Non-aortic vascular findings on chest CT angiogram: including arch vessels and bronchial arteries

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Abstract: CT angiogram (CTA) has become the modality of choice for imaging of thoracic vascular pathologies, involving the aorta and the pulmonary arteries. Apart from showing exquisite details of these large arteries, pathologies and anatomic variants of their branches can also be studied to a great extent. The major branches of aortic arch can be affected by a wide variety of pathologies ranging from atherosclerosis to trauma and vasculitis. Bronchial arteries in spite of supplying only 1% of lung parenchyma can become hypertrophied in various congenital and acquired conditions, becoming an important source of collateral circulation as well as a source for life threatening hemoptysis. CT also plays an important role in diagnosis of vascular compression at the thoracic outlet. With advances in CT technology, the acquisition, interpretation and clinical applications of CT angiography will continue to grow in the years to come.

Keywords: Aortic arch branches; bronchial arteries; central veins; chest CT angiogram (chest CTA)

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Introduction

CT angiogram (CTA) has become the modality of choice for imaging of thoracic vascular pathologies, involving the aorta and the pulmonary arteries. Apart from showing exquisite details of the aorta and pulmonary artery, CTA provides an accurate picture on the anatomy and pathology of the arch vessels and other aortic branches with far greater information than what we can achieve with ultrasound or plain radiography. The purpose of this article is to describe the common non-aortic and non-pulmonary vascular pathologies a radiologist may come across in a chest CTA.

CT angiography protocol for aortic arch vessels and other aortic branches

The exclusive imaging of arch vessels requires an optimal combination of temporal resolution, contrast opacification and spatial resolution. The ability to achieve the best possible image has significantly improved over the years and we have come to the point of rapid sub-second imaging with the least possible contrast dose using the current generation of dual source CT scanners (1). The intravenous line is usually placed on the asymptomatic upper limb or by default on the right side to avoid streak artefacts across the arch vessels. At our institute, we use iso-osmolar iodinated contrast of concentration 320 mg/mL with a saline chase; the contrast dose being 100 to 120 mL based on the patient's weight. A flow rate of 4 to 5 mL/second is ideal. A bolus tracking technique (threshold of 150 Hounsfield units) is used to trigger the acquisition with the region of interest placed in the descending aorta just below the level of the carina. We use automated attenuation-based selection of individualized tube parameters to have an optimal radiation exposure. The field of view should cover from the skull base to the upper abdomen based on the anteroposterior and...
lateral scouts. Finally, in patients with compromised renal function, rapid dual source CT imaging in arterial phase can be made use of to limit the dose of contrast to as low as 40 mL (2).

**Anatomy of the arch and great vessels**

The most common pattern of aortic arch branching is the trifurcation pattern i.e., the innominate artery, left common carotid artery and the left subclavian artery, which is seen in approximately 70 percent of patients (3). Six pairs of branchial arch arteries develop in the fetus. The common variations of aortic arch can be attributed to abnormal persistence or disappearance of segments of these branchial arch arteries. The common “variant” aortic arch patterns include left common carotid artery origin from innominate artery (Bovine arch) which is seen in 13% of the population, left vertebral artery arising directly from aortic arch (0.5%), aberrant right subclavian artery (0.4% to 2%). Other rare variants include aberrant right vertebral artery, double/right sided aortic arch (4). Identifying these variants in the preprocedural CTA provides valuable information to the interventional radiologist about the access pathway to the cervical, cerebral or upper limb vasculature and will obviate the need of a diagnostic arch aortogram during the interventional procedure.

Aortic arch is classified into three types based on the distance of innominate artery origin from the top of aortic arch, with reference diameter being the diameter of right or left common carotid artery (5). If the innominate origin is at the level of the top of the aortic arch, it is type 1 (Figure 1A). If the innominate origin is inferior to the top of aortic arch by 1.5 to 2 times the diameter of the common carotid artery, then it is type 2; if still lower, then it is type 3 (Figure 1B). Type 2 and type 3 arches pose significant challenges in carotid and neurovascular interventional procedures. Appropriate catheter selection can be planned prior to these procedures anticipating the difficult access.

