# Endovascular Repair of Blunt Aortic Injury

Do we have the right devices yet?

BY BENJAMIN W. STARNES, MD, FACS, AND GABRIEL ALDEA, MD, FACS

Blunt aortic injury (BAI) occurs in approximately 0.3% of all trauma patients who survive to emergency department presentation and is the second leading cause of trauma-related deaths, with an estimated 8,000 deaths per year. The most common cause is a motor-vehicle crash, and typical patterns of injury to the aorta occur just distal to the left subclavian artery. Most patients (approximately 85%) will die before ever reaching the hospital, and repair, if feasible, has drastically transitioned from open to endovascular repair over the past decade. In many modern case series and in the recently published AAST2 trial,[1] endovascular repair is associated with significantly reduced mortality, paraplegia, and stroke rates.

## CASE PRESENTATION

A 19-year-old male patient was involved in a high-speed motorcycle crash where he experienced rapid deceleration injury when he struck an automobile broadside. He was hypotensive in the field but responded to gentle fluid boluses. Upon arrival to the emergency department, he was hemodynamically stable, and associated injuries included an open, comminuted, displaced right humeral fracture and widened mediastinum with pulmonary contusions on chest x-ray (Figure 1). Contrast-enhanced computed tomographic angiography (CTA) of the chest demonstrated BAI with associated significant pseudoaneurysm and mediastinal hematoma (Figure 2). The maximum diameter of his thoracic aorta


**Figure 1. Chest x-ray showing a widened mediastinum with bilateral pulmonary contusions (A). Right upper extremity severe open fracture with suspicion for vascular injury (B).**

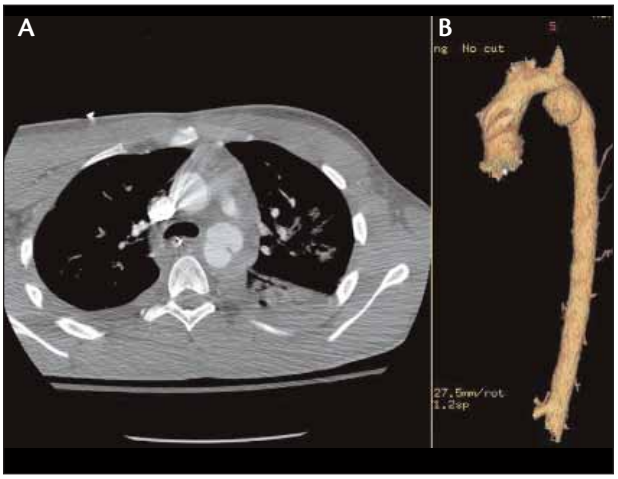


**Figure 2. Contrast-enhanced CTA (A) with reconstruction (B) demonstrating BAI with associated pseudoaneurysm, mediastinal hematoma, and left pleural effusion.**

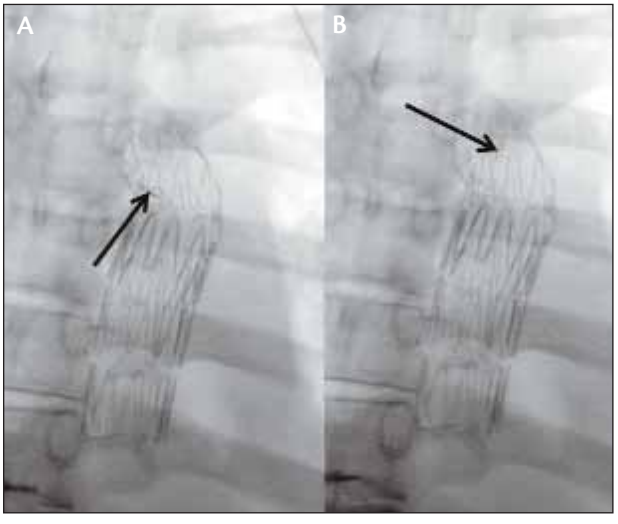


**Figure 4. Consecutive fluoroscopic images depicting intermittent collapse of the proximal stent graft with each cardiac cycle. Arrow depicts proximal stent graft marker during diastole (A) and systole (B).**

was 19 mm. Due to concern for a vascular injury in the right upper extremity, he was taken to the operating room for arteriography and possible simultaneous treatment of his BAI. Surprisingly, right axillary and brachial arteriography was normal. He subsequently underwent simultaneous off-label treatment of his BAI with two stent grafts measuring 22 X 55 mm (Cook Medical, Bloomington, IN). His left subclavian artery was intentionally covered at the time of the procedure. He tolerated this operation well and was transferred to the intensive care unit after appropriate reduction of his right humeral fracture.

