Case Report

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Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) as an Adjunct to Damage Control Surgery for Combat Trauma: A Case Report of the First REBOA Placed in Afghanistan

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This case report details a trauma case – transpelvic gun shot wound with hemorrhagic shock- treated with REBOA as an adjunct to resuscitation. This is the first reported case of REBOA in Afghanistan at the Role 3 Multinational Medical Unit in Southern Afghanistan.

Keywords: *REBOA; Balloon Occlusion; Combat; Austere*

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INTRODUCTION

Balloon occlusion of the aorta for hemorrhage control in the combat setting has been well described, its first use was during the Korean War [1]. Recently, balloon control of aortic bleeding saw a resurgence in the vascular community for the treatment of ruptured abdominal aortic aneurysm (AAA) [2–5]. Landmark studies in 2011 [6,7], defined as 'resuscitative endovascular balloon occlusion of the aorta' and coining the acronym 'REBOA,' paved the way for clinical trials that compared balloon versus open aortic occlusion for traumatic hemorrhage [8]. New devices enabling fluoroscopy and wire-free placement, as well as continuous arterial monitoring (Figure 1) [9], allowed care to move further forward in the military environment. In line with military applications, clinical practice guidelines for deployed providers supported the use of REBOA as an alternative to thoracotomy for aortic occlusion [10].

With general enthusiasm and promising preclinical and clinical data for REBOA use in non-compressible torso hemorrhage (NCTH), reports of in-theater usage began to emerge. The first four cases reporting successful placement and outcomes in a far forward setting were released in 2017 [11]. We report the first use of REBOA

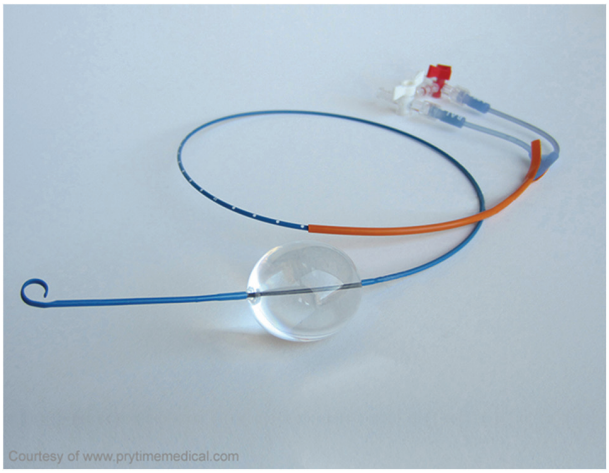

Figure 1 Fluoroscopy-free ER-REBOA device (Prytime Medical Inc., Boerne, TX, USA).

during combat operations in Afghanistan, used as a bridge to definitive hemorrhage control for an abdominopelvic gunshot wound with exsanguinating hemorrhage.

Case Report

This patient was an approximately 18-year-old casualty injured during combat operations in southern Afghanistan. He received a gunshot wound from a high velocity round, with a periumbilical entry wound, transabdominopelvic trajectory and exit out the inferior left sacroiliac joint. Field care included placement of an abdominal dressing and immediate transfer to a forward surgical team. On arrival, he was confused with a blood pressure of 76/50, a heart rate of 120, and with evisceration of his abdominal contents through his abdominal wall. He was taken emergently to the operating room (OR) where he underwent a damage control laparotomy. Massive pelvic bleeding was encountered, primarily reported as low rectal and presacral plexus bleeding, temporarily controlled with packing. A temporary abdominal closure was performed with an Ioban occlusive dressing. The patient was then transferred to our facility for further surgical and critical care.