**Pathology of great vessels**

The great vessels that originate from the aortic arch can be affected by a wide range of pathologies within the thoracic cage. Commonly encountered ones include aneurysms, trauma, atherosclerotic disease large vessel vasculitis, and thoracic outlet syndrome (TOS).

**Aneurysms**

Common causes of aneurysms of supra-aortic arch branches include atherosclerosis, Marfan syndrome and connective tissue disorders, arteritis, mycotic, post traumatic or post-operative states. Isolated aneurysms of distal segment of subclavian arteries are likely to be due to TOS. Aneurysms of the arch vessels comprise 0.4% to 4% of all aneurysms (6). They may be asymptomatic or sometimes present with features of mass effect on vital structures such as dyspnea and hoarseness of voice, rupture (11% risk), distal thrombo-
embolic phenomenon (50%) and infection (7) (Figure 2). In one of the largest reported case series involving arch vessel aneurysms, the most commonly affected vessel was the subclavian artery (50%), followed by the common carotid (26%), internal carotid (10%) and innominate arteries (3%) (6). Aneurysms can be fusiform, when there is a circumferential luminal dilatation, or saccular, when there is a focal outpouching, or a combination of the two.

Treatment is indicated for symptomatic aneurysms, saccular aneurysms and asymptomatic aneurysms greater than 3 cm usually by surgical resection, exclusion by stent graft or hybrid procedures (8). Cross sectional imaging is essential to look for status of bilateral vertebral arteries, particularly if endovascular treatment is contemplated. MDCT angiography is essential for diagnosis, characterization and treatment planning (9). It provides the required information for planning endovascular reconstruction of the vessel including the length of the diseased segment, proximal and distal landing zones and side branches in the treatment zone which can serve as endoleaks in future.

**Trauma**

Trauma to the aortic arch branches results from blunt or penetrating trauma to the upper chest or neck. They can either occur along with aortic injury or in isolation. They are clinically occult and require a low threshold of suspicion. Manifestations include traumatic occlusions, dissections, contrast extravasations, pseudo-aneurysms and arterio-venous fistulæ. Hematoma in the lower cervical region or superior mediastinum usually indicates brachiocephalic or proximal subclavian artery injury (Figure 3). Injury to internal mammary artery can be overlooked but may lead to catastrophic effects by impaired right ventricular filling due to mass effect due to the expanding hematoma, particularly on the left side (10). CT is useful for identifying vascular injuries and associated osseous/pulmonary/soft tissue injuries which often coexist and for planning surgical or endovascular treatment. Findings in the CT angiography include irregular vessel margins, filling defects, active contrast extravasation, occlusion of a vessel, and caliber changes in the vessels (11). A negative CTA even in the presence of hematoma obviates the need for diagnostic angiogram (12). One limitation of CTA in the situation of trauma to the great vessels is in assessment of the subclavian artery ipsilateral to the venous contrast inflow; can be avoided by careful evaluation of the plain CT and planning contrast injection accordingly.

**Atherosclerosis**

Atherosclerosis is the commonest cause of obstructive lesions involving the arch vessels. Patients typically present with clinical features of cerebrovascular and upper limb ischemia or steal phenomenon when it involves the subclavian artery. Atherosclerotic diseases of upper extremities are uncommon compared to lower extremities.
Atherosclerotic disease of the great vessels. (A) VRT image of a CTA of the thorax in a patient with right arm claudication showed a critical stenosis in the first part of right subclavian artery proximal to the vertebral artery origin; (B) DSA of the same patient confirming the same finding. Incidental severe atherosclerotic disease of the right carotid bulb is also noted. VRT, volume rendering technique; CTA, CT angiogram; DSA, digital subtraction angiogram.

