CASE REPORT

Temporary hemodynamic response with resuscitative endovascular balloon occlusion of the aorta (REBOA) during cardiopulmonary resuscitation in a case of traumatic cardiac arrest

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ABSTRACT

Uncontrolled hemorrhagic shock due to trauma is a life-threatening condition requiring rapid intervention. Every minute in the management of these patients is valuable. In recent years, resuscitative endovascular aortic balloon occlusion (REBOA) has emerged as a valuable tool in emergency and trauma practice, providing additional time for the patient, particularly in cases where surgical hemostasis is delayed. A 62-year-old male patient with no known comorbidities was transported to our tertiary trauma center after receiving five minutes of cardiopulmonary resuscitation (CPR) and intubation at an external facility following a high-energy traffic accident. Upon presentation, the patient's blood pressure was 50/20 mmHg and pulse rate was 128 beats/min. He had extensive pelvic trauma, lower extremity trauma, major soft tissue loss, and vascular and bone injuries. He underwent hemostatic resuscitation along with whole-body computed tomography (CT) imaging; however, cardiac arrest recurred after imaging. During CPR, simultaneous imaging studies revealed no trauma or bleeding in the brain or thorax. REBOA was planned for the patient. Temporary return of spontaneous circulation (ROSC) was achieved 38 minutes after REBOA. During this period, the patient received a total of six units of packed red blood cells, three units of fresh frozen plasma, two units of cryoprecipitate, and calcium replacement. The REBOA procedure was performed by emergency physicians and cardiovascular surgeons who had received hands-on training using a REBOA simulation model developed by our team. However, despite achieving a temporary hemodynamic response, the patient could not be stabilized for surgical intervention and was pronounced deceased. In this case, we share the first REBOA experience of emergency department physicians trained with a locally produced simulation model. We believe that simulation-based training will contribute to physician experience and direct field application in rare or rapidly evolving emergencies.

Keywords: Resuscitative endovascular balloon occlusion of the aorta (REBOA); simulation training; cardiopulmonary resuscitation (CPR); trauma; hemorrhagic shock; iliac artery injury.

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INTRODUCTION

Uncontrolled hemorrhagic shock due to trauma is a clinical condition with high mortality that requires rapid intervention. Especially in pelvic and intra-abdominal bleeding, temporary stabilization of circulation during the preoperative period is of critical importance. In recent years, with improvements in emergency services, critical care units, surgical teams, and equipment, resuscitative endovascular balloon occlusion of the aorta (REBOA) has gained increasing attention in emergency and trauma medicine.[1,2] REBOA, which requires advanced training and specialized equipment, may offer a window of opportunity for patients in traumatic cardiac arrest by allowing time for surgical intervention.

In this case report, we discuss a patient who presented with extensive soft tissue loss and major vascular and skeletal injuries, developed hemodynamic instability followed by cardiac arrest, and received REBOA during ongoing cardiopulmonary resuscitation (CPR). The procedure was performed by emergency physicians trained using a domestically developed REBOA simulator. The case also evaluates the contribution of this locally produced simulation model to the clinical training process for such high-risk scenarios.

CASE REPORT

A 62-year-old male patient with no known comorbidities was transferred to our tertiary care center following a high-energy motor vehicle collision. He was initially taken to the nearest healthcare facility, approximately one hour from our hospital. Cardiopulmonary resuscitation was initiated there for about five minutes before spontaneous circulation was restored, followed by endotracheal intubation. The patient received tranexamic acid, tetanus prophylaxis, triple antibiotics, three units of packed red blood cells, and one unit of fresh frozen plasma. A norepinephrine infusion was initiated, and the patient was transferred to our hospital due to the need for multidisciplinary surgical management.

Upon arrival, the patient had spontaneous circulation, was intubated, and remained hypotensive (blood pressure 50/30 mmHg). Open fractures of the pelvis and right lower extremity were noted, including multiple fractures of the right tibia, fibula, and femur, as well as a comminuted fracture of the right iliac wing. There were extensive soft tissue loss and laceration extending from the lower abdomen to the perineum, including the external genitalia. No peripheral pulse was palpable in the left lower extremity.

Table 1. Main laboratory findings

Parameter	Value
Hemoglobin	4.1 g/dL
Hematocrit	11%
pH	6.94
Base excess	-22
Lactate	4.82 mmol/L
Creatinine	2.36 mg/dL
Urea	35.41 mg/dL

Figure 1. The patient was taken to the resuscitation area, where CPR was initiated.