The patient arrived with a blood pressure of 147/102, a heart rate of 115, and was taken directly to the OR. Upon transfer from the gurney to the OR table, 18 minutes after arrival, the patient was noted to have a systolic blood pressure of 62/38. Anesthesia was being prepared in the ventilator, and instruments were still being opened at this point, so the decision to proceed with balloon occlusion over open vascular control was made. Simultaneously, while one surgeon was preparing the abdomen for laparotomy, a second surgeon rapidly performed a cut down over the right groin. The patient was quite thin and the common femoral artery was isolated in approximately one minute. A 21-gage micropuncture needle was used to access the vessel, and a 5 Fr

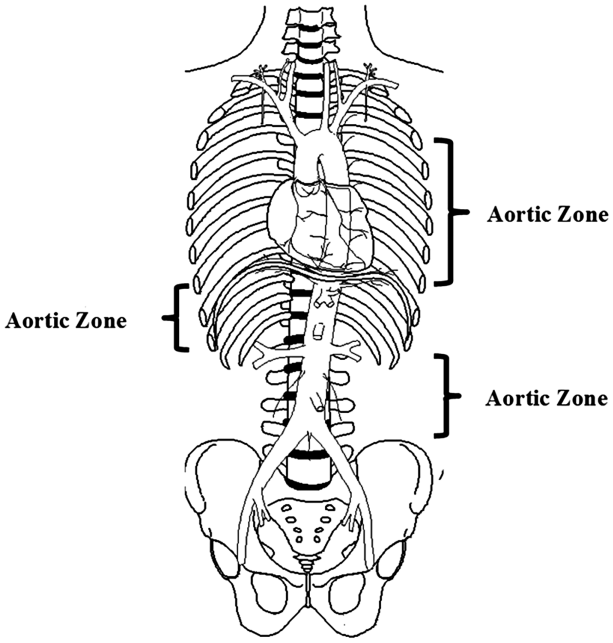

Figure 2 Zones of aortic occlusion recommended by clinical practice guidelines.

Zone 1 is above the diaphragm, Zone 2 between the renal arteries and diaphragm, and Zone 3 is below the renal arteries in the abdominal aorta, above the iliac bifurcation.

introducer sheath was placed over a wire. This was immediately upsized to a 10 Fr sheath (no 7 Fr sheath was available). An ER-REBOA catheter was selected, measured for Zone 1 occlusion (45 cm from xiphoid to the tip of the sheath in this case), and placed through the sheath (Figures 2 and 3). No attempt was made to obtain radiographic confirmation of position. Unable to get an arterial tracing through the arterial port, the arterial line tubing was moved from the arterial port on the ER-REBOA to the side port of the 10 Fr sheath, and the ER-REBOA balloon was inflated until the arterial tracing was lost, indicating proximal aortic occlusion. 10cc of saline was required to achieve occlusion. Upper extremity arterial pressure reading recovered to a systolic blood pressure of 110 with balloon occlusion.

With hemodynamic stability achieved, the patient was re-explored. Approximately 1000 cc of blood was evacuated from the pelvis. No arterial bleeding was encountered, only a large non-expanding large retroperitoneal hematoma and brisk venous pooling. The left and right common iliac arteries were easily identified and exposed at the iliac bifurcation and encircled for inflow control. Alternatively, adjustment of the balloon to a Zone 3 position would have been possible, but after rapid open vascular control was obtained the need for this maneuver was obviated. At this point, the ER-REBOA balloon was deflated and the patient remained hemodynamically stable (total occlusion time was 10 minutes). A left iliac vein laceration was identified and repaired, and pelvic venous bleeding was controlled with additional