and may remain asymptomatic due to collaterals. Tandem lesions are common (13) (*Figure 4*). Symptoms are mostly chronic with acute exacerbations due to distal thromboembolic phenomena leading to digital ischemia, or neuroocular symptoms. Arm claudication symptoms and blood pressure differences between the arms are commonly noted. In case of proximal subclavian occlusions symptoms of subclavian steal syndrome with Transient ischemic attacks or syncopal attacks predominate. In patients with internal mammary artery grafts, proximal subclavian occlusion may lead to myocardial ischemia and pre-procedure evaluation of subclavian arteries is indicated prior to coronary bypass grafting procedures (14). The left subclavian artery is the most commonly involved vessel and majority of the lesions are prevertebral (15). Patients presenting with signs and symptoms of upper limb or cerebrovascular

*Figure 3* Subclavian artery injury. (A) Active extravasation noted in the first part of left subclavian artery following polytrauma (arrow); (B) digital subtraction angiogram (DSA) showing the injured artery with extravasation (arrowhead); (C) post stent-graft repair DSA showing no leak. The patient succumbed 2 days later due to multiorgan dysfunction secondary to severe shock.
ischemia are typically evaluated with Duplex ultrasound as the first investigation. However, the utility of duplex ultrasound is limited in the setting of atherosclerotic disease of the intrathoracic arch vessels. Echocardiography performed from the suprasternal notch has been shown to be a valuable tool in screening of the supra-aortic arch vessel pathology. However, CTA is the imaging modality of choice for accessing atherosclerotic disease of the arch vessels as it provides exceptional spatial resolution for assessment as well as treatment planning, i.e., the length and degree of obstruction and presence of tandem lesions. It can also show collateral pathways which maintain limb or cerebral perfusion in chronically symptomatic patients and help in decision making on best medial management or intervention (16). CTA can also quantify the calcific burden of a stenosis or occlusion which has a strong bearing on the choice of intervention, viz., endovascular or surgical.

Vasculitis

Takayasu arteritis is the commonest form of vasculitis affecting the arch vessels. It is a non-specific inflammatory disease of aorta and great vessels predominantly, also involving the pulmonary and coronary circulations with a strong female predominance. It is characterized by concentric wall thickening and fibrosis early on, further leading on to stenosis and aneurysmal dilatations. Diagnosis is based on either Ishikawa/American college of Rheumatology criteria. The disease is classified into 5 types based on the location of involvement, of which types I and II can involve the supra-aortic branches. There is no preference noted in the involvement of the arch vessels. Symptoms are initially constitutional; as the vascular lesions progress and lead to stenotic foci or aneurysms, patients may present with a spectrum of features including, but not limited to, neuro-ocular syndromes, weakened pulses, vascular bruits and renovascular hypertension. Duplex ultrasound can be used as an effective screening tool to demonstrate a long segment, smooth, echogenic, circumferentially thickened vessel wall (macaroni sign) with stenotic flow in the accessible vessels (17). CT/MR angiography is the imaging modality of choice and depicts both luminal and mural changes. Mural changes include concentric wall thickening with venous phase enhancement in the active phase of the disease (at least 3 mm concentric thickening) and intra-mural calcifications in the burnout phase (Figure 5). Edematous inner wall and enhancing outer wall—the so called “double ring sign” is also said to be characteristic for the disease and is associated with poor prognosis (18). MRA is advantageous for diagnosis and follow up of these patients as it offers a radiation free demonstration of the findings. The active lesions are FDG-avid in active phase. Luminal changes include stenosis, occlusions aneurysmal dilatations. Mid segment of subclavian/carotid arteries, distal innominate artery and non-ostial proximal renal artery involvement are said to be
characteristic. Giant cell arteritis, polyarteritis nodosa, other forms of aortitis and peri-aortitis may also involve the great vessels but can be differentiated clinically and radiologically, although there may be overlap of the spectrum (19).

