Case Report

Vol. 7, No. 3; 2023; pp 93–97
DOI: https://doi.org/10.26676/jevtm.18304

REBOA: A Device to Gain Time

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The management of trauma and emergency procedures (i.e., aneurysm repair, visceral and pelvic bleeding, and others) has undergone considerable changes due to the presence of new endovascular and mini-invasive approaches, which have supplanted the surgical approach in some cases. The use of Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) has been largely used to manage trauma patients, but it is, nowadays, increasingly also being used for other types of bleeding, such as vascular emergencies, post-partum hemorrhages, and gastrointestinal and iatrogenic or spontaneous bleeding. We present a case of an unexpected hemorrhagic shock in a patient with a locally advanced cervix neoplasm involving sacrum and pelvic vessels, where we used a REBOA to manage an intraprocedural massive bleed due to the rupture of the descending branch of the right hypogastric artery.

Keywords: *Resuscitative Endovascular Balloon Occlusion of the Aorta; REBOA; Aortic Occlusion; Endovascular Procedures; Emergency; Bleeding*

Received: 7 November 2023; Accepted: 27 December 2023

INTRODUCTION

Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) is a minimally invasive endovascular intervention capable of stopping bleeding and preserving cerebral and cardiac perfusion in the case of hemorrhage from the thorax, abdomen or pelvis [1].

REBOA can be inflated in three aortic zones, based on the site of bleeding: Zone 1, extends from the origin of the left subclavian artery to the celiac artery; Zone 2 extends from the celiac artery to the lowest renal artery; Zone 3 extends from the lowest renal artery to the aortic bifurcation [1].

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Presentation: This study was presented at "The Italian Chapter of Endovascular Resuscitation: Trauma and Beyond", ECIO 2023, and also as a poster at CIRSE 2023.

The use of REBOA has been largely used to manage trauma patients, but it is, nowadays, increasingly being used also for other types of bleeding, such as vascular emergencies, post-partum hemorrhages (PPH), and gastrointestinal and iatrogenic or spontaneous bleeding [2]. The role of REBOA in these settings is predominantly as a bridge to definitive surgical or endovascular treatment [2].

Five sequential steps have to be considered for the use of REBOA: (1) arterial access and positioning of sheath; (2) selection and positioning of the balloon; (3) inflation of the balloon; (4) deflation of the balloon; and (5) sheath removal [3].

The aortic balloon must present the following features: a large diameter to perform the occlusion and high compliance in order to reduce the risks of dissection or rupture of the aorta [4].

Complications of REBOA can be related to arterial access and balloon positioning, balloon inflation and deflation, and to sheath removal [5]. The most serious complication that can happen when REBOA has been used for a prolonged period of time is ischemia caused by total aortic occlusion. A prolonged ischemia followed by reperfusion can result in multiple organ failure including acute kidney injury, liver failure, spinal cord infarction, intestinal ischemia, myonecrosis, limb loss, and death [5].

We present a case of an intraprocedural unexpected hemorrhagic shock in a patient with a locally

advanced cervix neoplasm referred to the Interventional Radiology (IR) service for chronic metrorrhagia and otherwise unmanageable anemia.

CASE REPORT

We present a case of a 54-year-old female affected by locally advanced cervix neoplasm despite multiple lines of chemotherapy and radiotherapy treatment. The patient was admitted to the emergency department of our Institution (Fondazione IRCCS Cà Granda Ospedale Maggiore Policlinico, Milan, Italy) due to the occurrence of severe rectorrhagia and metrorrhagia at home.

At arrival, the patient was in hemorragic shock, confused, hypotensive, tachycardic, with lactacidemia up to 10 mmol/L: resuscitation required crystalloid infusion 2,000 mL, Norepineprine (maximum dose 0.1 mcg/kg/min) and blood volume replacement (4 packed red blood cells (PRBC), 4 fresh frozen plasma (FFP), 2 g Fibrinogen). Tranexamic acid bolus and continuous infusion were started. Once hemodynamic stability was obtained, contrast-enhanced computed tomography (CECT) of the abdomen and pelvis was performed as first imaging modality, which showed a locally advanced cervix tumor involving almost all of the pelvic structures. No active bleeding but an infiltration of major vessels, such as the hypogastric right artery, was observed (Figure 1). The patient was subsequently transferred to the sub-intensive care unit to continue the hemodynamic monitoring while awaiting an oncological consult. A few hours later, a new episode of severe bleeding occurred requiring the intervention of the medical emergency team: a further 2 PRBC, 2FFP, and 1 Platelet pool were transfused. Due to the persistence of metrorrhagia and rectorrhagia, despite the radiological evidence of active bleeding on the CT scan, an endovascular treatment was also considered.

