Case Report

Vol. 3, No. 1; 2019; pp 45–50
DOI: 10.26676/jevtm.v3i1.74

Use of REBOA as a Bridge to Endovascular Aortic Repair in Blunt Abdominal Aortic Injury

V Chiarini MD[1], C Coniglio MD[2], E Ferri MD[2], C Lupi MD[2], G Tugnoli MD[3], N Montanari MD[4] and G Gordini MD[2]

[1]Anesthesia and Intensive Care Residency Program, Department of Medical and Surgical Sciences, University of Bologna, Italy
[2]Trauma Intensive Care Unit, Anesthesia, Intensive Care and EMS Department, Trauma Center "Maggiore" Hospital, AUSL Bologna, Italy
[3]Trauma Surgery Unit, Emergency Department, Trauma Center "Maggiore" Hospital, AUSL Bologna, Italy
[4]Diagnostic and Interventional Radiology Unit, Service Department, Trauma Center "Maggiore" Hospital, AUSL Bologna, Italy

Blunt abdominal aortic injury (BAAI) is a rare but challenging traumatic lesion. Since BAAI is difficult to suspect and diagnose, frequently lethal, and associated to multiorgan injuries, its management is objective of research and discussion. Resuscitative endovascular balloon occlusion of the aorta (REBOA) is an accepted practice in ruptured abdominal aortic aneurysm. Conversely, blunt aortic injuries are the currently most cited contraindications for the use of REBOA in trauma, together with thoracic lesions. We report a case of BAAI safely managed in our Trauma Center at Maggiore Hospital in Bologna (Italy) utilizing REBOA as a bridge to endovascular repair, since there were no imminent indications for laparotomy. Despite general contraindication to blindly placing REBOA in aortic rupture, we hypothesize that a multidisciplinary approach, involving endovascular specialists able to exclude the lesion with the balloon, could be feasible and relatively safe when introduced in a resuscitative damage control protocol.

Keywords: *REBOA; Blunt abdominal injury; EVAR; Endovascular aortic repair; Aortic rupture; Damage control approach*

Received: 18 October 2018; Accepted: 12 January 2019

Corresponding authors:

Valentina Chiarini MD, Division of Anesthesiology and Intensive Care, Department of Medical and Surgical Sciences, University of Bologna, via Massarenti 9 - 40139 Bologna, Italy.

Email: vchiarini1987@gmail.com

Carlo Coniglio MD, Trauma Intensive Care Unit, Anesthesia, Intensive Care and EMS Department, Trauma Center "Maggiore" Hospital, AUSL Bologna, largo Bartolo Nigrisoli, 2 – 40133 Bologna, Italy.

Email: c.coniglio@118er.it

Author contributions: All of the authors have made a substantial contribution to the manuscript.

Conflicts of interest: None.

Funding: None.

Presentation: The case report contained in the manuscript was presented as a poster at ERC Congress – Resuscitation 2018 in Bologna.

© 2019 CC BY 4.0 – in cooperation with Depts. of Cardiothoracic/Vascular Surgery, General Surgery and Anesthesia, Örebro University Hospital and Örebro University, Sweden

INTRODUCTION

Blunt abdominal aortic injury (BAAI) is defined as an injury of the abdominal aorta from the diaphragmatic hiatus to the aortic bifurcation. Aortic injuries are classified into four categories based on severity [1]: (1) grade 1, intimal tear; (2) grade 2, intramural hematoma; (3) grade 3, aortic pseudoaneurysm; and (4) grade 4, free rupture. To date, BAAI is reported in less than 1% of all blunt trauma [2,3] and the leading cause is motor vehicle collisions [4]. BAAI is one of the most challenging injuries because of the associated lesions and because of the hemodynamic instability of those who survive to reach the hospital [4]. In Italy victims of severe trauma (Injury Severity Score (ISS) > 15) are estimated at 400/500 per million population per year, mainly from traffic injuries [5].

BAAI is rarely found as an isolated lesion [6]. Therefore, the diagnosis of BAAI is challenging: the presence of concomitant multiorgan injuries may by themselves explain hemodynamic instability and extended focused

assessment with sonography in trauma (E-FAST) could be either positive for the bleeding of other intra-abdominal organs or negative because of retroperitoneal rupture. This makes it difficult to suspect BAAI without performing advanced diagnostic imaging such as a computed tomography (CT) scan or angiography.

