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CASE REPORT

Successful management for a ruptured abdominal aortic aneurysm using resuscitative endovascular balloon occlusion of the aorta via the brachial artery route—a case report

Seokkon Kim[1], Jaegyok Song[1,*], Nayoung Choi[2]

[1]Department of Anesthesiology and Pain Medicine, Dankook University College of Medicine, 31144 Cheonan, Republic of Korea
[2]Department of Anesthesiology and Pain Medicine, Dankook University Hospital, 31144 Cheonan, Republic of Korea

***Correspondence**
drjack@nate.com
(Jaegyok Song)

Abstract

Ruptured abdominal aortic aneurysms pose a challenge to anesthesiologists. Resuscitative thoracotomy and aorta-cross clamping are used to prevent cardiopulmonary collapse during ruptured abdominal aortic aneurysm repair. Recently, resuscitative endovascular balloon obstruction of the aorta has been introduced as an alternative to resuscitative thoracotomy and aorta-cross clamping. Resuscitative endovascular balloon obstruction of the aorta is a minimally invasive and low risk procedure compared to resuscitative thoracotomy and aorta-cross clamping, with minimal blood-borne pathogen exposure to healthcare workers. A 63-year-old man was scheduled for emergency repair of a ruptured abdominal aortic aneurysms. The patient's vital signs were unstable, and aggressive treatment with transfusion and vasopressor infusion was not effective. Resuscitative endovascular balloon obstruction of the aorta was performed using the brachial artery. After initiation of resuscitative endovascular balloon obstruction of the aorta, the patient's vital signs immediately stabilized, and hematoma evacuation and aorta reconstruction were completed successfully. The total balloon inflation time during resuscitative endovascular balloon obstruction of the aorta was approximately 45 min. The patient was discharged on the 62nd postoperative day. Resuscitative endovascular balloon obstruction of the aorta is a promising minimally invasive alternative to resuscitative thoracotomy and aorta-cross clamping in patients with ruptured abdominal aortic aneurysms. Resuscitative endovascular balloon obstruction of the aorta may also be a good treatment option for patients with non-compressible torso bleeding under the diaphragm.

Keywords

Aortic aneurysm; Aortic rupture; Balloon occlusion; Endovascular procedures

1. Introduction

The overall mortality rate of patients with a ruptured abdominal aortic aneurysm (AAA) is 65–85% [1]. Anterior wall rupture of the AAA into the peritoneal cavity usually is dramatic and is often associated with death of the patient at the scene. Posterolateral wall rupture of an aortic aneurysm may be temporarily sealed with clot formation, a retroperitoneal hematoma, and abdominal muscle tone. However, a more extensive rupture may occur within several hours. The period between the two ruptures is the intermediate period when diagnosis and emergency repair should be performed. During this critical time period, resuscitative thoracotomy and thoracic aorta cross-clamping (RTAC) have been performed to prevent AAA rupture and massive bleeding [2]. Recently, resuscitative endovascular occlusion of the aorta (REBOA) has been suggested as an alternative to RTAC [2]. REBOA is used for trauma patients with abdominal bleeding and pelvic bone fractures via the common femoral artery route. Here, we describe the successful treatment of a patient with a ruptured AAA using the REBOA procedure via the brachial artery route. We report this case with a brief review of the literature.

2. Materials and methods

A 63-year-old man (American Society of Anesthesiologists, class IV; weight, 80 kg; height, 185 cm) with a ruptured AAA was scheduled for emergency aortic reconstruction and bleeding control. Preoperative computed tomography showed an atherosclerotic AAA (anteroposterior diameter, 6.7 cm; Fig. 1). He had a history of hypertension and was being treated with calcium channel blocker medications. Preoperative laboratory findings were normal: hemoglobin level, 9.0 mg/dL; hematocrit, 26.3%; and platelet count, 138,000/μL. Electro-