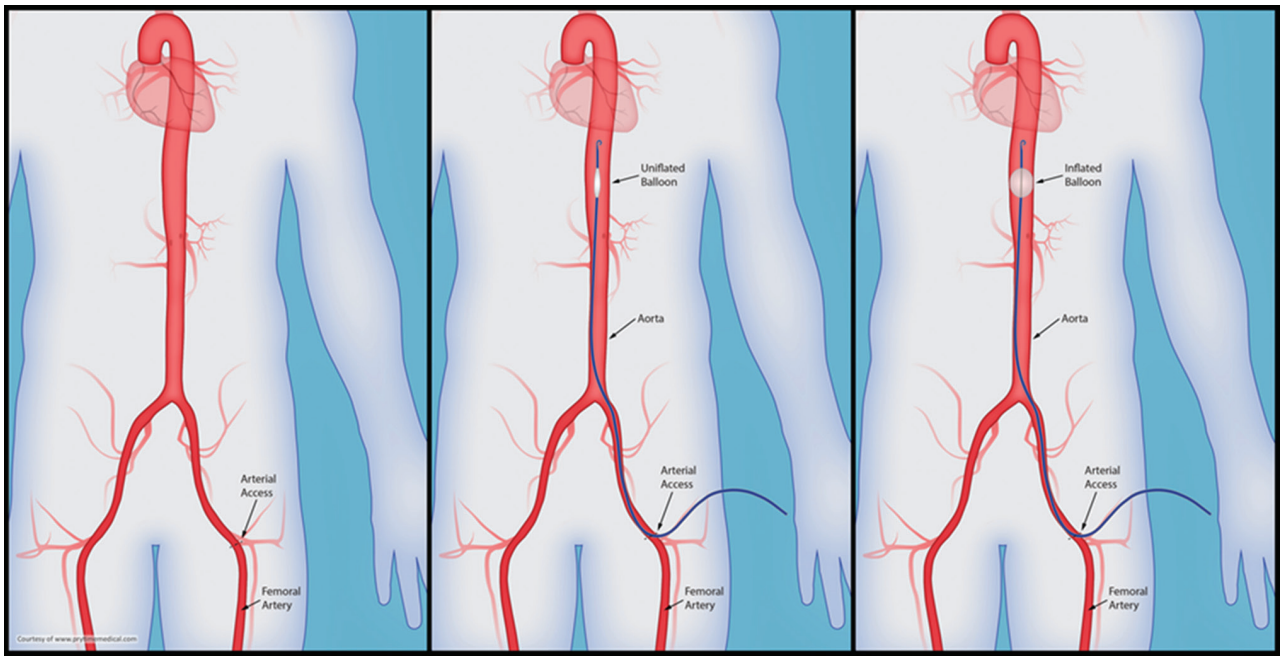

Figure 3 Zone 1 balloon occlusion of the aorta, above the diaphragm via femoral artery access (Prytime Medical Inc., Boerne, TX, USA).

packing. Additionally, a large rectal injury was excluded, and several enterotomies were stapled. A temporary abdominal dressing was applied.

A completion angiogram of the right iliofemoral vessels was performed through the indwelling sheath to evaluate for distal embolism which was negative. However, the sheath was noted to be near occlusive, so it was removed and the arteriotomy closed. The patient was then taken to the ICU for further resuscitation.

Over the first 24 hours after arrival at the Role 3, the patient received an additional 22 units of packed red blood cells (pRBCs), 12 units of fresh frozen plasma (FFP), 12 units of platelets, and four units of cryoprecipitate. His lowest pH was recorded at 7.11, lowest base deficit –10, highest international normalized ratio was 2.4 mg/dL, and highest lactate 8.4 mg/dL. All physiologic and lab values normalized over the patients subsequent intensive care. He returned to the OR multiple times for restoration of intestinal continuity, diverting colostomy, abdominal and sacral irrigation and debridement, abdominal closure, and advancement flaps to cover his open sacral fracture. The patient was ambulatory (with a partial left sacral nerve palsy) and tolerating oral intake, with normal cognition upon transfer to a local national hospital.

DISCUSSION

As has been well defined by the current conflicts in Iraq and Afghanistan, hemorrhage, and particularly NCTH, are the leading causes of preventable death on the battlefield [12–15]. Aortic occlusion can be required to control exsanguinating hemorrhage from these injuries and preserve cardiac and cerebral blood flow. Besides cardiac massage, the above goals can be achieved via balloon occlusion. Despite conclusive prospective data, many trauma centers have adopted REBOA for a multitude of indications [16–18].

With the hallmark injury pattern of modern conflicts being complex lower extremity blast injuries, a combined blunt and penetrating mechanism leading to NCTH, the application of REBOA in the military setting appears to be logical. REBOA has been used in the prehospital civilian setting [19], in the deployed setting [11], and it has been demonstrated that experienced medics are capable of fast and accurate REBOA placement [20], allowing the technology to move closer to the point of injury.

We describe the first case of REBOA in the Afghanistan theater. A basic endovascular capability 14 Fr sheaths, stiff wires and a 30 mm CODA balloon- were available for use. We prioritized upgrading to the fluoroscopy-free ER-REBOA system and trained available surgeons and emergency providers in the indications and steps for REBOA, reinforcing the Joint Theater Trauma System relevant to Clinical Practice Guideline on REBOA for hemorrhagic shock with all providers.