A Western Trauma Association multicenter retrospective study about patients presenting with BAAI [4] reported that the majority of those with aortic rupture presented with hypotension and about 30% of them experienced a cardiac arrest either before arriving at the radiology service or at the operating room (OR). In a half of the cases, resuscitative thoracotomy with aortic cross clamping was performed, despite poor outcomes of this procedure in blunt trauma [7].

We report a case of BAAI safely managed in our Trauma Center at Maggiore Hospital in Bologna (Italy) utilizing resuscitative endovascular balloon occlusion of the aorta (REBOA) as a bridge to endovascular repair, since there were no imminent indications for laparotomy.

CASE PRESENTATION

We report the case of a healthy 47-year-old woman, the victim of a high impact collision with a bus when, due to an engine breakdown, she was stationed with her car in the highway emergency lane.

The patient was initially found unconscious. The Helicopter Emergency Medical Service (HEMS) was activated, while venous access was set and initial fluid bolus started. On scene, after a prolonged and complex extrication, the primary survey showed a Glasgow Coma Scale of 11 (E3V2M6), a respiratory rate (RR) of > 30/min, a heart rate (HR) of 130 beat/min and systolic blood pressure (SBP) of 60 mmHg. Due to a pelvic instability and a negative E-FAST, a pelvic binder was applied and an infusion of 1000 ml of crystalloids started in refracted bolus, with poor hemodynamic response. She was rapidly transferred to the Emergency Department (ED) of Maggiore Hospital, the Level 1 Trauma Center in Bologna (Italy), while activating the trauma team. She was intubated under general anesthesia and a pleural drainage was inserted because of a hemo-pneumothorax. Since the patient remained unresponsive also to massive transfusion, the Intensive Care Physician cannulated the left common femoral artery under ultrasound guidance, and an 8 F introducer sheath was placed through the Seldinger technique (Fig. 1). A REBOA was promptly positioned in zone 3 (Fig. 2), ascribing the life-threatening hemorrhagic shock to pelvic trauma [8,9]. Abdominal US = ultrasound also confirmed zone 3 balloon position.

We used a NUMED PTS® sizing balloon catheter (Fig. 3) designed for pediatric cardiovascular defect measurement as a REBOA.

This device does not require placement over a guide wire and allows pressure measurement through an arterial port distal to the balloon. We utilized a partial-REBOA technique [10–12] achieving a target SBP of 90 mmHg, with a residual distal flow (confirmed by arterial pressure measurement through the femoral sheath).

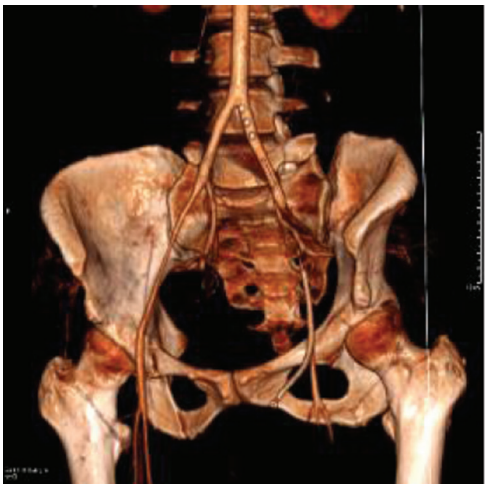

Figure 1 Introducer sheath positioned in the left common femoral artery (note that the image was taken for the best resolution and visualization of the introducer, but REBOA is retracted during the phase of replacement from Zone 3 to Zone 2).

Figure 2 CT-scan showing REBOA in zone 3, between renal arteries and aortic bifurcation.

Figure 3 Balloon catheter used as REBOA.