A 5-Fr right arterial femoral access was obtained, and the diagnostic angiogram of the left hypogastric artery showed an anomalous tumor vascularization which was treated with spongeal foam embolization (Figure 2).

A diagnostic angiogram of the right hypogastric artery was then performed which showed neither the source of bleeding nor anomalous tumor vascularization (Figure 3).

However, a bland embolization with spongeal foam was carried out. The procedure was intended to be the final intervention but a sudden new episode of metrorrhagia was observed, with a loss of approximately 2 to 2.5 L of blood in about 10 minutes. The patient's parameters became unstable, with systolic arterial

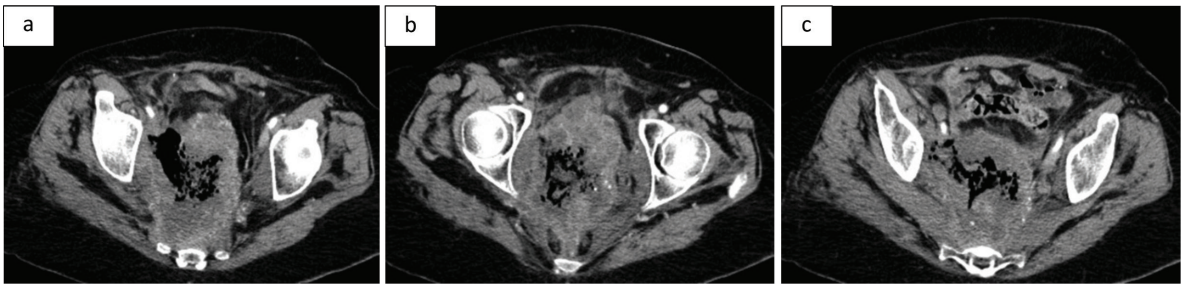

Figure 1 Contrast-enhanced computed tomography (CECT) showing a cervix tumor with the infiltration of the body of the uterus, vagina, rectum, bladder, ureters, pelvic floor muscles and sacrum. No active bleeding was observed but an infiltration of the major vessels, such as the hypogastric right artery, was observed.

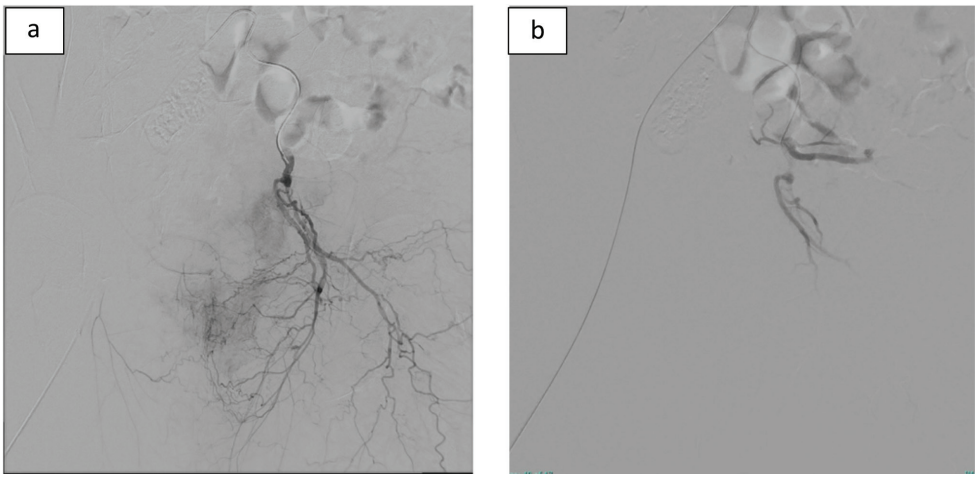

Figure 2 Diagnostic angiography of the left hypogastric artery showed an anomalous tumor vascularization (**a**). Embolization with spongeal foam on this left side was made, providing satisfactory final angiographic control (**b**).

