

# Training for Vascular Trauma

Preparing for the unpredictable, ideal first cases, and stepwise mentoring concepts.

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Unintentional injury is the leading cause of death for people aged 1 to 44 years in the United States,<sup>1</sup> and it is the fourth leading cause of death overall. In 2013, more than 33,000 people died from motor vehicle crashes.<sup>2</sup> The endovascular treatment of a trauma patient can bring vascular interventional radiologists face-to-face with the sobering reality that the patient's survival is acutely dependent on their ability to identify and successfully treat the underlying problem.

Effective therapy requires a multidisciplinary approach involving trauma surgeons, anesthesiologists, and vascular interventionists that is synchronous and efficient. Resuscitative measures should be initiated and ongoing until definitive measures can be instituted. In our experience, the ability of the vascular interventional radiologist to seamlessly incorporate image interpretation into actionable information that can be applied to treatment strategies is vital in this setting. For example, there is no need to await a preliminary read from a diagnostic radiologist, given the imaging expertise of an interventional radiologist. Further, experience in endovascular treatment of malignant and benign tumors of the abdomen and pelvis provides an excellent complement of technical skills that can be applied to the treatment of the trauma patient.

Because most trauma seen at our institution involves solid abdominal organ and pelvic vascular injuries, these areas will be the primary focus of this discussion. In addition, therapeutic strategies will focus on the approach to injured vasculature and treatment with embolization (with the exception of a patient with an acute thoracic aortic injury and a rare collaborative effort with the vascular surgery team), described from the perspective of vascular interventional radiology (VIR).