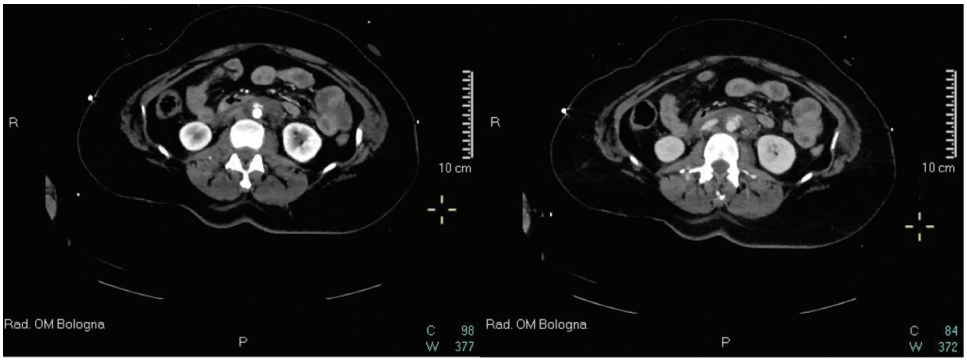

Figure 4 Aortic leak in the arterial and portal phases.

After obtaining an acceptable hemodynamic response, it was possible to transfer the patient to the radiology service and to perform a CT scan, which showed two important bleeding sources: a grade 4 BAAI just below the renal arteries (Fig. 4) and a pelvic injury with active arterial blush (Fig. 5).

Since our trauma team has multidisciplinary components, after collegial discussion, the REBOA was repositioned with CT guidance in zone 2, between the celiac tripod and the superior mesenteric artery, despite contraindication [9], to exclude the aortic injury and stop the bleeding. Considering the elevated grade of the aortic injury and the ready availability of both vascular

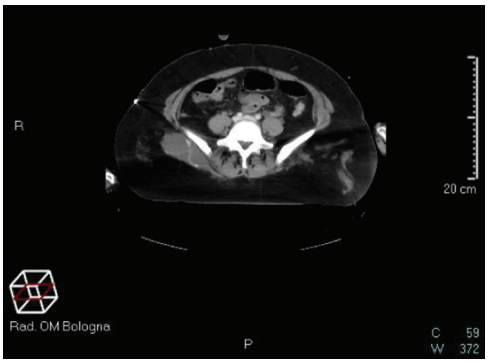

Figure 5 Gluteal arterial blush with hematoma (portal phase).

Figure 6 Endovascular prothesis.

surgeon and interventional radiologist we decided to perform endovascular aortic repair (EVAR) first.

In about 1.5 hours from the arrival at the ED, we transferred the patient to the OR with REBOA inflated in zone 2 above the IV grade BAAI. The team leader performed the anesthetic management. The vascular surgeon isolated and cannulated the right common femoral artery. When everything was ready to perform the angiographic study, we deflated and removed the REBOA. A covered endoprosthesis Endurant™ II (Medtronic, ETLW1616C93EE) was placed just below the renal arteries, with a proximal landing zone of 1 mm, and above the iliac bifurcation (Fig. 6). At the end of the procedure, the arteriotomy was sutured with Prolene 6/0 and a drainage left in place. It was a relatively simple procedure, requiring 1 hour. Renal artery flow was documented at the end of the procedure. After collegial discussion we decided not to infuse heparin, because of the ongoing bleeding. The pelvic blush was stopped subsequently by the interventional radiologist through the same sheath in the left femoral artery, with hemostatic sponge in several branches of the right hypogastric artery.

Total inflation time of the REBOA was 30 minutes in zone 3 and 45 minutes in zone 2. The catheter was left in place for 2 hours. The sheath was left in place for 19 hours, in case of emergent reintervention. It was then removed by our interventional radiologist utilizing the Angio-Seal™ vascular closure device. A distal flux was present during the angiography, demonstrating that the size of the introducer fits the vessel avoiding limb ischemia, until the removal left limb was clinically evaluated as normothermic and well perfused. Access site surveillance was carried out by our Intensive Care Unit nurses.

The patient survived the procedure and is still alive with a positive outcome, despite having an ISS of 75. Other main injuries included: subarachnoid hemorrhage, traumatic right carotid artery dissection, thyroid hematoma, multiple rib fractures, bilateral lung contusions, hepatic laceration, spleen devascularization, closed pelvic fracture, gluteal hematoma and multiple vertebral fractures. Early continuous renal replacement therapy was started to prevent crush syndrome consequences. The patient suffered from transient intestinal impairment and acute limb compartment syndrome as major complications of REBOA positioning, possibly related to ischemia-reperfusion injury.