The patient, in this case, would be considered a 'transient responder,' displaying hemodynamic lability even after initial abdominal packing and receiving a massive transfusion. The addition of coagulopathy and acidosis to ongoing hemorrhage placed the patient at high risk for cardiovascular collapse. The placement of the REBOA balloon allowed near immediate proximal control of bleeding and improved the patient's hemodynamics. It took approximately 2–3 minutes to obtain occlusion,

verified by loss of arterial pulsatility on the arterial line. Ultrasound is readily available in the Role 3 setting, but was not routinely turned-on in the OR, leading to the choice for femoral cutdown. The unavailability of a 7 Fr sheath (on order and pending delivery at the time) forced an upsizing to a 10 Fr size. The small diameter of the ER-REBOA balloon catheter makes the arterial port less reliable when not well flushed, as was the case here. The alternative of using the sheath side port for an arterial tracing, and subsequently evaluating for LOSS of an arterial tracing (and improvement in proximal blood pressure), worked well in this case to confirm occlusion.

Though bleeding was not arterial in this case, we feel that aortic occlusion did allow for controlled entry into the abdomen, safe dissection, and control of the iliac vessels, and provided time for anesthesia to 'catch up' with resuscitation. Control of venous bleeding with REBOA has been demonstrated previously [21]. After operative control of the iliac vessels, we were able to deflate the balloon without further hemodynamic compromise. Total balloon time was estimated to be 10 minutes, well within the times generally considered safe [16].

We elected to perform a completion angiogram of the access vessel. The small caliber of the patient's vessels made the 10 Fr catheter nearly occlusive, and we elected to remove the sheath. The site was repaired operatively, which we recommend for a 10 Fr arteriotomy in the setting of coagulopathy. In retrospect, the use of an 8.5 Fr Cordis introducer catheter (although not optimal is nearly universally available) may have allowed for adequate access and prevented the need for open repair. Despite reduced access compilations with newer devices [22], multiple experts (personal communication with Megan Brenner MD and Joseph DuBose MD. March 2017) recommend routine angiography of the access site prior to removal of the sheath, and we agree. Despite the smaller catheter size of the ER-REBOA, access complications are still possible, and if not completely preventable can at least be mitigated with careful attention to closure.

CONCLUSION

Balloon aortic occlusion is a technique with great potential for treating or temporizing NCTH, perhaps especially so, in the military setting. Increasing exposure to the technique, supported by preclinical and clinical data, will further define the ideal role for balloon occlusion. This case represents the first described REBOA in Afghanistan, demonstrates its usefulness in a combat casualty, and further supports increased consideration for use of REBOA in the forward setting.

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COMMENTARY on:

Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) as an Adjunct to Damage Control Surgery for Combat Trauma: A Case Report of the First REBOA Placed in Afghanistan, by Jacob Glaser, et al.

This dramatic description of the use of resuscitative endovascular balloon occlusion of the aorta (REBOA) to save the life of a young man who most certainly would have died from a high velocity gunshot wound to the abdomen and pelvis underscores the game-changing value of this technique in treating non-compressible torso hemorrhage (NCTH) on the battlefield.

Although the use of endovascular balloon aortic control for hemorrhage is not new, recent advances in equipment (balloons) and techniques have enabled REBOA to be used dependably without wire guidance or fluoroscopy. This is truly a landmark achievement which will result in the saving of many lives that would otherwise be lost in both battlefield and civilian settings. It will have particular value in younger individuals whose arteries are not tortuous and in whom external landmarks can guide accurate balloon positioning.

Although the experience in the successful use of REBOA is just beginning, cases like this prove the unique value of the technique. Since life-threatening uncontrollable hemorrhage from traumatic injuries will continue to occur in increasing numbers in our supposedly civilized world, this technique will gain greater acceptance and be used increasingly to save lives that would otherwise be lost. The horrible trans-pelvic gunshot injury sustained in the attempted assassination of one of our leading Congressmen in the United States, Steve Scalesi, is only one striking example.

REBOA is a most substantial advance in the treatment of traumatic injuries, and it will quickly gain increasing recognition as a major development in trauma surgery.

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