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EMERGENCY RADIOLOGY

PICTORIAL ESSAY

The spectrum of computed tomography findings in blunt trauma of the subclavian/axillary artery: a pictorial essay

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ABSTRACT

Traumatic injuries of the subclavian and axillary arteries are uncommon but have high morbidity and mortality. In contrast to penetrating injuries, which are often lethal, blunt injuries present a wide and heterogeneous spectrum of imaging findings. If a vessel tear or transsection is a life-threatening circumstance, minor injuries might be overlooked in an emergency setting but could cause or aggravate the functional loss of a limb. The aim of this pictorial essay is to acquaint radiologists with the spectrum of imaging findings that could be encountered during the radiological evaluation of the subclavian/axillary artery (SAA) in trauma patients and offer tips and tricks to improve the diagnostic workup of patients with suspected blunt SAA injuries.

KEYWORDS

Subclavian artery, axillary artery, trauma, computed tomography, emergency radiology

Injuries to the subclavian/axillary artery (SAA) are relatively uncommon, accounting for 5% of traumatic arterial injuries.[1] The SAA can be injured by penetrating objects that disrupt the integrity of the skin from the outside or by blunt trauma. Penetrating traumas are mostly described in series from the United States and are relatively uncommon in European or Asian papers.[2] Penetrating injuries of the SAA are mostly caused by gunshot or stab wounds and are often lethal. They will not be discussed in this paper.[1,3]

Blunt SAA injuries (BSAAIs) are uncommon, representing 0.4–5%[4,5] of traumatic vascular injuries, and they are mostly determined by high-energy traumas,[6] commonly high-speed road traffic accidents.[2,4] The specific mortality rate for BSAAIs remains difficult to establish, as most of the published data do not report the type of injury nor distinguish blunt from penetrating trauma. Papers that have reported detailed mortality for penetrating and blunt injuries agree that BSAAIs present a lower mortality rate (blunt 0–24%, penetrating 20–38%).[7-9] However, BSAAIs are heterogeneous, and most patients with severe injuries sustained high-energy trauma and presented in shock with multiple associated lesions. Therefore, the specific mortality rate for BSAAIs is challenging to determine.

BSAAIs can present with a wide imaging spectrum. In some cases, the clinical and radiological presentation is very subtle. Therefore, it could easily remain unnoticed, particularly in a polytrauma setting, resulting in a higher morbidity rate when compared with penetrating injuries.[5] Morbidity after trauma to the thoracic outlet or upper limb depends on multiple factors, including an associated brachial plexus injury. Maintaining an adequate arterial supply to nerve roots is critical for the healing process and outcomes of surgical management.[10] The imaging modality of choice in trauma patients and the diagnostic workup of traumatic injuries of the SAA is computed tomography (CT). In a systematic review, Jens et al.[11] reported a pooled sensitivity and specificity of 96.2% and 99.2%, respectively, in the diagnosis of traumatic arterial injury of the upper and lower limb. Digital subtraction angiography is mainly used for therapeutic purposes but, in some cases, could be used to investigate unclear CT

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findings. Depending on the type of injury, BSAAIs can be treated either using an endovascular (stent or stent grafts) or a surgical approach.[9]

The aim of this pictorial review is to illustrate the spectrum of CT findings in SAA blunt trauma and show tips and tricks to simplify the diagnostic workup of patients with suspected BSAAIs.

Anatomical considerations

The subclavian and axillary arteries are the major blood supply of the upper limbs and posterior cerebral fossa. In left-sided aortic arches, the right subclavian artery originates from the brachiocephalic trunk (innominate artery), while the left subclavian artery emerges from the aorta (see Figure 1a). This pattern is appreciable in 70–80% of patients.[12] Anatomical variants are uncommon but should be described to optimize treatment: in 0.16–4.4% of cases, the right subclavian artery originates from the distal part of the aortic arch[13-15] and typically presents a retro-esophageal course (see Figure 1b). Less frequent variants (incidence <1%) include a common carotid trunk (see Figure 1c), in which both the subclavian arteries arise directly from the aortic arch, and the right aortic arch (see Figure 1d), in which the pattern of emergence of the vessels from the aorta is mirrored.[16] The branching pattern of the subclavian artery from the aortic arch is essential in planning an endovascular approach (i.e., the choice of catheter and the anterograde/retrograde/rendezvous approach). Both subclavian arteries emerge through the thoracic outlet, where they come in contact with the clavicle, the first rib, and the scalene muscles. They then pass behind the clavicle until the outer margin of the first rib, where they become the axillary artery. The axillary artery is the continuation of the subclavian artery beyond the outer border of the first rib until the inferior border of the teres major,[17] where it becomes the brachial artery. The anatomy of the axillary artery is quite consistent, and anatomical variants are rare; in 2% of cases, the ulnar or radial artery might originate from the axillary artery.[18] A high origin of the radial or ulnar artery should be included in the radiological report, as it could influence the choice for endovascular arterial access (radial or brachial). A high origin of the radial artery might preclude its use and influence the choice of treatment, as the involvement of the origin of the radial/ulnar, depending on the branching pattern in the forearm, may preclude the employment of stent grafts and make a surgical approach mandatory.

Main points

- Blunt subclavian/axillary artery injuries (BSAAIs) are uncommon lesions with high morbidity and mortality rates.
- The spectrum of imaging findings of BSAAIs is very wide and heterogeneous, but even minor lesions, when overlooked, might have detrimental effects on the functioning and healing of a limb.
- Prompt and correct identification and description of BSAAIs reduce time-to-treatment and limb-threatening complications.

Mechanisms of injury

Bony (clavicle and ribs), muscular (scalene and subclavian muscles), and fascial (deep cervical fascia) structures that surround the subclavian artery protect it from trauma. The axillary artery is protected by the humerus laterally. Direct, blunt injuries to the SAA are usually determined by high-energy forces that disrupt the integrity of the thoracic outlet, such as falls from heights, road traffic accidents, and motorcycle collisions.[19,20] Bone fractures should be carefully evaluated because these can indirectly indicate the forces applied to subclavian or axillary arteries (see Figures 2, 3a, and 4b). Moreover, the subclavian artery is fixed at the thoracic outlet but highly mobile at its distal end and could be damaged by relatively low-energy impacts that produce extreme shear forces (i.e., a fall on an outstretched arm) that create an excessive strain load on the vessel.[4,21] Injury to the subclavian artery commonly involves the distal segment of the vessel.[19]

Clinical features

Clinical evaluation is essential in assessing BSAAIs because the recognition of the injured arm will permit the tailoring of imaging. The clinical appearance of BSAAIs depends on the type of injury. Clinical signs of arterial injury of the extremities have been divided into hard signs (absent distal pulse, distal ischemia, active hemorrhage, large hematoma, bruit, or thrill) and soft signs (history of hemorrhage, small hematoma, hypotension, or deficit of the associated peripheral nerve). However, only 50% of patients present with hard signs of traumatic injury of the SAA.[22] The presence of an arterial pulse cannot rule out a BSAAI, as the collateral circulation could efficiently compensate for the occlusion of the main trunk.[1] The clinical presentation of BSAAIs often overlaps with brachial plexus injury, making clinical evaluation more arduous. Vascular injuries should always be excluded in the presence of an injury to the brachial plexus (pain, numbness, loss of feeling, or paralysis of the arm).[10]

CT technique

Managing the CT evaluation of BSAAIs could be challenging, as these lesions commonly present in polytrauma settings. Integrating an appropriate evaluation of the upper limbs in a polytrauma protocol could be difficult, particularly if the BSAAI is not clinically suspected (i.e., minor lesions such as intimal tears or a non-occluding dissection) or in the case of unconscious patients. Moreover, polytrauma CT protocols are not completely standardized and could vary on a regional basis (i.e., employment of enhanced and venous phases or split bolus). Therefore this section will focus on methods to customize the exam in case of suspected BSAAI.

