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Imaging of vascular pseudoaneurysms in the thorax and abdomen ☆,☆☆

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ABSTRACT

Introduction: This review article illustrates a spectrum of arterial pseudoaneurysms that may occur in various locations throughout the thoracoabdominal region. This article discusses the common etiologies and typical clinical presentations of arterial pseudoaneurysms as well as the imaging modalities employed in their diagnosis and potential treatment options.
Objective: The goal of this review article is to familiarize radiologists with the diagnosis of thoracoabdominal arterial pseudoaneurysms, the prompt identification and treatment of which are crucial in this patient population.
Conclusion: In summary, a thorough understanding of the etiologies, imaging characteristics, and clinical implications of pseudoaneurysms can help optimize identification and management of this spectrum of disease.

1. Introduction

Vascular disorders and their downstream effects are a significant cause of morbidity and mortality; any condition that weakens the blood vessel wall may lead to the development of an aneurysm, as intraluminal pressure applied to a weakened wall results in swelling/protrusion of that portion of the blood vessel. True aneurysms involve all three layers of the blood vessel wall, may be fusiform or saccular in appearance, typically demonstrate a broad neck, and are generally less prone to rupture than pseudoaneurysms. In contradistinction, pseudoaneurysms by definition do not involve all three layers of the blood vessel wall, typically feature a narrow neck, and can be thought of as a contained arterial rupture surrounded by relatively thin adventitia or surrounding perivascular soft tissue [1]. Complications associated with a pseudoaneurysm are unpredictable, as the risk of rupture is greater than that of a true aneurysm due to the relative weakness of the surrounding tissue [2–5].

The emergence of new imaging modalities with higher spatial and contrast resolution has improved the noninvasive detection of symptomatic and asymptomatic pseudoaneurysms and may preempt the complications of late diagnoses. While conventional angiography remains the gold standard for diagnosis, given its invasive nature and the often nonspecific clinical presentation of pseudoaneurysms, noninvasive diagnostic cross-sectional modalities [e.g. computed tomographic (CT) and magnetic resonance imaging (MRI/MRA)] should be included in the initial workup, as these modalities may readily diagnose the pseudoaneurysms as well as their potential complications [6]. It is important for radiologists to be familiar with the imaging appearance of pseudoaneurysms across a variety of imaging modalities, as they are often encountered incidentally on studies ordered for unrelated indications. Specifically, a thorough understanding of the imaging features of arterial pseudoaneurysms along with the pros and cons of the imaging modalities (Table 1) allows the radiologist to identify causes (Table 2), precise anatomic location, morphologic features, relevant comorbidities, and prognosticate the risk of rupture, thereby providing clinically actionable information.

From the traditional surgical option of open repair to minimally invasive endovascular procedures, therapeutic outcomes have greatly improved in recent years, with modern techniques such as embolization and stent grafting gaining rapid therapeutic relevance. Consequently, this has led to a marked decrease in the morbidity and mortality rates associated with arterial pseudoaneurysms [7–10]. Previous literature related to thoracoabdominal pseudoaneurysms is mostly in the form of case reports. In this comprehensive review, we discuss the prevalence, etiology, clinical presentations, and diagnostic techniques for the most frequently encountered pseudoaneurysms of both the thorax and the abdomen. Finally, we briefly discuss the most common therapeutic interventions/options for thoracoabdominal pseudoaneurysms, as management often falls within the realm of interventional radiology.

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Table 1
Pros and cons of different imaging modalities

Imaging modality	Pros	Cons
1. CT/CTA	• Noninvasive • Faster (less than 5 min) • Less expensive • Readily available	• Radiation exposure • Allergy to iodinated contrast media
2. MRI	• No ionizing radiation • Superior soft tissue contrast	• Expensive • Time consuming (around 30 min) • Allergy to gadolinium-based contrast media • Not available 24/7 at most institutions
3. Angiography	• Diagnostic as well as therapeutic	• Expensive • Invasive • Radiation exposure

1.1. Thorax

1.1.1. Cardiac left ventricle (LV) pseudoaneurysms

Left ventricle pseudoaneurysms may arise from a variety of causes including cardiac surgery, trauma, myocardial infarction (MI), post-MI free wall rupture, infection, or inflammation. Cardiac pseudoaneurysms typically occur in the LV apex (Fig. 1) and are oftentimes an incidental finding encountered during imaging for other medical reasons [11]. In a study by Frances et al., 55% of the LV pseudoaneurysms were induced by a prior MI [12]. Similarly, Higgins et al. reported 78% of LV pseudoaneurysms as a result of prior MI [13]. Patients with LV pseudoaneurysms typically have a nonspecific clinical presentation (chest pain, dyspnea, dizziness, syncope) and an unpredictable course with rupture reported in up to 50% of the cases [11]. Cardiac CT, especially with the advent of cardiac gating, is an excellent noninvasive imaging modality, which allows for the simultaneous analysis of the coronary tree and the neighboring cardiac structures.

