Infected ("Mycotic") Thoracic Aneurysms: Pathophysiology and Imaging

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The term Mycotic Aneurysm was introduced by Sir William Osler in 1855 to describe a "Mushroom Shaped" aneurysm secondary to an infectious process in the arterial wall.

This name can result in confusion, since the majority of these lesions have bacterial origin rather than fungal.

Osler W: The Gulstonian lectures on malignant endocarditis. BMJ 1885; 1: p 467

Infected aortic aneurysm. Gross specimen of a resected aortic segment reveals thickening of the aortic wall (white arrows) and aneurysmal dilatation (yellow arrows).
Definition

- All aneurysms caused by infection of the arterial wall, which do not necessarily share the originally described pathogenesis are described as Mycotic aneurysms.

- Less than 10% of infected aneurysms have this mechanism.

- In surgical literature, the term Infected Aneurysm (IA) has been proposed to more accurately describe these lesions that can involve multiple pathophysiologic mechanisms.

Right lower lobe pulmonary artery mycotic aneurysms in a patient wit bacterial endocarditis (arrow)
Risk Factors

- **RISK FACTORS**
  - Endovascular medical devices
  - IV drug abuse
  - Immunosuppression (70% of patients)
    - Diabetes mellitus, cirrhosis, chronic hemodialysis, transplant, HIV, alcoholism, chronic steroid therapy, chemotherapy, malignancy, etc

- Infected aneurysms associated with immunosuppressed states may present with atypical clinical and radiologic features.

- The aorta is the most commonly affected vessel, likely because it is the most frequent site of atherosclerosis and aneurysm formation, however IA can present in any artery.

Mitral valve endocarditis with a large vegetation (arrow)
Pathogenesis

Three different mechanisms have been proposed:

1. Microbial arteritis with secondary aneurysm formation secondary to septic emboli of cardiac origin (classic) or secondary to a non cardiac origin.

2. Superimposed infection of an atherosclerotic aneurysm from systemic or local infection.

3. Infected posttraumatic pseudoaneurysms (drug abuse).
1. Microbial Arteritis

- The wall of a normal artery can be infected by contiguous spread of a local infection resulting in abscess formation, focal perforation and pseudoaneurysm formation.
- Bacterial seeding can occur in non-aneurysmal arteries with preexisting wall irregularities caused atherosclerosis or congenital abnormalities (e.g. coarctation, PDA).
- Diffuse infection of the arterial wall can also result in rapid development of a true aneurysm, which typically results in a more eccentric dilation than in a degenerative / atherosclerotic aneurysm.
- Osler’s Mycotic aneurysms share this pathophysiologic mechanism.
Septic emboli of cardiac origin may lodge in the lumen or occlude the vasa vasorum.

The rapid, focal, and progressive deterioration of the vessel integrity is secondary to ischemia and infection of the arterial wall that cause a saccular or multiloculated appearance.

Locally contained rupture and formation of a false aneurysm have been described.

They can be multifocal, typically at arterial bifurcations and are most commonly seen in the aorta, intracranial circulation, and splanchnic and femoral arteries.

Most common location of cardiac vegetation in infectious endocarditis.
2. Infection of Preexisting Aneurysms

- Preexisting aneurysms can be secondarily infected by hematogenous or contiguous spread.

- The diseased intima of preexisting aneurysms is susceptible to infection, bacterial seeding and deeper infection of the arterial wall.

- Bacteria can be found in the thrombus associated with degenerative aneurysms without clinically apparent infection
  - 38% of ruptured, 13% of symptomatic, and 9% of asymptomatic aneurysms in surgical specimens.

- Higher risk for rupture compared to atherosclerotic aneurysms.
3. Posttraumatic Infected Pseudoaneurysms

- Arterial trauma leads to direct bacterial inoculation of the arterial wall.

- Increasingly common mechanism
  - Inadvertent or intentional intra-arterial injection in drug abuse.
  - Arterial catheterization performed for invasive de monitoring, diagnostic and therapeutic interventions.
    - Percutaneous vascular closure devices are associated with an increased incidence of infected pseudoaneurysms
  - Peri-graft infections belong in this group

Infected left ventricular pseudoaneurysm extending through the chest wall (arrow) after removal of an infected left ventricular assist device (LVAD).
Imaging

- CTA is the gold standard for the diagnosis and follow up of infected aneurysms.