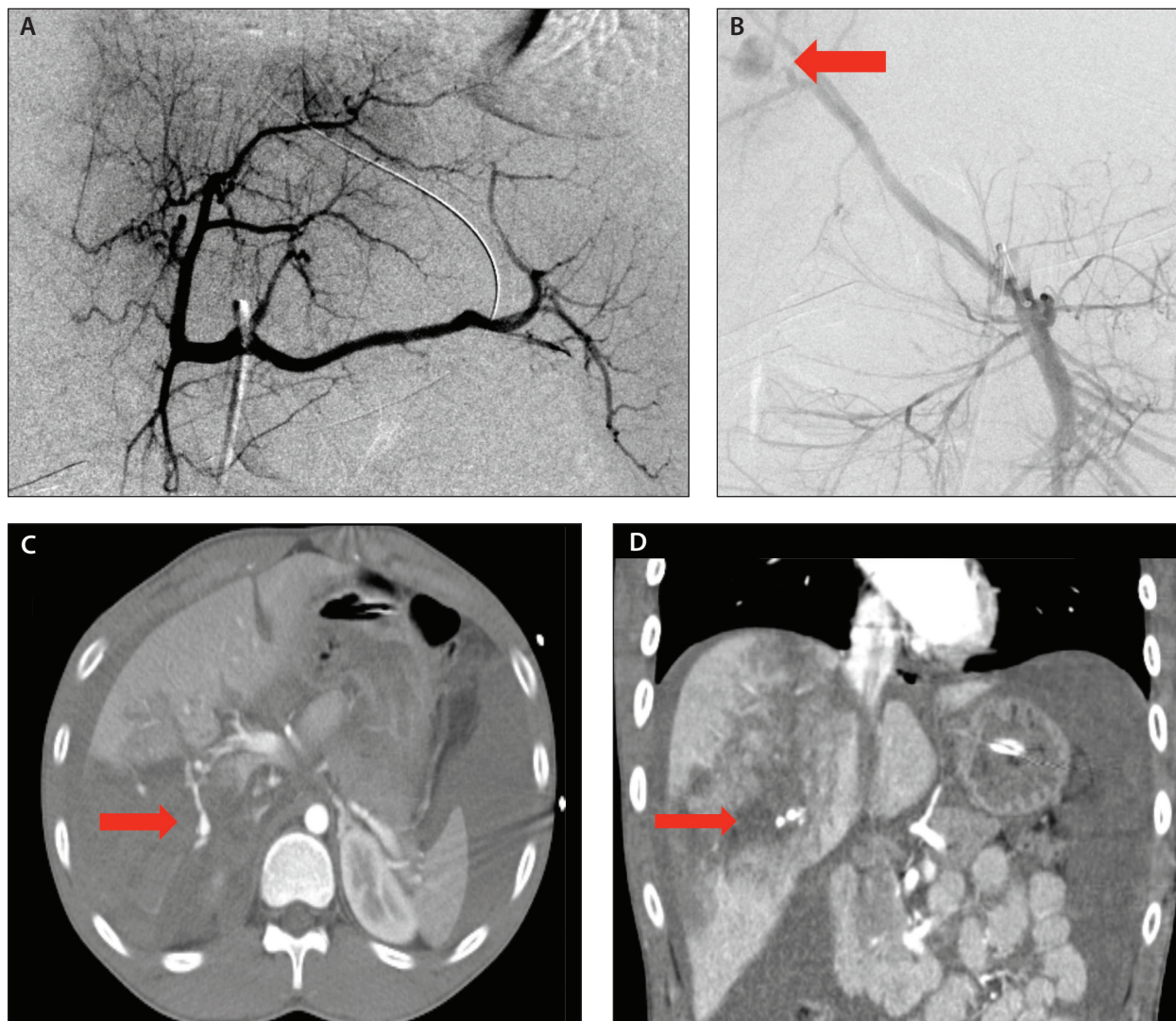
## PREPARING FOR THE UNPREDICTABLE

"Know thyself" is an ancient Greek aphorism attributed to Socrates, and it is applicable to many parts of one's life. This is certainly the case in the treatment of the trauma patient. In vascular intervention, the primary operator must know the range and limits of his/her skill set, as well as the capabilities of staff members. This knowledge, along with the ongoing periodic evaluation and upkeep of the equipment (eg, an older fluoroscopy unit) as well as appropriately stocked inventory (eg, appropriately sized coils), can be a crucial time saver at critical junctures during a procedure.

At the outset, as much information as possible should be gathered from the trauma team about the



**Figure 1.** Left brachial artery access in a 69-year-old man who was hit by a car while riding a bicycle. He sustained severe unstable pelvic fractures. Neither common femoral artery could be palpated or seen clearly on ultrasound.



**Figure 2.** A 15-year-old boy in a motor vehicle collision with laceration of the right lobe of the liver. There was no active extravasation on this celiac artery injection (A). Active extravasation (red arrow) was seen after the injection of the replaced right hepatic artery arising from the superior mesenteric artery (B). An axial CT image shows the active extravasation (red arrow) (C). A coronal CT image likewise shows the active extravasation (red arrow) around the injured right hepatic lobe (D).

patient's clinical status. Is the patient hemodynamically stable? Does the patient have other injuries that may take precedence, such as head or chest trauma? Generally speaking, given the acuity of the patient's condition, usually only a brief survey of the patient is possible upon arrival to the angiography suite. This evaluation should include assessment of the femoral and pedal pulses if common femoral artery access is planned. In instances in which the patient is directly transferred from the trauma unit or operating suite and no CT angiography (CTA) is available, a strategy for diagnostic assessment needs to be employed. This will

largely depend on the site of injury. Given that most of the cases referred to VIR at our center are related to intra-abdominal solid organ or pelvic vascular injury, abdominal aortography is generally performed as the initial step in imaging. This may reveal unsuspected injuries and possibly demonstrate the extent of the pathology.

Arterial access can be a challenge in a trauma patient, particularly if there is a pelvic binder in place and/or if the patient has pelvic and/or proximal lower extremity fractures. If traditional common femoral artery access is not an option, alternative access should be considered

(eg, radial, axillary, or brachial artery access) (Figure 1). Depending on the level of injury (eg, pelvis or lower extremity), radial access—which is typically associated with fewer complications compared to axillary or brachial access—may be a challenge because available diagnostic catheters may not be long enough to reach the site of injury. Complication rates have been reported as 1.4%, 3.3%, and 7% for radial, brachial, and axillary artery access, respectively.<sup>3-5</sup>

If available, information about the patient's renal function can be very useful. In patients with renal insufficiency, a more dilute concentration of iodinated contrast material can be used. Carbon dioxide use has been described in many procedures<sup>6-8</sup>; however, data in the context of the trauma patient are limited but certainly worth consideration in patients with renal dysfunction.