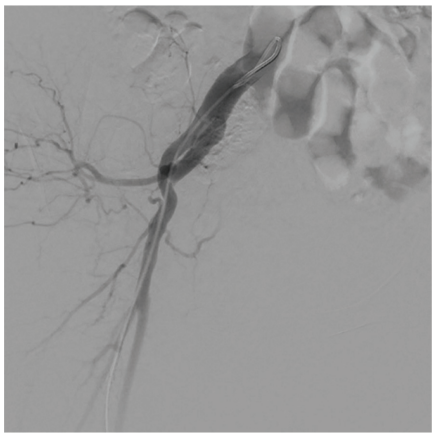

Figure 3 Diagnostic angiography of the right hypogastric artery with no evidence of source of active bleeding.

pressure 50/30 mmHg, heart rate 120 bpm accompanied by loss of consciousness. As an immediate measure, a rapid infusion of crystalloid and noradrenaline was started followed by 4 FFP and 4 PRBC. Therefore, in consideration of the uncontrollable bleeding, the decision was made to inflate the REBOA (Rescue Balloon Occlusion Catheter, Tokai Medical Products, Japan) in Zone 3.

Therefore, the 5-Fr sheath was changed to a 7-Fr sheath over the wire (180 cm long, 0.018 inch hydrophilic guidewire (Radiofocus, Terumo, Leuven, Belgium)) and the balloon was inserted under fluoroscopic guidance.

Balloon inflation required administration of analgesia due to the sudden occurrence of acute pain in the lower limbs. The inflation with approximately 10 mL of a mixture of sterile saline and iodinated contrast (Visipaque 370) was maintained until the blood pressure increased and the contralateral femoral pulse was stopped. An intermittent REBOA (iREBOA) inflation and deflation of the balloon was made twice, with a total of 12 minutes of inflation (5 minutes for each session and 2 minutes of deflation). A progressive final slow deflation was made, guided by the new hemodynamic stability obtained (Figure 4). Finally, a diagnostic aortography showed the presence of bleeding with active contrast media extravasation from the right hypogastric artery. An embolization using glue (1:1 of Glubran 2 :Lipiodol) followed by a distal embolization with coils (Azur TM CX Peripheral Coil system, Terumo Europe) to avoid contralateral collateralization was made and the final angiogram showed no further active bleeding (Figure 5*a*,*b*). However, an angiogram of the inferior mesenteric artery showed an anomalous vascularization of the pelvic mass, and therefore it was embolized using a microcoil (Azur TM CX Peripheral Coil system, Terumo Europe) (Figure 5*c*,*d*).

The final angiogram demonstrated no active bleeding, and the vital parameters were stable with blood pressure 90/50 mmHg and heart rate 110 bpm; the patient was conscious and not suffering. The patient was still lactacidemic (lactate 11mmol/L and standard base excess –11), anemic (hemoglobin 6.2 g/dL) and requiring moderate vasopressor dose (norepinephrine 0.07 mcg/kg/min). Volume resuscitation required further infusion of PRBC, FFP and platelets in a 1:1:1 ratio. The patient was discharged from the angiography suite to the sub-intensive care unit with a trend toward vital parameter improvement and lactate decrease, with anemia already resolved.

Ethical Approval and Informed Consent

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from the patient included in the study.