The specific imaging characteristics on cardiac CT include a focal outpouching from the LV apex, typically with a narrow neck (narrower than the aneurysm sac), and occasional discontinuity of the left ventricular wall. Cardiac MR has emerged as perhaps the best diagnostic tool for imaging of left ventricular pseudoaneurysms and typically clearly demonstrates delayed enhancement of the thinned/fibrotic myocardium as well as focal nonenhancing mural thrombus [14]. However, the general radiologist is more likely to encounter LV pseudoaneurysms and associated thrombus in the setting of routine contrast-enhanced chest CT or cardiac gated CT angiography (CTA). Both modalities can be used to reliably detect a pseudoaneurysm, though differentiating from a true aneurysm can prove difficult in practice [15]. True aneurysms are more likely to demonstrate a neck which is as wide as the aneurysm sac and more likely to occur at the anterior wall as opposed to the inferior wall in the case of a pseudoaneurysm [14].

Gudrun et al., while assessing the diagnostic performance of cardiac CT for the detection of pseudoaneurysms, reported 97% sensitivity, 88% specificity, 97% positive predictive value, and 88% negative predictive value [16]. Once the diagnosis is confirmed, treatment options depend on a variety of factors including the hemodynamic stability of the patient, clinical concern for imminent rupture, and comorbidities of the patient (Fig. 2) [17]. One of the more important and common complications of a left ventricular pseudoaneurysm is LV apex thrombus formation, secondary to stasis in the blood pool contained within the pseudoaneurysm. It is important to identify thombus, seen as an LV apex filling defect on contrast-enhanced CT, as the presence of thrombus presents a systemic embolic risk which can result in cerebrovascular accidents, mesenteric ischemia, or distal extremity thrombosis [18]. In the setting of chronic pseudoaneurysm LV thrombosis, systemic anticoagulation is often instituted to decrease risk of embolism [19].

Table 2
Causes of aneurysm and pseudoaneurysm

	Aneurysm	Pseudoaneurysm
Etiology	Congenital Atherosclerosis Hypertension Vasculitis Connective tissue disorders Syphilis MI FMD	Trauma Iatrogenic Mycotic aneurysm Vasculitis Inflammation FMD Penetrating atherosclerotic ulcer

1.1.2. Coronary artery pseudoaneurysms

Coronary artery pseudoaneurysms are an uncommon disease entity, which have been described in association with bypass graft procedures, percutaneous transluminal angioplasty, or chest trauma. Atherosclerosis and Kawasaki disease are the two most common causes of true coronary artery aneurysms, and since the imaging characteristics overlap, it is important to investigate for any of the aforementioned histories [20].

Specific imaging characteristics of this entity include a focal short segment dilatation to greater than 1.5 times the diameter of the adjacent artery affecting less than 50 % of the total vessel length [21]. Differentiating pseudoaneurysm and true aneurysm is very difficult based on noninvasive imaging alone; clinical history of recent trauma or catheter-based intervention is telling.

In a study of 694 patients presenting with chest pain, Daoud et al. found a 1.4% incidence of coronary artery pseudoaneurysms [22]. Though rare, symptomatic patients may display a vague clinical presentation, which includes shortness of breath and intermittent chest pain, possibly pleuritic in nature. While coronary angiography has been the preferred practice in making the appropriate diagnosis, cross-sectional imaging such as cardiac MRI and coronary CTA (Figs. 3, 4) are promising noninvasive alternatives capable of serving as appropriate diagnostic approaches. Due to the rarity of this disease and its variety of causes, there is no all-purpose established therapy; however, surgical resection may be considered in symptomatic or rapidly expanding coronary arterial pseudoaneurysms [2,23].

1.2. Aortic pseudoaneurysm

Aortic pseudoaneurysm, a rare and potentially fatal condition, occurs in less than 0.5% of the general population and is capable of mimicking acute coronary syndrome, pericarditis, pleuritis, aortic dissection, and pulmonary embolism. Amongst the various causes which include focal pseudoaneurysms due to penetrating ulcers, mycotic aneurysms, and contained rupture of degenerative aneurysms, aortic pseudoaneurysms are most commonly caused as a complication of aortic surgery or trauma in approximately 1% and 3%–4% of patients, respectively [2]. While some cases of aortic pseudoaneurysm remain asymptomatic and are detected incidentally, others present with dyspnea and chest pain; devastating symptoms, like rupture, and sudden death have also been reported in previous studies by Fedriga and Razzouk et al. [24,25]. An important diagnostic distinction between aortic pseudoaneurysms caused by surgery and trauma is that while the