Case Report

Vol. 2, No. 2; 2018; pp 77–80
DOI: 10.26676/jevtm.v2i2.47

A Case Report of Simultaneous Hypotensive Patients Managed with Concurrent REBOA in a Single-Surgeon Austere Combat Casualty Environment

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Current trends in combat damage control resuscitation (DCR) and damage control surgery (DCS) are moving toward increased support and utilization of resuscitative endovascular balloon occlusion of the aorta (REBOA). The initial reports of successful utilization in combat casualty care, spearheaded by the development of the smaller Prytime ER-REBOA™ catheter, have helped to drive further investment into expanding the use of REBOA. We present a case report that highlights the multiple benefits of REBOA in DCR and DCS. This case report involves the simultaneous management of two combat casualties with non-compressible torso hemorrhage (NCTH) and hypotension. Concurrent use of REBOA in this situation, where both patients required immediate surgery with only one surgeon and operating room table available, emphasizes that REBOA use provides temporization of immediately life-threatening NCTH, a relatively dry operative field, reduced time to operative hemorrhage control, and decreased use of blood products.

Keywords: *REBOA; Austere; Combat*

Received: 4 December 2017; Accepted: 3 February 2018

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Author contributions: All authors have made a substantial contribution to the entire manuscript and attest to approving this final version for submission. In addition, this manuscript has been approved for release by Public Affairs, 24th Special Operations Wing, US Air Force Special Operations Command.

Conflicts of interest: None.

Funding: None.

Presentation: This work has not been presented at any meetings nor has it been submitted for consideration.

Disclosure: The viewpoints expressed in this manuscript are those of the authors and do not represent the official positions of the US Air Force, US Army, or Department of Defense.

INTRODUCTION

Non-compressible torso hemorrhage (NCTH) has been shown to be a leading cause of death on the battlefield [1, 2]. The use of resuscitative endovascular balloon occlusion of the aorta (REBOA) in the management of trauma patients with NCTH is an emerging practice that continues to gain momentum in civilian trauma centers as well as in the far-forward combat casualty care environment [3-5]. Advancements in equipment (e.g. Prytime ER-REBOA™ catheter) and increased training opportunities have further facilitated the progression of this technology [6, 7]. Examples of the combat use of REBOA include recent reports by Manley et al. and Glaser et al., which describe the use of the Prytime ER-REBOA™ catheter [4, 5]. The US Air Force Special Operations Surgical Team (SOST) currently have the most experience with combat utilization of REBOA, this was a total of 20 cases at the time of writing [8].

The US Air Force SOST is a mobile six-person surgical team typically including a surgeon, emergency physician, anesthesia provider, critical care/emergency nurse, respiratory therapist, and scrub technician. SOST members undergo extensive medical and tactical training to provide care to combat casualties in austere environments on opportune air, land or sea platforms in various threat environments [9]. SOST surgeons, emergency physicians, and anesthesiologists are trained in REBOA use at the Basic Endovascular Skills for Trauma (BEST) course prior to deployment [4, 8].

Case Description

Forward resuscitation team care

Two partner force soldiers suffered dismounted blast and fragmentation injuries from an improvised explosive device (IED). They were transported by non-medics in the bed of a pick-up truck to a forward damage control resuscitation (DCR) team within 30 minutes of injury. The forward DCR team included a physician and combat medics from the US Army. They were positioned in a building of opportunity approximately 20 km from the front line of troops. No pre-hospital field interventions had been performed by the local partner forces prior to transport.

Patient Alpha arrived hypotensive with extensive fragmentation wounds and a mangled right lower extremity with a partial amputation at the level of the mid-tibia. During resuscitation, an extended focused assessment with sonography for trauma (eFAST) was positive in the abdomen. After the transfusion of one unit of low-titer type O whole blood (LTOWB), one unit of packed red blood cells (PRBC) and one unit of liquid plasma (LP), the patient's blood pressure improved to 96/56.

Patient Bravo was initially normotensive and tachycardic and suffered a right open tibia-fibula fracture, left femur fracture and extensive fragmentation injuries. An eFAST exam was similarly positive in the abdomen. He received one unit of LTOWB and was normotensive (BP 114/67) just prior to transfer.

