

From Trauma to Treatment: Optimizing Vascular Trauma Patient Management

A look at improving the care of traumatic vascular injuries in a new era of vascular surgery.

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Treatment paradigms for bleeding and major vascular injury have evolved with the rise of endovascular surgery. This increasingly available armamentarium of endoluminal interventions forces a closer look at optimizing the pathway to treatment for these complex patients. In general, better outcomes can be achieved by early recognition and control of bleeding along with mobilizing the appropriate team.

Recognition of a traumatic vascular injury begins in the field by the first-response emergency medical team.¹ Evidence or report of hard signs of vascular injury should prompt activation of the receiving institution's highest level of trauma care.² Prehospital use of a tourniquet or adjunctive hemostatic device can be indicative of an operative vascular injury.³ Recent military experience has led to changes in the Tactical Combat Casualty Care manual to prioritize exsanguination over Airway, Breathing, Circulation, Disability, and Exposure/Evacuate (XABCDE). The experience of the Iraq and Afghan wars suggests that hemorrhage is the greatest preventable cause of death in the military trauma setting.⁴ A recent Department of Homeland Security initiative, "Stop the Bleed," aims to encourage the public to focus on hemorrhage control in disaster situations (Figure 1). Tourniquet use is encouraged in the algorithm proposed by the National Security Council and has repeatedly been found to have a low associated risk of complications while predicting those who would go on to require operative vascular intervention. A recent study found that up to 10% of patients requiring a tourniquet are missed in the prehospital setting.⁵ So-called junctional hemorrhage involving joint spaces such as the inguinal or axillary regions have been the subject of recent innovation with the development of several external compression devices for the field, including the junctional emergency treatment tool (JETT; North American Rescue), the combat ready clamp (CRoC; Combat Medical Systems), and the abdominal aortic and junctional tourniquet (AAJT; Compression Works LLC).⁶



Courtesy of US Department of Defense.

Figure 1. Department of Homeland Security's logo for the "Stop the Bleed" campaign. Available at: <http://www.dhs.gov/stopthebleed>.

INTAKE

At our institution, hypotension with a systolic blood pressure < 90 mm Hg represents the threshold for Code Yellow activation, which mobilizes a receiving trauma team including an attending surgeon, clears the nearby CT scanner, and alerts the operating room. Initial assessment and management follows the American College of Surgeons' Advanced Trauma Life Support protocols of prioritizing airway management and protection. Aggressive blood pressure augmentation is avoided when vascular injury is suspected, and a strategy of permissive hypotension with a goal systolic blood pressure \leq 100 mm Hg is employed in the absence of end-organ dysfunction.⁷ Involvement of the vascular surgical call team is at the discretion of the trauma surgeon. The trauma primary survey is followed by a careful neurovascular exam in patients with a suspicion of vascular injury. Careful arterial palpation and auscultation is a must, and the presence of a thrill or bruit predicts vascular injury requiring operative intervention the majority of the time.²

DIAGNOSTICS

The physical exam can be augmented by use of a Doppler ultrasound probe, pulse oximeter, or measurement of the patient's bedside ankle-brachial index. Physical and ultrasonographic exams can be limited in the trauma bay; pulse waves may transmit through fresh thrombus, and vaso-

spasm or vasoconstriction can make healthy vessels difficult to palpate. An ankle-brachial index > 0.9 effectively rules out a significant arterial injury causing ischemia and can eliminate the need for further investigation.² Oximeter readings of normal pulsatility and saturation can similarly rule out arterial injury in patients with various orthopedic injuries.⁸ Ultrasound is efficacious at diagnosing arteriovenous fistulas or pseudoaneurysms and for follow-up of interventions but is limited in the acute phase.⁹ CT angiography is a rapid diagnostic tool that can guide endovascular or open surgical intervention in the absence of significant renal dysfunction.¹⁰ The specificity and sensitivity of CT approaches catheter-based angiography; however, smaller intimal tears and defects may be missed.¹¹ Digital subtraction angiography remains the best choice for visualizing smaller vessels and is preferred for hand or foot trauma with evidence of ischemia.¹²

RESOURCE MOBILIZATION

When the luxury of time is available with a hemodynamically stable patient, preoperative imaging may reveal whether the vascular injury is amenable to endoluminal techniques. Whenever possible, we prefer to undertake endovascular cases in our hybrid operating suite, which involves activation of the fluoroscopic radiology technician team in addition to an endovascular-savvy operating room staff. Our radiology technicians prepare the hybrid C-arm, power injection system, as well as handheld and intravascular ultrasound devices. The scrub team opens a variety of basic wires, catheters, and a major basic vascular instrument set that remains on a separate back table. An adjacent storage room is stocked with a variety of balloon occlusion catheters and covered stent grafts. Percutaneous arterial and venous cannulation systems and cardiopulmonary bypass machines are readily available.