TOS

TOS includes a complex of neurological or vascular upper extremity symptoms related to extrinsic compression of the neurovascular structures at the point of exit from the thorax. Although classically diagnosed by the clinical signs and symptoms, imaging plays a crucial role in excluding alternative diagnoses and plan treatment. The syndrome can be neurological or vascular; however, considering the scope of this review, vascular TOS is discussed in detail. It can be arterial or venous.

The thoracic outlet can be divided into three spaces, namely the scalene triangle, the costoclavicular space and the subcoracoid pectoralis minor space (20). The thoracic outlet, at all these levels, is a dynamic space; abduction of the ipsilateral arm results in narrowing of the space. Patients with TOS experience compression of the neurovascular structures during this process. Conventional radiography as the preliminary investigation can show presence of cervical rib or anomalous 1st rib as cause of the TOS, particularly in patients who are scheduled for MRI as the confirmatory modality. Cross sectional angiographic imaging, either CT or MRI, forms the cornerstone of imaging in vascular TOS (21). Dynamic maneuvers (abduction of the arms) are performed during the imaging process to elicit the causative vascular event. MRI has a particular advantage in this group of patients who are predominantly young, owing to the need for dynamic imaging which can increase the radiation dose in the case of a CTA.

Neurogenic TOS accounts for 90% of the cases of TOS. Among the vascular cases, venous is more prevalent. The classic site of venous compression is the costoclavicular space, between the first rib, subclavius muscle and the clavicle. Two types of presentations can be seen; acute axillosubclavian venous thrombosis (effort thrombosis or Paget Schroetter syndrome) and chronic intermittent upper extremity swelling without thrombosis (McCleery syndrome). Bony anatomy is often normal. CT or MR angiography, in the venous phase, demonstrates axillosubclavian venous thrombosis, narrowing of the subclavian vein or venous collaterals (21).

Arterial TOS is the least common of the three subtypes, accounting for 3% of all cases of TOS. The primary damage to the subclavian artery that occurs at the level of the first rib and the resultant distal embolic phenomena are the two main issues in arterial TOS. It is invariably associated with underlying bone abnormalities, such as a cervical rib (Figure 6), anomalous first rib, or a malunited fracture of the first rib or clavicle. CT angiography clearly depicts the tell-tale signs of vascular damage at the compression site, in the form of dissection, aneurysm formation or thrombosis. Distal embolic phenomena can also be identified (Figure 7). Dynamic maneuvers provide supportive evidence to demonstrate the narrowing of the subclavian artery at the thoracic outlet, but standalone, it is not sufficient for the diagnosis of TOS (21).

Assessment of post-operative patients of TOS with
Figure 7 Arterial TOS due to scalene compression. (A) Oblique axial reformatted image of the CTA showed kinking of the left SCA by the scalene muscle (arrow); (B) VRT image showed embolic occlusion of the left radial artery. TOS, thoracic outlet syndrome; CTA, CT angiogram; SCA, subclavian artery; VRT, volume rendering technique.

recurrent symptoms is excellent with CT angiography as it clearly depicts the post-surgical bony alterations, native vessel/vascular graft status and other soft tissue complications.

**Bronchial arteries**

**Introduction**

Lung has two vascular systems—pulmonary and bronchial circulations. Bronchial system provides 1% blood supply and carries oxygenated blood in high pressure. It does not participate in gas exchange but provides nourishment to the supporting structures of the lungs, including the pulmonary arteries (22,23). Both systems are interconnected through several microvascular anastomoses at the level of the alveoli and respiratory bronchioles (23).

**Anatomy of bronchial artery**

Bronchial arteries arise directly from the proximal descending thoracic aorta between superior endplate of T5 vertebra and inferior endplate of T6 vertebra (orthotopic origin). Any other site of origin is termed as ectopic origin (20,24-26). Incidence of ectopic bronchial artery ranges from 8.3-56% (25,27,28). Common ectopic sites of origin include the inferior aortic arch, distal descending thoracic aorta, subclavian artery, brachiocephalic trunk, thyrocervical trunk, and internal mammary artery and even a coronary artery (25). Bronchial arteries which originate from a coronary artery may be asymptomatic or may lead to myocardial infarction or angina due to coronary steal phenomenon (29).

