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Resuscitative endovascular balloon occlusion of the aorta for control of noncompressible truncal hemorrhage in the abdomen and pelvis

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Abstract

BACKGROUND: Noncompressible truncal hemorrhage is a leading cause of potentially preventable death in trauma and acute care surgery patients. These patients are at high risk of exsanguination before potentially life-saving surgical intervention may be performed. Temporary aortic occlusion is an effective means of augmenting systolic blood pressure and perfusion of the heart and brain in these patients. Aortic occlusion temporarily controls distal bleeding until permanent hemostasis can be achieved. The traditional method for temporary aortic occlusion is via resuscitative thoracotomy with cross clamping of the descending aorta. While effective, resuscitative thoracotomy is highly invasive and may worsen blood loss, hypothermia, and coagulopathy by opening an otherwise uninjured body cavity. Resuscitative endovascular balloon occlusion of the aorta (REBOA) achieves temporary aortic occlusion using an occlusive balloon catheter that is introduced into the aorta via endovascular access of the common femoral artery. For this reason it is thought that REBOA could provide a less-invasive method for temporary aortic occlusion. Our purpose is to describe our experience with the implementation of REBOA at our Level 1 trauma center.

METHODS: A retrospective case series describing all cases of REBOA performed at a prominent level 1 trauma center between October 2011 and September 2015. The study inclusion criteria were any patient that received a REBOA procedure in the acute phases after injury. There were no exclusion criteria. Data were collected from electronic medical records and the hospital's trauma registry.

RESULTS: A total of 31 patients underwent REBOA during the study period. The median age of REBOA patients was 47 (interquartile range [IQR] = 27 to 63) and 77% were male. A majority (87%) of patients sustained blunt trauma. The median injury severity score was 34 (IQR = 22 to 42). The overall survival rate was 32% but varied greatly between subgroups. Balloon inflation resulted in a median increase in systolic blood pressure of 55-mm Hg (IQR 33 to 60), in cases where the data

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were available (n = 20). A return to spontaneous circulation was noted in 60% of patients who had arrested before REBOA (n = 10). Overall, early death by hemorrhage was 28% with only 2 deaths in the emergency department before reaching the operating room.

CONCLUSIONS: REBOA is an effective method for achieving temporary aortic occlusion in trauma patients with noncompressible truncal hemorrhage. Balloon inflation correlated with increased blood pressure and temporary hemorrhage control in a vast majority of patients.

Hemorrhage remains the leading cause of potentially preventable deaths in traumatically injured patients.[1–4] Hemorrhage can be broadly categorized as compressible (ie, amenable to control with direct pressure or tourniquet application) or noncompressible (ie, solid organ injury). Patients with noncompressible truncal hemorrhage (NCTH) have very high-mortality rates, ranging from 18% to 50%,[5–7] are at high risk of exsanguination before potentially life-saving surgical interventions can be performed. These critically injured patients are at high risk of progression to cardiovascular collapse if rapid hemorrhage control cannot be obtained.

Historically, resuscitative thoracotomy (RT) with clamping of the thoracic aorta has been performed in patients with cardiovascular collapse from NCTH. Aortic cross clamping provides for increased afterload with improved cardiac and cerebral perfusion as well as temporary inflow control to slow hemorrhage arising below the diaphragm. The use of RT is typically a reactive procedure that is reserved for patients with loss of vital signs. Although RT is effective, this procedure is maximally invasive and may worsen blood loss, hypothermia, and coagulopathy by opening an otherwise uninjured body cavity. Despite the physiologic benefits of aortic cross clamping, the performance of RT results in a significant physiologic insult to the patient and a relatively poor survival rate of 0% to 15%.[8–15]

In recent years, there has been a renewed interest in the utilization of resuscitative endovascular balloon occlusion of the aorta (REBOA) as minimally invasive alternative to open aortic cross clamping to provide temporary aortic occlusion.[16–19] This technique involves placement of an occlusion balloon via a sheath placed into the common femoral artery. Balloon occlusion of the aorta has been shown to mitigate hemorrhage and augment systolic blood pressure (SBP) and perfusion of the heart and brain.[8,9,20] REBOA allows for the same physiologic result as open aortic cross clamping through a less invasive, endovascular approach. Because of its minimally invasive nature, REBOA can be performed as a proactive (rather than reactive) measure in patients with refractory hemorrhagic shock from intra-abdominal/pelvic bleeding. Our purpose is to describe our initial experience with the implementation of REBOA at our American College of Surgeons–verified Level 1 Trauma Center.

Patients and Methods

We retrospectively identified all patients that underwent REBOA at The Texas Trauma Institute, an American College of Surgeons–verified Level 1 Trauma Center in Houston, Texas between October 2011 and September 2015. Inclusion criteria were all patients that underwent REBOA during the study period. No patients that underwent REBOA were excluded from the study. Demographic data, mechanism of injury, injury severity score (ISS), Abbreviated Injury Scale, admission vital signs/laboratory values, morbidity, mortality, and discharge disposition were all obtained from trauma registry data. The change in SBP before and after REBOA inflation was obtained from chart review of nursing documentation and review of the performing surgeon's procedure notes. Zone of occlusion was determined by review of digital radiographs obtained at the time of REBOA insertion.

All surgeons performing REBOA during the study period had received formal training in technique. Two of the surgeons were trained at the Endovascular Skills for Trauma and Resuscitative Surgery course.[21] The remaining trauma surgeons were trained via a modified version of the Advanced Surgical Skills for Exposure in Trauma course. Each surgeon was required to demonstrate proficiency with the technical aspects of REBOA placement before clinical use. The zones of aortic occlusion (see Fig. 1) are defined as follows: zone 1 is from the takeoff of the left subclavian artery to the celiac artery, zone 2 is from the celiac artery to the lowest renal artery, and zone 3 is from the takeoff of the lowest renal artery to the aortic bifurcation. Zones 1 and 3 are the preferred zones of occlusion and

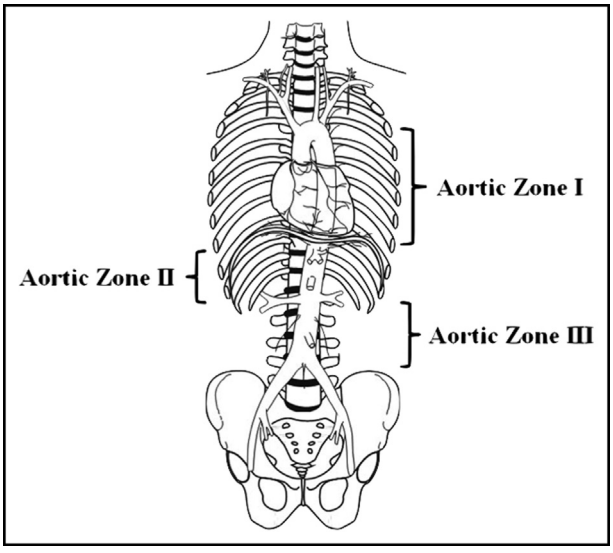

Figure 1 Aortic zones of occlusion.