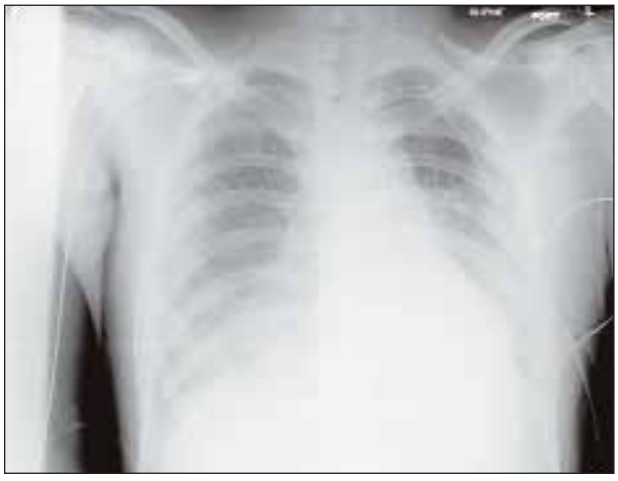

**Figure 3. Chest x-ray showing patency of the thoracic stent graft without evidence of compression of collapse.**

## AN INTERESTING TWIST

Four days after this procedure, while recovering in the postanesthesia care unit from a wound debridement, his systolic blood pressure was noted to be 45 mm Hg in an arterial line placed in his right dorsalis pedis artery. (His right arm was covered with a cast and external fixation device, and his left subclavian artery had been previously covered with the stent graft repair.) The patient was mentating and comfortable. Pulse examination revealed bilateral weak femoral pulses and bounding 2+ carotid and temporal artery pulses.

## DIAGNOSIS

Out of concern for stent graft compression/collapse, a plain chest radiograph was rapidly obtained, which revealed a patent stent graft (Figure 3). He was then taken to the operating room at which time live fluoroscopy was performed and showed intermittent compression of the device with each cardiac cycle (Figure 4). A giant Palmaz stent (Cordis Corporation, Bridgewater, NJ) was inflated in the arch under adenosine-assisted transient cardiac pause (arrest) without difficulty. On 6-month follow-up, the patient was thriving without complaint, and repeat CTA revealed a stable repair without need for secondary intervention (Figure 5).

## CHALLENGES

BAI is an injury that is ideally suited for simultaneous "damage control" and definitive management using an endovascular approach. Most modern trauma centers have welcomed these advances in the management of BAI with associated decreased rates of mortality, paraplegia and stroke when compared with traditional open repair. This approach also obviates the associated morbidity of antico-

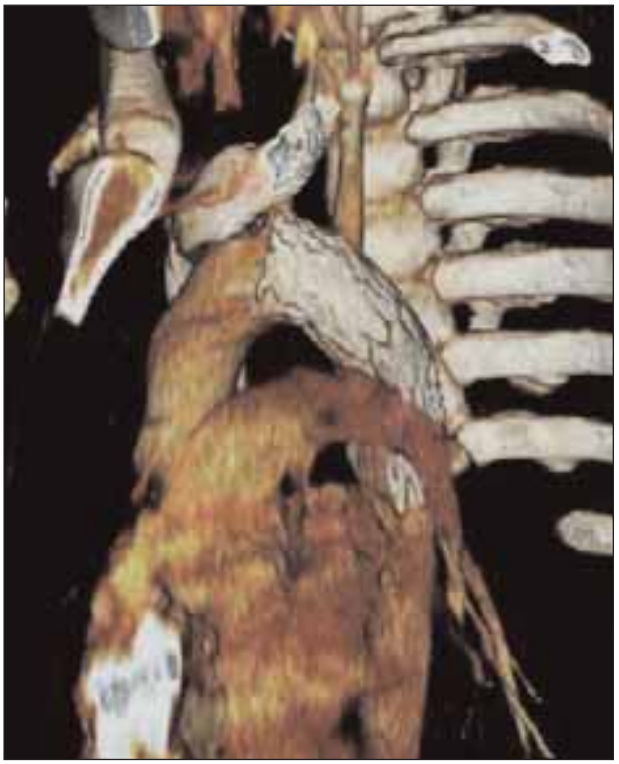

Figure 5. Six-month follow-up CTA with three-dimensional reconstruction demonstrating stable repair of BAI.

