Case Report

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# Successful Partial Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in an Octogenarian Trauma Patient

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**Background:** To perform effectively Resuscitative Endovascular Balloon Occlusion of the Aorta (REBOA) in an extreme elderly trauma patient, the distinct issues that make a difference are the anatomical and physiological changes. Multiple maneuvers were performed simultaneously for favorable outcomes to balance between critical organ perfusion and bridging control of bleeding.

**Method:** We demonstrate how to perform successfully REBOA in an octogenarian patient with coma and profound hypotension on arrival. A primary survey found unstable pelvic fracture and severe head injury. Admission laboratory investigations in the intensive care unit showed normal renal and liver function with not significantly increased serum lactate.

**Conclusion:** To perform ABO/REBOA in an extremely elderly trauma patient, the partial balloon technique with a goal systolic blood pressure to balance associated injuries in polytrauma patients is essential. The specific concern in this group would be related to reserve function and changing vascular access. Techniques for detection and solving uneventful conditions should be prepared and learned to successfully save elderly patients.

**Keywords:** *Resuscitative Balloon Occlusion of the Aorta; REBOA; Trauma; Resuscitation; Hemorrhage control*

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## INTRODUCTION

Uncontrolled hemorrhage is the most common cause of preventable death in trauma patients [1]. Most cases of uncontrolled hemorrhage present with non-compressible torso hemorrhage (NCTH), such as intra-abdominal bleeding, pelvic fracture, and junctional hemorrhage, which cannot be controlled by simple hemorrhagic control methods [2]. During this endovascular intervention era, a technique called endovascular resuscitation using resuscitative endovascular balloon occlusion of the aorta (REBOA) has been introduced to facilitate early hemorrhage control [3–9]. Compared to non-REBOA patients, REBOA showed significantly better hemorrhage control in the pelvic trauma group [5,10].

It is also important to note the anatomic and physiologic changes that develop in older patients (age >65 years) that make REBOA more challenging, such as atherosclerosis and organ reserve, respectively. These concerns must be considered and addressed in addition to the customary resuscitation concerns and objectives that include bridge

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therapy and critical organ perfusion. This case was complex because we had to balance between the need for damage control resuscitation [11] and the simultaneous need not to worsen the patient's traumatic brain injury (TBI). It is challenging to balance these two opposing objectives, especially when Advanced Trauma Life Support (ATLS®) protocol [12] calls for maintenance of blood pressure above the average to ensure adequate perfusion to critical organs, such as the brain.

However, the supraphysiologic pressure that is caused by REBOA zone I may influence adverse physiologic outcomes, and may also increase the risk of bleeding in proximal organs. As such, a target systolic blood pressure (SBP) should be achieved and maintained using partial REBOA (P-REBOA), especially in older patients with TBI who have a potentially progressive intracranial hemorrhage (ICH). Multiple studies of P-REBOA in a porcine model showed increased proximal pressure and extended survival time compared to the none REBOA group [13,14].

## CASE DESCRIPTION

An 86-year-old male cyclist who was struck by a car was transferred to the Level I Trauma Center at Siriraj Hospital (Bangkok, Thailand) within 30 minutes of the accident. His clinical signs upon arrival were coma, SBP of 120 mmHg, irregular heart rate at 110 beats per minute, and oxygen saturation of 90% at room air. During the initial assessment, the patient was given 1 liter of fluid due to tachyarrhythmia, and the patient responded. A primary survey found an unstable pelvic fracture and clinically severe head injury with a Glasgow Coma Scale (GCS) score of 8 (Figure 1). On physical examination, the abdomen showed no distension, no peritoneal sign, and no visible wound. Focused assessment sonography for trauma (FAST) initially gave a negative result. A pelvic binder was applied and the orthopedic team was consulted for a treatment plan.

Our goals of resuscitation were hemorrhage control and maintenance of SBP above 100 mmHg due to the patient's TBI and extreme elderly age to prevent secondary brain injury and to maintain critical organ perfusion.

