REBOA for Acute Injury

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Indications for Procedure

- Hemodynamic instability unresponsive to initial resuscitative measures in a patient with a source of hemorrhage below the level of the diaphragm.
- REBOA may be considered in a patient with cardiac arrest with a presumed source of hemorrhage below the level of the diaphragm; utilizing this approach rather than a resuscitative thoracotomy remains controversial.

Impact of Associated Injuries

- REBOA should not be placed if presumed major intra-thoracic injuries, injuries to aorta, great vessels, or exsanguination from above the diaphragm (neck, upper extremities etc).
    - Chest radiograph is done to evaluate for a widened mediastinum which can suggest severe aortic injury, or massive hemothorax.
- FAST exam is used to evaluate for hemopericardium or hemoperitoneum.
- Pulse differential in femoral arteries particularly in setting of penetrating pelvic injury may suggest an ilieofemoral injury which may be problematic for insertion. If a pulse differential is appreciated, access the CFA on the least or non-affected side.

Pre-procedure Preparation

- Chest radiograph and FAST exam are used to assist in the decision to place a REBOA.
- Assess for groin scars, previous history of vascular surgery in aorto/iliac/femoral regions.
- Bilateral lower extremity neurovascular exam is performed prior to the procedure and documented.
- Consider placing a common femoral A-line early. If the decision is made to perform REBOA the A-line catheter can be upsized easily (7Fr or 12Fr depending on which REBOA device is used)

Procedural Considerations

Arterial access

- Access the ***common femoral artery (CFA)***.
    - Arterial access must be obtained in the CFA, not the SFA.
    - This can be done using an open or percutaneous technique.
    - Exchange of the catheter over a guidewire from an existing femoral arterial line can be performed, assuming it is in the CFA.
    - If any difficulty is encountered with percutaneous access, move to an open approach rapidly.
    - To ensure placement in the common femoral artery, access the vessel 2 cm below the inguinal ligament, above the bifurcation of profunda/superficial femoral artery (SFA). External landmarks for the inguinal ligament are the anterior superior iliac spine to the superiolateral pubic tubercle.
- Ultrasound should be used to locate the artery when feasible.

- If the initial femoral arterial line is not in the CFA, do not upsize to a 7Fr or 12Fr sheath. Large sheaths in the SFA or at the bifurcation will likely result in thrombus formation, thromboembolic events, obliteration of the bifurcation requiring extensive reconstruction, limb ischemia, and/or limb loss.

Selection and Position of the Balloon

- Zones of the aorta include:
    - Zone I is the descending thoracic aorta between the left subclavian and celiac arteries
    - Zone II is between the celiac and lowest renal artery
    - Zone III is the infrarenal aorta
- There are a variety of balloon catheters available:
    - Original procedures utilized long guidewire platforms and large sheaths (10-14Fr).
    - There is a new smaller catheter compatible with a 7Fr sheath (see device IFU for list of compatible sheaths (see diagram), which is able to transmit systemic arterial pressure proximal to the balloon. It is important to know the requirements and FDA-approved instructions for use of the catheter before use.
- Approximate the correct position for balloon placement using external landmarks:
    - Zone 1: bottom of balloon just above xiphoid for intra-abdominal or retroperitoneal hemorrhage
    - Zone 3: bottom of balloon just above the umbilicus for severe pelvic or lower extremity hemorrhage

Balloon Inflation/Deflation with ER-REBOA® (Prytime Medical Inc), a 7Fr Compatible Device

- A chest or abdominal radiograph should be obtained to confirm position prior to balloon inflation (optional in patients in arrest) if not performed under fluoroscopy. Radiopaque markers are at the proximal and distal ends of the balloon. The balloon catheter must be secured at the sheath BEFORE, DURING, AND AFTER INFLATION. The ER-REBOA catheter can migrate distally.
- Inflate the balloon with iodinated contrast in a mixture of approximately 1/3 contrast and 2/3 saline, ideally under fluoroscopy. If contrast is not available in a timely fashion, normal saline is adequate. The mixture of contrast and saline is important; contrast is very sticky so too much in the balloon will make it difficult to entirely deflate the balloon and then it cannot be removed from the sheath
- Inflate until the balloon abuts to the aortic wall, which can be determined by the amount of resistance in the syringe.
- Know the maximal volume of fluid for the balloon being used. The volume for Zone III positioning will be significantly less than for Zone I; for example, zone III is typically 6-18cc while zone 1 is 15-24cc. The ER-REBOA balloon holds a maximum of 24cc to inflate it to a diameter of 3.2cm.

- Over inflation of the balloon can injure the aorta. Confirmation of device placement prior to inflation will ensure the balloon is not inflated in the iliac (or alternate vessel) which may result in vessel rupture with the smallest inflation amounts.
- Do not inflate the balloon in Zone II if possible. Reposition and re-image.
- The maximal time of balloon inflation is not known. Remove the balloon when hemostasis is controlled.
- Deflation can be accompanied by hypotension and reperfusion injury (acidosis, hyperkalemia), be sure to communicate with anesthesia colleagues.

Removal/Post-procedure Management

- The large diameter sheaths (>7Fr) should be removed with open surgical exposure and direct repair of the vessel. The arteriotomy should be closed transversely with 5-0 or 6-0 monofilament suture.
- Smaller diameter sheaths (7Fr) can be removed at the bedside once coagulation status is optimized. Direct manual pressure should be applied for approximately 30 minutes and the patient should be kept supine for six hours.
- Regardless if open or percutaneous removal is utilized, distal perfusion should be assessed before and after removal. Inadequate back-bleeding or in-flow, dissection flaps, visualized thrombus, lack of distal perfusion, or uncertainty in evaluating any of these should prompt exploration and on-table angiography.

Complications

- Rupture of the aorta at the site of balloon inflation or injury to the aorta from placement/migration.
- Worsening hemorrhage if balloon placed distal to a proximal site of bleeding.
- Injury (dissection) of the iliac or femoral artery.
- Ischemia of the extremity distal to site of access
- Significant central hypertension especially at Zone I.

Considerations for Special Populations

- No absolute contraindications have been established. However, it is advisable to refrain in patients with known previous femoral-femoral bypass, axillary-femoral bypass, iliac artery stenosis, or aortoiliac aneurysms.

Suggested Readings

- Stannard A, Eliason JL, Rasmussen TE. Resuscitative endovascular balloon occlusion of the aorta (REBOA) as an adjunct for hemorrhagic shock. J Trauma 2011;71(6):1869-72.

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Image of 7F REBOA catheter