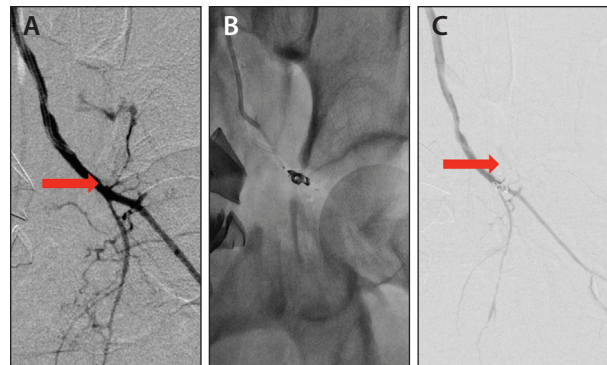
Given the area of suspicion, selective angiography is the next step. A working knowledge of common vascular variants in the abdomen and pelvis is essential. For example, in a patient with an injury to the right lobe of the liver, a replaced right hepatic artery from the superior mesenteric artery should be suspected if no arterial supply is noted to the right lobe on celiac artery injection (Figure 2).

Once the site of bleeding is identified, an embolization strategy needs to be decided. To some degree, the choice will be dictated by the patient's hemodynamic status, site of injury, and available tools. If the patient is unstable, proximal embolization with a temporary embolic agent such as Gelfoam (Pfizer, Inc.) (gelatin sponge) may be the best choice. Ideally, in the liver or pelvis, the site of an injured vessel would be crossed and coiled in a distal to proximal fashion if time permits (Figure 3). In special circumstances, a liquid embolic agent can be used when the injured vessel cannot be crossed.<sup>9</sup> Spherical embolic agents are not typically used in these instances, as the intent is not ischemia at the arteriole level such as in the treatment of tumors.

Finally, when the case is complete, consideration should be given to the appropriate method of closure. In a coagulopathic patient, we have found the Angio-Seal (St. Jude Medical) closure device to be effective.

## IDEAL FIRST CASE

The ideal first case for a vascular interventionist to undertake would include many of the features discussed earlier. Certainly, it is preferable to have a hemodynamically stable patient, as this does offer more time to obtain history, perform a physical evaluation, and assess results of laboratory testing and imaging studies. A conscious and coherent patient who can provide accurate clinical information can be a great resource.



**Figure 3.** Active extravasation from a branch of the left inferior gluteal artery (red arrow) (A). Coil embolization distal and proximal across the injured vessel with Tornado (Cook Medical) coils (2 mm X 3 mm X 4 cm and 2 mm X 4 mm X 4 cm) (B). Postembolization arteriogram shows the resolution (red arrow) of the previously seen site of extravasation (C).