During the 1-hour wait for computed tomography (CT) imaging results and for multidisciplinary team planning, the patient developed hypotension. His lowest SBP was 50 mmHg. Resuscitation was started with blood transfusion. Due to the patient's clinically profound shock, a decision was made to perform REBOA to increase the patient's SBP to ensure critical organ perfusion.

The REBOA protocol at our center requires an adjunct primary survey by FAST and chest X-ray (CXR). The results of those two investigations showed no evidence of cardiac injury, including pericardial effusion or great vessel injuries, such as widening mediastinum, massive left hemothorax, or loss of aortic knob.

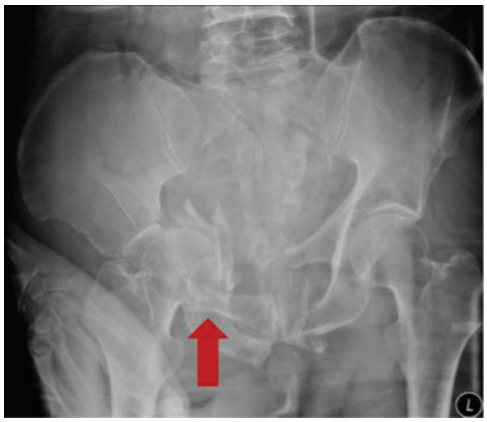

***Figure 1*** Portable pelvic X-ray demonstrated comminuted acetabular fracture, and head of femur penetrating the pelvic wall on the patient's right side.

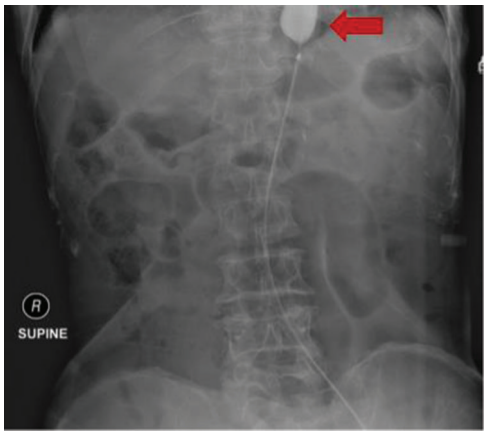


***Figure 2*** Portable X-ray in the trauma resuscitation room confirms intra-aortic balloon position at zone I of the aorta.

The decision to position the balloon at zone I was predicated on his extremely unstable condition, and we could not conclusively exclude the involvement of intra-abdominal organ injury. A FAST examination is operator-dependent and cannot exclude retroperitoneal bleeding.

Zone I REBOA was performed via the left common femoral artery by palpation technique using femoral sheath 7 Fr 10 cm Radiofocus Introducer II (Terumo Medical Corp. Ethicon, MD, USA) with an intra-aortic balloon (Rescue Balloon, Tokai, Japan).

We used a surface marker at just above the xiphoid process as a landmark for positioning the balloon. After the REBOA balloon insertion, the position of the balloon was confirmed by mixed contrast inflation and portable X-ray in the trauma resuscitation room (Figure 2).

Due to the patient's advanced age and the known age-associated reduction in organ reserve, the balloon

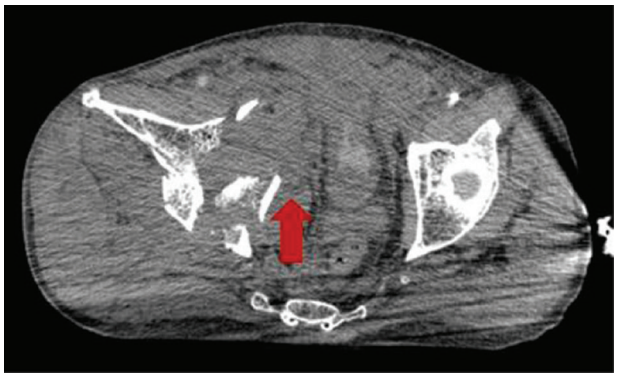

***Figure 3*** CT imaging demonstrating the comminuted fracture pattern, extravasation from the right internal iliac artery, and no other intra-abdominal injury.