Venous access

During trauma diagnostic workups, a contrast medium is typically injected into a vein of the arm or through a central venous catheter in the jugular or subclavian vein. As CT angiography necessitates elevated flow rates (3.5–5 mL/s), the bolus of the contrast medium is usually very dense and could generate beam-hardening artifacts in the neck, reducing the quality and diagnostic potential of the exam (see Figure 5a). In the case of clinically suspected injury to the SAA, the venous access for the contrast medium injection should be in the contralateral arm or a lower extremity.[20]

CT acquisition

The subclavian artery is included in the CT acquisition of the thorax, but the axillary artery may not be, depending on the position of the arm. Moreover, the evaluation of the entire limb is critical in the management of BSAAIs to estimate distal vascularization (distal ischemia and the presence of a viable brachial artery for an endovascular approach), and the entire arm should always be included, if possible, in the acquisition. According to the guidelines of the European Society of Emergency Radiology for polytrauma patients,[23] arms could be positioned down to optimize time (Time/Precision Protocol) or up to reduce radiation exposure (Dose Protocol), and the extremities should not be included in whole-body CT protocols. However, if there is a

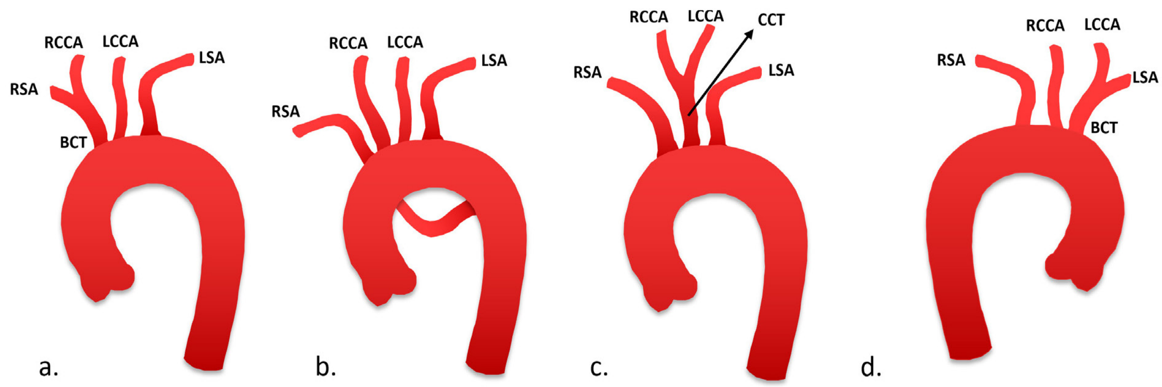

Figure 1. Branching patterns of the subclavian artery from the aortic arch. **(a)** The most typical pattern in which the aorta is left-sided, and the BCT (or innominate artery), the LCCA, and the LSA emerge from the aortic arch. **(b)** Aberrant RSA or "arteria lusoria". The RSA emerges from the distal part of the aortic arch and presents a retroesophageal course **(c)** CCT. In this case, the common carotid arteries emerge from a small carotid trunk, and the subclavian artery originates from the aortic arch on both sides. **(d)** Right-sided aortic arch. The LSA originates from the left BCT, and the RSA emerges from the distal part of the aortic arch but does not present a retroesophageal course. BCT, brachiocephalic trunk; RSA, right subclavian artery; RCCA, right common carotid artery; LCCA, left common carotid artery; LSA, left subclavian artery; CCT, common carotid trunk.

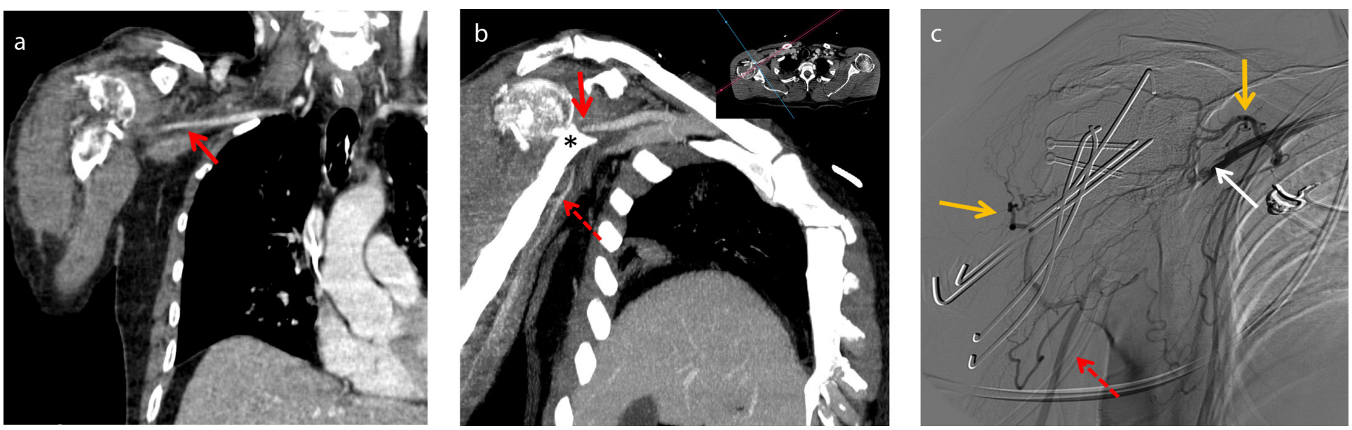

Figure 2. Dissection and occlusion. A 54-year-old male patient who sustained a fracture of the humeral head after a road traffic accident. **(a)** Coronal-reconstructed computed tomography (CT) angiography demonstrated a faint axillary artery but no contrast medium extravasation. **(b)** A coronal-reformatted maximum intensity projection reconstruction of the venous phase demonstrated an entrapment of the axillary artery (red arrow) within the bony fragments of the humerus (*) and the brachial artery (red dotted arrow) refilled by collateral vessels. This injury was overlooked on the admission CT. The patient underwent surgery to reduce the fracture of the humeral head the day after the accident. After 15 days, the patient was dismissed from the intensive care unit and described functional limitation of the right upper limb. **(c)** Angiography confirmed the CT findings and demonstrated complete occlusion of the axillary artery (red arrow), probably due to dissection: part of the dissection flap and floating thrombotic material are appreciable at the proximal end of the occlusion (white arrow). In this image, the large and efficient collateral circulation of the upper limb is appreciable and more evident around the glenohumeral joint (yellow arrows).

high suspicion of a BSAAI, the limb should be positioned alongside the body, or an arm can be placed on the patient's abdomen to redistribute possible streaking artifacts.[23] Some authors suggest positioning the arm of the patient with a suspected arterial injury of the upper limb over the head in prone decubitus ("superman position").[24] The shoulders of the patient should not touch the gantry to avoid possible artifacts (see Figure 5b).

CT angiography is fundamental to evaluating the SAA: excellent vascular opacification can be obtained with a compacted and high-density bolus that necessitates vascular accesses with a high rate of infusion.[6] An unenhanced phase may be performed if active bleeding is suspected to distinguish bony fragments or calcification from active extravasation. Dual-energy CT acquisition during the arterial phase permits the production of virtual, non-enhanced reconstructions and can be employed to avoid unnecessary radiation exposure. In our opinion, a venous phase should always be performed in case of suspected BSAAI: dissection and occlusion could cause a low run-off in the vessels, both upstream and downstream of the injury, which could give the impression of reduced vascularization of the limb or generate false radiological signs of occlusion (pseudo-thrombus).[24,25] Even in cases of rupture or transsection, we suggest a venous phase because the hematoma could determine a mass effect on the vessel (see Figure 6) that slows down the blood flow. Moreover, in the case of reduced flow, a venous phase is fundamental in determining the distal vascularization of the limb and estimating bleeding activity.[23]

CT post-processing

The axial plane offers a poor depiction of the subclavian artery due to its horizontal and slightly curved course. The course of the axillary artery depends on the position of the arm during CT acquisition. A proper evaluation of the subclavian and axillary arteries should include coronal and sagittal reformatting, as well as non-orthogonal planes. Maximum intensity projection reconstructions