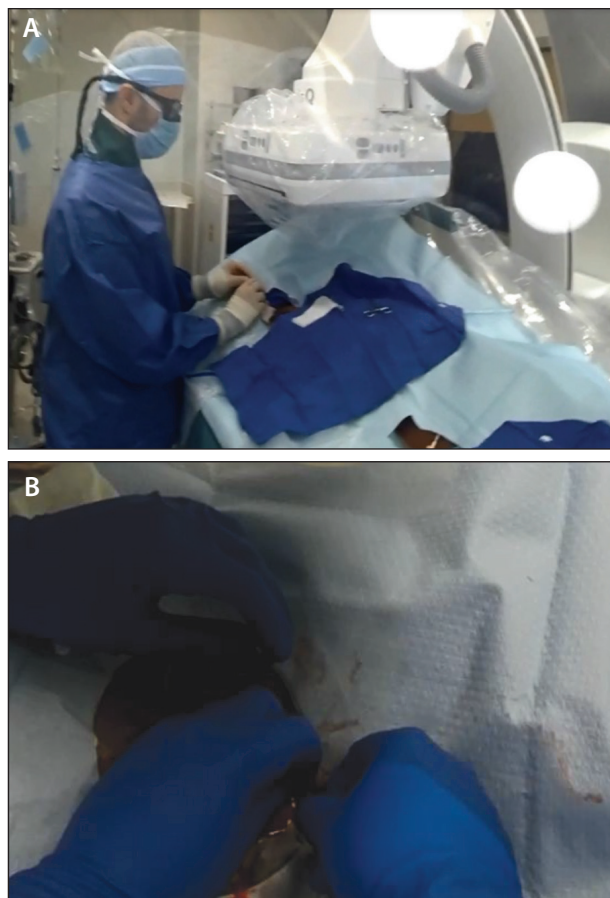
Further, the absence of coagulopathy, renal insufficiency, and severe allergies can aid in mitigation of compounding problems during the treatment of these patients.

Beyond the previously mentioned favorable clinical parameters, a CTA demonstrating the exact location of the bleeding vessel can be an enormous time saver. This, coupled with feeder vessels that are not tortuous and the absence of variant anatomy, can make embolization a lot easier. In the case of liver and pelvic vascular injuries, the ability to cross the site of an injured vessel and treat across the lesions can be done to ensure there is no retrograde or “back door” bleeding source. With regard to injuries to the renal artery, it is not necessary to embolize distal to the injury. Because most are end-organ vessels, there are minimal intraparenchymal collaterals.<sup>10</sup> An immediate clinical response along with no subsequent recurrent bleeding would make for a perfect ending to the ideal first case.

## STEPWISE MENTORING CONCEPTS

To some degree, the challenge of efficiently managing the complexities of a trauma patient are compounded when also balancing the demands of training medical students, residents, and fellows. Particularly as it relates to VIR trainees, there should be a method of increasing clinical and procedural responsibility as training progresses over the course of the residency and fellowship. This must be matched with the skill level of the trainee.

The oversight of VIR trainee development in the arena of trauma treatment can parallel the approach to any patient seen in interventional radiology. There are typically three main components of emphasis: clinical



**Figure 4.** Direct observation of the VIR fellow's endovascular technique was done with a video recording using Google Glass (A). This was reviewed with the fellow after the case, and a constructive critique was provided. The primary operator's view of the procedure, using Google Glass (B).

cal assessment/preparation (eg, resuscitation in the case of the trauma patient), seamless integration of image interpretation, and minimally invasive treatment. Although inpatient follow-up is possible, these patients are not typically seen as outpatients in the VIR clinic, as their longitudinal care is usually managed by the trauma service. In other areas of VIR, there is flexibility with respect to time and an opportunity to explain one's thought processes to the trainee while performing the case. Time is often not a luxury afforded when treating a trauma patient and, as a consequence, it is more difficult to provide this type of interaction with the resident or fellow. Other teaching strategies should be developed in order to compensate for this lost opportunity.