Four days after trauma, after clinical suspicion , we diagnosed the compartmental syndrome of the left limb by measuring the circumference (right thigh 55 cm vs. left thigh 60 cm; right calf 32 cm vs. left calf 38 cm) and compartmental pressure (left calf internal compartment 70 mmHg; external compartment 86 mmHg). Fasciotomy was therefore performed as an emergency within 1 hour of diagnosis. Despite negative pressure therapy, necrosis of the fasciotomy occurred, making left leg amputation mandatory.

She also experienced post-traumatic stress disorder, extreme brady-arrhythmias requiring implantation of a pacemaker and an abscess of the gluteal hematoma requiring repeated surgical debridement.

After a total hospitalization time of three months she was discharged to a rehabilitation facility with an excellent neurological outcome, being autonomous in daily activities and without chronic organ failure.

DISCUSSION

REBOA is a resuscitative technique which involves percutaneous or surgical cut-down arterial access—usually via the femoral artery—to place a catheter balloon inside the aorta. The purpose of this procedure is partial or total occlusion of the aorta at different zones, in order to stop a distal hemorrhage. This procedure has been recently gaining popularity in the management of non-responsive hemorrhagic shock in different contexts, such as post-partum and gastrointestinal bleeding, abdominopelvic trauma and ruptured abdominal aortic aneurysm (rAAA) [13–16]. The first use of an aortic tampon for emergency control of a ruptured abdominal aneurysm dates back to 1964 [17]. A recent systematic review found 50 studies in which REBOA was used to control hemorrhagic shock in rAAA [18] and it is now considered a standard of care in this setting.

Indications and contraindications of REBOA in trauma are objects of discussion and revision [18–20]. Despite the experience in rAAA, the currently most cited contraindications are aortic injury together with thoracic lesions, especially of the large pulmonary vessels [19], since its distal placing would have the sole effect of increasing the bleeding [9]; nonetheless an anecdotal case of good outcome has been described [21]. For these reasons, reported use of REBOA in traumatic abdominal aortic injury remains sporadic [16].

In the past, laparotomy was used to manage BAAI and EVAR was not deemed suitable because the time needed to set up the procedure was considered too long given the impending risk of death. Patients suitable for EVAR were reported to be younger, hemodynamically stable and less critically ill (lower ISS) [4]. Recently, successful endovascular treatment of BAAI has been described, revolutionizing the approach for this scenario [1,22], although there is a lack of comparative data between the pros and cons of the two techniques. A Cochrane Review comparing EVAR versus open repair in rAAA reported no difference in the 30-day mortality outcomes [23], even though none of the trials have randomized patients with hemorrhagic shock.

When available, anatomically feasible and safe EVAR is preferred over open repair [24], so it is reasonable to consider REBOA as a bridge to allow definitive endovascular treatment in more severe traumatic aortic injuries, as in rAAA.

In our case, the reasons for hemodynamic instability were multiple and the elevated grade of aortic rupture made patient survival very unlikely. One hypothesis was that severe hypotension (caused by thoracic, aortic and pelvic bleeding) in the pre-hospital phase prevents exsanguination from the aortic rupture. We also supposed that due to some precautions the aortic rupture was not iatrogenic: we placed the REBOA without a guidewire, we confirmed the correct balloon placement with ultrasound and we never overinflated the balloon, but used a partial inflation technique. In addition, an aortic injury below the renal arteries was compatible with the dynamic of the trauma, the vertebral fractures of D10 and L1–4, and the clinical presentation.

The use of REBOA in this case followed two different strategies: the first was the indication of a patient in extremis (the zone 3 step); the second, compared with rAAA, was the use under CT or fluoroscopic guidance to exclude the traumatic aortic lesion (the zone 2 step).