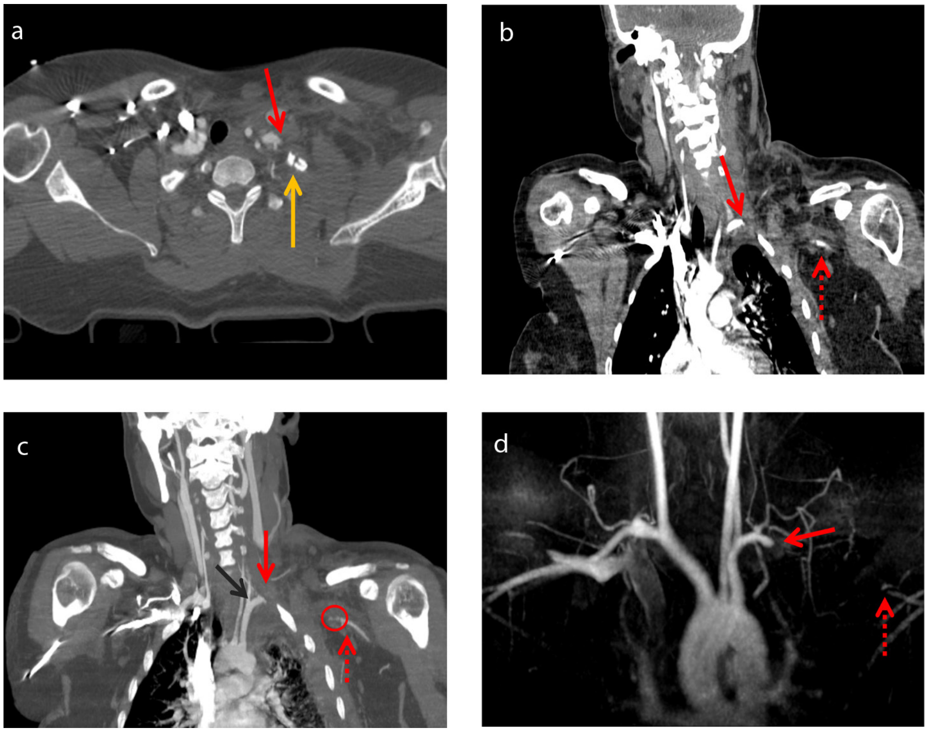

Figure 3. Dissection and occlusion. A 26-year-old female patient who was involved in a motor vehicle accident and sustained an impact to the left shoulder. The patient presented with complete palsy of the left upper limb. **(a, b)** Computed tomography angiography with maximum intensity projection reconstructions. **(c)** Occlusion of the left subclavian artery (red arrow) was demonstrated; slight, retrograde perfusion of the axillary artery is appreciable (red dotted arrow). Small defects are visible in the distal portion of the subclavian artery (red circle). In this case, the mechanism of injury was possibly a dissection downstream of the origin of the vertebral artery (black arrow) and determined massive thrombosis in the lumen of the vessel with consequent occlusion. The injury passed unnoticed during the diagnostic workup, and physicians focused on the brachial plexus injury. **(d)** Magnetic resonance angiography performed after one month during the evaluation of the brachial plexus revealed the complete occlusion of the subclavian artery (red arrow) and an axillary artery perfused by collateral vessels (red dotted arrow).

are a valuable tool in evaluating endoluminal defects, creating images that resemble an angiographic view, which can be useful in planning endovascular approaches (see Figures 2b, 3c). Volume rendering reconstructions are very helpful in demonstrating the three-dimensional relationship of the vessel with bony structures (see Figure 7d). Vessel reconstructions on a curved multiplanar plane help to evaluate the lumen's caliber and delineate endovascular signs, such as intimal tears and flaps (see Figure 7).

Radiological findings

Vasospasm

Vasospasm is determined by the contraction of the smooth muscle fibers within the arterial wall and represents the mildest response of the vessel to an injury.[26] Vasospasm appears as one or multiple segmental contractions of the arterial wall and, when focal (see Figure 8), could be indistinguishable from an intimal tear (see Figure 9). Unlike an intimal tear, vasospasm is transient and tends to reduce or disappear over time.[26] Mild vasospasm could be unnoticed on contrast-enhanced CT, but it is usually well appreciable at DSA.

Intimal tear

An intimal tear is a small rupture of the innermost layer of the vessel that separates the intimal layer from the medial layer and creates a small flap.[26] Intimal tears are primarily seen in blunt aortic traumas. On CT and an-

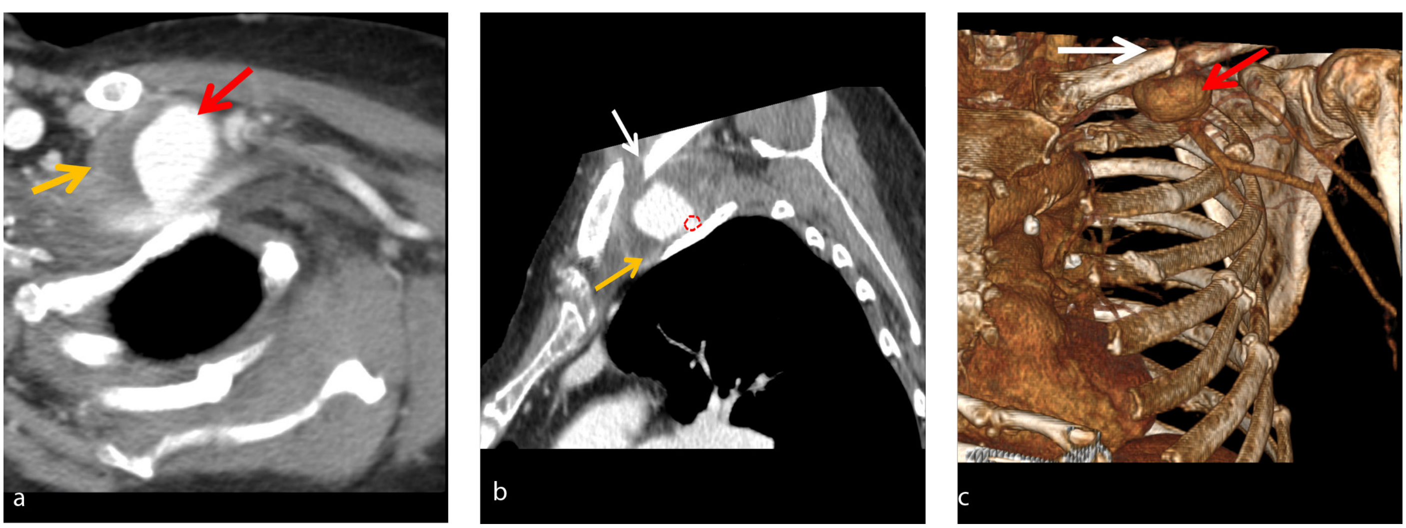

Figure 4. Pseudoaneurysm. A 64-year-old patient who sustained a fracture of the clavicle after trauma to the left shoulder due to a car accident. **(a)** Computed tomography (CT) angiography revealed a large pseudoaneurysm of the subclavian artery. The patent lumen (red arrow) and the wall (yellow arrow) are visible on the axial plane. **(b)** CT angiography reformatted on the sagittal plane demonstrated the lumen of the subclavian artery (red dashed circle), the wall of the pseudoaneurysm (yellow arrow) with parietal thrombus, and a fracture of the clavicle (white arrow). This image offers a good clue about the mechanism of injury that created the pseudoaneurysm: the distal stump of the fractured clavicle probably pierced the subclavian artery against the first rib, damaging the arterial wall. **(c)** Three-dimensional volume rendering offers an optimal depiction of the relationship of the pseudoaneurysm with bony structures.

