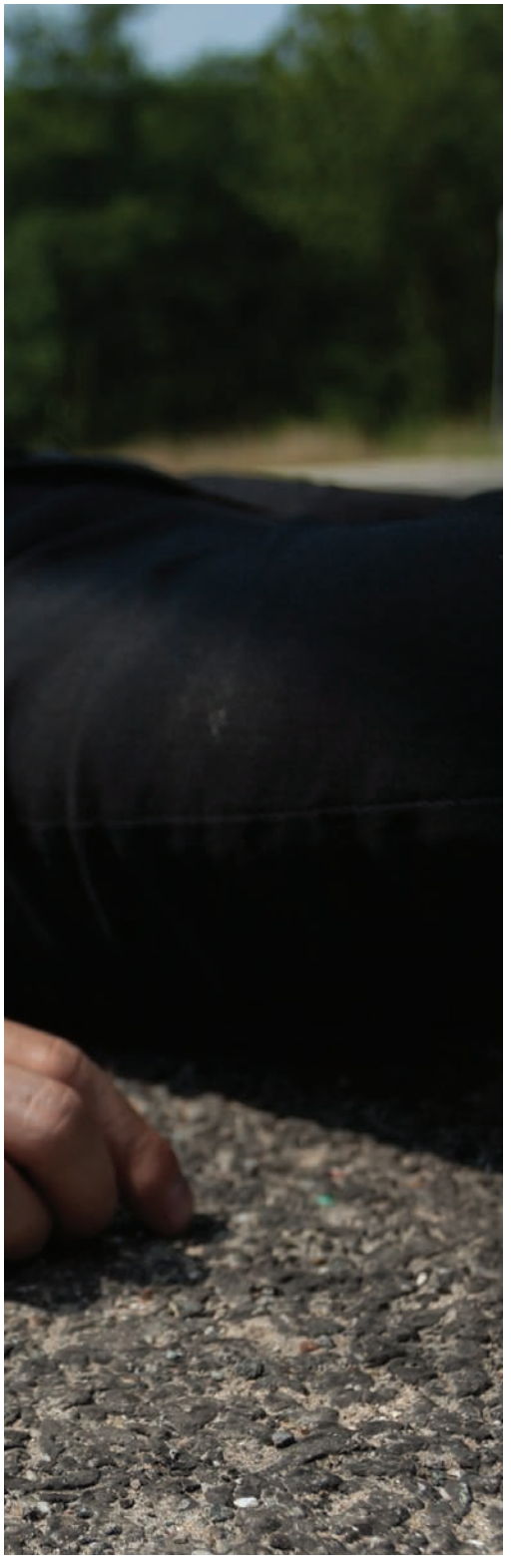

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# Managing noncompressible torso hemorrhage with REBOA

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**Abstract:** Resuscitative endovascular balloon occlusion of the aorta (REBOA) has reemerged as a treatment for noncompressible torso hemorrhage. This article discusses indications and contraindications for REBOA, describes the procedure, and reviews nursing considerations for patients undergoing REBOA.

**Keywords:** NCTH, noncompressible torso hemorrhage, REBOA, resuscitative endovascular balloon occlusion of the aorta, resuscitative thoracotomy, trauma

IN RECENT YEARS, the use of a percutaneous technique called resuscitative endovascular balloon occlusion of the aorta (REBOA) has reemerged as a treatment for noncompressible torso hemorrhage (NCTH), a leading cause of potentially preventable trauma mortality in both military combat personnel and civilian patients.[1] This type of hemorrhage is not readily accessible or responsive to external compression. REBOA involves placement of an endovascular balloon in the aorta to control bleeding and provide a window of opportunity for resuscitation and definitive hemorrhage control.[2] This article discusses indications and contraindications for REBOA, describes the procedure, and reviews nursing considerations for patients undergoing REBOA.

## Military origins

REBOA was first described in the Korean War as a less invasive alternative to resuscitative thoracotomy; however, outcomes were poor.[3] But in recent years, REBOA reemerged as an effective adjunct in hemodynamically unstable patients with uncontrolled NCTH to provide a period of temporary stability before and during injury repair (see *How does REBOA compare with resuscitative thoracotomy?*).