The right bronchial artery commonly shares its origin with an intercostal artery (30) (52% of cases at CT angiography), a finding known as a common intercosto-bronchial trunk (ICBAT). Less commonly, the left and right bronchial arteries share a common origin (32% of right and 36% of left bronchial arteries at CT angiography), known as the common trunk of both bronchial arteries.

There are 9 types of variations in the origins and number of the bronchial arteries (Figure 8); the most common is type 1 (40.6% of cases), with one right bronchial artery arising from a common ICBAT and two left bronchial arteries. Type 2 is the second most common pattern (21.3%), consisting of a single bronchial artery on each side. Type 3 is the third most common pattern (20.6%), consisting of two bronchial arteries on each side, with one of the right bronchial arteries originating from an ICBAT. Types 4-9 are other rarer variants. Both bronchial arteries usually travel behind the trachea and mainstem bronchi before entering the lung via the hila (30). Normal bronchial arteries are small, measuring less than 2 mm at their origin and 0.5 mm distally as they enter the bronchopulmonary segment. Normal bronchial arteries manifest on CECT as small nodular or linear enhancing structures and are best depicted on multiplanar images, given their undulating course (20,30,31).

The bronchial arteries normally receive only about 1% of the total cardiac output and help maintain airway and lung function (32). They provide systemic blood supply to the
tracheobronchial tree, visceral pleura, esophagus, vasa vasorum of the thoracic aorta and pulmonary arteries, nerves, pulmonary veins, and lymph nodes in the thorax (26,33). When there is an inflammatory pathology involving lungs or an increase demand of oxygenated blood to lung tissue, it undergoes smooth muscle wall hypertrophy and dilatation (23,33).

Pathology

When bronchial arteries are dilated, its diameter increases to greater than 2 mm and become tortuous (31). Visualization of dilated bronchial arteries at imaging should alert the radiologist to rule out obstructive disorders affecting the pulmonary circulation, chronic infectious and/or inflammatory processes, chronic thromboembolic disease, and congenital cardiovascular anomalies of the thorax.

The causes of bronchial artery dilatation can be divided into four categories as follows:

(I) Congenital pulmonary artery anomaly;
(II) Acquired intrinsic pulmonary artery obstruction;
(III) Acquired extrinsic pulmonary artery obstruction;
(IV) Acute or chronic inflammation.

Congenital pulmonary artery anomaly

The congenital conditions that are most commonly associated with pulmonary vascular insufficiency leading to bronchial artery dilatation are Tetralogy of Fallot (TOF), proximal interruption of the pulmonary artery and anomalous origin of the left coronary artery from the pulmonary artery (ALCAPA).

In TOF, systemic arteries called major aortopulmonary collateral arteries (MAPCA) develop and supply the insufficient pulmonary bed. These may be difficult to differentiate from hypertrophied bronchial arteries (34) and are further discussed in detail under a separate topic. In cases of proximal pulmonary artery interruption, the mediastinal portion of the right or left pulmonary artery is atretic, affected lung is hypoplastic and the distal pulmonic circulation is supplied by systemic collaterals, via subclavian, intercostal and most commonly bronchial arteries (8,35). In ALCAPA, hypertrophied bronchial arteries may supply the left coronary artery territory (36,37).

Acquired intrinsic pulmonary artery obstruction

The causes include chronic pulmonary thromboembolism and arteritis involving the pulmonary circulation (Takayasu arteritis), where the bronchial artery hypertrophy is induced by chronic hypoxemia of the lung tissue (35,38–40).