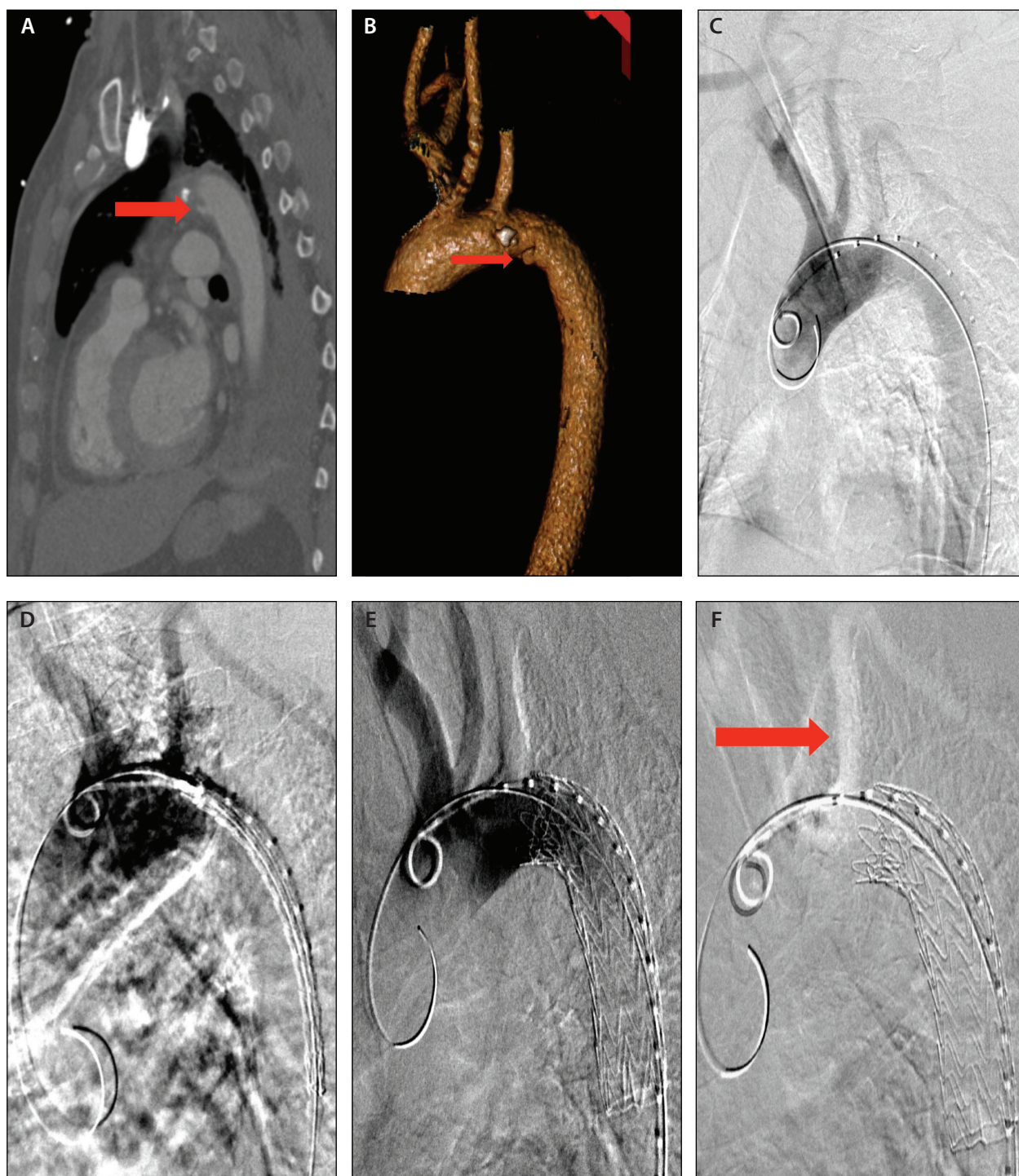
At our institution, there is typically an attending-to-attending request made by the trauma service to the VIR service for a procedure. As such, the trainee may

not have the opportunity to pose the many questions needed to obtain the relevant information from the trauma team. One approach includes having the VIR fellow contact their counterpart on the trauma service. They are then instructed to call the VIR attending at a designated time and present the case. In this way, the attending has the information needed to initiate a timely treatment plan while granting the trainee an opportunity to develop their history-gathering and critical thinking skills. Feedback should be provided to the fellow about the assessment and plan for the case.

Given their background, image interpretation is typically a strength of VIR trainees. In addition to history taking, imaging findings should be initially evaluated independently by the trainee before a discussion with the attending. Although the imaging findings may be evident to the trainee, it is just as important how they integrate this information into the treatment plan. For example, active extravasation from the left inferior gluteal artery on CTA would be important to identify, but so would the recognition of a right common femoral artery occlusion, as this would affect potential access sites.