NCTH, which can result from both venous and arterial injury, involves bleeding into the chest, abdominal cavity, and pelvis, as well as junctional hemorrhage from noncompressible sites in the axilla or groin.[4] Due to rapid exsanguination, it is associated with high mortality.[3]

For definitive treatment, NCTH requires immediate access to a surgical team or interventional radiologist. Aortic occlusion as part of initial trauma resuscitation can reduce the amount of bleeding and provide a window of opportunity for resuscitation and definitive hemorrhage control.[2]

**NCTH is a leading cause of potentially preventable trauma mortality in both military combat personnel and civilian patients.**

## Indications for REBOA

REBOA is indicated for traumatic life-threatening hemorrhage below the diaphragm in adults who present in hemorrhagic shock and who have been unresponsive to standard fluid resuscitation.[5] REBOA is not FDA-approved for use in pediatric patients. Although use of REBOA in pediatric patients has been reported, no guidelines have been developed for its use in this population.[6]

In adults with a penetrating injury to the pelvis or groin area with uncontrolled hemorrhage from a vascular injury of iliac or common femoral vessels, REBOA can provide temporary hemorrhage control until surgical laparotomy or interventional radiology procedures can be employed. Contraindications include traumatic aortic injury and hemorrhage proximal to the zones of occlusion for balloon inflation (discussed below), which include areas of the neck, axilla, and superior mediastinum.[2] A chest X-ray should be obtained before initiating REBOA to rule out aortic injury. REBOA is also contraindicated in patients who are not candidates for resuscitative thoracotomy and patients with penetrating thoracic trauma or evidence of thoracic hemorrhage.[2]

Relative contraindications to REBOA include older age (over age 70), pulseless electrical activity arrest lasting longer than 10 minutes, inability to access the femoral artery (the recommended access site), and the presence of terminal illness or profound comorbidities.[2,4]

## Zoning in on the procedure

For the purposes of REBOA, the aorta is divided into three separate zones (see *Landmarks for inflation zones*). Selection of the inflation zone is based on the suspected zone of injury.

- Aortic Zone I extends from the origin of the left subclavian artery to the celiac trunk. Occlusion in this zone controls blood flow to the abdominal viscera, the pelvic region, and the lower extremities.[3,4]
- Aortic Zone II extends from the celiac artery to the lowest renal artery and is considered a "no occlusion" zone due to the difficulty of occluding bleeding vessels at this aortic

## How does REBOA compare with resuscitative thoracotomy?

Prior to the reemergence of REBOA, aortic occlusion was accomplished by emergent thoracotomy with clamping of the descending aorta. Resuscitative thoracotomy (RT) has been used for severely ill trauma patients as a last effort for resuscitation of patients in extremis. However, RT has been associated with low survival rates. REBOA is a less-invasive method of aortic occlusion compared with RT with aortic cross-clamping. REBOA allows for hemorrhage control by blocking blood flow through the aorta via balloon inflation, promoting clot formation and hemodynamic stabilization. REBOA also augments blood flow to organs above the point of occlusion, including the brain and heart.[2]

Currently no high-grade evidence has demonstrated that REBOA improves outcomes or survival compared with standard treatments for severe hemorrhage.[5] Comparing the use of REBOA with RT, the American Association for the Surgery of Trauma's aortic study group concluded that overall survival rates may be higher in patients who underwent REBOA in certain patient populations.[14] Patients who did not require CPR before the initiation of the aortic occlusion might benefit most from REBOA. No difference was seen in survival of patients who required CPR before aortic occlusion with REBOA or RT.[14]

location and the risk of injury to visceral or renal vessels.[7]

• Aortic Zone III includes the infrarenal abdominal aorta from the lowest renal artery to the aortic bifurcation. This site is used to control bleeding in the pelvis, groin, and lower extremities.[3]

The REBOA procedure involves inserting an endovascular balloon catheter into an artery, usually a femoral artery, and advancing it into the patient's aorta, where the balloon is inflated. Once inflated, the balloon occludes arterial flow, giving surgeons time to operate.

The REBOA procedure has five fundamental steps:

**Step 1: Arterial access.** The common femoral artery, accessed via a femoral artery, is most commonly used to establish access for the aortic balloon catheter. Arterial access may be difficult and require femoral cutdown. After femoral artery access is obtained, a 7 Fr vascular access sheath is introduced for insertion of the REBOA balloon catheter. This catheter has an arterial monitoring port above the balloon for continuous BP monitoring.