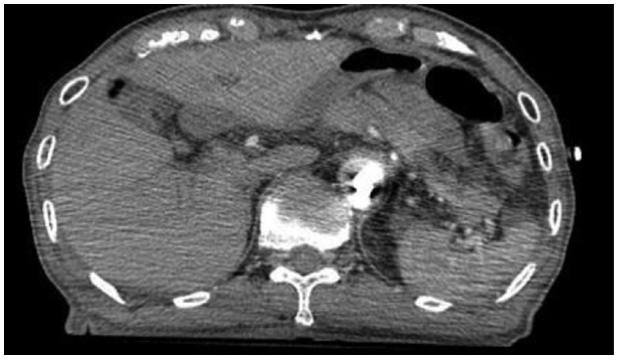

***Figure 4*** Abdominal CT scan showing partial balloon inflation with perfusion to visceral abdominal organs and the intra-aortic lumen.

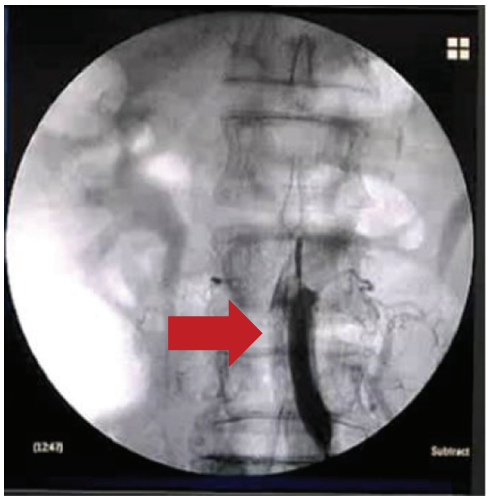

***Figure 5*** Intraoperative aortography showing the collapsed intra-aortic balloon with patent aortic column. No extravasation was presented.

was only partially inflated with 15–18 mL of normal saline solution (NSS) and-contrast solution (1:1). Arterial line monitoring was commenced to achieve an SBP above 100 mmHg due to the presence of coexisting TBI. This was performed with the aim of preserving visceral perfusion in the part distal to the balloon, and to prevent supraphysiologic pressure in organs proximal to the balloon, which can increase cardiac workload and increase the chance of intracranial bleeding.

After REBOA, a CT scan was performed to evaluate associated injuries while the operating room and angiography suite were simultaneously prepared. The results showed extravasation from the right internal iliac artery, and no other intra-abdominal injury (Figure 3). CT scan showed successful partial balloon inflation with visceral perfusion of the abdominal organs (Figure 4). The CT scan of the head revealed minimal subdural hematoma. The consulting neurosurgeon evaluated the patient and decided to manage the patient non-operatively.

The CT result showed no intra-abdominal injury, so the balloon was repositioned to zone III under fluoroscopy before the first operation. The appropriate surgical and orthopedic procedures were then performed by surgical and orthopedic teams.

After repositioning of the balloon to zone III and during all necessary operations, the patient remained hemodynamically stable. Unexpectedly, during deflation of the balloon before removal, we observed fresh blood through the balloon port. A ruptured balloon was suspected, which was subsequently confirmed by aortography (Figure 5). A decision was immediately made to remove the balloon by an open technique based on our prediction that the balloon would be unable to be withdrawn through the 7-Fr sheath (Figure 6). After that operation was performed, the patient was sent to the angio-suite for angioembolization at branches of the right internal iliac artery with glue embolization (Figure 7).

Throughout all of the procedures to stop the bleeding, including skeletal traction, pelvic external fixation, pre-peritoneal pelvic packing, and angioembolization at the right internal iliac artery, the patient was given only 4 units of packed red blood cells (PRBCs), and no inotropic support was required. The first 2 units were rapidly given during REBOA implementation due to clinical hypotension, and the other 2 units were given during all of the procedures that were performed after REBOA placement.

Total inflation time was 167 minutes, including the no occlusion period during partial and intermittent REBOA technique (P-REBOA and I-REBOA, respectively). Regrettably, there was a misunderstanding among the residents and nurses regarding who would be responsible for recording and timing inflations and deflations across the 167 minutes of REBOA time, so it is not known how much REBOA was P-REBOA and how much was I-REBOA.