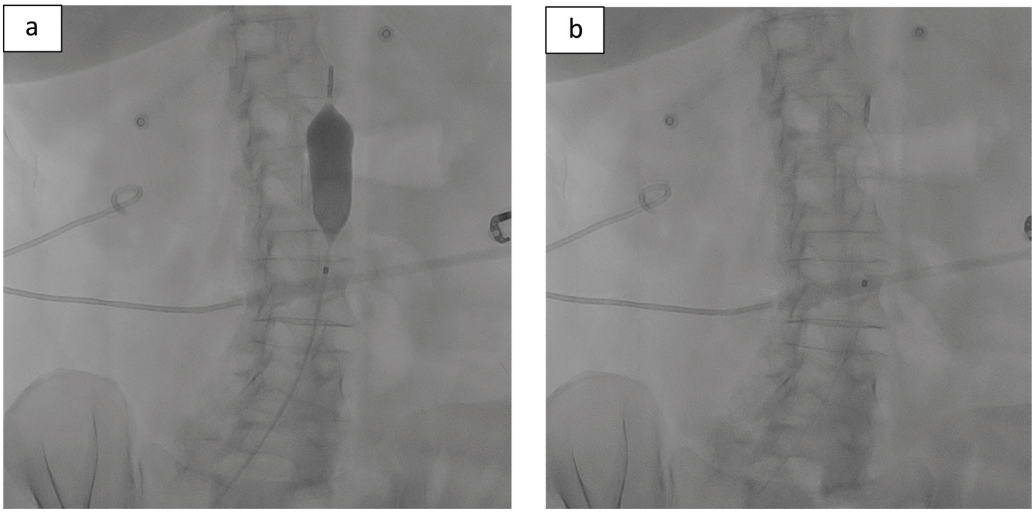

Figure 4 Fluroscopic images during the inflation of the REBOA (**a**) with a deployment in Zone 3 of the aorta and after deflation of the REBOA (**b**).