To stabilize the patient, a massive transfusion protocol was initiated while the norepinephrine infusion continued. Blood samples were collected for surgical preparation, and whole-body computed tomography (CT) was performed. Laboratory findings revealed hemoglobin 4.1 g/dL, hematocrit 11%, pH 6.94, base excess -22, lactate 4.82 mmol/L, creatinine 2.36 mg/dL, and urea 35.41 mg/dL (Table 1).

CT imaging showed no traumatic findings in the brain or cervical spine. Fractures were noted in the proximal left humerus and the second and fifth left ribs. A subcapsular hematoma in the liver and a grade 1 splenic laceration were

Figure 2. Extensive pelvic and lower extremity fractures, including pubic diastasis.

Figure 3. Extensive pelvic and lower extremity fractures, including pubic diastasis.

also observed. Additionally, there were extensive pelvic and lower extremity fractures, including pubic diastasis. No blood flow was visualized distal to the left external iliac artery. In contrast, flow was present in the right internal iliac, external iliac, and common femoral arteries. The Injury Severity Score (ISS) was calculated as 59. Toward the end of the CT scan, the patient developed cardiac arrest.

The patient was deemed a suitable candidate for REBOA and was taken to the resuscitation area, where CPR was initiated. The cardiovascular surgery and orthopedic teams were informed (Fig. 1, 2).

To facilitate faster catheterization, external mechanical chest compressions were applied to minimize motion artifacts during CPR. Approximately five hours after the trauma occurred, a 9F, 11-cm femoral sheath was inserted into the right common femoral artery with the assistance of the cardiovascular surgery team. Although a linear ultrasound probe was used to locate the femoral artery, trauma-induced anatomical changes hindered vascular identification (Fig. 3). The bladder was gently displaced cephalad using sterile towels, and a vessel-like structure with a tubular lumen was identified. Ultrasound was used again to confirm arterial identity. A Mustang 10×60 mm balloon dilation catheter was introduced via the sheath. Due to anatomical distortion, the umbilicus could not be used as a reference point, and the balloon was advanced to a depth of 28 cm and inflated in Zone 3. Position was confirmed with direct radiography and ultrasonography. Due to the presence of a suspicious subcapsular hepatic hematoma on CT, the balloon was deflated and repositioned into Zone 1. The balloon was inflated sequentially with 6 mL and 8 mL of saline, achieving pressures of 9.6 and 11 atm, respectively (Fig. 4).

Thirty-eight minutes after REBOA deployment, return of spontaneous circulation (ROSC) was achieved. The patient developed ventricular fibrillation three times and was successfully defibrillated into normal sinus rhythm (Fig. 5). After the return of spontaneous cardiac activity, jugular venous dis-

Figure 4. Balloon was repositioned into Zone 1.

Figure 5. Normal sinus rhythm was detected on the monitor.

Figure 6. Jugular venous distension and carotid pulsation were confirmed by bedside ultrasound.

tension, carotid pulsation, and myocardial contractility were confirmed by bedside ultrasound (Fig. 6). However, before the patient could be transferred to the operating room, another cardiac arrest occurred. A total of 131 minutes of CPR was performed from arrival until death. Approximately 310 minutes had passed since the trauma and 100 minutes since REBOA deployment. Death was confirmed by the absence of cardiac motion on bedside ultrasound (Table 2).

During resuscitation, the patient received a total of six units of packed red blood cells, three units of fresh frozen plasma, two units of cryoprecipitate, 450 mg of calcium gluconate, and 4000 mL of intravenous fluids.

DISCUSSION

According to the Adult Trauma Life Support Guideline, emergency resuscitative thoracotomy is an invasive surgical intervention performed to achieve direct control of intrathoracic

Table 2. Chronological clinical timeline

Time	Description
0 min (Trauma)	High-energy traffic accident
~60 min	External hospital: 5 min CPR → ROSC, intubation, fluids and blood products, norepinephrine initiated
~120 min	Transfer to tertiary trauma center
Admission to our center	BP 50/30 mmHg, tachycardia, extensive pelvic and lower extremity trauma
+ CT (Trauma center)	Brain/thorax normal; liver subcapsular hematoma, grade 1 splenic laceration, iliac artery flow loss
End of CT	Cardiac arrest; CPR initiated
~30 min (after CT)	REBOA performed (Zone 3, then Zone 1)
+38 min (post-REBOA)	Transient ROSC; defibrillated to sinus rhythm
+100 min (post-REBOA)	Re-arrest; total of 131 min CPR
~310 min (5 h 10 m after trauma)	Exitus/Death confirmed