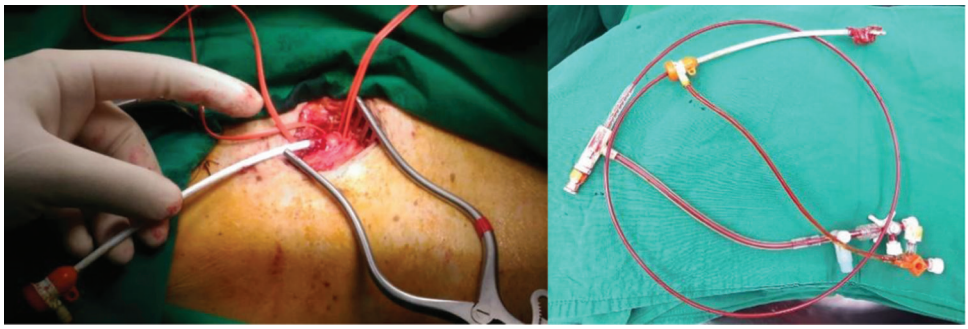

***Figure 6*** Open removal of the balloon revealed a small hole in the balloon and blood in the balloon port and catheter system.

***Figure 7*** Angiography demonstrated extravasation from branches of the right internal iliac artery before embolization was performed.

Admission laboratory investigations in the intensive care unit showed normal renal and liver function. Serum lactate was not significantly increased (from 4.3 to 5.6 mEq/L). Coagulopathy was shown based on prolonged prothrombin time (PT) of 18.1 seconds, activated partial thromboplastin time (APTT) of 38.7 seconds, and low fibrinogen level of 129.1 mg/dL.

## DISCUSSION

Elderly status and extreme elderly status is defined as ages older than 65 years and 80 years, respectively [15]. Patients in both of these age categories often have anatomic and physiologic presentations that are different from those observed in patients in younger age categories. The most notable anatomic change is the presence of atherosclerosis [16]. Regarding physiologic changes, decreased organ reserve is often observed among older people, especially the central nervous system, cardiopulmonary, and renal function.

In every trauma case, the trauma team performs an initial assessment according to Advanced Trauma Life Support (ATLS®) standard. Our patient was a transient responder, given his later development of profound shock. Our primary goals of resuscitation were hemorrhage control and maintenance of SBP above 100 mmHg due to his advanced age and the presence of TBI. This case was particularly complex because we had to navigate the delicate balance between damage control resuscitation and attempting not to worsen the patient's TBI. NCTH is a well-known leading cause of traumatic death [2,12], and pREBOA was needed in this case as a bridge therapy until definitive hemorrhage control could be achieved. Several studies have reported the advantages of REBOA in sub-diaphragmatic bleeding, including pelvic fractures [5,7,9,10].

Regarding the technique used for vascular access, we decided to introduce a 7-Fr sheath due to the patient's extremely unstable condition and the immediate need to increase the patient's blood pressure. A palpation-blind method, which relies upon anatomical correlation, was used. The catheterization was performed by a cardiothoracic trauma surgeon.

P-REBOA and I-REBOA were implemented in this case due to concerns about visceral blood supply impairment related to age, and our awareness that overinflation of the balloon could cause supra-physiologic pressure to organs proximal to the balloon, such as the brain, heart, and lungs. P-REBOA and I-REBOA are able to control the proximal pressure, so we chose to use these techniques to balance the effect of REBOA and to ensure visceral perfusion.

The balloon type that was used in this case did not have a side port for pressure measurement. Accordingly, arterial line monitoring was established in the resuscita-

tion room by an anesthesiologist. This monitoring method provided precision guidance for us to achieve our SBP goal. To verify correct P-REBOA, we used decreasing contralateral palpable distal pulse and simultaneously adjusted the volume, as needed, to achieve our SBP goal. CT scan confirmed patent visceral organ perfusion.