Hybrid operating rooms offer a number of advantages to using portable C-arms, particularly for aortic arch and cerebrovascular procedures and can be integrated into the trauma pathway as an alternative to a traditional operating room. The hybrid room can be useful with concomitant orthopedic injuries as well as visceral hemorrhage amenable to embolization. A Canadian trauma group has designed a purpose-based hybrid room geared toward the exsanguinating trauma patient termed the *resuscitation with angiographic percutaneous techniques and operative repair (RAPTOR) suite*. The future will likely see a greater use of endovascular techniques in the trauma realm and a greater interest in the development of next-generation operating rooms to better serve these patients.¹³

CHOOSING TREATMENT PATHWAYS

The decision for endovascular or open intervention can be difficult and is guided by the patient's clinical status

and anatomy of the injury. When patients are unstable, there is little debate that open surgery takes precedence; however, in the reasonably stable patient, data are scarce to guide decision making. As technology changes rapidly, the traditional thinking of mandatory surgical exploration is challenged.¹⁴ Blunt traumatic vascular injuries are largely amenable to endovascular therapy, and some previously high-mortality, penetrating injuries like those to the visceral vessels can now sometimes be successfully treated with covered stenting.¹⁵ Medical management and observation have been shown to be effective for a range of arterial and venous injuries, particularly subcentimeter intimal flaps or intramural hematomas. Thoracic aortic as well as axillosubclavian injuries are associated with favorable endovascular outcomes and have the most robust data supporting their use.^{16,17} A multidisciplinary team is required to make appropriate treatment decisions and weigh the risks and benefits of available treatment modalities to best serve these patients. The trauma surgeon is behooved to have some basic training in angiographic technique and balloon occlusion as well as an understanding of new technologies, medications, and when to consult those with advanced interventional skills. The University of Maryland group has created a curriculum using simulation to teach basic wire/catheter/sheath techniques and have documented rapid success of their teaching program for acute care surgeons.¹⁸

The advent of resuscitative endovascular balloon occlusion of the aorta (REBOA) has increased the interest of the emergency medicine, critical care, and trauma surgery communities in learning endovascular skills. Patients presenting with penetrating injuries to the chest or severe pelvic injuries may have initial resuscitation augmented by an aortic occlusion balloon.^{19,20} Previously requiring 12- to 13-F sheaths with wire and catheter manipulation, a new 7-F device by Pryor Medical Devices, Inc., obviates the need for a lengthy wire and consists of a balloon-guided J-tip catheter, an occlusion balloon, pressure transducer, and angiographic sideport (Figure 2). This device may make for a greater utility of REBOA into remote/rural areas without the angiographic support and training previously required. Those leading a resuscitative effort must be keen to recognize when time spent pursuing balloon control is wasted and delays definitive surgical treatment.²¹

Successful REBOA use in the field has been reported in Europe, begging the question whether 7-F devices may eventually be approved for use in ambulances or helicopters in the United States.²² Logistic questions such as protocol for safe transport of patients with aortic occlusion balloons in place will require industry guidelines that will likely mirror those for aortic balloon pumps and involve special staff such as certified perfusionists or cardiovascular technicians.²³