**Step 2: Balloon selection and positioning.** The depth for REBOA advancement is determined using radiographic or external landmarks. The location and measurements for inflating the balloon are based on anatomical landmarks associated with the desired occlusion zone.[8] After the REBOA balloon catheter is inserted through the vascular access sheath to the desired depth, placement is confirmed by ultrasound or radiography.

**Step 3: Balloon inflation**. Once correct placement has been confirmed, the balloon can be inflated with a balloon inflation medium or 0.9% sodium chloride solution. During aortic occlusion, expedient surgical exploration is conducted to identify and treat life-threatening injuries.

Balloon inflation time is equivalent to aortic cross-clamp time used in resuscitative thoracotomy. Perfusion to the abdominal viscera and lower extremities is halted until the balloon is deflated. The balloon should be inflated until BP stabilizes or begins to rise and contralateral femoral pulses are absent. Unintended overinflation of the balloon may lead to balloon rupture or vessel injury.[5]

Accurately monitoring the length of time the balloon is inflated is critical because prolonged occlusion can cause profound distal ischemia. The literature suggests that occlusion times of less than 1 hour can be tolerated in patients with Zone I occlusions, but survival is dismal when occlusion lasts longer than 1 hour. Zone III occlusion is well tolerated for several hours with constant monitoring of distal perfusion.[9]

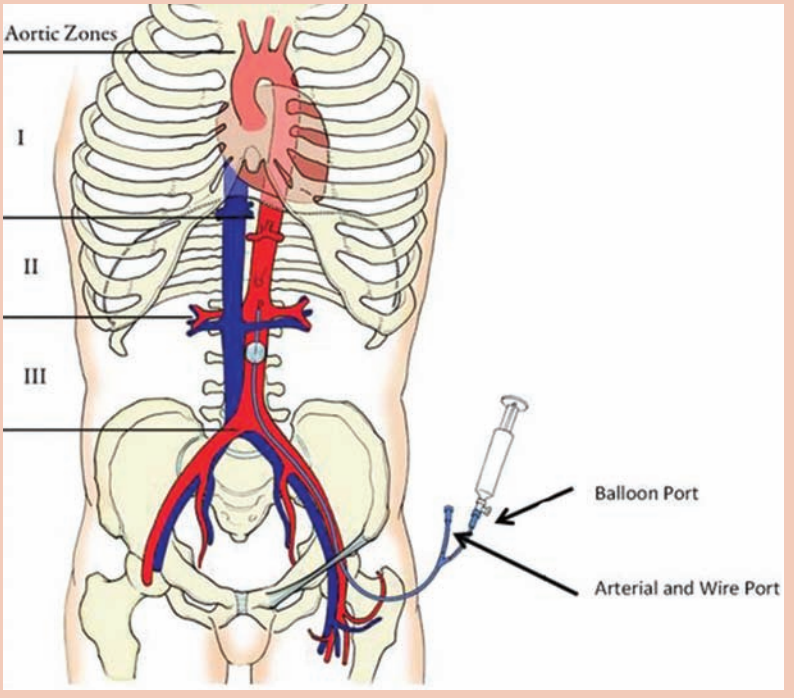
The provider may temporarily deflate the balloon and allow for transient reperfusion intervals until definitive hemorrhage control is achieved. This strategy preserves organ perfusion above the area of occlusion but allows for hypotension resuscitation below the area of occlusion. It may also decrease ischemia and reperfusion injuries associated with aortic occlusion.[2]

Throughout this process, resuscitation should be ongoing with appropriate administration of blood and blood products.

**Step 4: Balloon deflation.** Once hemorrhage has been controlled, the balloon is slowly deflated with continuous monitoring of the patient's physiologic response to deflation.

**Step 5: Catheter and sheath removal**. When the patient has been stabilized and the REBOA device is no longer needed, the balloon catheter and sheath can be removed. Manual pressure should be applied at the puncture site for at least 20 minutes before a pressure dressing is applied. If a sheath larger than 12 Fr was used for access, surgical repair is required for adequate arterial closure.[3]

## Landmarks for inflation zones




Source: Luedi MM, Phillips MC. *100 Selected Case Reports from Anesthesia & Analgesia.* Philadelphia, PA: Wolters Kluwer.; 2019.