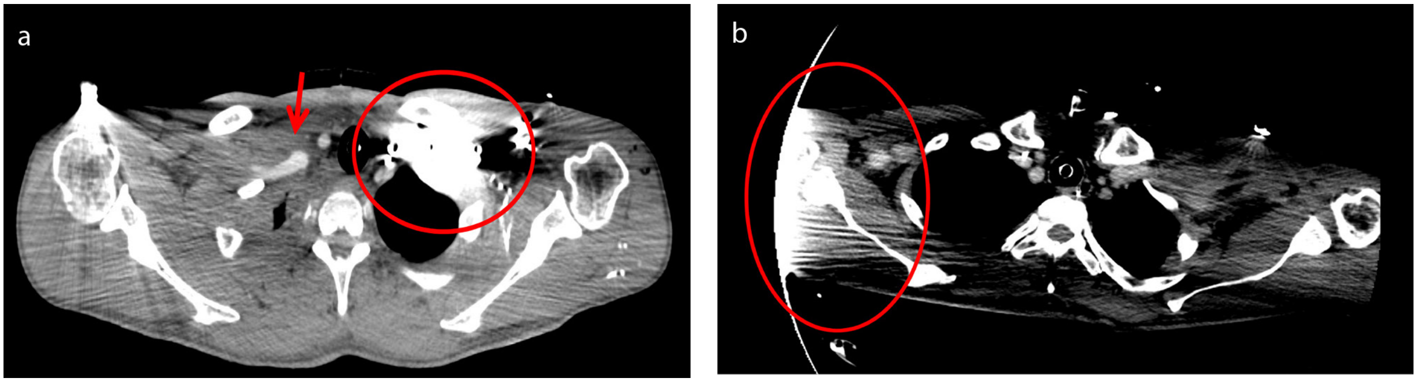

Figure 5. Artifacts. **(a)** A 56-year-old patient sustained a thoracic trauma. Contrast-enhanced computed tomography (CT) was performed, and a contrast medium was injected (flow rate 4 mL/s; 110 mL) into an antecubital vein of the left arm. The compacted bolus of the contrast medium created a streaking artifact (red circle) in the subclavian vein that deleted the signal from nearby anatomical structures. The right subclavian artery is appreciable on the contralateral side (red arrow). **(b)** Streaking artifact by the collision of the shoulder of the patient with the CT gantry.

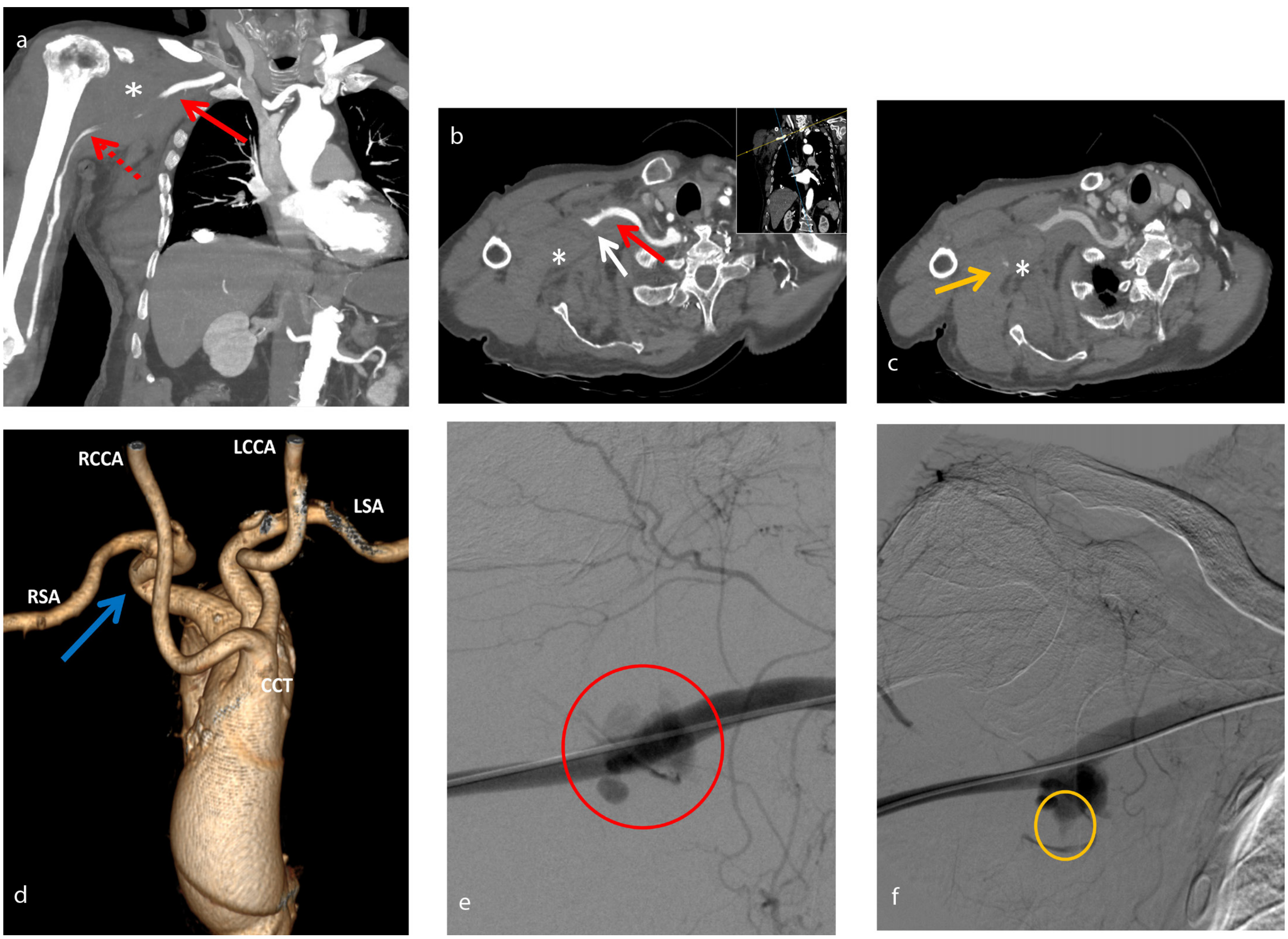

Figure 6. Ruptured pseudoaneurysm. An 84-year-old patient who fell from a bike and landed on an outstretched arm. **(a)** Computed tomography (CT) angiography coronal-reformatted maximum intensity projection demonstrated the course of the subclavian (red arrow) and axillary (red dotted arrow) arteries compressed by a hematoma (*). **(b)** CT angiography demonstrated a hematoma of the right shoulder (*) that dislocated the subclavian and axillary arteries. The subclavian artery presented a narrowing in its distal third (white arrow) that involved the axillary artery (red dotted arrow). The acute margin at the proximal part of the subclavian artery (white arrow) might suggest the presence of a dissection flap with occlusion of the vascular lumen. **(c)** However, the venous phase demonstrated the presence of active contrast medium extravasation within the hematoma (yellow arrow). **(d)** Volume rendering demonstrated the presence of a common carotid trunk and a right aberrant subclavian artery with a retroesophageal course and a tight kinking in its middle part (blue arrow). **(e, f)** A selective angiogram of the subclavian artery was performed using a retrograde approach from the brachial artery. The exam revealed the presence of a pseudoaneurysm (red circle) and active contrast medium extravasation (yellow circle). No endoluminal defect or dissection was appreciable on the angiogram. The complete angiographic sequence is available in Supplementary Video 1. In this case, the mass effect of the hematoma nearly occluded the vessel and created an ambiguous radiological scenario. This represents a good example of the hemodynamic alteration created by hematomas.