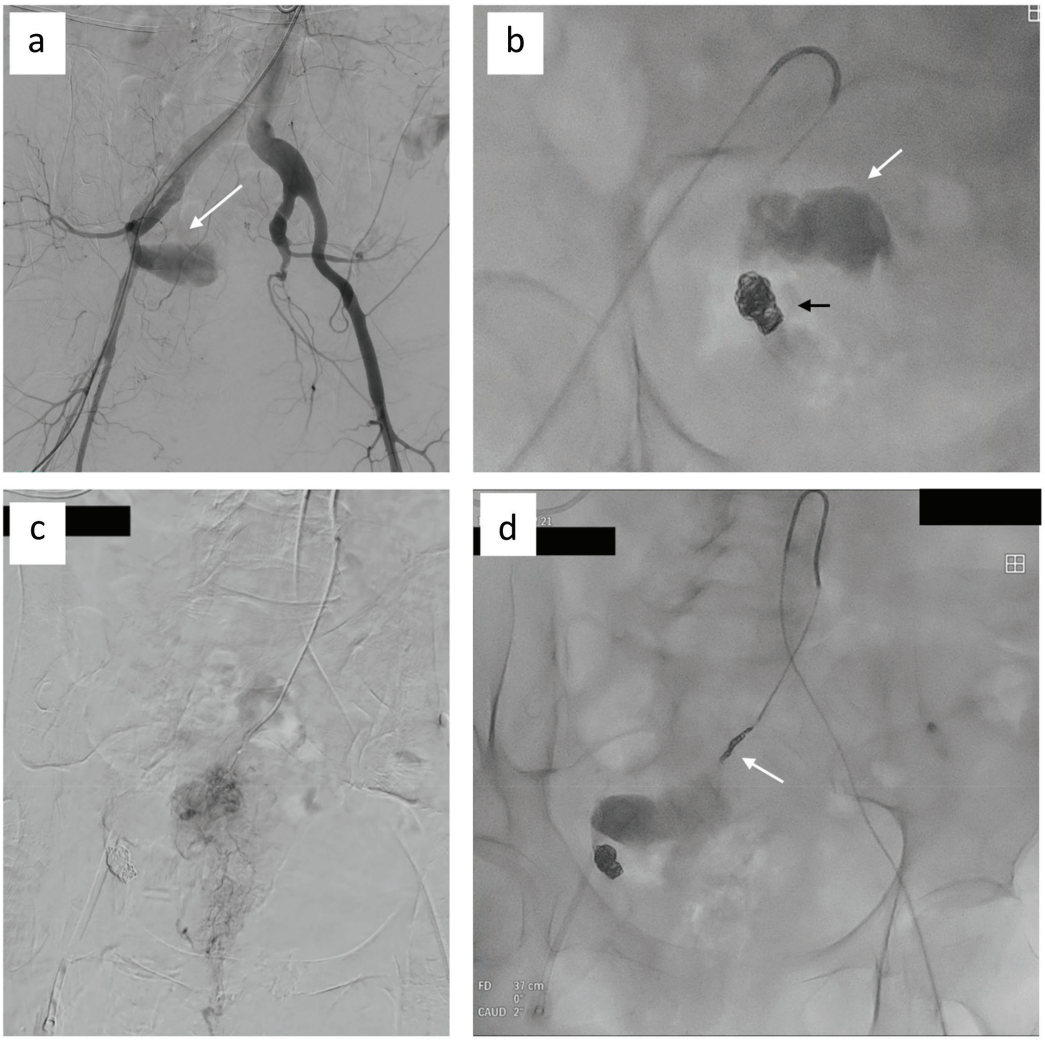

Figure 5 A diagnostic aortogram performed with a pig-tail catheter shows the presence of bleeding with active contrast media extravasation from the right hypogastric artery (white arrow (**a**)). Embolization using glue (1:1 of Glubran 2: Lipiodol) (white arrow) and coils (Azur TM CX Peripheral Coil system, Terumo, Leuven, Belgium) (black arrow) was performed (**b**). The angiography of a branch of the inferior mesenteric artery (IMA) rising an anomalous vascularization of the pelvic mass (**c**) and embolization with a microcoil (Azur TM CX Peripheral Coil system, Terumo, Leuven, Belgium) (white arrow (**d**)).

DISCUSSION

In the case presented, the inflation of REBOA permitted the re-establishment of vital parameters and allowed time to be gained to plan for the correct strategy to arrest hemorrhage and enable resuscitation supplies so as to recover blood loss. The intra-procedural new episode of metrorrhagia was so copious as to simulate the sound of an "open tap".

The most important steps during the use of REBOA are the correct and rapid placement of the device, and the management of the inflation and deflation of the balloon.

The technique can provide total occlusion of the aorta either just above the diaphragm (Zone 1), to control intra-abdominal bleeding, or above the aorto-iliac bifurcation (Zone 3), to control bleeding in the pelvis or proximal extremities. The inflation of the balloon in Zone 2 is usually not recommended due to the potential severe complications [5].

The balloon inflation represents a "key step" in the procedure and must be performed carefully.

In order to avoid over-inflation and consequent rupture of the balloon and/or of the aorta, continual monitoring of systolic blood pressure (SBP) and contralateral femoral pulse is recommended.

REBOA is associated with ischemia–perfusion injuries and multiple organ failure when used for a long time. Aorta occlusion exceeding 40 minutes can result in irreversible organ injury and death [5].

Furthermore, supraphysiological rises in blood pressure proximal to the occlusion balloon may contribute to heart failure and traumatic brain injury [5].

Reva et al. evaluated organ damage following 30 and 60 minutes of aortic balloon inflation in an ovine model with severe hemorrhagic shock and showed that 60 minutes of occlusion results in significant metabolic derangement and organ damage [6].

Morrison et al. conducted a systematic review of 83 studies reporting a total of 11 arterial injuries that required surgical interventions to restore lower extremity perfusion, and in three cases lower extremity amputation was also required [7].

In order to minimize the risk of ischemia, new methods, such as partial REBOA (pREBOA) and iREBOA have been introduced [2].

In our case, we decided to use an iREBOA inflation, with the cooperation of the anesthetist. Communication with the resuscitation team is also fundamental during the deflation of the balloon. In the literature, cases of refractory hypotension, which ultimately lead to hemodynamic collapse after balloon deflation, are described [8]. In these cases, an immediate re-inflation of the balloon is needed.

In our case, we carried out an iREBOA inflation and a final slow deflation with a total restoration of vital parameters [9].

One of the real advantages of using REBOA is the possibility of using a small caliber sheath (7-Fr). As blood flow is inversely proportional to the vessel cross-sectional area, it is acceptable that large-sized sheaths may decrease blood flow to the extremities.[5] For this reason, the use of a balloon catheter via a 7-Fr sheath appears to have fewer complications despite relatively prolonged placement.[5] In our experience, it is advisable to use a slightly larger introducer to facilitate the removal of the device at the end of the procedure, such as an 8-Fr sheath.

Teeter et al. evaluated the safety of 7-Fr REBOA catheters and demonstrated that their use can significantly elevate systolic blood pressure with no access-related complications [10].

In fact, there is a low level of evidence of REBOA's use for other types of hemodynamic instabilities outside of the trauma setting. The case presented in this report highlights the advantage of having all kinds of device available, including REBOA. Situations like ours are unpredictable, and a simple maneuver with experienced hands and multi-specialty cooperation may be life-saving.

Ethics Statement

(1) All the authors mentioned in the manuscript have agreed to authorship, read and approved the manuscript, and given consent for submission and subsequent publication of the manuscript.
(2) The authors declare that they have read and abided by the JEVTM statement of ethical standards including rules of informed consent and ethical committee approval as stated in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Funding

This study was not supported by any funding.

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