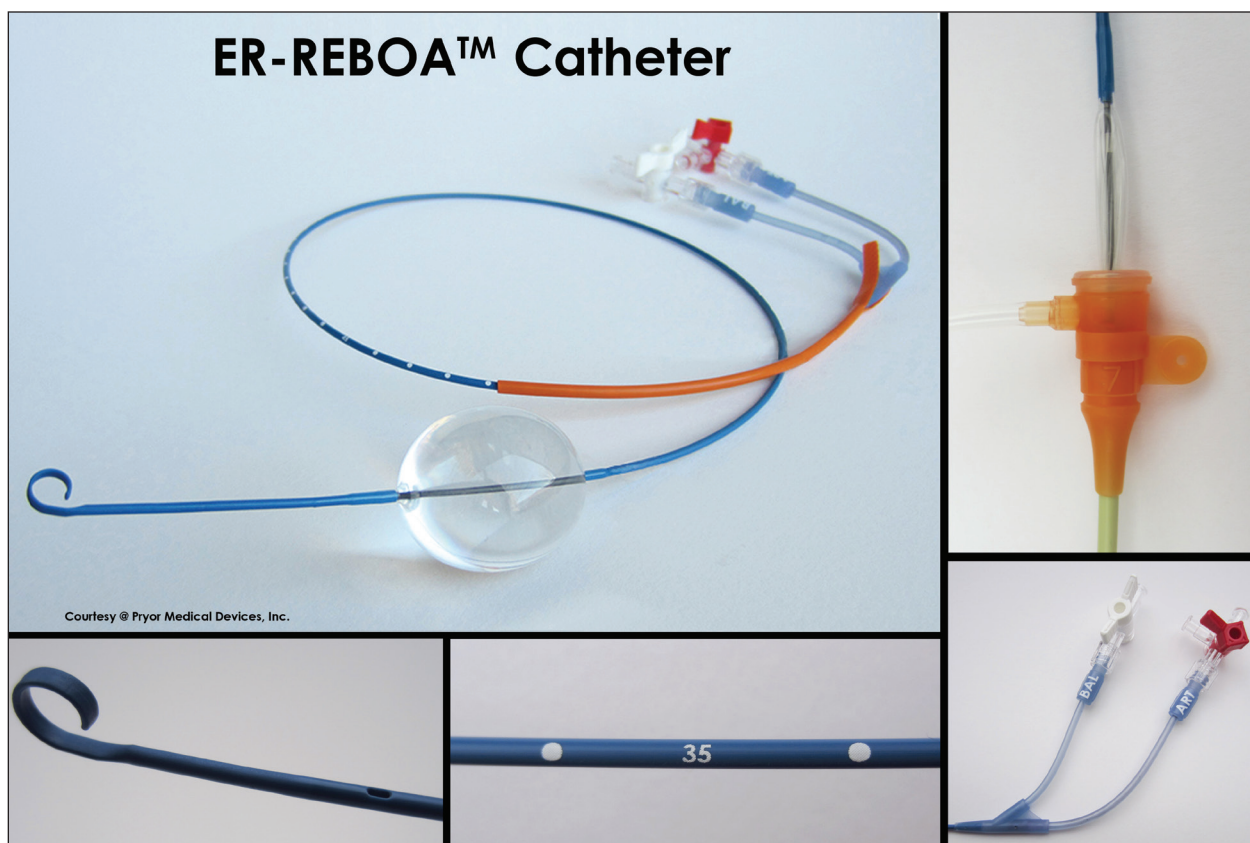


Figure 2. The ER-REBOA catheter by Pryor Medical Devices, Inc. The white sideport is labeled for balloon inflation, and the red is for arterial pressure transduction or arteriography via the hole pictured in the left lower inset. A key limitation is the lack of an ability for wire exchange of the catheter.

POSTTRAUMATIC CARE

Once a patient has undergone an endovascular intervention, he or she is almost invariably committed to lifelong follow-up and often a strict medication regimen. The trauma patient population represents a special challenge for follow-up because patients often have disadvantaged backgrounds, are underinsured, and impoverished, making compliance with medication and follow-up less likely. Smoking cessation and blood pressure and cholesterol control are critical for improving long-term outcomes for these patients. The role of the vascular or trauma surgeon is to communicate the need for and treatment length of any medical management to the primary care physician as well as the planned follow-up intervals. Signs of treatment failure must be described to colleagues who will see these patients more frequently to prompt earlier follow-up or admission. Late failures or infections of arterial reconstructions can be catastrophic and remind us that choosing a durable and autogenous option initially for the patient may mean a better outcome at the expense of operative time.

CONCLUSION

The pathways for treating victims of vascular trauma are changing rapidly with available technology, requiring evermore complex teams and support to optimize care. Improvement in care begins at the prehospital level with public health initiatives, paramedic training and triage protocols. Institutional preparedness with appropriate trauma activation procedures and complex resource readiness are needed to streamline care and minimize time to definitive treatment. A multidisciplinary approach—that does not end with patient discharge—is needed to ensure long-term freedom from injury-related morbidity. ■

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