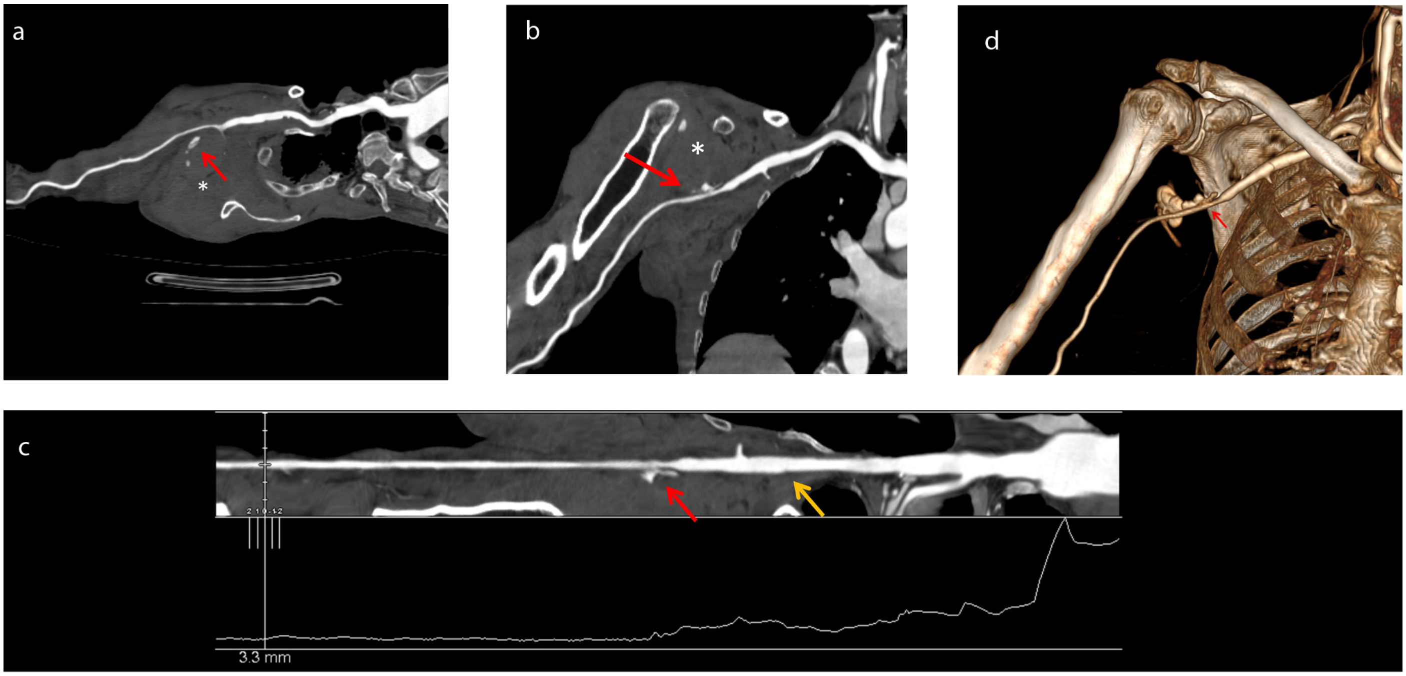

Figure 7. Computed tomography post-processing. A 76-year-old patient who fell from a bike and sustained a partial tear (red arrow) of the right axillary artery. Curved reformatting reconstruction along the lumen of the vessel on the **(a)** axial, **(b)** coronal, and **(c)** orthogonal planes of the lumen with caliber calculation. **(d)** Three-dimensional volume rendering demonstrating the subclavian-axillary artery. A partial tear is appreciable in the first third of the axillary artery (yellow arrow).

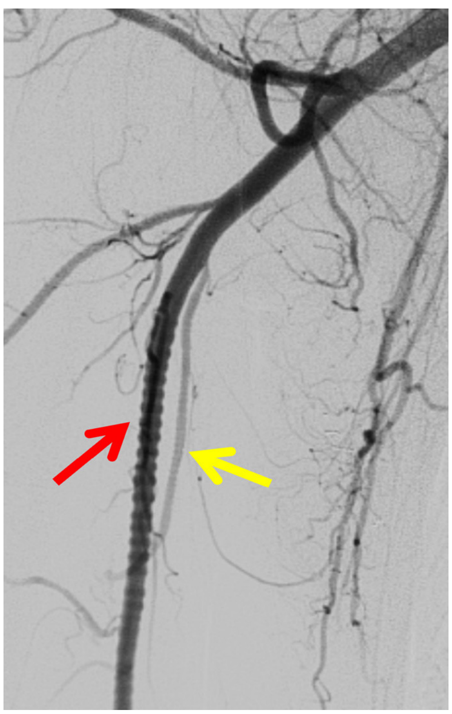

Figure 8. Vasospasm. A 37-year-old male patient who sustained major injuries to the upper limbs during a traffic accident. The patient was ejected from his motorcycle after a collision with a car. At admission, the left arm was pulseless, and the right arm presented a faint pulse. Computed tomography revealed a dissection with occlusion of the left axillary artery and a regular right subclavian/axillary artery. The right arm was evaluated during angiography to rule out possible damage. The selective angiogram demonstrated the presence of marked vasospasm of the axillary artery (red arrow) that involved the collateral branches (yellow arrow).

giography, it appears as a small intraluminal defect floating in the vessels (see Figure 10). Intimal tears can be a source of thromboembolic material or evolve into large dissection flaps, but most heal spontaneously (see Figure 9).[26]

Arteriovenous fistula (AVF)

An AVF is generated by injuries that involve both the SAA and vein (i.e., a bone fragment that penetrates both vessels). The pressure difference creates a passage of blood from the artery to the vein. AVFs are more commonly seen in penetrating traumas[26] and are exceedingly rare in blunt injury. During contrast-enhanced CT and DSA, early and asymmetrical opacification of a vein near an arterial vessel might be consistent with AVF (see Figure 10), even if the breach in the vessel is not appreciable.[6,24]

Dissection and occlusion

A dissection is an intimal tear that creates a large intimal flap. Depending on the flap shape and characteristics, it can float within the lumen or adhere to the vessel's wall, causing stenosis of the lumen (see Figure 11) or creating a false lumen in which blood collects. If the dissection creates a false lumen, blood flow could propagate the dissection along the vessel. Dissection can ultimately result in stenosis or occlusion if the false lumen obstructs the true lumen and blood coagulates within it (see Figures 3, 4, and 12). In such cases, on contrast-enhanced CT, the stenosis typically presents smooth margins that could create an acute interface (see Figures 3 and 12). The presence of flaps in the lumen proximal to the occlusion is suggestive of a dissection that causes an occlusion (see Figure 2c). If the vessel is occluded, the diagnostic differential between dissection and occlusion could be challenging. If the tear in the vessel reaches the sub-adventitial medial layer, the dissection could generate a pseudoaneurysm.[26] At DSA, the dissection flap is well appreciable within the lumen, and it usually appears as a linear defect that fluctuates with blood flow or is pushed against the wall of the vessel (see Figure 11b-d).

Pseudoaneurysm

A pseudoaneurysm is determined by a tear in the arterial wall involving the intimal and medial layers. The blood collects into the breach and creates a lumen outside the vessels delimited only by the adventitial layer. A pseudoaneurysm could occur or become clinically noticeable days after the initial trauma.[6] On CT, pseudoaneurysms show round and smooth margins. The lumen of the pseudoaneurysm presents early opacification in the arterial phase that persists in the venous phase due to internal turbulence (see Figures 4 and 13). The wall of the pseudoaneurysm could exhibit variable parietal