- Imaging signs suggestive of infection include:
  - Saccular, multilobulated or eccentric aneurysms
  - Periarterial fluid collections, soft tissue inflammation or surrounding mass
  - Air within the aneurysm or surrounding tissues
  - Pseudoaneurysm formation or contained rupture
  - Rapidly enlarging or rapidly evolving aneurysms
  - Absence of significant atherosclerotic disease

- Short-term serial CT scans are valuable when the initial CT findings are inconclusive.

- In addition to early diagnosis and follow-up, CTA is also a valuable tool for the planning and execution of the often complex procedures used for the palliation or reconstruction of infectious aneurysms.
MRI/MRA may be helpful when contrast CT is contraindicated.

Ultrasonography can be helpful in the initial diagnosis of femoral, carotid, lower and upper extremity aneurysms, but is not specific and cannot confirm the diagnosis.

Indium 111–labeled white blood cell scanning can be used to identify prosthetic graft infections.

Bone and leukocyte scintigraphy to show the extent of adjacent soft tissue involvement and in lumbar osteomyelitis.

Positron emission tomography (PET) alone or in combination with CT has also been used effectively for the detection of arterial infections.

Mycotic (pyogenic) aneurysm of the thoracoabdominal aorta in a patient with acute spondylodiskitis
Aortic arch vessels

- Infected aneurysms of the subclavian and carotids extracranial carotid artery rarely occur.

- Most frequently due to embolization from infectious endocarditis
  - *S. aureus* and *S. pyogenes* are the most common causative pathogens.

- In immunosuppressed patients, direct extension of local pharyngeal infection can result in carotid infected aneurysm formation.

Scout chest image of the chest in an IV drug abuser with disseminated Staphylococcus infection, demonstrates widening of the mediastinum (arrowheads). Axial CECT shows significant dilatation and circumferential arterial wall thickening from a large mycotic aneurysm of the brachiocephalic artery (arrow).
Infected thoracic aortic aneurysms are highly lethal, with an associated mortality reported to be 30% to 50%.

Symptoms are usually nonspecific, and the most common clinical presentation is rupture.

89% of patients with an infected aneurysm had contained or frank rupture noted at operation.

Partially thrombosed and infected saccular aneurysm of the descending aorta (arrow) in a patient with ESRD and DM with severe sepsis.
Patient with SCC of the lung and Streptococcic pneumonia with secondary spondylodiskitis.

CT shows a large infected aortic aneurysm (arrows) in direct contact with the infected disk as well as partial collapse of the adjacent vertebral bodies and intervertebral disc.

MRI demonstrates vertebral marrow edema and protrusion into the spinal canal.
Saccular aneurysm of the aortic arch (arrows) with significant inflammation throughout the adjacent mediastinal soft tissues.

Infection was subsequently confirmed by PET-CT which demonstrated high FDG uptake in the tissues adjacent to the aneurysm.
58 y/o female with chest pain, fever and hemoptysis. PMH of recent staphylococcus pneumonia three weeks before. CT shows an infected aneurysm of the distal aortic arch (arrows).
Infected (mycotic) aneurysm of the thoraco-abdominal aorta. CT shows the extensive soft tissue abnormality in the retrocrural space (arrows)
Tuberculous aortitis

- First described in 1882 by Weigert

- Tuberculous aortitis
  - Involves distal aortic arch and descending aorta
  - Due to:
    - Direct extension from mediastinal lymph nodes, empyema, or pericarditis
    - Hematogenous or lymphatic spread
  - Circumferential aortic mural thickening with caseous necrosis evident at pathology
  - Risk of perforation increases with presence of cold abscess

- Incidence is expected to increase with increasing incidence of Mycobacterium tuberculosis infection

Tuberculous pseudoaneurysm in the descending aorta. Gross specimen of the resected aortic segment reveals thickening of the aortic wall and aneurysmal dilatation. Histological exam of the aortic wall shows necrotizing granulomas (arrow).
History of recent homograft repair for aortic arch aneurysm, with early postoperative recurrence of the aneurysm and development of a second saccular aneurysm at the distal aortic arch (arrows). Surgery revealed extensive inflammation in and around the aneurysm with tissue and blood cultures positive for Aspergillus Niger.
Luetic (syphilitic) aortitis

- Cardiovascular syphilis (tertiary syphilis) occurs 5-30 years after the primary infection with Treponema pallidum
- Incidence among patients with syphilis has decreased from 20-35% to < 1% since early 20th century due to antibiotic access
- Site: ascending aorta > 60%, arch 30%
- Lab diagnosis with positive VDRL and TPHA
- Chronic aortic inflammation with fibrosis and wrinkling of the intima (tree-barking) ultimately leading to aneurysm formation; calcification of ascending aorta is typical but uncommon

PA chest radiograph shows aneurysm of the aortic arch (arrows) in a patient with tertiary syphilis.