(Courtesy of W. L. Gore & Associates.)

Figure 6. W. L. Gore & Associates C-TAG precurved prototype stent graft for managing BAI.

(Courtesy of Cook Medical.)

Figure 7. TX2 with Pro-Form with better accommodation of aortic arch curvature.

agulation and coagulopathy of a thoracotomy with partial bypass (left atrial–femoral artery) in a typically polytraumatized patient with lung contusion, multiple fractures, and frequently associated head injuries. The AAST2 trial looked at 193 patients from 18 centers over a 26-month period.[1] The overall mortality rate was 7.2% for endovascular repair versus 23.5% for open repair. Similarly, the rate of paraplegia was significantly reduced with endovascular repair (0.8%) versus open repair (2.9%). Graft-related complications, however, were noteworthy at 20%, and one of the concluding statements from this trial was that "there is a major and urgent need for improvement in the available endovascular devices." There exist little data, however, on long-term follow-up of these patients.

**Size**

Until June of 2009, the only FDA-approved device for the management of thoracic pathology was the Gore TAG endoprosthesis (W. L. Gore & Associates, Flagstaff, AZ), and the smallest available device was 26 mm for treating aortic diameters of no less than 23 mm. In a review of the past 10 years of experience treating these injuries at our institution, 134 patients with BAI were reviewed.[2] The mean aortic diameters of these patients measured just 20 mm. Thus, the overwhelming majority of patients in our own series and others would have aortic diameters too small for conventional endovascular treatment and be susceptible to major device-related complications such as graft collapse. Many specialists have resorted to using stent graft limbs or even "stacked" aortic cuffs[3] from approved infrarenal devices to treat thoracic aortic pathology. This is clearly not ideal because these devices are preloaded in shorter delivery systems and may not reach the intended target from a groin approach. The result is an increase in the usage of aortic and iliac conduits and significant off-label device modification with reloading of devices into longer sheaths to achieve the intended result. Furthermore, these infrarenal devices were not intended to be deployed in the thoracic aorta and as a result may migrate during deployment due to a "windsock" effect. These challenges have recently been alleviated with the approval of the Talent thoracic device (Medtronic, Inc., Minneapolis, MN) with graft diameters as small as 22 mm.

**Curvature**

Probably of more importance today is the desperate need for grafts that can accommodate the steep curvature of the aortic arch in young, healthy aortas. Industry has led the charge to solve this problem. W. L. Gore & Associates has developed precurved and conformable thoracic grafts

(C-TAG) without scallops that are manufactured in smaller sizes (Figure 6.) A clinical trial (Evaluation of the Gore Conformable TAG Thoracic Endoprosthesis for Treatment of Traumatic Transection of the Descending Thoracic Aorta [TAG 08-02]) is currently ongoing and should provide good data on the success rates of these endeavors in the future. Other stent graft manufacturers have made modifications to current stent grafts that may also prove useful for the problems faced with curvature. Cook Medical was recently granted FDA approval for the Zenith TX2 with Pro-Form (Figure 7), which adds a second set of constraining ties to the standard thoracic graft between the proximal two stents, allowing the graft to accommodate very difficult anatomy with the use of the same trigger wire mechanism.

## OTHER CONSIDERATIONS

### Left Subclavian Coverage

In our own experience, we have rarely experienced complications with intentional coverage of the left subclavian artery for patients presenting with BAI. Exceptions to this would be in patients with a clearly dominant left vertebral artery, nonexistent right vertebral artery, or left internal mammary bypass graft from previous coronary artery bypass surgery on preoperative imaging. Approximately 30% of patients will require intentional coverage of the left subclavian artery.[4]

### Lumbar Drains

We do not routinely use lumbar drains for the treatment of these injuries because the length of aortic coverage is so small. Consideration should be given to spinal drainage in any patient with previous abdominal aortic replacement or any patient who develops a neurologic deficit in the postoperative period.

## CONCLUSIONS

Do we have the right devices to treat BAI in many patients? The answer is yes, but there is vast room for improvement in device design. These improvements couldn't get here soon enough. Worldwide, the incidence of blunt vehicular trauma in emerging countries is on a dramatic rise, and the focus of much of our energies as a society should be in the area of prevention and safety. Unfortunately, these injuries will continue to occur. Endovascular approaches for managing BAI are here to stay, and knowledge of current pitfalls is essential for giving our patients the care they deserve and avoiding common misadventures. ■

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