Acquired extrinsic pulmonary artery obstruction

Fibrosing mediastinitis is a benign but sometimes progressive disorder characterized by infiltrative fibrous tissue in the mediastinum. It can be nongranulomatous or granulomatous (41). It can involve pulmonary arteries (42) causing constriction and obstruction of the pulmonary
arteries, generally unilateral (41). Ipsilateral bronchial artery dilatation is seen when fibrous tissue encases and narrows a pulmonary artery as a physiologic response to decreased blood flow to the lung (43).

**Acute or chronic inflammation**

Inflammatory response of lung parenchyma leads to release of angiogenic growth factors which promote neovascularity as well as hypervascularity via collateral pathways with an increase in bronchopulmonary anastomosis at precapillary and capillary levels (24,44). Causes include bronchiectasis (Figure 9), chronic infection, primary and secondary lung cancers (Figure 10) (45). Such patients may present with hemoptysis, which can be life threatening at times. CECT is useful in demonstrating the cause and site of bleeding and identifying abnormal bronchial arteries or, rarely, active contrast agent extravasation as the source (46).

**Bronchial arteriovenous malformation**

Bronchial arteriovenous malformation is a rare congenital or acquired disorder which results in a left-to-left or left-to-right extracardiac shunt. Acquired causes are infectious
or inflammatory lung diseases, penetrating lung trauma, and tumor-primary/secondary (47). It is characterized by a tortuous and enlarged bronchial artery that communicates with a pulmonary artery or pulmonary vein (47,48). It is more common in men, can occur at any age, and usually affects the right lung. Patients often are asymptomatic, but the condition may result in massive hemothysis and death. Contrast CT with arterial and venous phases is the noninvasive investigation of choice. It manifests as a tortuous and dilated bronchial artery, often with focal aneurysms and anomalous communication with a pulmonary artery or vein. Digital subtraction bronchial angiography confirms the diagnosis. It can be treated endovascularly via coils or vascular plugs.

Hemothysis and bronchial artery intervention

Massive hemothysis is generally defined as expectoration of greater than 300 mL of blood in 24 hours or any amount of blood which causes a 2 gm% drop in hemoglobin from baseline or hemodynamic instability. In 90% of cases, the source of hemothysis is a hypertrophied bronchial artery (22,26). Most cases of clinically significant hemothysis are treated with bronchial artery embolization (BAE). Contrast CT images are useful in the pre-embolization assessment of patients with hemothysis as it allows identification of dilated bronchial arteries, their origins as well as the disease process causing hemothysis (Figure 11). CT imaging is fast and provides a detailed vascular road map for the interventional radiologist before the procedure (20,22). The use of CECT before angiography reduces the rate of catheterization failures and the number of patients needing surgical intervention (49).

Recent advances in clinical application of bronchial arteries

Chronic rejection is one of the main causes of death following lung transplantation and it manifest as bronchiolitis obliterans (50). There is an inflammation affecting smaller airways-bronchioles which manifests with wall thickening, eventually obliteration with reduction in airflow, pulmonary artery perfusion and resultant airway ischemia. Transplant surgeons usually revascularize only the pulmonary blood flow after lung transplantation but airways derive 50% of their blood supply from the bronchial arteries and 50% from the pulmonary arteries. Hence emerging evidences advocate bronchial artery revascularization along with pulmonary artery in an attempt to avert or delay the development of bronchiolitis obliterans syndrome (50). Hence accurate mapping of the degree and location of the bronchial arteries by CTA will become a necessity before lung transplantation in future.

Miscellaneous conditions

MAPCAs

MAPCAs are branches of the descending thoracic aorta, exclusive of the bronchial arteries, which collateralise the pulmonary bed in patients with a spectrum of pulmonary artery insufficiency. They represent persistent intersegmental arteries which fail to regress due to demand supply of the suboptimal pulmonary blood flow. The two
congenital heart diseases associated with MAPCAs are pulmonary atresia with ventricular septal defect and Fallot’s tetralogy (51).