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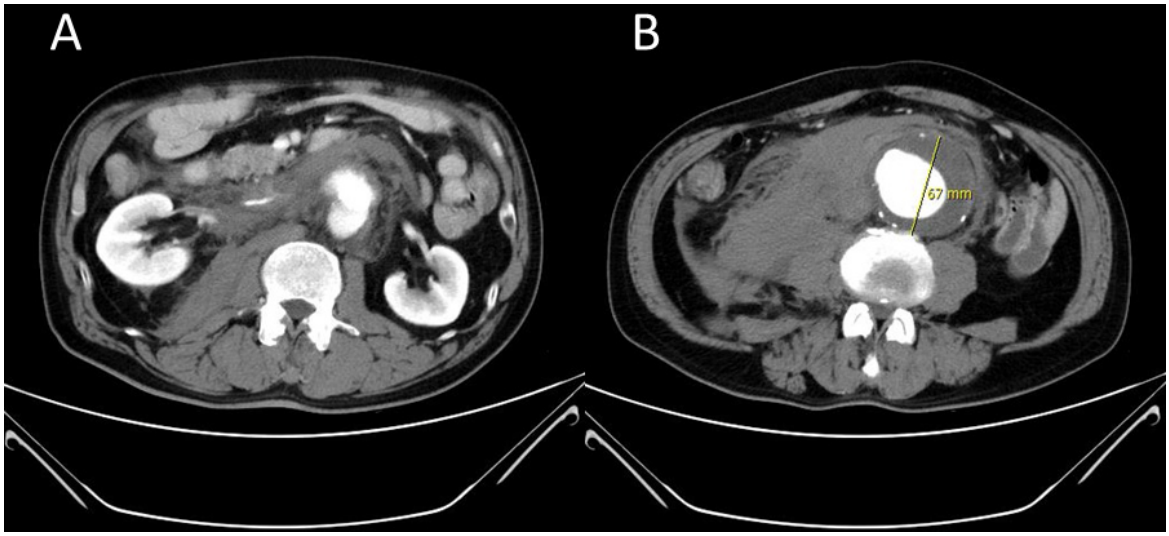

FIGURE 1. Preoperative computed tomography showing an atherosclerotic abdominal aortic aneurysm. (A) Focal contrast extravasation along the lower abdominal aorta. (B) Atherosclerotic abdominal aortic aneurysm with large mural thrombus (anteroposterior diameter: about 6.7 cm).

cardiography and chest radiography were also normal. After admission to the operating room, patient monitors were instituted, including electrocardiogram, continuous blood pressure, pulse oximetry, bi-spectral index monitor, central venous pressure, and continuous arterial blood pressure monitoring with radial artery and dorsalis pedis artery catheter insertion. His initial vital signs were blood pressure of 83/55 mmHg, heart rate of 93 beats/min, and respiration rate of 23 breaths/min. General anesthesia was induced with intravenous injection of 60 mg lidocaine, 10 mg etomidate, and 70 mg rocuronium, and was maintained with 7 vol% desflurane. Conventional endotracheal intubation was performed with direct laryngoscopy, and a 7.5 mm plain tube was inserted. After intubation, dopamine (5 μg/kg/min), dobutamine (5 μg/kg/min), and norepinephrine (0.1 μg/kg/min) infusions were started to treat hypotension. However, the patient's blood pressure fluctuated from 60/30 to 90/60 mmHg, even with aggressive treatment. After a discussion, the surgeon and anesthesiologist decided to implement REBOA.

A vascular surgeon assessed the right brachial artery for REBOA using a 7F sheath (Standard kit, Terumo Vietnam Medical Equipment Co., Ltd, Hanoi, Vietnam) under ultrasound guidance and inserted a balloon catheter (occlusion balloon catheter, Tokai Medical Products, Inc., Aichi, Japan). The balloon was placed in Zone I, which was confirmed using a portable chest radiograph. The patient's blood pressure suddenly dropped from 90/50 mmHg to 68/42 mmHg after the laparotomy and his hypotension did not respond to aggressive treatment, including volume replacement (five units of packed red blood cells) and inotropic agent infusions. Re-rupture of the aortic aneurysm was considered. Therefore, during REBOA the balloon was inflated with 10 mL of saline until the dorsalis pedis artery pulse disappeared; his blood pressure recovered immediately to 140/70 mmHg. Retroperitoneal hematoma evacuation and abdominal aorta repair were performed. The REBOA was deflated after proximal aortic cross-clamping and the total REBOA balloon inflation time was approximately 45 minutes.

3. Results

The operation lasted approximately 3 h and 43 min, and the patient was infused with crystalloid (6000 mL), colloid (500 mL), packed red blood cells (15 units), and fresh frozen plasma (5 units). His urine output was 700 mL and estimated blood loss was approximately 5000 mL. The patient was transferred to the intensive care unit and kept sedated with endotracheal intubation.

After the operation, the patient had adult respiratory distress syndrome and was treated with mechanical ventilation and conservative management. There were no complications related to the REBOA insertion. On the eighth postoperative day (POD 8), his condition worsened, and he was treated with a veno-venous extracorporeal membrane oxygenator (ECMO) for two days. On POD 28, the patient was transferred to the general ward and was discharged without complications on POD 62.