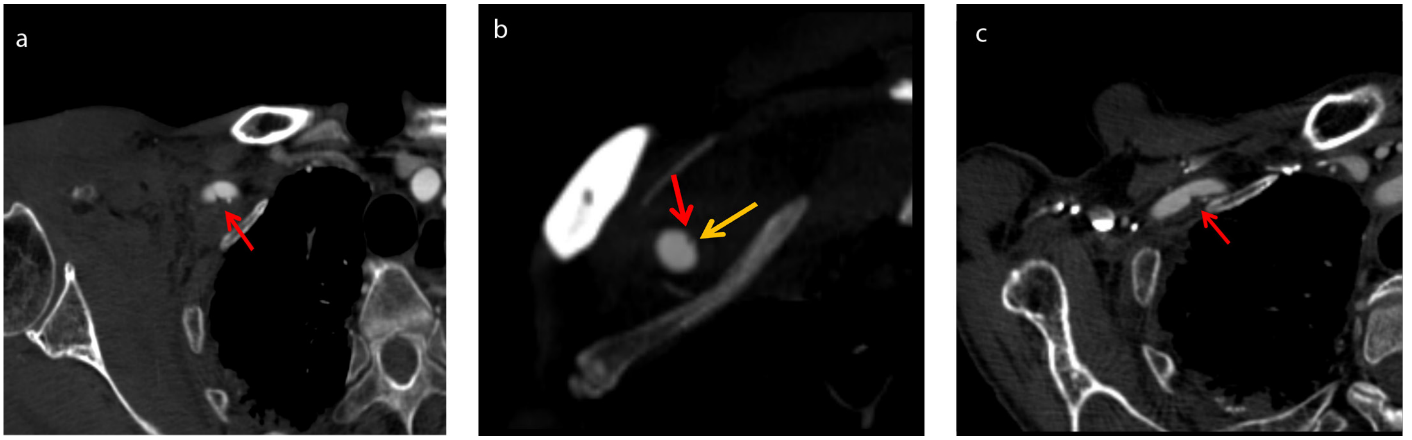

Figure 9. Intimal tear. A 76-year-old patient who fell from a bike and sustained a partial tear of the right axillary artery. **(a)** The axillary artery presented a small intimal tear and a non-occluding luminal defect with a sharp margin (red arrow), referable to a small intimal flap. **(b)** Computed tomography (CT) angiography sagittal-reformatted reconstruction demonstrated the presence of a very small intimal tear (red arrow) and a defect in the wall (yellow arrow). These findings could also be consistent with focal vasospasm. **(c)** A CT after 18 months demonstrated the persistence of the intimal flap and mild lumen stenosis.

Figure 10. Arteriovenous fistula. A 61-year-old male patient who sustained a fall from a three-meter wall. **(a)** Computed tomography angiography of the upper thorax demonstrated an intact right subclavian artery (red arrow) but early, linear enhancement of the right subclavian vein (yellow arrow). **(b)** The selective angiogram of the right subclavian artery confirmed the presence of an arteriovenous fistula between the subclavian artery (red arrow) and vein (yellow arrow) at its distal end.

thrombotic apposition, and in such cases, the lumen will demonstrate partial filling with contrast media.[6] In contrast to a partial tear, if the wall of the pseudoaneurysm remains intact, there is no hematoma, but there could be appreciable stranding in the nearby tissue due to small breaches in the wall. If the adventitial layer ultimately disrupts, blood passes into surrounding tissues and creates a hematoma (see Figure 13). Angiography could better delineate the size of the pseudoaneurysm and demonstrate the ruptured wall.

Partial tear

A partial tear is a breach in the arterial wall that involves all the layers but does not involve the entire circumference of the vessel. In case of a partial tear, the continuity of the vessel is preserved, and the patient can be treated using an endovascular approach. The breach produces a direct communication between the lumen and the perivascular tissues, resulting in a hematoma (see Figures 14 and 15). The margins of a hematoma are irregular. The hematoma could be hyperdense in unenhanced acquisition due to internal clotting processes. In contrast to penetrating injuries, the blood collects in the space around the vessel, limiting the bleeding to varying degrees. The hematoma could even determine a mass effect on the injured vessel, producing ambiguous radiological signs that could be mistaken for dissection or occlusion.

Vessel transsection

Vessel transsection is the complete rupture of the vessel. It is a life-threatening situation with a poor prognosis. A massive hematoma with active contrast medium extravasation is typically appreciable on contrast-enhanced CT. Transsection is the result of extreme shear forces applied to the vessel, and arterial stumps could be projected away from one another due to elastic recoiling (see Figure 16). Digital subtraction angiography might demonstrate active contrast medium extravasation or a truncated vessel.

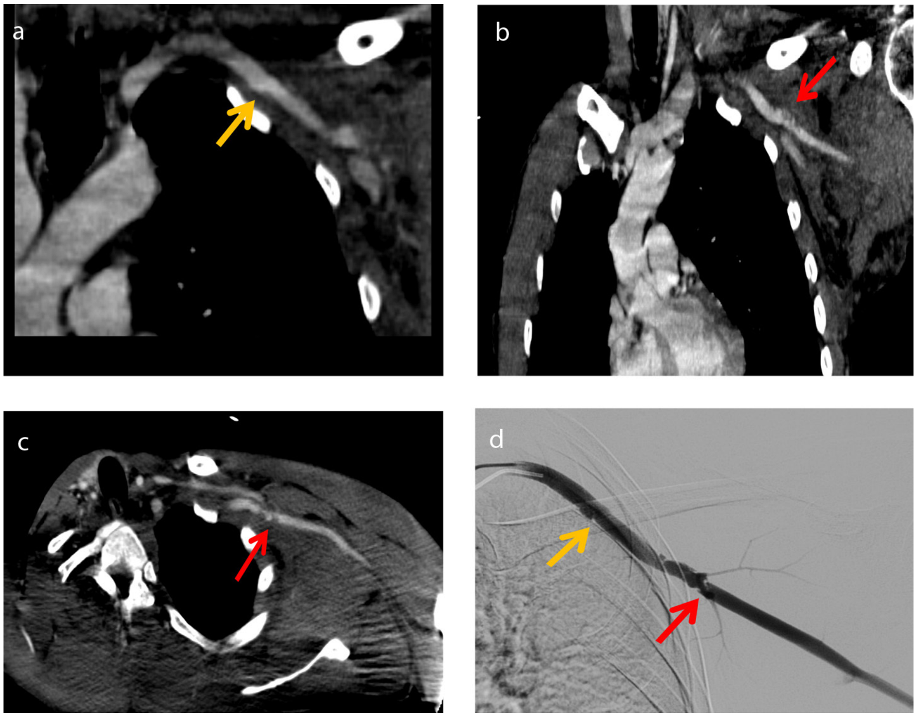

Figure 11. Dissection. A 33-year-old male patient who sustained a distraction injury after falling from a motorcycle. **(a)** Coronal reformatted computed tomography angiography demonstrated the presence of a small intimal tear (yellow arrow) in the left subclavian artery and an irregular endoluminal defect (red arrow) in the proximal portion of the axillary artery **(b)**. These findings are consistent with a dissection without thrombosis. **(c)** The venous phase confirmed the presence of an endoluminal defect in the axillary artery, referable to a dissection flap adherent to the arterial wall (red arrow). **(d)** The selective angiogram of the left subclavian artery confirmed the presence of an intimal tear (yellow arrow) and an irregular wall in the proximal axillary artery consistent with a dissection flap.

