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Use of Endovascular Balloons may Simplify Proximal and Distal Control in Complicated Vascular Trauma

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INTRODUCTION

The optimal management of vascular injuries remains a significant challenge of modern trauma care, especially when the injuries are complex or located in anatomic areas that are difficult to surgically expose or control. The mortality rates from these injuries can be high, despite recent progress in the application of damage control management concepts [1,2]. As an additional challenge, many of these injuries may require initial management by trauma or vascular surgeons who do not routinely manage complex vascular injuries [3]. Advancements in endovascular techniques have introduced new alternatives to traditional open repair strategies that may prove useful in the setting of complex vascular injury [4], but the introduction of these novel strategies is not yet commonplace.

The basic tenet of proximal and distal vascular control prior to definitive repair remains an important strategy of vascular injury treatment. In practice, many patient factors such a body habitus and physiologic condition of the patient make less invasive options attractive. Intravascular balloon occlusion is a novel endovascular strategy that may be of particular use in these situations. This case report highlights successful utilization of this less invasive approach and affords an opportunity to review a simplified approach using endovascular balloons as proximal and distal control measures, in order to limit the challenges represented by more extensive anatomic exposures in a victim of trauma.

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Case Description

A previously healthy 20-year old male cyclist was severely injured when struck by a motor vehicle. In the prehospital phase of care, his vitals were: blood pressure, 110/74; heart rate, 114; GCS, 10; and reduced breath sounds bilaterally. Needle thoracostomy was performed bilaterally and the patient was transferred to a nearby hospital. Upon arrival to the trauma bay, the patient was intubated and ventilated. Thoracostomy tubes were inserted simultaneously to both sides of the chest, with the evacuation of a small amount of air and blood bilaterally. On physical examination, a large

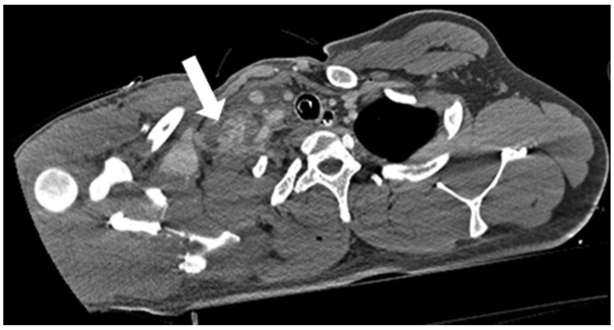

Figure 1 Contrast media extravasation to upper mediastinum hematoma in late phase chest CT angiography scan (white arrow).

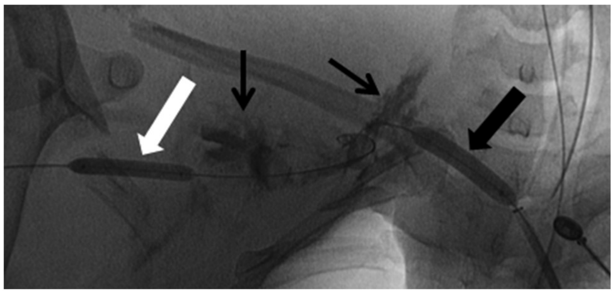

Figure 2 Contrast media extravasation (two small black arrows), proximal occlusion balloon (black arrow) and distal occlusion balloon (white arrow).

hematoma was noted on the right upper chest anteriorly above and below the right clavicle. Multiple bilateral rib fractures were clinically diagnosed. No radial pulse was able to be palpated in the right upper extremity. The remainder of the patient's physical examination was unremarkable. Focused abdominal sonography for trauma (FAST) did not reveal any sign of pericardial or peritoneal fluid. The patient remained stable and underwent additional imaging. Computed tomography (CT) of the brain, neck, and abdomen was interpreted as normal. Chest CT showed small bilateral pneumothorax, multiple right-sided rib fractures, a scapula fracture, and a displaced fracture of the right clavicle with surrounding large hematoma expanding to the neck, upper mediastinum, and right shoulder. Complete occlusion of the right subclavian artery (RSCA) with significant contrast extravasation was noted on CT angiography (Figure 1).