We changed P-REBOA and I-REBOA multiple times to maintain our SBP goal of 100 mmHg. During resuscitation, we found the patient's physiologic status to be very dynamic. The balloon inflation amount was adjusted between 15–18 mL to reach the SBP goal.

Concerning the amount of volume and SBP, as shown in peripheral arterial monitoring, the benefit of a relation between central and peripheral pressure might help obtain a more precise goal in resuscitation and less complication from supraphysiologic pressure in the proximal area to the balloon.

There are multiple possible causes of balloon rupture, including the amount of balloon inflation in a hypovolemic patient and atherosclerotic change in an elderly patient [16]. CT scan showed heavily calcified plaque along the aorta and arteries that could have caused the balloon to rupture (Figure 8).

Multiple P-REBOA and I-REBOA inflation cycles did not reveal any bleeding through the arterial port until our preparation for balloon deflation and removal. After confirming the balloon's position at zone III by fluoroscopy, the balloon showed good contour and no extravasation in the aortic column. No physiologic change occurred nor was any resuscitation needed before the balloon ruptured.

Regarding the outcome of TBI, the patient demonstrated persistent drowsiness the day after the surgery. CT scan of the head was repeated, and the results showed the progression of ICH. Neurosurgical evaluation revealed survivable TBI with no mass effect, such as midline shift. The prognosis was discussed with relatives, and a non-operative approach was decided due to the patient's advanced age. At approximately 3 months after surgery, the patient died due to respiratory failure and sepsis. During admission, his clinical status was stable with no need for inotropic support or renal replacement therapy.

Our review to identify the cause of intracranial bleeding progression revealed the presence of undetected and uncorrected coagulopathy. Accordingly, assessment for coagulopathy has been added to the multidisciplinary assessment protocol. Although we do not currently have this instrument at our center, thromboelastography would improve our ability to identify the presence of or risk for coagulopathy in traumatized patients. ICH progression may also have been due to supraphysiologic pressure from the REBOA even though we attempted to maintain SBP at a high enough pressure to perfuse organs, but not high enough to worsen the ICH.

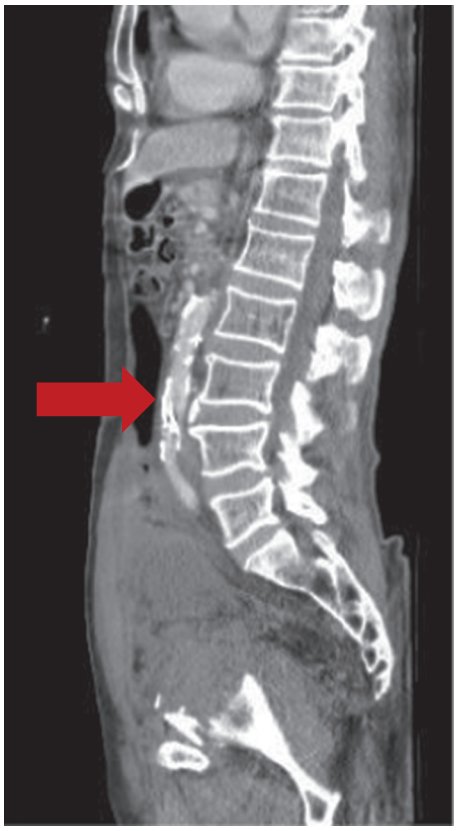

***Figure 8*** CT scan showed heavily calcified plaque along aorta and arteries, especially in the infra-renal abdominal aorta.

A combination of factors presented in this case highlights the delicate balance that must be achieved in older traumatic injury patients with coexisting TBI that require REBOA. Given the range of events and outcomes that can occur or develop, the multidisciplinary trauma team should be alert for and know how to manage endovascular-related complications.

## CONCLUSION

Partial REBOA was shown to be effective for controlling pelvic fracture-related hemorrhage in the profiled octogenarian trauma patient with coexisting TBI. However, this case was complicated by the competing needs of controlling bleeding, maintaining critical organ perfusion by increasing SBP, and not worsening the patient's ICH. The details provided in this report may help to improve existing protocols for managing this type of case at other centers.

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