REBOA requires a skilled operator and a team fully trained in using the technique and device to assist with the setup and monitoring. Providers require additional training to become sufficiently familiar with the procedure.[3] Many times this expert skill and the necessary equipment are not readily available for the successful use of REBOA, limiting its usefulness in many settings.

## Complications

Most complications to REBOA are related to groin access, technique, and duration of aortic occlusion. Complications related to femoral access include arterial disruption, dissection, pseudoaneurysms, hematoma, thromboemboli, and extremity ischemia, which can result in rhabdomyolysis and renal failure. Unintended inflation of the balloon in the iliac vessels may lead to thrombosis or vessel rupture. All of these complications can be fatal or cause limb loss.[5,10]

In addition, balloon rupture may occur if the balloon is overinflated relative to the diameter of the aorta. Prolonged aortic occlusion can cause prolonged ischemia.[5] Prolonged ischemia followed by reperfusion may result in multilevel organ failure and other potentially fatal complications, including acute kidney injury, liver failure, spinal cord infarct, intestinal ischemia, myonecrosis, and limb loss.[11]

**Vigilant patient monitoring begins with initial resuscitation and continues during and after the REBOA procedure.**

## Nursing implications

Patients who are being considered for REBOA are in extremely critical condition. Nurses need to closely monitor the patient's hemodynamic status to recognize any life-threatening changes. Vigilant patient monitoring begins with initial resuscitation and continues during and after the REBOA procedure. The patient's cardiovascular status is assessed via continuous cardiac monitoring, BP monitoring, and pulse oximetry. Any change in clinical status needs to be reported to the resuscitation team immediately.

Before the procedure, the clinical nurse needs to be familiar with the necessary equipment and setup. Facilities that utilize REBOA should have a guideline along with the clinical algorithms outlining the use of REBOA. The necessary equipment should be bundled into a REBOA kit that is easily accessible in a central location (see *Suggested contents of a REBOA kit*). This kit should be routinely checked for completeness, functionality, and expiration dates.[3]

During the procedure, precise documentation is imperative. Timing of balloon inflation and total inflation time must be accurately recorded. The patient should be closely monitored for any life-threatening conditions such as hypotension, cardiac dysrhythmias, respiratory compromise, and altered mental status throughout the procedure. Administer fluid resuscitation and blood transfusions as prescribed.

After balloon deflation and removal, the patient continues to require close cardiovascular monitoring as well as neurovascular assessments of the vascular access extremity. A clinical management guideline is imperative to direct postprocedure assessment and care. A recommended protocol is to assess vital signs every 15 minutes for the first 2 hours following the procedure, then every 30 minutes for the next 2 hours, and then hourly.[3]

Assess the vascular access extremity with each vital sign assessment for active bleeding or hematoma formation, and document findings. Also assess and grade peripheral pulses and assess for any sensory or motor deficits.

### Suggested contents of a REBOA kit[3]

- personal protective equipment: gowns, sterile gloves, mask
- sterile drape
- access needle (18 gauge)
- 7 Fr introducer sheath with guidewire
- 4 prefilled 10-mL syringes containing 0.9% sodium chloride solution
- 30-mL syringe
- scalpel
- REBOA balloon catheter
- arterial pressure monitoring device
- catheter clamp
- nylon suture
- large transparent dressing.

The vascular access extremity must also be continually monitored for compartment syndrome, which along with rhabdomyolysis can result from reperfusion.[3] Reperfusion injury occurs when blood flow is restored to tissue after a period of ischemia, leading to pain and edema. Increasing edema leads to further ischemia and injury. To recognize signs and symptoms of compartment syndrome, remember the 5 P's: pain out of proportion during passive stretch, pallor, paresthesias, pulselessness, and paralysis.[12,13]

## Improving survival

NCTH from abdominal or pelvic hemorrhage remains a leading cause of potentially preventable death from trauma. REBOA can be a useful adjunct in controlling hemorrhage but it also has major limitations, such as the potential for vascular injury and the need for highly trained personnel. With advances in technology, training, education, and experience, however, many of these limitations can be overcome. ■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