CT Angiography in Trauma

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KEYWORDS

• Angiography • Trauma • Multidetector • CT

CT has become the primary imaging modality used in patients who suffer significant trauma. With the advent of the multidetector CT (MDCT) technology, high-resolution images with shorter acquisition times are now routine and the quality of multiplanar and 3-D reformations has revolutionized the evaluation of trauma victims. These technologic advances, in particular the shorter image acquisition times, enable complex, multiphasic imaging studies of the entire body specifically aimed at determining the integrity of the vasculature.

Rapid assessment and diagnosis of traumatic arterial injuries are critical in the evaluation of acutely injured patients because these injuries contribute considerably to the morbidity and mortality of major trauma. CT angiograms (CTAs) of the head and neck, chest, pelvis, and extremities have become common imaging methods in busy trauma centers. Although digital subtraction angiography (DSA) historically was the preferred method for evaluating patients with possible vascular injuries, it has been largely replaced by CTA due to its speed, noninvasive nature, accuracy, and widespread availability. Rapid acquisition of submillimeter isotropic data sets allows for accurate assessment of vascular injury extending from the head and neck to the torso and extremities. This article reviews the current use of MDCT angiography in trauma with attention to technique and protocol considerations, illustrates findings of many commonly encountered injuries, and discusses the clinical implications of vascular trauma throughout the body.

TECHNIQUE

The diagnostic quality of a CTA examination depends on many factors, but careful attention to technique and adequate patient preparation are always necessary, especially in the setting of trauma when multiple events often happen simultaneously and every second may be critical.

The importance of proper patient positioning cannot be underestimated. Patients are typically placed supine on a CT table. In the majority of cases (chest, abdomen, pelvis, or lower-extremity imaging), placing both arms above the head is the preferred position for image acquisition. For upper-extremity CTA, the injured extremity is ideally raised above the head to decrease beam-hardening artifact from the torso and secured with adhesive tape to decrease artifact from patient motion. In the rare scenario where there is suspicion for bilateral upper-extremity vascular lesions, both arms should be raised. An alternative positioning is to place patients prone with 1 or both extremities raised over the head, the so-called superman position. If a patient's clinical condition does not allow an injured extremity to be raised over the head, both arms are secured by the patient's side. This is also the preferred positioning for CTA of the head and neck. For lower-extremity CTA, the legs are secured to the table and both limbs are included in the field of view. Inclusion of the contralateral extremity in trauma CTA may be useful as a reference during interpretation of findings in the injured side.

The protocols used at the authors' institution were designed for 64-row scanners but can be used with other generations of MD scanners with only minor modifications. In all cases, an 18- or 20-gauge intravenous catheter is placed in a superficial vein in the antecubital fossa (ideal), the forearm, or the dorsum of the hand (less optimal). For upper-extremity CTA, venous access

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should be placed in the arm contralateral to the injury. This is an important, but often forgotten, technical point. For the extremities, the acquisition typically includes the joint proximal to and the joint distal to the injured segments.

Using 64-row CT scanner, images are acquired at 0.625-mm detector collimation, with a pitch of 0.984 and gantry rotation time of 0.5 seconds. This results in a table speed of 8 cm per second (64–slice LightSpeed VCT, GE Healthcare, Milwaukee, WI, USA). Thicker axial slices (1.25–3.75 mm) and 2-D and 3-D reconstructions are reconstructed from the original data set and are used for study interpretation.

The speed of 64-row CT scanner allows for rapid acquisition of multistation examinations, using a single bolus of intravenous contrast material. Complex multiphasic studies are planned on whole-body (head to toe) CT digital radiographs (scout views).

The total contrast load necessary for the CTA varies with the type of scanner available and the number and sequence of regions of the body that are imaged. Contrast agents with higher concentrations of iodine (350 to 370 mgI/mL) and high injection rates (at least 4–5 mL/s) are preferred and are always followed by a 30 to 50 mL saline chaser, also injected at a rate of 4 to 5 mL per second. At the authors' institution, 100 to 120 mL of contrast medium is used for a standard chest/abdomen/pelvis study with a 64-row scanner. When CTA is integrated into a whole-body trauma scan to include head and neck, torso, and extremities, this single bolus of 100 to 120 mL of intravenous contrast material is used for the multiphasic torso and extremity imaging. In cases of isolated extremity angiography in which no torso imaging is required, 60 mL of intravenous contrast are used.

Three methods are commonly used to time the beginning of acquisition after the contrast bolus injection: standard delay, automated bolus tracking, and test injection. The standard delay method is simple and quick and the authors have found it robust when used in the trauma population, especially when the protocol includes imaging of multiple body parts (**Table 1**). A standard delay of 30 seconds for initiation of the routine thoracic scan is used in the majority of patients. A different standard delay technique is used when the chest CTA is integrated into a whole-body scan that includes head and neck, pelvis, extremities, chest, and abdomen, in that order. In these circumstances, typical standard delays used are 20 seconds for the head and neck, 23 seconds for the pelvis, 25 to 27 seconds for the upper extremities and proximal lower extremities, and 27 to 30 seconds for the distal lower extremities. Thoracic acquisition immediately follows pelvis or extremity imaging.

Table 1
Standard delay and contrast bolus in trauma CTA

	Standard Delay (Seconds)	Contrast Bolus (mL)
Routine torso scan		100–120
Chest	30	
Abdomen and pelvis[a]	70	
Isolated extremity angiography	Standard delay/test bolus	60
Whole-body scan		100–120
Head and Neck	20	
Pelvis	23	
Upper or proximal lower extremity	25–27	
Distal lower extremity	27–30	
Chest	~30[b]	
Abdomen and pelvis[a]	70	

[a] Delayed-phase image acquisition may be acquired at 5 to 7 minutes.
[b] Immediately follows CTA of other regions.

Test injection and bolus tracking methods are more precise (albeit slightly more cumbersome) and should always be used when the study is limited to the extremities, in the elderly population, and in patients whose cardiovascular system is compromised. If the more distal arteries of the extremity are imaged, the test injection method is preferred, because bolus tracking requires precise placement of the region-of-interest (ROI) cursor in the artery of interest. This is not always practical or feasible using a precontrast image.

For the test injection method for extremity CTA, circulation time to the affected area is determined in a vessel immediately proximal to the region of suspected injury. An appropriate artery—such as the brachial artery for a proximal upper-extremity trauma—is selected as the target for placement of the ROI measurement. A 20-mL injection of intravenous contrast material is injected at 4 to 5 mL per second followed by a 30-mL saline chaser, using a dual-syringe power injector. Contrast material arrival time is determined from a time attenuation curve generated from 12 to 14 low