Min: Minute; CPR: Cardiopulmonary resuscitation; ROSC: Return of spontaneous circulation; CT: Computed tomography; BP: Blood pressure.

injuries, decompress pericardial tamponade, and occlude the aorta to prevent exsanguination, thereby aiming to stabilize the patient's condition.[3,4] Similarly, the Joint Trauma System Clinical Practice Guidelines declare left anterolateral thoracotomy as the gold standard technique for aortic occlusion in cases of cardiac arrest secondary to trauma.[5] However, in traumatic arrests resulting from isolated abdominal aortic injuries or pelvic fractures, its application remains limited due to the induction of a broader ischemic region and the requirement for a more invasive surgical approach.[5] REBOA, conversely, has emerged as an alternative aortic occlusion strategy in carefully selected patients.

REBOA is an invasive approach used to achieve temporary hemodynamic stabilization in patients with non-compressible hemorrhage, particularly in pelvic and abdominal trauma, before definitive surgical control is possible.[6] Compared to emergency resuscitative thoracotomy, REBOA offers a less invasive alternative for selected trauma patients requiring aortic occlusion.

The success of REBOA implementation depends on patient selection, timing, operator experience, logistical preparedness, associated injuries, and the need for concurrent cardiopulmonary resuscitation.[7] Education and training are crucial for the effective and safe execution of this procedure. According to the Joint Trauma System Clinical Practice Guidelines, providers must have comprehensive knowledge of device usage, indications, and potential complications before attempting REBOA. Successful training should include both didactic and hands-on components, preferably using high-fidelity simulators, perfused cadavers, or live tissue models.[8]

In the study by Brenner et al.,[9] the Basic Endovascular Skills for Trauma (BEST) course is described as a model in which participants are trained in endovascular techniques, including REBOA, using perfused cadavers. The training includes ultrasound-guided common femoral artery access, percutaneous and open cannulation, and arterial repair.

In our case, all providers had completed REBOA training through a national course supported by the Emergency Medicine Specialists Association, in collaboration with cardiovascular surgeons. The training utilized a simulation model—ZMD—designed and developed by our team, which includes ultrasound-compatible and anatomically realistic modules for common femoral artery access, sheath placement, guidewire manipulation, and balloon deployment.

This REBOA simulation model was actively used in REBOA training courses in 2024 and has since entered the process of commercial licensing. It represents not only an educational innovation but also a translational contribution bridging simulation and real-world application. Despite the providers' proficiency with ultrasound, trauma-related anatomical distortions and extensive soft tissue loss limited the effectiveness of sonographic guidance, rendering vascular access a rate-limiting step in this case.

REBOA success is heavily influenced by patient selection criteria. While these criteria have evolved, common parameters are emphasized across trauma centers. Brenner et al.[10] suggest that REBOA can be applied in patients with subdiaphragmatic life-threatening hemorrhage and in those who are unresponsive or transiently responsive to resuscitation, including traumatic arrest.

Similarly, Glaser et al.[11] recommend REBOA in cases of blunt or penetrating abdominal, pelvic, or junctional trauma with systolic blood pressure <90 mmHg and no or transient response to initial resuscitation. They also caution against its use in patients with severe thoracic injuries or penetrating neck, chest, or extremity trauma.

Hadley et al.[12] emphasize that REBOA may be effective in

patients with systolic blood pressure (SBP) <80 mmHg due to pelvic or extremity hemorrhage and traumatic arrest but is not recommended for intrathoracic bleeding.

In our case, upon arrival at the emergency department, the patient's SBP was <80 mmHg, prompting the initiation of a massive transfusion protocol and CT imaging. The absence of brain or thoracic hemorrhage on CT during concurrent CPR strongly supported the indication for REBOA. Earlier REBOA implementation may have improved circulatory outcomes.