Thickening of the ascending aortic wall (arrow) in a patient with syphilitic aortitis.
Coronary arteries

- Rare complication of infective endocarditis with an incidence is 0.2-0.8%.
- Frequently present with distal embolization and secondary myocardial infarction
- High risk of rupture and may result in cardiac tamponade and sudden death.

CECT in a diabetic male s/p RCA stent placement presenting with S. Aureus bacteremia and septic shock demonstrates an irregular thick wall saccular aneurysm (arrows) with pericardial effusion.

Autopsy revealed an infected RCA aneurysm with purulent pericarditis.
RCA mycotic aneurysm in a 63 y/o male 3 weeks post CABG with fever and dehiscent sternotomy. CCTA shows RCA dilation and wall thickening (arrows).
RCA mycotic aneurysm in the same patient (arrows). CCTA shows RCA dilation and wall thickening.

Catheter angiography confirms RCA aneurysm which was not present on the preoperative angiography immediately before surgery.
Aneurysm of the left coronary sinus of Valsalva in a patient with bacterial endocarditis. Axial (a) and sagittal (b) reconstructions of a MDCT shows the abnormal collection of contrast (arrows) on the left posterolateral aspect of the proximal ascending aorta, displacing the anterior wall of the left atrium.
Pulmonary arteries

- Most infected aneurysms of the pulmonary arteries are secondary to endovascular seeding due to septic pulmonary emboli.

- Frequently associated with right side infective endocarditis, necrotizing pneumonia, or chronic tuberculosis.

- They may be single or multiple, central or peripherally located.

Renal transplant patient presenting with a fungal pneumonia complicated with hemoptysis. NECT shows a large heterogeneous density soft tissue mass with a layering density and surrounding consolidation. DSA of the right pulmonary artery shows a large saccular pseudoaneurysm of the inferior pulmonary arterial branch.
Right lower lobe pulmonary artery mycotic aneurysm (arrows) secondary to enterococcal bacterial endocarditis.

DSA confirms an abnormal focal dilation of the right lower lobe pulmonary artery (arrows).
Angioinvasive mucor infection with necrotizing pneumonia and a right PA pseudoaneurysm (arrows).
Rasmussen Aneurysm

- Rasmussen aneurysms is a pulmonary artery pseudoaneurysms caused by arterial wall erosion by an adjacent tuberculosis (TB) infection/ cavitation.

- Though less common, Tuberculous aneurysms of the bronchial arteries have also been documented.

- They are relatively uncommon, but have been reported in 4% of cases in autopsy series of patients who died from chronic cavitary TB.

- Rasmussen aneurysms are known to be associated with massive hemoptysis.

Proven pulmonary TB with hemoptysis and Rasmussen aneurysms (arrows) from a subsegmental right pulmonary artery branch.
31 y/o patient with history of recurrent pulmonary TB treated in two opportunities. Presents several episodes of massive hemoptysis which required catheter embolization. Sputum culture and BAL were positive for Aspergillus niger. CT shows a right lower lobe cavity with pseudoaneurysm (arrows).
Pulmonic valve stenosis and endocarditis in a 38 y/o female with a mycotic pseudoaneurysm in the right lower lobe (white arrows). ECG gated CT demonstrates the thickened and irregular pulmonic valve (black arrow) with post-stenotic dilatation.
Management

- Regardless of the mechanism, the management involves:
  - Prolonged antibiotic therapy
  - Resection of diseased arterial segment, debridement of perivascular tissue and abscess drainage
  - Surgery (frequently extra-anatomic bypass)
  - Less frequently endovascular procedures.

Persistent hypodense collection with gas pockets (arrow) after stenting of the infected aneurysm in the descending aorta.
Summary

• Although uncommon, thoracic mycotic (infectious) aneurysm are life threatening. Diagnosis can be challenging and their clinical manifestation is usually obscure.

• Diagnostic imaging, especially CTA, play a major role in early diagnosis and follow-up, improving mortality and morbidity, in affected patients. Early diagnosis of infected aneurysms and pseudo-aneurysms is critical for appropriate patient management.

• Infected or mycotic aneurysm are variable in presentation and a low threshold of suspicion is recommended.
Recommended readings


- Restrepo CS, Carswell AP. Aneurysms and pseudoaneurysms of the pulmonary vasculature. Seminars in Ultrasound CT MRI 2012;33:552-566.
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