MDCT angiography assessment of the MAPCAs, along with the native pulmonary arteries, forms a cornerstone of management of pediatric and adult patients with these congenital heart conditions (52). It accurately depicts the number, origin, course and intrapulmonary connections of the MAPCAs (Figure 12). These vessels may also show pathological segments of aneurysmal dilatation or stenosis. Communication between MAPCAs and native pulmonary arteries may be central (at the hilum or major lobar branches), or peripheral (at segmental or subsegmental levels). Knowledge of the degree of pulmonary artery stenosis and the number and size of the MAPCAs is essential in planning the definitive treatment of these patients.

Differentiation of MAPCAs from bronchial arteries may pose a diagnostic challenge. Unlike bronchial arteries, MAPCAs do not have mediastinal branches, connect to larger pulmonary artery branches and never anastomose with intercostal arteries.

**Broncho-pulmonary sequestration**

Pulmonary sequestration is a condition, either congenital or acquired, in which there is an abnormal mass of lung tissue

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**Figure 11** A 65-year old male with massive hemoptysis and reactivated pulmonary tuberculosis. (A) extensive fibrocavitary changes of the right upper lobe noted in the axial section of the CT chest along with tortuous dilated artery (arrow) supplying the diseased lung; (B) VRT image showing the tortuous right bronchial artery; (C) DSA showed an extremely tortuous and dilated right bronchial artery supplying the diseased right upper lobe; (D) post embolisation angiogram showed stasis in the embolised bronchial artery. VRT, volume rendering technique; DSA, digital subtraction angiogram.
A 2-month-old female child with Tetralogy of Fallot and severe pulmonic stenosis. (A) Oblique axial reformatted image of the CTA showed hypoplastic pulmonary arteries due to pulmonic stenosis; (B) coronal maximum intensity projection (MIP) of the CTA depicted the dilated MAPCA (arrow) arising from the descending aorta and joining the right pulmonary artery; (C) VRT image showing the MAPCA in great detail. CTA, CT angiogram; MAPCA, major aortopulmonary collateral arteries.

Intralobar pulmonary sequestration in a 6-month-old child with recurrent respiratory infections. (A) Axial CT chest in lung window showed multiple cystic foci in the right lower lobe; (B) dilated systemic arterial supply (arrow) clearly seen on a coronal MIP image of the chest CTA; (C) venous drainage into the pulmonary vein seen on a coronal MIP image in the delayed venous phase. MIP, maximum intensity projection; CTA, CT angiogram.

which has lost communication with the tracheobronchial tree. It is typically characterised by systemic arterial supply which usually enters through the inferior pulmonary ligament (53). Pulmonary sequestration can be intralobar or extralobar.

Intralobar sequestration (ILS), which is the commonest of the two, presents in childhood and adolescence with repeated respiratory infections. It is most common in lower lobes (left > right), shares the pleura with adjacent lung, and drains into a pulmonary vein (Figure 13). Extralobar sequestration presents in neonatal period with respiratory distress, has a separate pleural cover, and drains into a systemic vein.

The systemic arterial supply, being a striking feature in both types, is most apparent in the CT angiography of the thorax, imaged in the arterial and venous phases (54). The systemic arterial supply takes origin from the descending thoracic aorta in most instances (70–80%); in the rest of the patients it originates from abdominal aorta, celiac axis, or splenic artery, intercostal artery, and rarely from the subclavian, internal thoracic, and pericardiacophrenic
arteries. The anomalous venous drainage is generally via the pulmonary veins in ILS, and through the azygos vein/hemiazygos system, portal vein, right atrium, or IVC in ELS.

Conclusions

With the widespread availability and ease of procedure, CTA has replaced diagnostic angiography as modality of choice for evaluation of thoracic vascular pathologies. Similar to evaluation of aorta, CT angiography also plays a significant role in diagnosing, characterization and pre-treatment work up of non-aortic vascular pathologies of the chest. With advances in CT technology the acquisition, interpretation and clinical applications of CT angiography will continue to grow in the years to come.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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