Case Report

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Resuscitative Endovascular Balloon Occlusion of the Aorta as a Bridge to Organ Donation after Blunt Trauma

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Solid organ transplantation is limited worldwide by a shortage of donor organs. Trauma patients with unsurvivable injuries comprise a large portion of potential organ donors, but many of them die from cardiovascular collapse before donation can be pursued. We report the use of resuscitative endovascular balloon occlusion of the aorta (REBOA) to stabilize a deteriorating patient with blunt trauma who was ultimately able to donate multiple organs and tissues. Survival to organ donation is a tangible and beneficial outcome of REBOA.

Keywords: *Resuscitative Endovascular Balloon Occlusion of the Aorta; REBOA; Traumatic Brain Injury; Organ Donation; Blunt Trauma*

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Despite increases in the number of organs transplanted each year, a substantial disparity remains between available organs and prospective recipients. As of August 2021, there were 106,782 candidates on the waiting list for a transplant in the United States [1]. Deceased patients comprise the majority of the current donor pool. In 2019, a total of 11,870 cadaveric donors provided 32,322 transplanted organs, representing 81% of organs transplanted that year. Among deceased donors, traumatic brain injury (TBI) is the second most common cause of death, closely following cerebrovascular accident.

The shortage of available organs has led to a variety of efforts to expand the potential donor pool. One strategy that could increase donation among patients with an unsurvivable TBI, many of whom die from cardiovascular collapse before organ procurement can occur [2–4], is the use of resuscitative endovascular balloon occlusion of the aorta (REBOA). Here we present a case in which REBOA facilitated rapid hemodynamic stabilization of a patient with blunt trauma who arrived *in extremis*, was found to have a devastating TBI, and survived to organ recovery.

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CASE

A 53-year-old woman was brought to our Level I trauma center in cardiac arrest following a high-energy motor-vehicle collision. According to prehospital providers, she had not had signs of life prior to arrival other than agonal respirations and had been undergoing cardiopulmonary resuscitation (CPR) for 17 minutes. Her pupils were fixed, and the only other external sign of injury was a lip laceration.

Because of the duration of CPR, we suspected that the patient's condition would not be salvageable, and she was not a candidate for resuscitative thoracotomy based on our institutional protocol [5,6]. However, when chest compressions were paused upon her arrival in the emergency department, she had a faint carotid pulse. The Extended Focused Assessment with Sonography for Trauma (E-FAST) was unremarkable. We, therefore, placed a 7-French introducer sheath into the right common femoral artery and inserted an ER-REBOA Catheter (Prytime Medical Devices, Boerne, Texas), which was positioned at 45 cm at the skin. Immediately after we inflated the balloon with 13 mL of saline-diluted contrast, her blood pressure increased to 117/60 mmHg. The time, catheter position, and balloon volume were

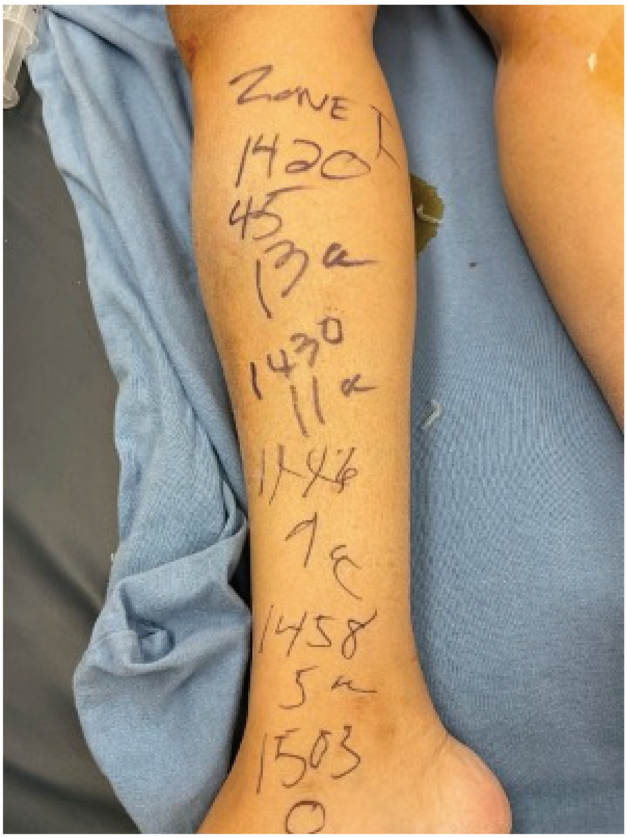

Figure 1 The time, catheter position, and balloon volume were recorded on the patient's right lower extremity.