From receipt-to-transfer, this care took about 30 minutes. A partner force ambulance, with limited medical resources and training, transported both patients to a DCS team located 45 minutes away.

Surgical facility care

The surgical facility was a makeshift building with a small three-bed resuscitation area and single bed operating room (OR). The only imaging modality available was handheld ultrasound. There were no laboratory capabilities. Blood products were limited. Post-operative patients were generally transferred by local partner force ground ambulance to a hospital with surgical and critical care capability about four hours away.

Both patients arrived at the surgical facility simultaneously approximately 1 hour 45 minutes from injury. Patient Alpha was found to be confused with a BP of 80/50 and HR 110. It was noted that Patient Bravo was also confused with an initial BP of 90/60 and HR 120. A right-sided chest tube was placed in Patient Bravo for pneumothorax without any significant blood output. At this time, it was recognized that both patients required immediate surgery with only one surgeon and OR available. The decision was made by the surgeon to place REBOA catheters in both patients. Both patient's chests were cleared for hemothorax with ultrasound.

Patient Bravo was resuscitated with LTOWB while the right common femoral artery (CFA) was accessed under ultrasound guidance with a 21 G micro-introducer needle, 0.018″ wire and 5 Fr sheath. This was upsized to a 7 Fr sheath using a 0.035″ wire. The REBOA catheter was placed in zone 1 (to 46 cm as measured by external landmarks) and inflated to full occlusion with 8 ml normal saline. The procedure was completed by an emergency physician. Patient Alpha also underwent ongoing resuscitation with LTOWB while the surgeon placed a REBOA catheter in the left CFA using the technique described above. Our standard practice at this point would be to place either a 5 Fr micropuncture sheath or 7 Fr arterial sheath to establish CFA access. This allows for arterial pressure monitoring while facilitating subsequent REBOA catheter placement. In this case, the surgeon planned for preoperative partial and/or intermittent inflation techniques while the other patient underwent surgery, and therefore opted to proceed with REBOA catheter insertion.

Our experience with REBOA has shown that external landmarks are reliable for marking the depth of insertion. Our practice is to verify placement manually at the time of surgery. We have found ultrasound to be unreliable in verifying balloon placement.

Both patients' arterial pressure was monitored with the Centurion Compass UniversalHg™ in-line pressure monitor. This device allows for easily maintainable and transportable invasive arterial pressure monitoring. SOST has refined the use of this device with REBOA for both verification of adequate balloon inflation as well as monitoring of central mean arterial pressure above the balloon. This is achieved by placing the in-line pressure monitor on the arterial port of the Prytime ER-REBOA™ catheter. We believe this device should only be used for short-term monitoring of arterial pressure such as during REBOA use.

Patient Bravo was taken to the OR first. The patient had abdominal scars and deformities from previous surgeries that indicated a hostile abdomen. He also demonstrated the more immediate need for surgery given his transient response to resuscitation. Exploratory laparotomy was performed with extensive lysis of adhesions (LOA), mesenteric hemorrhage control, multiple enterotomy repairs, ascending colon resection, and abdominal

washout and packing. After LOA, exploration was performed for major sources of bleeding beginning with the retroperitoneal zones and solid organs. No retroperitoneal or solid organ sources were identified. Clamps were then placed on all areas of mesenteric injury. The balloon was deflated once bleeding was controlled with clamps. Aortic occlusion (AO) time was 28 minutes followed by 5 minutes of partial occlusion. Partial occlusion was used as an adjunct during balloon deflation to allow anesthesia to "catch-up" with resuscitation efforts. Partial occlusion was achieved by removing half of the balloon volume (approximately 4 ml). The balloon was completely deflated once anesthesia confirmed that the patient was tolerating partial deflation. Total OR time was approximately 1.5 hours.