The patient was then taken to surgery were repeated attempts to traverse and repair the RSCA tear endovascularly, using both the femoral artery as well as right brachial artery approaches failed. The decision was made to attempt open exposure and the direct repair of the injury. Our operating room is not a hybrid room but allows the use of C-arm with high imaging quality. In order to reduce the blood loss during the subsequent open surgical exposure in a difficult anatomic location, proximal and distal arterial control was achieved with two percutaneous transluminal angioplasty balloons (Cordis PowerFlex Pro, Milpitas, CA, USA). An 8 × 40 mm^2 balloon was inserted percutaneously via a right femoral approach and placed in the proximal RSCA and a 7 × 40 mm^2 balloon, was inserted via the right brachial artery and placed in the right axillary artery (Figure 2). The femoral sheath used was 10 Fr and 80 cm length, and the brachial sheath was 6 Fr and 11 cm length. The RSCA was exposed using both supraclavicular and infraclavicular incisions, in order to prevent removal of the clavicle. No active bleeding was noted from the arterial injury. A 5-cm gap between the proximal and the distal edges was repaired using an 8-mm ringed polytetrafluoroethylene (PTFE) interposition graft (WL Gore & Associates, Inc., Flagstaff, AZ, USA), which was tunneled under the clavicle. The total occlusion time was 1 hour and 45 minutes, with no vertebral artery occlusion. During the surgery, the patient received two units of blood and three units of fresh frozen plasma. The postoperative course was complicated by right femoral artery thrombosis, presenting on the second postoperative day, most probably associated with the duration of sheath utilization (8 hours), which was treated by thrombectomy. The rest of his course was uneventful and he was discharged home on postoperative day twelve.

DISCUSSION

The most common causes of death among trauma patients, who arrive at the hospital alive, are brain injury and bleeding. These patterns of immediate (within 24 hours) deaths have remained consistent during the last three decades [5,6]. Among trauma victims dying from hemorrhage, the majority die from bleeding originating from large vessels in the torso [7]. The literature describes high mortality rates even in well-established trauma centers for this subset of patients. Asensio et al. reported 54% mortality rate in a study of 302 consecutive trauma patients with abdominal vascular injury and showed a strong correlation between mortality and the number of injured vessels [1]. The mortality secondary to neck and chest vascular injuries is similar, reported as 55% in one study of 165 trauma patients [8]. The reason for these poor results is likely to be multifactorial. The management of complex vascular injuries requires significant surgical skill and experience. Achieving control of vascular injury is very difficult at particular anatomic locations, including specific regions of the chest, and junctional regions such as zone 3 neck injuries. Treating surgeons may need to be experienced and facile with a number of different approaches, exposure types and extension adaptations.

The evolution of endovascular trauma management has recently gained popularity in the vascular and trauma surgery community – either as a primary definitive treatment modality or as part of a hybrid approach combining endovascular and open treatment tools [9]. Several potential benefits of endovascular adjuncts in this setting have been proposed, including shorter hospital stays, lower morbidity and, potentially, even decreased mortality.

Although endovascular management has become the preferred treatment modality of many providers in specific scenarios, it is important to note that the present day experience has primarily been accumulated among hemodynamically stable patients. The utilization of these adjuncts also has limitations in use that must be appreciated. As in our illustrated case, to be adequately addressed by endovascular means, lesions must be traversed by a guidewire for the majority of endovascular repair options to be adequately applied. For those patients who are not stable, or for whom a wire cannot be placed across the injury, open repair remains the standard of care.

Open surgical exposure mandates proximal and distal control of the injured vessel prior to repair. Most optimally, these control locations are obtained in uninjured "virgin" fields, away from the injured vessel which is surrounded by hematoma. This approach is pursued in order to minimize blood loss during repair. In specific anatomic locations, however, such pristine distal and proximal exposures are challenging. Notorious locations in this regard include the tight anatomic confines of the thoracic inlet, within the thoracic cage and the pelvic region.

The use of two endovascular balloons as measures of gaining proximal and distal control, as was done novelly in this case, limits the amount of dissection that must be done outside the field of injury among hemodynamically stable patients. Once active bleeding is arrested in this fashion, operative incision and exposure of the injury itself can be undertaken in a more controlled fashion that affords thoughtful consideration and minimizes risk to adjacent anatomical structures that may be obscured by the hematoma or other sequelae of injury.

The outlined case demonstrates a successful collaboration between the trauma surgeon, vascular surgical providers, and the invasive radiologist to achieve optimal repair of a difficult injury using a hybrid endovascular/open approach to injury control and repair. While additional study is required to define the optimal utilization of similar applications, this type of approach warrants communication and additional study.

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