Vascular Imaging in the Setting of Trauma

Computed tomographic angiography has become the primary vascular imaging triage tool.

BY ELI ATAR, MD, FSIR

Trauma is the leading cause of death worldwide in patients younger than 45 years and the sixth leading cause of all death, accounting for 10% of all mortality.[1] Vascular injury progressing to exsanguination and hemorrhagic shock is second to central nervous system injury; thus, imaging diagnosis is crucial for the trauma victim as early as possible from admission to the hospital.

TRIAGE IMAGING

The imaging workflow during emergency department triage depends on the type of incident level (ie, single-patient incidents, multiple-casualty incidents, mass-casualty incidents, medical disasters, and incidents occurring during wartime), especially if the hospital itself is under attack. The more trauma patients and the greater the environmental risk, the more focused the triage must be on resuscitation and early evacuation.

The trauma team must know the capabilities of the various imaging modalities and understand the skills of the interventional radiology team to choose the quickest and the most suitable modality and subsequently select the best surgical or endovascular treatment for all types of injury.

FAST

Of the five imaging modalities available—plain x-ray, ultrasound, computed tomography (CT), magnetic resonance imaging, and magnetic resonance angiography—x-rays and magnetic resonance angiography are of no use for the imaging evaluation of vascular trauma. Ultrasound is best used to detect free fluids in the abdominal spaces under an examination protocol known as *FAST* (Focused Assessment With Sonography for Trauma).

In the context of traumatic injury, free fluid is usually caused by hemorrhage and contributes to the assessment of the circulation. This application has replaced the abdominal tap and can be performed quickly in the emergency department in single- or multiple-trauma incidents, including during those occurring in wartime. The use of focused ultrasonography has now become an extension of the physical examination in the trauma patient and a decision-making tool to help determine the need for transfer of the patient to the operating room, CT scanner, or angiography suite.[2,3]

Figure 1. Active bleeding from the left vertebral artery in a 15-year-old boy from metallic shrapnel in a suicide bomber attack. While manual compression of the neck was performed, the patient was brought to the emergency department and was rushed to the angiography suite. The bleeding was identified (A, B) and immediately embolized (C).

FAST examination is primarily helpful in hemodynamically unstable patients when the cause of hypotension is unclear, patients who need an emergent bedside procedure, patients at a community hospital who require transfer to a trauma center, intoxicated patients who can be observed and re-examined, and patients who have penetrating trauma with multiple wounds or unclear trajectory, especially with wounds in the upper abdomen or lower chest. Other applications for ultrasound examinations in the setting of vascular trauma are very limited and are optional in superficial organs such as the testes and in pediatric trauma patients.

CT ANGIOGRAPHY

Previously, angiography was the gold standard and the first-line imaging modality used to assess vascular injury; CT has since replaced diagnostic angiographic examinations, which were only used complementary to inconclusive CT examinations. Endovascular interventions are focused on a specific damaged vessel and thus are performed quickly, without time wasted on access, anatomic variants, and equipment selection. Angiography as the primary imaging modality is very exceptional and is optional in unstable patients with penetrating injuries that are difficult to control surgically (Figure 1).

CT has an important and established place in a trauma patient's evaluation. The technology of multidetector CT enables depiction of detailed vascular anatomy, and CT angiography (CTA) is part of the routine evaluation. The only change is modification of the study protocol to provide adequate arterial phase. CTA as a first-line imaging modality in the setting of vascular trauma has several advantages, which include the following:

- The examination is noninvasive, available, and rapid, with excellent negative predictive value.
- It can save in the number of diagnostic angiograms needed and enables simultaneous evaluation of different body areas.
- During the same examination, extravascular pathologies can be depicted, and the vascular images are useful for the interventionist or surgeon who perform the subsequent treatment.
- In an incident of mass trauma, CTA serves as a triage tool.[4]

Several trauma-related vascular pathologies can be depicted by the CTA examination; these include arterial spasm, arteriovenous fistula, intimal flap, dissection, arterial occlusion, pseudoaneurysm, and active bleeding. In cases of more than single-organ injury, the traumatologist can choose the prompt therapy according to the level of trauma severity in different organs.[5]

Workstation interpretation is usually necessary and can be time consuming but does not cause delay in treating the patient. Interpretation by the interventional radiologist and treatment selection may seem time consuming, but the treatment selection and the treatment itself are based on the vascular reconstructions, which then save time.

