling advancements in REBOA.

Our patient presented in traumatic hemorrhagic shock, venous and arterial access were obtained, appropriate blood product resuscitation was initiated, and the source of hemorrhage determined with information gained from imaging and interventions. Aggressive blood product resuscitation failed to improve hemodynamics, no contraindications to REBOA (thoracic vascular injury) were present, thus REBOA was indicated and performed. REBOA provided hemodynamic improvement and stability long enough for appropriate resuscitation and definite hemostasis with a positive outcome.

Intra-aortic balloon occlusion via an open approach was first described during the Korean War to control massive aortic hemorrhage [14]. Evidence suggesting REBOA improves outcomes in patients with traumatic hemorrhagic shock or traumatic cardiac arrest is promising [1-3,15-17]. Case reports describing REBOA for control of massive hemorrhages intraoperatively during vascular, pelvic, gastrointestinal, and hepatobiliary surgery suggest it is a life-saving procedure [18-23]. Formal REBOA training of acute care and trauma surgeons has demonstrated improvements in knowledge and procedural skills [24,25] and the Basic Endovascular Skills for Trauma™ course was recently adopted by the American College of Surgeons Committee on Trauma [26]. REBOA is an accepted adjunct to hemorrhage control in some trauma centers across the United States [1], and has been performed in the pre-hospital setting as well as emergency departments in the UK and Japan [27-29].

Algorithms for REBOA use are varied across institutions [1,2,11,30]. Indications for use in the ongoing AORTA trial in the United States, comparing EDT to REBOA, include use for traumatic life-threatening hemorrhage below the diaphragm in patients unresponsive or transiently responsive to resuscitation and patients presenting in arrest from blunt injury with presumed hemorrhage below the diaphragm [1]. Clinical indications are expanding with the introduction of a smaller, wire-free device.

Common femoral artery access is a rate-limiting step for REBOA initiation and if percutaneous access, with or without ultrasound, is not possible, a groin cut down is required. Approximately half of REBOAs performed in the AORTA trial required cut-down, the majority of which were patients in arrest, where percutaneous cannulation is more challenging [1]. Inflation of the balloon is indicated in the distal thoracic aorta (Zone 1) for patients in traumatic arrest or those with intra-abdominal or retroperitoneal hemorrhage. Inflation of the balloon is indicated in the distal abdominal aorta (Zone 3) for pelvic, junctional, or proximal lower extremity hemorrhage [1,2,11].

Complications from REBOA have been reported and include arterial dissection, pseudoaneurysms, hematoma, thromboembolism and extremity ischemia [1,31,32]. International data describes amputation in some cases [31], which has not been reported in the US as a direct cause of REBOA. Smaller catheters may be associated with fewer complications from REBOA [29]. Duration of balloon inflation in the distal

thoracic aorta or distal abdominal aorta has not been well defined, but translational studies are demonstrating partial REBOA may become an effective measure to decrease distal ischemia [33].

Hemorrhagic shock remains a leading cause of preventable death in trauma [6,34] and delays to definitive hemostasis increase mortality [35,36]. Civilian and military population based gap analysis have shown a population of patients that may benefit from REBOA [37,38]. REBOA use as an adjunct to resuscitation and a bridge to definitive hemostasis may be life-saving. Potentially survivable deaths in trauma have been shown to have had indications for REBOA. Continued research comparing the role of AO in EDT vs REBOA in specific patient populations is ongoing. Additional data to define which trauma patients benefit from REBOA, duration limits or partial occlusion for balloon inflation, and outcomes in differing practice environments with varied catheters is needed. Further understanding of the physiologic consequences and outcomes regarding balloon inflation may further the discussion of prehospital use or prior to hospital transfer. The goal of our NTCS to achieve zero preventable deaths after injury [39] may be aided by use of REBOA.

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Cite this article

Scheele B, DuBose J, Brenner M, Scalea T (2017) REBOA for Refractory Pelvic Hemorrhage: Preventing Mortality in Potentially Survivable Death after Trauma. *JSM Anat Physiol* 2(1): 1010.