4. Discussion

It is important to prevent bleeding and hypotension when treating a ruptured AAA. Anesthetic management in patients with ruptured AAAs may be challenging because of the risk of cardiovascular collapse during anesthetic induction and after the initiation of laparotomy due to the cardiac depressant effect of anesthetic agents, relaxation of abdominal muscles that reduce the compression effect, reduction of sympathetic tone, aggravation of the rupture, and massive bleeding. Severe bleeding may occur until overt cross-clamping of the abdominal aorta is performed. RTAC has been used to decrease this risk.

REBOA, a minimally invasive alternative to RTAC, has emerged as a viable option for the treatment of severe subdiaphragmatic bleeding [3]. A meta-analysis compared the

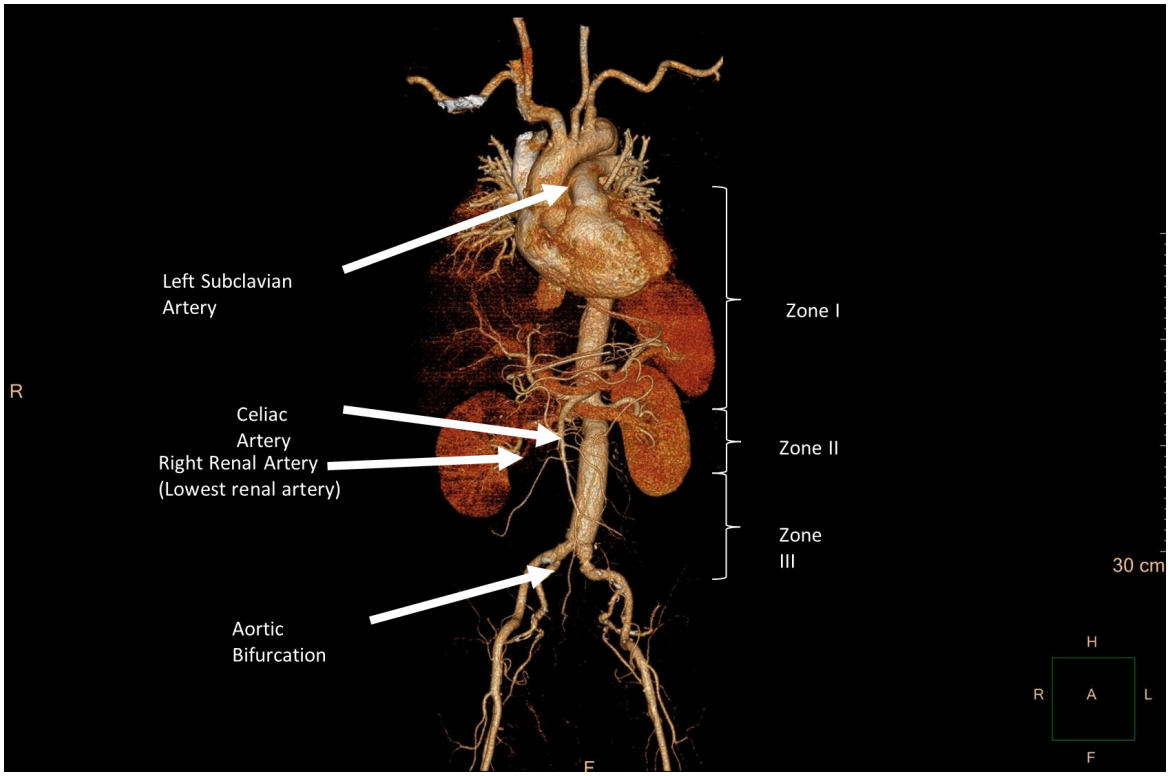

FIGURE 2. Aortic zones of occlusion (Computed Tomography Angiography of the patient). Zone I: the left subclavian artery to the celiac artery; Zone II: the celiac artery to the renal artery; Zone III: lowest renal artery to the aortic bifurcation cit [8].

effectiveness of REBOA and RTAC in non-compressible torso hemorrhage [2]. The REBOA group showed significantly higher systolic blood pressure and better survival on admission, and a lower mortality rate [2].