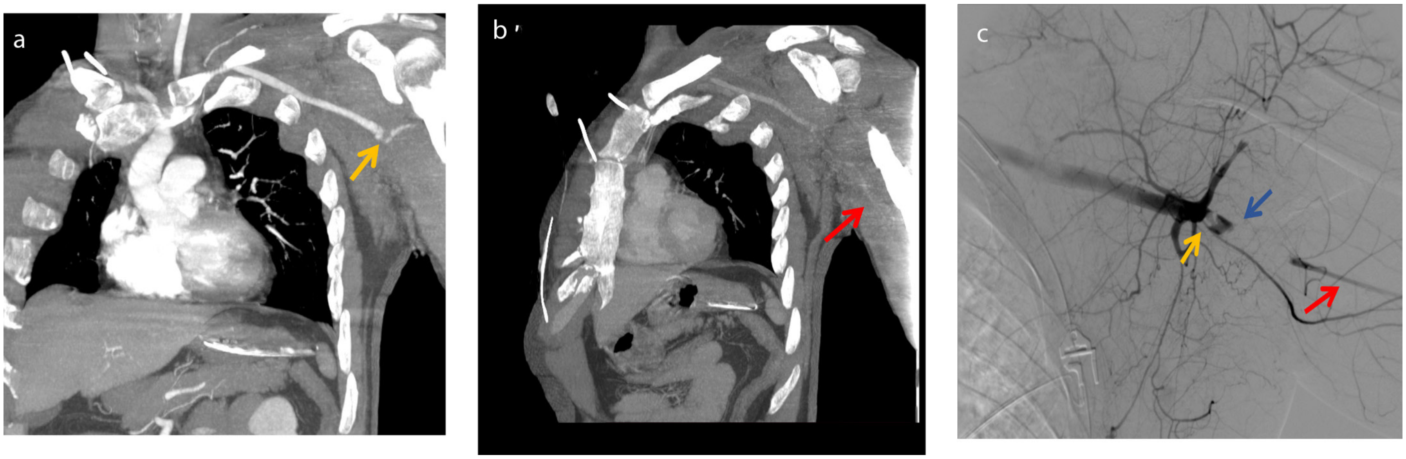

Figure 12. Dissection and occlusion. A 47-year-old male patient who underwent a traffic accident. The left arm was pulseless on arrival at the emergency department, but no swelling was appreciable at the first examination. **(a)** Computed tomography angiography reconstructed along the plane of the subclavian/axillary artery demonstrated an intact subclavian artery but a small defect in the lumen of the axillary artery (yellow arrow) and scarce distal vascularization. No hematoma was appreciable. **(b)** The venous phase demonstrated the presence of the brachial artery revascularized by collateral vessels (red arrow). **(c)** Digital subtraction angiography confirmed the presence of a thrombus within the lumen of the axillary artery (yellow arrow) and revascularization of the brachial artery (red arrow). The sharp margin of occlusion (blue arrow) is probably a dissection flap that occludes the axillary artery. The complete angiographic sequence is available in Supplementary Video 2.

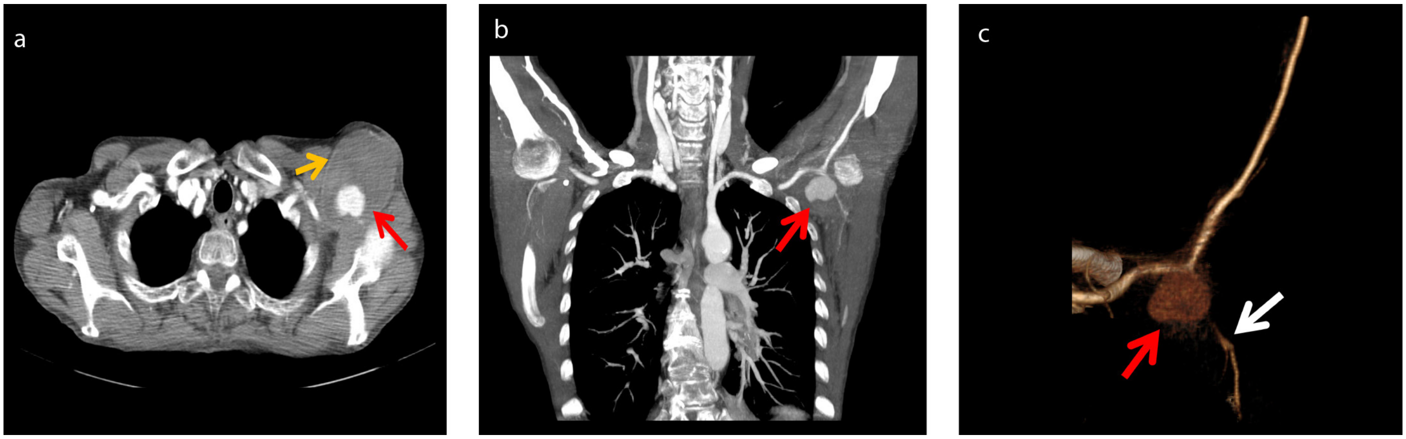

Figure 13. Pseudoaneurysm. A 56-year-old female patient who suffered a minor trauma to the left shoulder, which determined the emergence of a large, palpable, and pulsatile swelling above the humerus. **(a)** Computed tomography angiography demonstrated the presence of a massive pseudoaneurysm of the axillary artery with a definite wall (yellow arrow), partial parietal thrombosis, and a patent central lumen (red arrow). No signs of parietal fissures or extraluminal hematoma were appreciable. Coronal reformatted maximum intensity projection reconstruction **(b)** and three-dimensional volume rendering **(c)** demonstrated the relationship of the pseudoaneurysm with the axillary artery and a small neck near the origin of the lateral thoracic artery, which was partially compressed (white arrow).

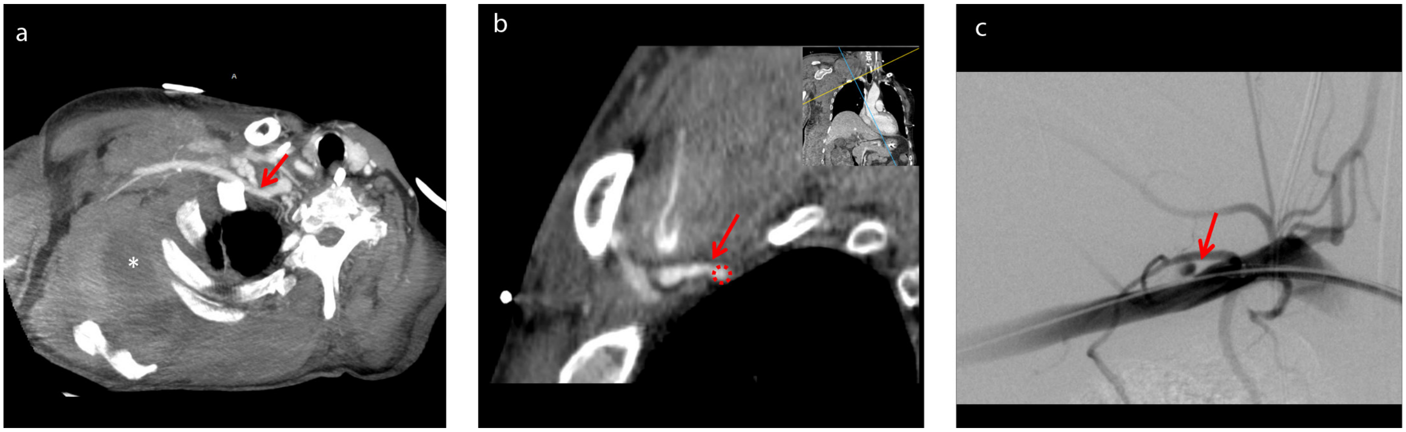

Figure 14. Partial tear. A 70-year-old man who fell from a two-meter wall. The patient was on antiplatelet therapy and presented with massive swelling of the supraclavicular fossa and axilla. **(a)** Maximum intensity projection computed tomography angiography revealed a partial tear of the subclavian (red arrow). **(b)** Sagittal reformatting demonstrated the lumen of the subclavian artery (red dotted circle) and a tear in the anterosuperior part of the arterial wall (red arrow). **(c)** The selective angiogram of the right subclavian artery confirmed the tear in the subclavian artery (red arrow).

Relevant ancillary findings

Ancillary findings may improve the detection of an arterial lesion and the diagnostic and therapeutic workup. Bone fractures are a direct or indirect sign of the forces applied to the body during trauma, and looking at the artery near bone fractures could unveil scarcely visible signs of BSAAIs (see Figures 2, 3a, and 4b).

The vascular anatomy of the aortic arch and the branching pattern of the SAA should always be described, as it could determine the type and timing of treatment (endovascular or open surgery and the type of arterial access). Aberrant origins from the aortic arch could necessitate different endovascular approaches. The vertebral artery is one of the most important branches of the subclavian artery. A BSAAI that involves the vertebral artery constitutes a life-threatening condition because of the possible impact on cerebral perfusion. Moreover, the origin of the vertebral artery and its distance from the injury should always be included in the radiologic report to improve treatment planning (i.e., the employment of a stent graft could be hazardous if the BSAAI is near the origin of the vertebral artery). The internal thoracic artery could be employed in coronary bypass surgery, and dissection or occlusion that involves the ostium of the internal thoracic artery could result in myocardial infarction.