REBOA for trauma is generally blindly placed in extremis and the precise nature of a patient's injuries are unknown. In all patients who are victims of high impact collisions and in found in extremis condition, it is possible to suspect an aortic lesion. Nevertheless, some of these patients fit the criteria for positioning of zone 3 REBOA—as did the patient in our case—which can be a lifesaving procedure, even if excluding the possibility of an aortic lesion remains impossible because CT scan or angiographic study cannot be performed at that time. We therefore believe that aortic rupture cannot be "a priori" a contraindication in itself and that REBOA must be positioned in zone 3 when the patient requires it. Some strategies are mandatory to minimize both the possibility of causing new vascular injuries or increasing pre-existing ones. Above all, the most important point is partial occlusion: it reduces aortic wall stress (which can determine a vascular injury itself) and allows a decrease in distal flow and bleeding without increasing aortic bleeding or rupture. It also allows a target SBP to be reached—measured at the tip of the catheter: in our case we tried to achieve a SBP of 90 mmHg, which can be considered adequate both in blunt trauma (with negative FAST and without traumatic brain injury (TBI)) and in rAAA. In fact, recent guidelines on the care of patients with an AAA by the Society for Vascular Surgery suggest that a permissive hypotension (defined as a SBP between 70 and 90 mmHg) "appears sufficient to maintain critical end-organ perfusion" and "limits excessive haemorrhage" [24]. In our view this strategy allowed the transfer to the CT scan room with partial hemodynamic stabilization despite the undiagnosed IV grade BAAI.

At that moment, taking inspiration from rAAA management, we repositioned the REBOA above the rupture—even if it was in Zone 2—postponing angioembolization of the pelvis and performing EVAR. We utilized REBOA as a bridge to definitive endovascular management, and no longer as a lifesaving blind procedure.

CONCLUSIONS

Complex management was made possible by the contemporary presence in the trauma bay of different specialists in a multidisciplinary approach. Together with intensive care physicians and trauma surgeons, endovascular specialists complete our trauma team. All advanced trauma centers should improve their endovascular competence, including vascular surgeons and an interventional radiologists, who can cooperate in a hybrid suite. This strategy guarantees a modern approach to trauma patients, with conservative management in several injuries or prompt damage control resuscitation.

The indication for the use of REBOA in BAAI is still lacking, due to the potential risk of extension of the aortic lesion and the paucity of reported cases. We think that, with some precautions, placing REBOA in zone 3 in patients with correct indications is also almost safe in undiagnosed BAAI and the possibility of this finding must not be an exclusion criterion "a priori". Partial occlusion is nowadays mandatory to minimize complications: it allows a tailored SBP target to be reached, to protect the aorta wall and to reduce both distal bleeding and unpredictable proximal bleeding. These considerations, together with progressive experience and equipage training, led our Trauma Center to include the REBOA in HEMS equipment.

If BAAI is then diagnosed, the REBOA must be replaced proximal to the lesion with fluoroscopic or CT-scan guidance. This technique could represent a bridge to definitive treatment in life-threatening situations. Given the agreement on REBOA use in rAAA and the increasing experience in traumatic settings, it seems desirable to upgrade this approach in BAAI, from a

"last-ditch" attempt into part of a damage control resuscitation protocol. We think this is an important issue, that is also achievable in centers without our multidisciplinary team and which necessitate transfer of the patient for definitive vascular management.

REFERENCES

[1] Azizzadeh A, Keyhani K, Miller CC, Coogan SM, Safi HJ, Estrera AL. Blunt traumatic aortic injury: initial experience with endovascular repair. J Vasc Surg. 2009;49(6):1403–1408.

[2] Deree J, Shenvi E, Fortlage D, et al. Patient factors and operating room resuscitation predict mortality in traumatic abdominal aortic injury: a 20-year analysis. J Vasc Surg. 2007;45(3):493–497.

[3] Burkhart HM, Gomez GA, Jacobson LE, Pless JE, Broadie TA. Fatal blunt aortic injuries: a review of 242 autopsy cases. J Trauma. 2001;50(1):113–115. http://www.ncbi.nlm.nih.gov/pubmed/11231680.

[4] Shalhub S, Starnes BW, Brenner ML, et al. Blunt abdominal aortic injury: a Western Trauma Association multicenter study. J Trauma Acute Care Surg. 2014;77(6):879–885.

[5] Di Bartolomeo S, Sanson G, Michelutto V, et al. Epidemiology of major injury in the population of Friuli Venezia Giulia—Italy. Injury. 2004;35(4):391–400.

