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Management of Intra-Abdominal Hemorrhagic Shock Using REBOA

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Hemorrhage is the leading cause of potentially preventable death after a traumatic injury.[1-3] Noncompressible torso hemorrhage (NCTH), which is a disruption of the vascular activity of the axial torso vessels, pulmonary parenchyma, solid organs, or the bony pelvis, accompanied by shock,[4] has an associated mortality of approximately 45%.[5] A significant number of these deaths often occur because of the delay in definitive hemorrhage control in an operative theater or interventional radiology suite. Therefore, a need for adjunct hemorrhage control is paramount to attaining temporary control of bleeding until definitive hemostasis can be achieved.[3-5] A key to improving outcomes in patients with NCTH is a "bundle" of measures that can facilitate early diagnosis, rapid control of hemorrhage, systemic and topical hemostatic support, and a short time at the scene. In the past decade a paradigm shift has occurred in treatment strategies and transfusion algorithms, with emphasis on hemostatic or damage control resuscitation.[2,6]

To promote early resuscitation and hemorrhagic control, one rational approach is early stabilization in the emergency department. Iatrogenic aortic occlusion has been a traditional way to attempt hemostasis. Two major techniques have been used to occlude the aorta. Resuscitative thoracotomy (RT) with aortic cross-clamping was first documented for trauma in 1976.[7] The other method uses resuscitative endovascular balloon occlusion of the aorta (REBOA), which is performed by a trained acute care surgeon. Interestingly, balloon occlusion as a resuscitative adjunct is not a new or novel intervention. In 1954, Hughes describes this technique as a resuscitative strategy for stabilization of the shock state in the setting of combat injuries.[8] Recently, REBOA has been reappraised because of the military's interest in developing a better way to manage hemorrhagic shock in the field. Until now, these efforts of damage control resuscitation have focused on training, hemostatic dressings, extremity and junctional tourniquet devices, and aggressive resuscitation using blood products and tranexamic acid. Therefore, the driving force behind REBOA in the hospital setting is the need to develop adjunct strategies to lessen shock states and improve survival.[9-11] Physiologically, occlusion of the aorta during hemorrhagic shock results in increased cardiac output, mean arterial pressure, coronary blood flow, carotid blood flow, and partial oxygen pressure of the brain.[9,12,13] Classically in trauma, aortic occlusion has been performed via aortic cross-clamping with a resuscitative thoracotomy. Unfortunately, the RT technique is maximally invasive and has a survival rate of less than 10% in modern settings.[14,15]

In comparison, REBOA supports proximal aortic pressure and minimizes hemorrhage, allowing for adequate resuscitation and surgical repair. Aortic occlusion balloon devices were originally used in the setting of ruptured abdominal aortic aneurysms (AAAs), which have a similar clinical sequela much like NCTH in trauma. Early on, the treatment for AAAs began with the thoracotomy approach as a means to obtain proximal aortic control and has now evolved into the common practice of using intra-aortic balloons. The effectiveness of REBOA in the setting of ruptured AAAs has been very well established and successful.[16-18]

From a brief technical standpoint, placement of REBOA can be divided into the following steps: (1) femoral arterial access, (2) balloon selection and positioning, (3) balloon inflation, (4) balloon deflation, and (5) sheath removal.[6] Obtaining arterial exposure and using plain radiographs to determine device placement are standard practices for trauma and acute care surgeons. The additional endovascular skills needed for sheath and wire insertion and optimal balloon positioning can be easily acquired with additional training.[19] When using REBOA, the trauma surgeon must determine which zone of occlusion should be used. The aortic zones of occlusion include zone I (origin of the left subclavian artery to the celiac artery), zone II (the celiac artery to the lowest renal artery), and zone III (the lowest renal artery to the aortic bifurcation). Inflation of REBOA in zone I is likened to thoracic aortic clamping that

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would be performed during RT. In comparison, zone I occlusion is often used in patients suspected of having intra-abdominal hemorrhage, and zone III occlusion is used for suspected hemorrhage from a confirmed pelvic fracture.[20]

Management of patients with NCTH of the chest, abdomen, and/or pelvis can be challenging, to say the least. The fate of a patient with potentially survivable injuries depends on the acute care surgeon's effective action and the availability of necessary resources.[10,11,19,20] It is critical that this technique be rigorously evaluated before it is widely used. In a current multicenter study of the American Association for the Surgery of Trauma, data are being collected on patients who undergo aortic occlusion via REBOA, thoracotomy, or laparotomy with aortic cross-clamping to compare outcomes. This study will likely supply valuable data on the outcomes in a variety of settings.[21] Widespread promotion of REBOA for use in trauma is premature at this time but should be considered as part of "toolbox" for the trauma and acute care surgeon as an adjunct for hemorrhage, along with the traditional ED thoracotomy, pelvic packing, surgical exploration, and/or angiography. Institutional resource allocation and training for trauma and acute care surgeons will likely have a large role in the adoption of REBOA as a first-line therapy as opposed to ED thoracotomy.[11,19,20]

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