Finally, the distal revascularization (i.e., viable brachial or radial artery) of the arm should be described in the radiologic report because it depicts the ischemic injury and time of devascularization. If the patient is suitable for endovascular or hybrid management, the interventional radiologist/vascular surgeon might make use of brachial or radial arterial access.

In conclusion, BSAAIs have a wide and heterogeneous spectrum of CT findings. Hematomas could slow the arrival time of contrast media and generate ambiguous radiological scenarios. BSAAIs presenting with active extravasation should be properly evaluated and could require adjunctive acquisition (venous and delayed phases). The role of the radiologist in the setting of a BSAAI is to perform high-quality diagnostic imaging and provide essential information to optimize treatment.

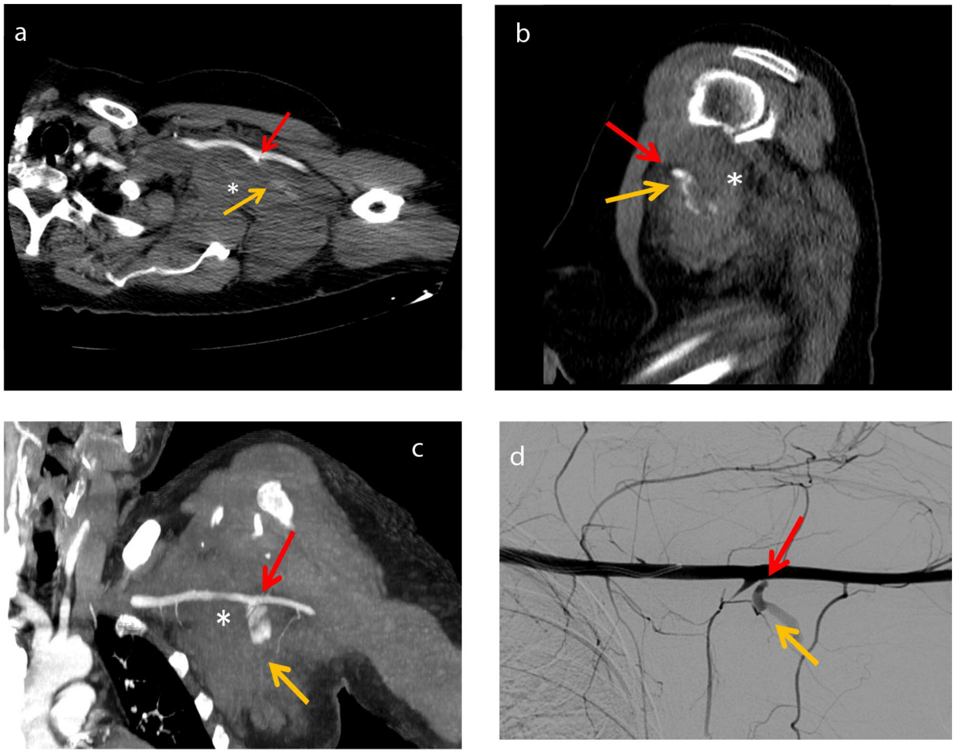

Figure 15. Partial tear. A 63-year-old female patient who was involved in a road traffic accident. **(a)** Axial and **(b)** sagittal computed tomography angiography demonstrated a partial tear in the axillary artery (red arrow), a hematoma (*), and **(c)** active contrast medium extravasation within it (yellow arrow). **(d)** Maximum intensity projection reconstruction created an image resembling a selective angiogram.

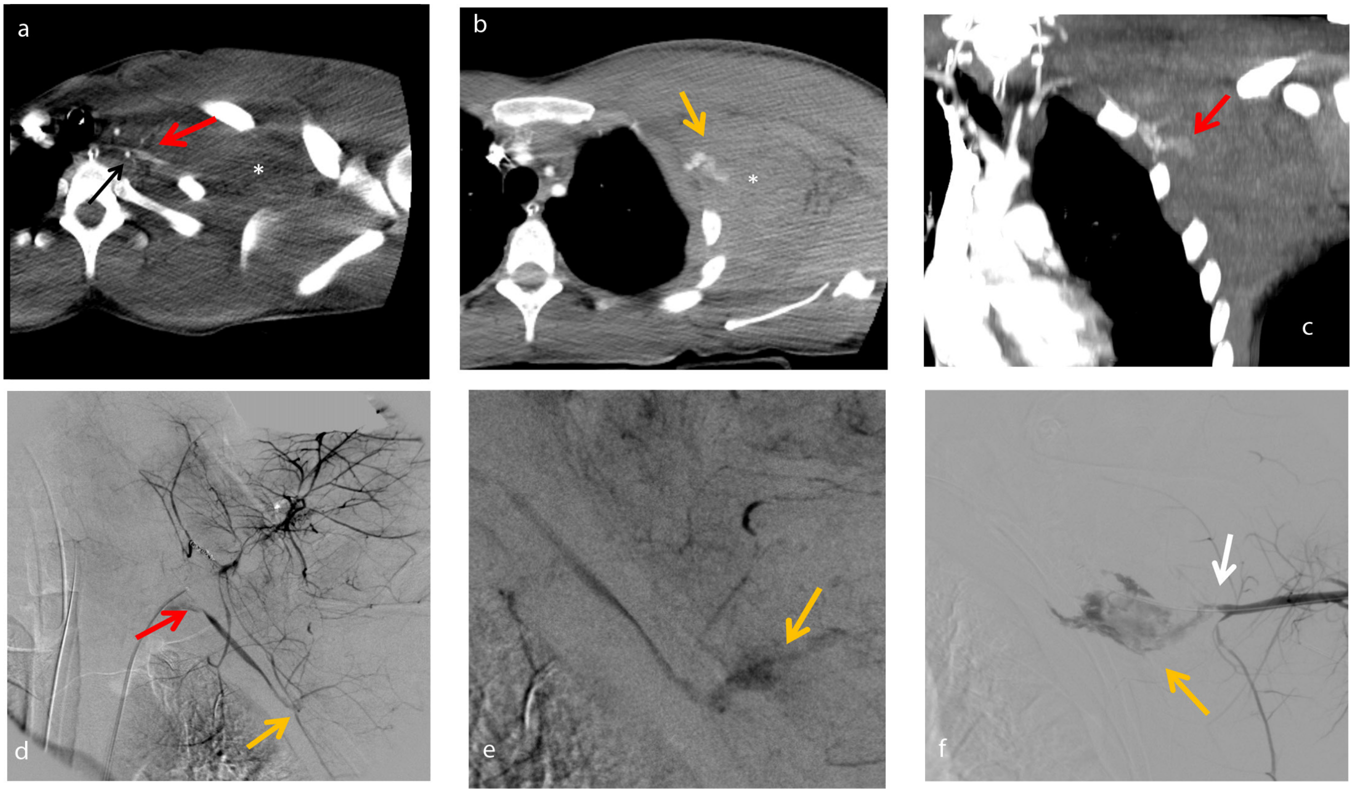

Figure 16. Transection. A 19-year-old male patient who was involved in a motorcycle accident during a competition. **(a)** Computed tomography angiography shows the subclavian artery, which seems occluded a few centimeters distal to the origin of the vertebral artery (black arrow). **(b)** A massive hematoma is appreciable in the lateral thoracic wall (*); signs of active bleeding are noticeable within it (yellow arrow). **(c)** Coronal reformatting revealed the subclavian artery, which is compressed against the ribs, and active extravasation from the proximal arterial stumps (red arrow). **(d)** The selective angiogram of the subclavian artery confirmed that the subclavian artery was compressed against the thoracic wall (red arrow), with signs of contrast medium extravasation (yellow arrow). In this case, blood flow was slowed by the compression of the hematoma, and active bleeding was seen better in the delayed phase **(e)**. **(f)** The selective angiogram performed using a retrograde approach from the radial artery revealed the location of the distal arterial stump (white arrow) several centimeters from the proximal one.

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Video 1: https://www.youtube.com/shorts/q_X0lVnXBVY

Video 2: https://www.youtube.com/shorts/Iae87vyy83Q