The third major component of emphasis is endovascular technique development. As previously mentioned, the experience of VIR trainees with the treatment of tumors involving the liver, kidney, uterus, and prostate gland provide a strong foundation in vascular anatomy, diagnostic and microcatheter manipulation, as well as some degree of the principles of embolization needed to treat the trauma patient. The same is the case with the treatment of oncology patients with thrombocytopenia, in which proximal splenic artery embolization is performed.<sup>11</sup>

The main difference is the tempo required by the operator during the procedures for trauma patients. Adjustments may be needed in real time in response to changes in the patient's vital signs or new findings on angiography. As such, the appropriate cases should be chosen to allow hands-on participation by the trainee. In a hemodynamically stable patient with known patent common femoral arteries and otherwise favorable anatomy, a trainee who has demonstrated proficient access on routine transarterial cases, such as transarterial chemoembolization, could be allowed to gain access as an appropriate starting point. The same would be true for obtaining an aortogram, mesenteric vessel selection, and branch vessel subselection. Although the supervising attending would ensure use of appropriate and safe techniques, as the trainee progressed during the residency or fellowship, an incremental increase in speed would also be encouraged.



**Figure 5.** Sagittal reformatted CT image shows a focal outpouching (red arrow) in the region of the aortic isthmus in a 60-year-old man involved in a motor vehicle collision (A). A three-dimensional volume-rendered CT also shows the injury (red arrow) (B). An arch aortogram with marked pigtail catheter in place (C). The positioning of the Conformable Gore TAG thoracic endoprosthesis (Gore & Associates) before deployment (D). Postdeployment aortogram shows the preservation of the left subclavian artery with coverage of the focal acute aortic injury (E). An aortogram with inverted gray scale better depicts the patient's left subclavian artery (red arrow) (F).

Although the traditional approach to teaching in VIR has been used for a long time, consideration should be given to newer alternatives. Simulation training has been shown in several studies as a safe way to aid in the development and assessment of endovascular skills.<sup>12,13</sup> Use in VIR has not yet become common, but the advantages are obvious. There is no replacement for live patient experience, but the ability to practice on high-fidelity mannequins with simulated fluoroscopic imaging in a variety of endovascular scenarios can serve as an excellent intermediary tool. The sequence of steps needed to appropriately treat a bleeding pelvic vessel, assessment of response to changes in the hemodynamic status, appropriate sizing of vessels to be coiled, tracking of fluoroscopic time and radiation exposure, along with contrast media use, are all metrics that could be monitored and evaluated. This training could serve as a quality improvement initiative, as well as an invaluable educational tool.

The use of wearable technology in endovascular training is currently in its infancy.<sup>14,15</sup> The ability to record dialogue along with video through the “eyes” of the operator may provide a useful educational tool for trainees. The same may be true for a trainee who is involved in a case, as recordings from either a trainee or observing attending could be reviewed in a constructive fashion and critiqued after the case (Figure 4).

Finally, there is always the potential to enhance the professional and educational experience when there is interdepartmental collaboration.<sup>16</sup> Most of the peripheral artery disease treatments, including extremity and aortic trauma, are managed by vascular surgery at our institution. The case represented in Figure 5 is a rare example of collaboration between VIR and vascular surgery, in which an acute thoracic aortic injury was treated with a thoracic endograft in a VIR suite. This allowed for preservation of the left subclavian artery while providing adequate cover of the small aortic pseudoaneurysm.

## SUMMARY

Endovascular treatment of a trauma patient offers a VIR physician the opportunity to play a major role in the treatment of severely, acutely injured patients. The timely treatment of these patients can often mean the difference between survival and demise. Further, the demands of teaching trainees in this setting can be overwhelming. Teaching an endovascular approach to treating intra-abdominal and pelvic tumors can provide a complementary skill set that may be transferred to the treatment of the trauma patient. Newer teaching methods, including endovascular simulation and wearable technology, need to

be evaluated as potential adjuncts to teaching. Lastly, collaboration between departments may serve to enhance patient care, as well as the educational experience of trainees. ■

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