Tips and Techniques

Vol. 2, No. 1; 2018; pp 33–36
DOI: 10.26676/jevtm.v2i1.35

Zone 1 or 3? Approach to Zone Selection and Pitfalls of REBOA Placement in Trauma

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The use of resuscitative endovascular balloon occlusion of the aorta (REBOA) in cases of non-compressible torso hemorrhage is becoming increasingly more common. While prospective multicenter data is being collected, and case reports are many, there is still significant debate on the ideal place for REBOA in critically ill trauma patients. With each application of the technique, there are opportunities for lessons learned and opportunities to inform other users while consensus in the trauma community is obtained. We report on the successful use of REBOA for the management of hemorrhagic shock and discuss several such lessons that may improve outcomes in future patients.

Keywords: *Trauma; Hemorrhage; Shock; Proximal Control; REBOA; Zone 1; Zone 3*

Received: 3 October 2017; Accepted: 13 November 2017

INTRODUCTION

The use of resuscitative endovascular balloon occlusion of the aorta (REBOA) in cases of non-compressible torso hemorrhage (NCTH) is becoming increasingly more common. While prospective multicenter data is being collected, and case reports are many, there is still significant debate on the ideal place for REBOA in critically ill trauma patients. While the technique has been liberally adopted at some centers, many question its widespread use preceding large evidence-based data supporting its use [1]. In addition, with the FDA approval of a streamlined device utilized through a 7 Fr sheath, REBOA use has increased in non-traumatic disease, in particular, those associated with high bleeding risk [2–4].

While the utility is debated, and may be for some time, early adopters of the technique are still on the upward slope of the learning curve. With each application of the technique, there are opportunities for lessons learned, and opportunities to inform other users while consensus in the trauma community is obtained. We report on the successful use of REBOA for the management of hemorrhagic shock and discuss several such lessons that may improve outcomes in future patients.

Case Report

This case involves a 45-year-old male, presenting to the trauma center after a reported fall from five stories (approximately 50 feet). The patient was awake upon arrival but confused. He had equal chest rise bilaterally. His initial vital signs included a systolic blood pressure (SBP) of 130 and a heart rate of 115. He had a fractured left pelvis and proximal left femur. His initial extended focused assessment with sonography (FAST) exam was negative for free fluid, but he had no lung sliding on the left side. His right chest was clear. At this point, after the primary survey, the patient became obtunded and a repeat SBP was 100 mmHg.

He was intubated and a left chest tube placed. He lost his radial pulse but had a palpable femoral pulse. Repeat blood pressure reported an SBP of 63 mmHg. Massive transfusion was initiated and the decision was made to use REBOA.

Ultrasound guidance was used to locate the right femoral artery and the access was obtained with an

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Conflicts of interest: None.

Funding: None.

18-gauge finder needle. A 7 Fr sheath was placed over a wire. An ER-REBOA catheter (Prytime Inc.) was measured to zone 3, assuming a pelvic source of bleeding, and placed. The balloon was inflated with 5 cc of saline, no contrast was used. Unable to attach an arterial line, the contralateral femoral pulse was used to confirm adequate balloon inflation (loss of the pulse, 4 minutes total time to occlusion).

Despite ongoing blood product resuscitation and zone 3 occlusion, his blood pressure did not recover. After repeat BP measurements below an SBP of 90 mmHg, the balloon was deflated, advanced to 50 cm, and re-inflated with 8 cc of saline. At this point, the patient responded adequately. He was stable enough for axial imaging, with the goal of identifying an appropriate target for intervention (persistent negative FAST in the trauma bay and pelvic fracture). He tolerated this well, with expected imaging limitations due to balloon occlusion. Imaging revealed a large retroperitoneal hematoma, minimal free fluid, and no solid organ injury. He was taken directly from CT to the operating room (OR) for laparotomy.

In the OR, the abdomen was opened and packed. With close communication with the anesthesia team, the REBOA balloon was partially deflated. After recovery from some hemodynamic derangements, it was then deflated fully. Total balloon time at zone 1 was 32 minutes. Packing was removed sequentially. In the right lower quadrant the cecum and terminal ileum had been avulsed off of their vascular pedicle, and this was managed with resection and suture control of the mesenteric bleed. A retroperitoneal zone 3 hematoma was seen but determined not to be expanding. No other major vascular or solid organ injury was identified. In a damage control manner, his abdomen was left open with abdominal packing in the right lower quadrant. His deflated ER-REBOA catheter was removed in the OR but the sheath was left in place, flushed with heparinized saline.