recorded on the patient's right lower extremity (Figure 1). A chest radiograph confirmed that the balloon was in zone I of the aorta and that there were no major thoracic injuries (Figure 2).

While we were placing the REBOA, the patient was intubated, intravenous access was obtained, and the pelvis was stabilized with a sheet. The FAST was repeated and did not show free fluid in the abdomen. Her hemoglobin was 11.4 g/dL, and her base deficit –22.0 mmol/L. The patient was taken to the computed tomography scanner with the balloon partially inflated with 11 mL of contrast (Figure 3) and was found to have bilateral cerebral subarachnoid hemorrhages, left frontal lobe intraparenchymal hemorrhage, intraventricular hemorrhage, atlanto-occipital dissociation, multifocal C1 fractures, and bilateral rib fractures. The rest of the whole-body scan was unremarkable. At this point, 26 minutes after balloon inflation, she had received three units of red blood cells and two units of plasma and had a blood pressure of 133/118 mmHg. Having ruled out hemorrhagic shock, we stopped transfusing blood products and continued to remove fluid from the balloon (Figure 1). At 43 minutes after REBOA placement, the balloon was completely deflated, and the catheter was withdrawn. Her blood pressure was 110/83 mmHg.

The patient was admitted to the surgical intensive care unit. A norepinephrine infusion was needed to maintain a systolic blood pressure >100 mmHg. She did not have brainstem reflexes, and magnetic resonance imaging showed evidence of grade 1 diffuse axonal injury and diffuse hypoxic-ischemic injury. Our neurosurgery team deemed her condition unsurvivable. After her family was approached by the local organ procurement organization and gave authorization for donation after circulatory death, the liver and both kidneys were recovered on the fifth hospital day and transplanted into three recipients. Biopsies of the kidneys taken during procurement were negative for acute tubular necrosis.

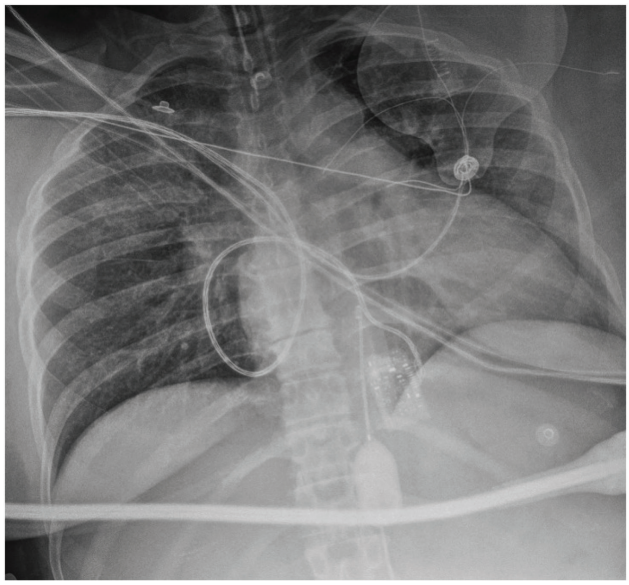

Figure 2 Chest X-ray immediately after balloon inflation.

