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Emergent Endovascular Treatment of Penetrating Trauma: Solid Organ and Extremity

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Penetrating injuries can result in acute or subacute arterial injuries of the solid organs or extremities. Although most penetrating injuries are managed conservatively, some patients require endovascular or surgical treatment. Often, the best method for management is controversial and the level of urgency for clinical decision-making is high. Once the decision has been made to intervene, the operator must also determine the best embolization material and technique to use. Not unfrequently, these decisions are made during the course of the procedure. There are numerous embolization agents, each of which serves a very specific purpose, depending on the clinical scenario. Within this article, we will review endovascular treatment indications, contraindications, and endovascular techniques for the treatment of penetrating trauma of the solid organs or extremities.

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Clinical Evaluation or Indication

Endovascular treatment of a solid organ vascular injury is indicated for the treatment of exsanguinating hemorrhage in several clinical scenarios: (1) Diagnostic angiography demonstrates active extravasation in an unstable patient despite attempts to stop the bleeding surgically; (2) Hemodynamically unstable patient that failed conservative therapy; (3) Vascular injury noted in targeted screening angiography performed weeks after the injury.[1]

Endovascular repair for extremity arterial injury is indicated in a patient with "hard signs" of vascular injury, which include pulsatile or expanding hematoma, diminished or absent pulses, bruit or thrill, critical limb ischemia, or active hemorrhage.

It is important to be aware of the potential for a delayed hemorrhage in the setting of penetrating trauma. There can be a latent period, often of many weeks and rarely even years, between the inciting trauma and the onset of life-threatening hemorrhage. This is theorized to be secondary to pseudoaneurysm formation with the initial trauma, which undergoes delayed expansion and rupture.

Contraindications

There are no absolute contraindications to solid organ embolization in the setting of trauma. Relative contraindications include pregnancy, renal insufficiency, and contrast allergy. Contraindications to embolization of an extremity arterial injury would include signs of compartment syndrome or skin ischemia or necrosis, as these patients would go directly to surgery.[2]

Equipment Needed

The choice of catheters used for subselection of arteries and deployment of embolic agents will depend on operator preference. A variety of embolic agents should also be available in any interventional radiology department that treats trauma patients. Gelfoam is typically the workhorse in trauma, but a variety of coils should also be available for

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select cases. Particles also have a role for distal embolization of solid organs. Glue is only appropriate in the hands of an experienced interventionalist.[1]

Overcoming Technical Challenges

There are several technical challenges for embolizing traumatic lesions in the extremities and solid organs. First, in cases of traumatic pseudoaneurysm, it may be difficult to access the distal feeding branch. Accessing and embolizing the distal branch is essential to prevent retrograde collateral flow.[2] This can often be achieved by performing angiography in multiple projections. If the distal limb can't be accessed, the vessel can be occluded with a balloon while the pseudoaneurysm is thrombosed percutaneously with thrombin or coils[2]. Balloon occlusion can also prevent exsanguination while the pseudoaneurysm is treated surgically.[3] Another technical challenge is choosing the right embolic agent for the right vessel (eg, site, size, and flow pattern). Liquid embolic agents like *n*-butyl cyanoacrylate are good embolic agents, but can have inadvertent distal embolization if used in locations prone to reflux.[4] Coils are effective for embolization of single, large vessels where precision is crucial.[5] Particulate agents are useful in small distal arteries where reflux is of relatively low concern.

Recognizing and Treating Complications

Common treatment complications include continued exsanguination, pseudoaneurysm, or arteriovenous fistula.[6] As can be seen with any femoral artery access case, there is also a risk of inguinal hematoma or retroperitoneal hematoma.[7] When embolizing arteries in the extremities, the most significant complication is inadvertent distal embolization,[5] which is why frequent neurovascular examinations are crucial in the perioperative period. Uncommon complications of solid organ embolization are infection and abscess formation. When using *n*-butyl cyanoacrylate, there is a risk of gluing the microcatheter to the arterial wall, necessitating microcatheter exchange immediately following embolization.[5]

Clinical Follow-Up

Follow-up of a patient with endovascular treatment of penetrating trauma should consist of serial serum hemoglobin measurements, usually every 6 hours, until stable. Additionally, the patient's vital signs and extremity neurovascular examination should be monitored frequently during the postoperative period. Follow-up angiography is typically only helpful following endovascular treatment of traumatic arteriovenous fistula, to ensure adequate treatment.

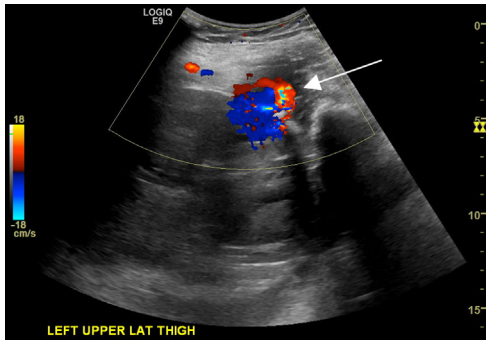

Figure 1 Color Doppler image of the left lateral thigh demonstrates a pseudoaneurysm (arrow) with classic Yin-Yang configuration. (Color version of figure is available online.)

Expected Outcomes

Published technical and clinical success rates of endovascular treatment of arterial injury in the extremities range from 80%-100% with relatively few complications, and as high as 83%-100% in the treatment of solid organ arterial injury.[1,7]

Case 1

A 24-year-old man was transported to our trauma center by ambulance after being found down pulseless with entry gunshot wounds to the left neck and left buttock. He was resuscitated in the emergency room and transferred to the operating room (OR) for extensive cardiothoracic surgery including subclavian vein repair and left upper lobectomy of the lung. Additional imaging demonstrated thoracic spine fractures with boney impingement of the spinal cord, as well as a retained bullet in the lateral left thigh. His hospital course was complicated by pulmonary embolism for which he was anticoagulated with coumadin. Approximately 7 weeks after admission, he was noted to have a

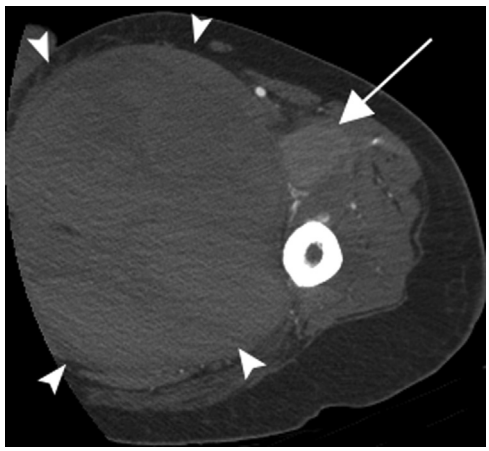

Figure 2 Computed tomography angiogram of the left thigh demonstrates a large expanding hematoma (arrowheads) in the medial thigh compartment. There is an ovoid, hyperdense lesion (arrow) in the anterior thigh abutting the hematoma, consistent with a pseudoaneurysm.