Postoperatively the patient continued to be somewhat hemodynamically labile and minimally responsive to ongoing resuscitation. He underwent diagnostic angiography of the pelvis and mesenteric vasculature. Images were excellent, but no active blush or treatable lesion was identified. His sheath was again left in place and removed at the bedside the next day. His hemodynamics improved over the next 24 hours, and he underwent repeat laparotomy with restoration of intestinal continuity and abdominal closure. His orthopedic injuries were addressed. He remained hemodynamically stable for 10 days and then was transferred to his home hospital, neurologically intact, for further care and recovery.

DISCUSSION

As stated above, the indications and scope of REBOA have yet to be fully elucidated. Regardless, we consider this case to be a success story. It also illustrates several potential areas of improvement and pitfalls that other users should be aware of.

The first issue to point out is in the decision to place the balloon occlusion in zone 3. Although the mechanism was reported to be a fall from height and thus was likely to have a large deceleration component, a negative abdominal sonogram and a pelvic fracture on plain films led us to feel that a zone 3 deployment was appropriate. When the patient's blood pressure did not immediately respond to aortic occlusion at this level (as it nearly universally will in our experience), we deflated the balloon and 'blindly' advanced the balloon to zone 1. This was an estimated distance, and we chose 50 cm as the 'best guess' appropriate distance. This is consistent with anatomic and cadaver studies for a zone 1 placement (minimal zone 1 distance should be 46 cm [5–7]). In retrospect, it may have been preferable to have 'premeasured' both for zone 1 and 3 prior to placement. Taking a mental note of the zone 1 distance may have been of benefit, allowing accurate, patient-specific anatomic balloon deployment versus relying on population-based standards. We recommend that the premeasurement of both zones be incorporated into placement algorithms. It only takes a moment, and in our opinion is several seconds that are well spent in an effort to avoid misplacement. An alternative would be to utilize contrast in the balloon and confirm position radiographically. This is a standard approach in many institutions. However, if this approach is taken, we feel that some of the advantages (primarily speed) of the fluoroscopy free device may be lost.

Our second point is in regards to securing the catheter in place. While several guidelines emphasize the use of commercially available securing devices, these were not immediately available in this case and we used tape and occlusive dressings to secure the balloon at 50 cm. Between placement of the patient into the CT scanner and the images being acquired, the balloon migrated to 43 cm. This is in part a result of the patient's aortic pressure, but more due to the inadequacy of the securing of the device. A commercially available device can be found in any central venous line kit (universally found in emergency departments), individually purchased or can be found in the 'ER-REBOA™ Catheter Convenience Kit' [8] that has been marketed. Suturing the catheter is NOT advised, as kinking of the arterial line lumen is likely.

Finally, during CT imaging, the balloon had migrated to zone 2, providing the unusual opportunity to evaluate images of balloon occlusion in 'no man's land' (Figure 1). We feel that the true danger of a zone 2 deployment is the risk of missing proximal bleeding. Fortunately, this patient had no vascular disease or calcifications, in which case the consequences may have been more severe. We are, however, able to see that there is indeed some flow beyond the balloon and that the hemodynamic benefit of the balloon can be gained without complete occlusion of the vessel (Figure 2).