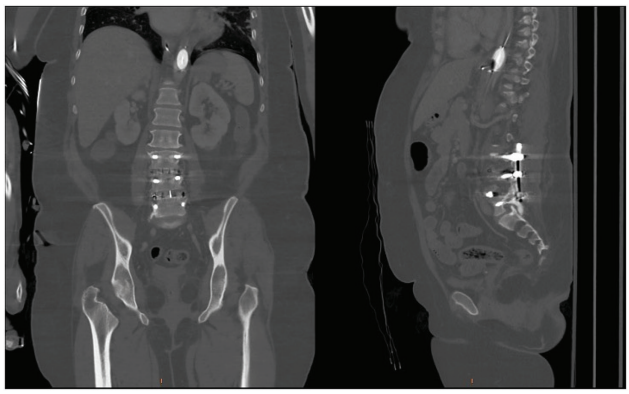

Figure 3 Coronal (left) and sagittal (right) views of the patient's computed tomography scan, which demonstrate positioning of the balloon in zone I just above the diaphragm.

Ethical Approval and Informed Consent

Ethical approval was not required. Informed consent was not possible because of the acuity of the patient's condition, and the information has been anonymized.

DISCUSSION

Brain injury, especially when progressing to brain death, is associated with hemodynamic, metabolic, and endocrine derangements that can result in multiorgan failure and cardiovascular collapse [7–10]. Consequently, one-quarter of trauma patients who are identified as possible organ donors are lost due to hemodynamic instability [2–4]. In our patient who arrived *in extremis* after a motor-vehicle collision, zone I REBOA deployment prevented imminent cardiovascular collapse and allowed for prompt diagnosis of her injuries as well as eventual evaluation for organ donation. The aorta was completely occluded for only 10 minutes, avoiding prolonged ischemia of the abdominal viscera. That timing was crucial because the duration of ischemia impacts the suitability of organs for transplantation. In livers, for example, warm ischemia times >20 minutes have been associated with decreased graft survival [11].

Utilization of REBOA to salvage possible organ donors follows numerous efforts over the last three decades to increase the quantity of transplantable organs [12]. The use of marginal or extended-criteria donors, including elderly, pediatric, and diabetic patients, has become more common. Longer cold ischemia times, non-heart-beating donation, and split-liver transplantation have become more widely accepted. Most recently, with the development of antiviral therapies, donors with bloodborne infections are allowed [13]. Success has been demonstrated with transplanting organs from patients with hepatitis C (HCV) to HCV-negative recipients. The 2013 HIV Organ Policy Equity Act allows HIV-positive individuals to donate to HIV-positive recipients and has been expected to expand the donor pool by 400–500 individuals annually. These strategies attempt to address the organ shortage crisis while conforming with the ethical expectations of society.

REBOA provides time for family members to make consensus decisions about organ donation. An alternative to REBOA for patients with unsurvivable injuries is the use of uncontrolled donation after cardiac death (uDCD) to maximize organ availability. uDCD is a form of organ recovery in which, once a patient has been declared dead, a procurement team is activated to recover organs. This strategy has increased available kidneys for transplantation in Europe [14]. Limitations include that organs undergo longer warm ischemia times, increasing the risk of non-function after transplantation [15]. uDCD has logistic, legal, and ethical barriers that currently hinder its use in trauma [16].

As this case demonstrates, survival to organ donation is a potential benefit of REBOA. While aortic balloon occlusion was first described in the trauma literature during the Korean War, its use has become more common due to technical improvements but remains controversial. In patients with hypovolemia, prompt aortic occlusion increases cardiac afterload and directs blood to the brain and heart. Thus, it is an integral step during resuscitative thoracotomy for injured patients *in extremis*. Initial investigations of REBOA have indicated a survival benefit in selected patients [17,18]. It is less invasive than resuscitative thoracotomy, which can also lead to organ donation [19]. Other applications of REBOA in the management of potential donors, for example, during normothermic extracorporeal perfusion after cardiac death [20], have been reported but require further investigation. Based on our experience with this patient, we advocate for more aggressive use of REBOA in the management of the hemodynamically unstable trauma patient, recognizing that it can increase the donor pool. Survival to organ donation should be studied in future work on outcomes of REBOA.

Conflict of Interest

The authors declare that they have no conflicts of interest.

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.

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Author Contributions

JJS, DPF, and EEM cared for the patient in this case report. JJS, DPF, and HBM reviewed the literature and wrote the manuscript, which EEM critically revised.

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