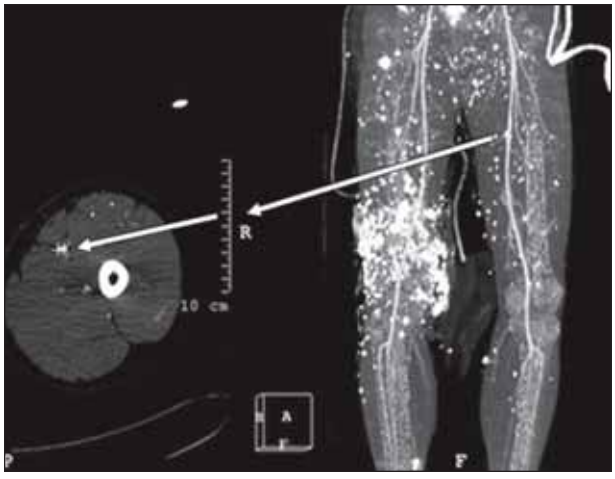

Figure 2. A 27-year-old male soldier with multiple pellets in both legs. Correlation of coronal reconstruction with an axial CTA scan allowed identification of shrapnel requiring extraction because of the threat to the superficial femoral artery.

Sensitivity and specificity of CT for detecting vascular damage in trauma patients in different areas are very high. Berne et al reported a sensitivity of 100% and specificity of 94% among 486 patients admitted with head and neck trauma.[6] In another series of 175 head and neck trauma patients, < 1% of the CT examinations were nondiagnostic.[7] In the thorax, CT has sensitivities of 97% to 99.3% and specificities of 87.1% to 99.8%. Routine use before angiography resulted in cost savings of more than $365,000 during a 4-year period.[8] Extremity injuries are also readily depicted by CT with similar sensitivity and specificity rates.[9,10]

Several pitfalls influence the accuracy of the CTA vascular damage diagnosis. Inferior spatial resolution on digital subtraction angiography can cause misdiagnosis of small blood vessels. Artifacts from foreign bodies, calcification, and adjacent anatomical structures can cause streak linear artifacts. Technical problems, such as inaccurate contrast timing, patient movements during the scan, and injection-site artifacts, are also causative factors in nondiagnostic CTA. However, these pitfalls are not frequent, especially in civilian injuries.

Foreign body artifacts are more frequent in combat and terror attack victims due to the existence of metallic shrapnel, pallets, pins, screws, and other metallic foreign bodies that are added to the explosive pay loads (Figure 2).[11-14] In such instances, angiography is the next diagnostic imaging modality, and its timing is based on the patient's

hemodynamic condition, other CTA findings, and the value of information lost due to artifacts.

Besides being a complementary imaging tool to nondiagnostic CT, angiography is mainly used for therapeutic purposes based on CTA findings. Angiography before CTA is very rare and is performed only for external bleeds that are difficult to control surgically and can be controlled more quickly by angiography.

ONE HOSPITAL'S EXPERIENCE

The role of imaging and triage of various civilian and combat injuries in a hospital that was under missile and rocket attack for a period of 1 month was described by Engel et al.[4] In their article, the authors share their experience in handling 79% of the 849 patients referred for imaging.

Of the physically wounded patients, 55% (281) had multitrauma, and in 102 patients, FAST examinations were performed (36%). Skeletal x-rays were taken in 399 patients; both imaging modalities were performed in the emergency department. Many of the patients (79%) continued to the radiology department for CT or CTA. Fifty-nine patients underwent 62 CTAs (14%) to rule out vascular damage. Zero to 23 CTAs were performed per day (up to eight peripheral CTAs per day). Ten angiography procedures were requested: five to exclude inconclusive CTA and five to stop bleeds as shown in the CTA. Thirty-nine vascular injuries were detected (7.6%)—four times more in combat injuries—and all were penetrating.

Because of an imminent rocket attack in the hospital, which was not rocket-proof, the emergency department evacuation was as quick as the imaging evaluation. Remarkably, after vascular surgical or endovascular repair, there were no deaths and no amputations.

CONCLUSION

FAST performed in the trauma room is a decision-making tool to help determine the need for transfer to the operating room, CT scanner, or angiography suite. CTA has become the main imaging vascular triage tool both in daily traumas, terrorist acts, and in wartime and is applicable to all types of trauma. It is important that the interventional radiologist joins the CT radiologist for CTA vascular diagnosis. Angiography for vascular diagnosis is performed only when CTA cannot confirm or rule out vascular injury. An angiography-first approach should only be taken for massive, controllable, active, external bleeding. The endovascular interventions performed in the early stages are focused on life-saving and stabilizing procedures. ■

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