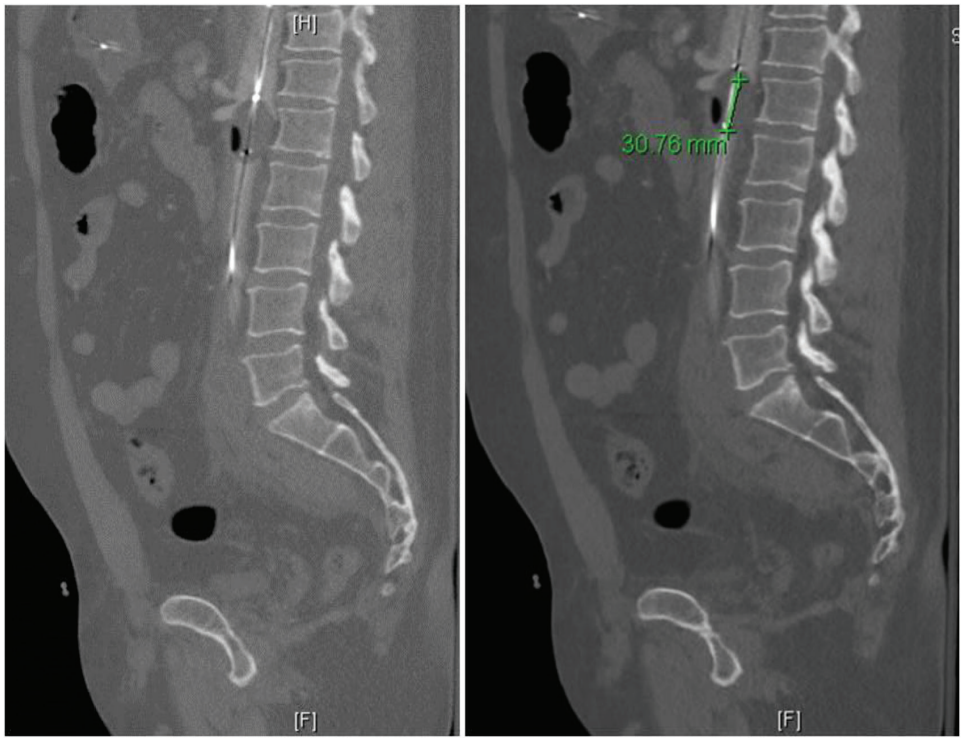

Figure 1 REBOA balloon inflated at 43 cm, displaying zone 2 occlusion. As displayed on the right, the advancement of the balloon to the recommended 46 cm or 47 cm would still have left the balloon in Zone 2.

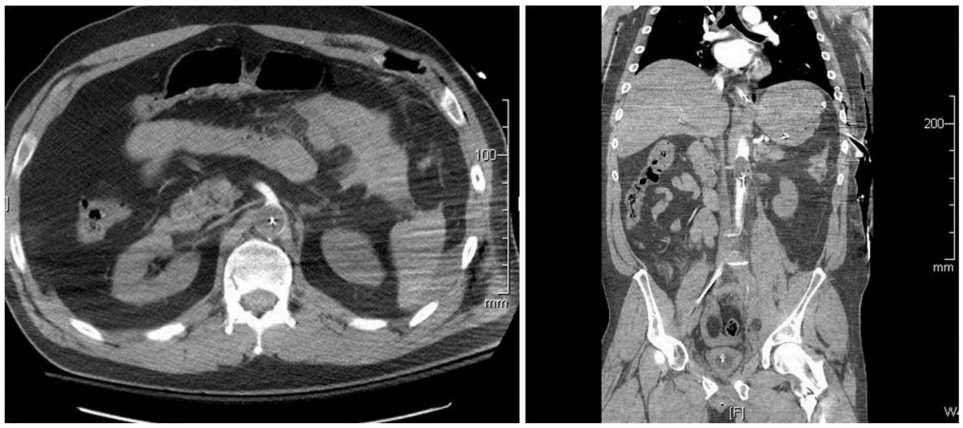

Figure 2 Zone 2 occlusion in axial and coronal views, displaying near complete occlusion of the aorta with persistent or reconstituted flow to the mesenteric vasculature. Also displayed are abdominal free fluid and a left intertrochanteric femur fracture.

One benefit of having these images is to reinforce the second point above. The balloon in these images was documented at 43 cm. As stated, the minimum distance recommended in the literature is 46 cm or 47 cm. The addition of 3 cm of distance in this patient would not have advanced the balloon to zone 1. This reinforces that an actual anatomic measurement, specific to the patient, should be obtained if possible. We feel that fixed distance placement (46 cm for zone 1 and 27 cm for zone 3) should be performed only in situations where anatomic distance cannot be measured.

CONCLUSION

REBOA for NCTH has been reinvigorated through the enthusiasm of several large trauma centers and promotion by early adopters. As the trauma community continues to work toward the best solutions to NCTH,

continued case by case reflection on gaps, areas for improvement, and successes for REBOA is paramount. Until large multicenter data is available, we must rely on the clinical decisions of the frontline trauma surgeons to maximize patient outcomes, and we hope the above reflections assist in getting closer to that goal.

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