The method of REBOA application and the preferred balloons for aortic occlusion have evolved over time. The first use of intra-abdominal aortic balloon occlusion (IABO) catheter for traumatic bleeding was reported in 1954 by Lieutenant Colonel (LTC) Carl Hughes, who described the use of an intra-aortic balloon occlusion catheter inserted through a 10-F arterial sheath.[13]

The need for repair of the common femoral artery (CFA) after the use of high-French sheaths and the increasing traumatic nature of battlefield injuries led to institutional efforts to develop new sheaths and REBOA catheters.[14]

Increasing awareness of the REBOA procedure has led healthcare professionals to implement it to support trauma patients. However, the lack of infrastructure in healthcare systems, prolonged transfer times for patients who could benefit from REBOA to well-equipped hospitals, and the increased risk of visceral organ damage due to prolonged balloon occlusion have prompted research into and trials of variations such as partial REBOA and intermittent REBOA.[15]

In our case, REBOA was performed using a REBOA kit prepared from existing equipment available at our hospital. The balloon used did not completely obstruct distal blood flow, making the procedure a spontaneous partial REBOA.

CONCLUSION

In severe trauma cases, especially those involving iliac artery injury and profound hemorrhagic shock, REBOA can be technically feasible and potentially beneficial during ongoing CPR. It may provide critical time for surgical intervention by temporarily stabilizing circulation. However, the success of REBOA is contingent on appropriate patient selection, timely application, team experience, and management of concurrent injuries. In this case, one of the key enabling factors for REBOA application during CPR was the simulation-based training and technical readiness achieved through the locally developed REBOA model. Further studies are warranted to evaluate the role of simulation-based training in improving clinical outcomes of REBOA in traumatic arrest.

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OLGU SUNUMU - *ÖZ*

Travmatik kardiyak arrest olgusunda kardiyopulmoner resüsitasyon sırasında REBOA ile geçici hemodinamik yanıt

Travmaya bağlı kontrolsüz hemorajik şok, hızlı müdahale gerektiren yaşamı tehdit eden bir durumdur. Bu hastaların yönetimindeki her bir dakika altın değerindedir. Son yıllarda resüsitatif endovasküler aort balon oklüzyonu (REBOA), özellikle cerrahi hemostazın geciktiği durumlarda hastaya ek zaman kazandırarak acil ve travma pratiğinde değerli bir araç olarak öne çıkmaktadır. Bilinen ek hastalığı olmayan 62 yaşında erkek hasta, yüksek enerjili bir trafik kazası sonrası götürüldüğü dış merkezde 5 dakika kardiyopulmoner resüsitasyon (KPR) uygulandıktan ve entübe edildikten sonra üçüncü basamak travma merkezimize sevk edilmiştir. Hastanın başvuru anındaki kan basıncı 50/20 mmHg, nabız 128 atım/dakika idi. Hastada geniş pelvik travma, alt ekstremite travması, majör yumuşak doku kaybı, vasküler ve kemik yaralanmaları mevcuttu. Hemostatik resüsitasyonla birlikte tüm vücut tomografi görüntülemesi yapılan hastada görüntüleme sonrasında tekrar kardiyak arrest gelişti. KPR sırasında eş zamanlı görüntüleme tetkikleri de incelenen hastada beyin ve toraks bölgesinde travma ve kanama tespit edilmedi ve hastaya REBOA uygulanması planlandı. REBOA uygulandıktan 38 dakika sonra geçici spontan dolaşım dönüşü (ROSC) sağlandı. Hastaya bu süreçte toplam 6 ünite eritrosit süspansiyonu, 3 ünite taze donmuş plazma, 2 ünite kriyopresipitat ve kalsiyum replasmanı yapıldı. REBOA işlemi, ekibimiz tarafından geliştirilen REBOA simülasyon modeli ile uygulamalı eğitim almış acil tıp hekimleri ve kalp damar cerrahi hekimleri tarafından gerçekleştirildi. Ancak geçici hemodinamik yanıt sağlanmasına rağmen hasta cerrahi müdahale için stabilize edilememiş ve eksitus kabul edilmiştir. Bu vakada yerel olarak üretilmiş bir simulasyon modeli ile eğitilmiş Acil servis hekimlerinin ilk REBOA deneyimi paylaşıldı. Nadir görülen veya hızlı müdahale edilmesi gereken acil durumlarda simulasyon temelli eğitimlerin hekim deneyimi kazanmasında ve doğrudan saha uygulamasına katkı sağlayacağını düşünmekteyiz.

Anahtar sözcükler: REBOA, simülasyon eğitimi, KPR, travma, hemorajik şok, iliak arter yaralanması

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