REBOA has several advantages over RTAC. There is no need to stop cardiac compression or ventilation while performing REBOA in a patient with circulatory collapse [3]. REBOA is a minimally invasive and low risk procedure compared to RTAC, with minimal exposure of blood-borne pathogens to healthcare workers [4]. Teeter *et al.* [5] reported that REBOA patients have higher end tidal CO_2 and cardiac compression fraction before and after aortic occlusion compared with patients treated with open-chest cardiac massage with aortic cross clamping. However, REBOA is contraindicated in thoracic injuries as REBOA may aggravate thoracic great vessel injury and pericardial tamponade; therefore, RTAC should be performed [6].

REBOA is a more accessible procedure than RTAC, and can be performed by emergency medicine physicians, anesthesiologists, and interventional radiologists using non-invasive methods [7]. Various zones of the descending aorta can be blocked as needed during REBOA (Fig. 2, Ref. [8]). REBOA is also a less time-consuming procedure and does not require one-lung ventilation or temporary lung deflation.

Hoehn *et al.* [9] reported 11 cases of non-traumatic intra-abdominal hemorrhage (3 cases of ruptured AAA, 1 case of renal artery bleeding, and 1 case of iliac artery bleeding), and 64% of these patients experienced cardiac arrest due to massive bleeding. Despite the severity of the patient's condition, the in-hospital survival rate was 64%, with no REBOA-related complications. Brenner *et al.* [10] reported that the REBOA group showed better outcomes including survival beyond emergency department admission, in-hospital survival, survival to discharge, and Glasgow Coma Scale score at discharge in trauma patients with hemorrhagic shock. A systematic review and meta-analysis showed that REBOA has been used in patients with ruptured AAAs with improved hemodynamic parameters and outcomes [11, 12].

The most common route of REBOA is the common femoral artery [8]. However, Hoehn *et al.* [9] recommended image-guided wires and balloon occlusion in ruptured AAAs, not the algorithmic-based approach. The balloon catheter does not pass through the ruptured aorta when using the brachial artery route, as done with our patient. The brachial artery route has fewer complications with a 7F sheath than the common femoral artery route [13]. We inserted the balloon catheter blindly and confirmed its placement using a chest radiograph. In addition, it was easily accessible when inflating and deflating the balloon compared to the femoral route, which would be under the surgical drape. There was no need to deflate and remove the balloon catheter before proximal cross-clamping during AAA repair. This route is also valuable in cases involving the iliac artery where the common femoral artery cannot be used.

Various complications related to REBOA have been reported, including ischemia secondary to prolonged balloon inflation, vascular injury (aortic or iliac artery injury, pseudoaneurysm), arterial thrombosis, and limb amputation [13]. Vascular complications were associated with larger sheaths (12~14 Fr) compared with a smaller sheath (7 Fr) [4, 13]. Smaller sheaths appear to have fewer complications despite their relatively prolonged placement and after sheath removal [4]. There were no sheath-related complications in the present

case.

Long-term occlusion may induce ischemia and related complications. Ischemia and reperfusion injury may follow long-term inflation during REBOA and increase the release of inflammatory mediators, risk of respiratory distress syndrome, and the use of vasopressors [4]. Definitive surgical treatment or intervention must be performed within approximately 60 min in cases of Zone I occlusion or 90 min in Zone III occlusions [13]. In our case, the total REBOA balloon inflation time was approximately 45 minutes. Our patient suffered from adult respiratory distress syndrome and needed intensive care, including long-term mechanical ventilation and ECMO.

The balloon should be inflated until the patient's blood pressure is augmented (usually monitored with radial artery pressure) and the femoral or dorsalis pedis artery pulse is stopped [4]. Wasicek *et al*. [14] studied endovascular balloon catheters with a swine model. They reported that over-inflation of the endovascular balloon catheter might cause aortic rupture, particularly beyond a circumferential stretch ratio of 1.8. Trained personnel should perform REBOA, and a vascular surgeon or interventional radiologist should be available to treat unexpected complications related to REBOA and the sheath.

Some studies have demonstrated that a partial occlusion technique maintained normal physiology, decreased organ ischemia, and reduced hemodynamic instability, allowing for a more extended period of balloon inflation during REBOA [4].

Surgeons and anesthesiologists should know the indications and risks of REBOA and should not hesitate to use REBOA in a patient at risk of severe bleeding [7]. When anesthesiologists have sufficient knowledge about REBOA, they can safely treat patients and minimize the occurrence of complications due to the use of REBOA, including reperfusion injury.