While awaiting surgery, the resuscitation team maintained Patient Alpha's SBP at about 100 mmHg with transfusion of four units of LTOWB. As there was no formally established SOST protocol, the resuscitation team did not utilize preoperative partial or intermittent AO. After transfer to the OR, the patient's SBP dropped to 90 mmHg and the REBOA catheter was inflated with 8 ml saline in zone 1 (measured at 49 cm). The decision to inflate the balloon at this point was to counter the hemodynamic effects of induction as well as give the surgeon a relatively dry operative field. He underwent exploratory laparotomy with mesenteric bleeding control, ileocecectomy and multiple small bowel resections. Major intraabdominal bleeding was controlled in a similar manner as stated above. Mesenteric injury was the only major source of bleeding identified. AO time was 12 minutes. Partial occlusion was not performed given the short duration of total AO.

Postoperatively, both patients maintained SBP >100 and were noted to be making urine. The REBOA catheters and sheaths were removed as the local national hospital was reportedly unfamiliar with the use of endovascular arterial devices. Manual pressure was held for 30 minutes at the CFA insertion sites. Our practice for sheath removal is manual pressure vs open arteriotomy repair. We do not currently utilize arterial closure devices due to lack of training and concern for infection in the austere environment. Distal arterial flow was demonstrated by ultrasound in both cases prior to transfer to the hospital.

Both patients survived the four-hour transport to the next level of care. Further outcomes were unable to be obtained from the local partner forces. This was due to operational limitations in an active war zone and the significant distance between our site and the local national hospital necessitating multiple patient handoffs during transfer.

DISCUSSION

This case report exemplifies the multiple benefits of REBOA for far-forward surgical assets and augments the growing body of evidence supporting its use. AO via resuscitative thoracotomy is reserved for patients in near arrest or in cardiac arrest. REBOA provides an alternative for AO in the patient who is a transient responder or non-responder with NCTH [10]. In our case, the decision for REBOA placement was multifactorial. Patient Bravo presented as a transient responder with extensive abdominal scars that indicated a difficult dissection. Patient Alpha presented with hypotension and the surgeon made the decision to place the REBOA catheter due to his concern for potential decompensation during Patient Bravo's surgery. The surgeon also intended for Patient Alpha to be treated with partial and intermittent AO while awaiting surgery. This could have resulted in clot formation/stabilization and conserved blood products. Inadequate communication of intent as well as lack of established protocols utilizing these techniques resulted in Patient Alpha's continued resuscitation utilizing permissive hypotension. REBOA use with the simultaneous presentation of hypotensive patients allowed the surgeon to focus efforts on the more demanding patient and provided a temporization to the other patient's ongoing hemorrhage, both in a "proactive" strategy.

In times of extreme resource limitations and mass-casualty scenarios (MASCAL), our situation could have resulted in the triage of one of the patients to "expectant" care. REBOA can potentially alleviate or postpone the need for "expectant" triage practices during MASCAL events.

The technique of hemorrhage control during laparotomy described above is our standard practice. We have found this to decrease the time of AO and overall operative time. Decreased time to control hemorrhage results in less blood product utilization as well as potentially reduced morbidity and mortality. AO provides the surgeon with a relatively dry operative field which speeds identification and control of hemorrhage. In this case report, it also provided time for extensive LOA. This resulted in less operative morbidity such as iatrogenic enterotomies.

Once initial hemorrhage sources are identified and controlled with clamps or packing, the balloon may be deflated to reveal sites of continued bleeding. This decreases the negative effects of an ischemia-reperfusion injury caused by AO. Intermittent occlusion, as well as partial occlusion, are additional techniques to reduce total AO times [11]. Further study is needed to better define how and when to use these techniques. In our case, these techniques could have resulted in decreased blood transfusion requirements and stabilization of blood pressure.

Balloon AO has been shown to decrease overall blood loss and subsequent transfusion requirements in complex surgical oncology cases [12, 13]. This is expected to be an added advantage with REBOA use in trauma over the relatively controlled situation of elective surgery. This is due to more rapid identification/control of hemorrhage as well as limiting the amount of transfused product lost to ongoing bleeding.

CONCLUSION

REBOA continues to show great promise in both civilian and military trauma settings. This case report adds to the growing body of evidence supporting the far-forward use of REBOA. It shows the multiple benefits of REBOA that are magnified in an austere resource-limited combat environment that is often met with unique challenges imposed by MASCAL events. Further study is required to define partial and intermittent inflation techniques which will broaden the scope of application for REBOA in both military and civilian practice.

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