[6] Raguan B, Shnaker A, Fajer S. Isolated abdominal injury of blunt aortic trauma: two case reports and review of the literature. J Endovasc Resusc Trauma Manag. 2018;2(3):123–126.

[7] Burlew CC, Moore EE, Moore FA, et al. Western Trauma association critical decisions in trauma. J Trauma Acute Care Surg. 2012;73(6):1359–1363.

[8] Coccolini F, Stahel PF, Montori G, et al. Pelvic trauma: WSES classification and guidelines. World J Emerg Surg. 2017;12(1):1–18.

[9] Davidson AJ, Russo RM, Reva VA, et al. The pitfalls of resuscitative endovascular balloon occlusion of the aorta: risk factors and mitigation strategies. J Trauma Acute Care Surg. 2018;84(1):192–202.

[10] Johnson MA, Neff LP, Williams TK, et al. Partial resuscitative balloon occlusion of the aorta (P-REBOA): clinical technique and rationale. J Trauma Acute Care Surg. 2016;81(5):S133–S137.

[11] Dubose JJ. How i do it: partial resuscitative endovascular balloon occlusion of the aorta (P-REBOA). J Trauma Acute Care Surg. 2017;83(1):197–199.

[12] Kuckelman JP, Barron M, Moe D, et al. Extending the golden hour for Zone 1 resuscitative endovascular balloon occlusion of the aorta. J Trauma Acute Care Surg. 2018;85(2):318–326.

[13] Brenner ML, Moore LJ, DuBose JJ, et al. A clinical series of resuscitative endovascular balloon occlusion of the aorta for hemorrhage control and resuscitation. J Trauma Acute Care Surg. 2013;75(3):506–511.

[14] Stannard A, Eliason JL, Rasmussen TE. Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) as an Adjunct for Hemorrhagic Shock. J Trauma Inj Infect Crit Care. 2011;71(6):1869–1872.

[15] Tsurukiri J, Akamine I, Sato T, et al. Resuscitative endovascular balloon occlusion of the aorta for uncontrolled haemorrahgic shock as an adjunct to haemostatic procedures in the acute care setting. Scand J Trauma Resusc Emerg Med. 2016;24(1):13.

[16] Sato R, Kuriyama A, Takaesu R, et al. Resuscitative endovascular balloon occlusion of the aorta performed by emergency physicians for traumatic hemorrhagic shock: a case series from Japanese emergency rooms. Crit Care. 2018;22(1):1–6.

[17] Heimbecker R. An aortic tampon. Canad Med Ass J. 1964;91:1024–1025.

[18] Borger van der Burg BLS, van Dongen TTCF, Morrison JJ, et al. A systematic review and meta-analysis of the use of resuscitative endovascular balloon occlusion of the aorta in the management of major exsanguination. Eur J Trauma Emerg Surg. 2018;44(4):535–550.

[19] Napolitano LM. Resuscitative endovascular balloon occlusion of the aorta: indications, outcomes, and training. Crit Care Clin. 2017;33(1):55–70.

[20] Allen BK, Callaway DW, Gibbs M, et al. Regarding the 'Joint statement from the American College of Surgeons Committee on Trauma (ACS COT) and the American College of Emergency Physicians (ACEP) regarding the clinical use of Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA).' Trauma Surg Acute Care Open. 2018;3(1):e000168.

[21] Strauss S, Engels P, Harlock J. Distal placement of resuscitative endovascular balloon occlusion of the aorta (REBOA) to restore hemodynamic stability in a patient with proximal aortic rupture. J Endovasc Ther. 2018;25(2):257–260.

[22] Guetta O, Shaked G, Greenberg G, Sebbag G, Czeiger D. Blunt abdominal aortic injury – a hybrid approach to combined injuries. J Endovasc Resusc Trauma Manag. 2018;2(2):81–85.

[23] Badger S, Forster R, Ph B, Ellis P, Kee F, Dw H. Endovascular treatment for ruptured abdominal aortic aneurysm (Review). Cochrane Database Syst Rev. 2017;5.

[24] Chaikof EL, Dalman RL, Eskandari MK, et al. The society for vascular surgery practice guidelines on the care of patients with an abdominal aortic aneurysm. J Vasc Surg. 2018;67(1):2–77.e2.