In conclusion, we successfully managed a patient during ruptured AAA repair with the aid of REBOA. REBOA is an excellent, minimally invasive alternative compared to RTAC. Blind REBOA catheter insertion via the brachial artery route with a 7F sheath was a safe, accessible option for emergency ruptured AAA repair. Anesthesiologists should be aware of the usefulness and related risks of REBOA with severe bleeding under the diaphragm.

AUTHOR CONTRIBUTIONS

SK and NC performed the anesthesia procedure in this case. SK and JS reviewed the case. JS and NC wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Institutional Review Board (IRB) approval (Dankook University Hospital IRB, 2021-06-004) and written informed consent were obtained for this study.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

[1] Sakalihasan N, Limet R, Defawe O. Abdominal aortic aneurysm. The Lancet. 2005; 365: 1577–1589.

[2] Manzano Nunez R, Naranjo MP, Foianini E, Ferrada P, Rincon E, García-Perdomo HA, *et al*. A meta-analysis of resuscitative endovascular balloon occlusion of the aorta (REBOA) or open aortic cross-clamping by resuscitative thoracotomy in non-compressible torso hemorrhage patients. World Journal of Emergency Surgery. 2017; 12: 30.

[3] Brenner M, Teeter W, Hoehn M, Pasley J, Hu P, Yang S, *et al*. Use of Resuscitative Endovascular Balloon Occlusion of the Aorta for Proximal Aortic Control in Patients with Severe Hemorrhage and Arrest. JAMA Surgery. 2018; 153: 130–135.

[4] Ribeiro Junior MAF, Feng CYD, Nguyen ATM, Rodrigues VC, Bechara GEK, de-Moura RR, *et al*. The complications associated with Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA). World Journal of Emergency Surgery. 2018; 13: 20.

[5] Teeter WA, Bradley MJ, Romagnoli A, Hu P, Li Y, Stein DM, *et al*. Treatment Effect or Effective Treatment? Cardiac Compression Fraction and End-tidal Carbon Dioxide are Higher in Patients Resuscitative Endovascular Balloon Occlusion of the Aorta Compared with Resuscitative Thoracotomy and Open-Chest Cardiac Massage. The American Surgeon. 2018; 84: 1691–1695.

[6] Biffl WL, Fox CJ, Moore EE. The role of REBOA in the control of exsanguinating torso hemorrhage. Yhe Journal of Trauma and Acute Care Surgery. 2015; 78: 1054–1058.

[7] Hilbert-Carius P, McGreevy D, Abu-Zidan FM, Hörer TM. Successfully REBOA performance: does medical specialty matter? International data from the ABOTrauma Registry. World Journal of Emergency Surgery. 2020; 15: 62.

[8] Stannard A, Eliason JL, Rasmussen TE. Resuscitative endovascular balloon occlusion of the aorta (REBOA) as an adjunct for hemorrhagic shock. The Journal of Trauma. 2012; 71: 1869–1872.

[9] Hoehn MR, Hansraj NZ, Pasley AM, Brenner M, Cox SR, Pasley JD, *et al*. Resuscitative endovascular balloon occlusion of the aorta for non-traumatic intra-abdominal hemorrhage. European Journal of Trauma and Emergency Surgery. 2019; 45: 713–718.

[10] Brenner M, Inaba K, Aiolfi A, DuBose J, Fabian T, Bee T, *et al*. Resuscitative Endovascular Balloon Occlusion of the Aorta and Resuscitative Thoracotomy in Select Patients with Hemorrhagic Shock: Early Results from the American Association for the Surgery of Trauma's Aortic Occlusion in Resuscitation for Trauma and Acute Care Surgery Registry. Journal of the American College of Surgeons. 2018; 226: 730–740.

[11] Borger van der Burg BLS, van Dongen TTCF, Morrison JJ, Hedeman Joosten PPA, DuBose JJ, Hörer TM, *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. European Journal of Trauma and Emergency Surgery. 2018; 44: 535–550.

[12] Ellis DY. REBOA: where are we now? Emergency Medicine Australasia. 2020; 32: 4–6.

[13] Osborn LA, Brenner ML, Prater SJ, Moore LJ. Resuscitative endovas-

cular balloon occlusion of the aorta: current evidence. Open Access Emergency Medicine. 2020; 11: 29–38.
[14] Wasicek PJ, Teeter WA, Brenner ML, Hoehn MR, Scalea TM, Morrison JJ. Resuscitative endovascular balloon occlusion of the aorta: rupture risk and implications for blind inflation. Trauma Surgery & Acute Care Open. 2018; 3: e000141.

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