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International Journal of Radiology and Imaging. . 01 (02). 30 Desember 2022: 26-37
e-ISSN 2830-506X
p-ISSN 2830-6007

THE ROLE OF CHEST CT ANGIOGRAPHY AS A DIAGNOSTIC TOOL AND ROAD MAP FOR THE MANAGEMENT OF RASMUSSEN'S ANEURYSM: A CASE REPORT

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Abstract

Rasmussen's aneurysm is a pulmonary artery pseudoaneurysm, secondary to the invasion of granular tissues to the pulmonary artery wall, causing massive hemoptysis. A 39-year-old male, with a history of pulmonary TB presented with massive hemoptysis, persistent cough, and dyspnea. Chest X-ray and Chest CT depicted active pulmonary tuberculosis and a co-infection with aspergillosis in the form of aspergilloma. Chest CT angiography (CTA) showed narrow-necked Rasmussen's aneurysm with the feeding artery coming from the pulmonary artery of the apicoposterior segment and the systemic artery from the left thyrocervical trunk branch and left bronchial artery. Fluoroscopy-guided transarterial embolization with polyvinyl alcohol (PVA) and gel foam was performed from the left bronchial artery and thyrocervical trunk branch followed by transcatheter embolization with glue insertion via the pulmonary artery in the aneurysmal site. After the procedures the embolic agent completely filled the aneurysm and there were no complaints of hemoptysis during the follow-up. Appropriate chest CT angiography procedures can help diagnose Rasmussen's aneurysm and become a road map for embolization. Transarterial catheter embolization from bronchial or non-bronchial systemic artery and pulmonary artery can be used as the treatment modality of choice for Rasmussen's aneurysm in pulmonary tuberculosis with aspergillosis co-infection in the form of aspergilloma.

Keywords: *Aneurysmal Embolization, Aspergillosis, Interventional Radiology, Pulmonary Cavity, Pulmonary Tuberculosis, Rasmussen's Aneurysm*.

INTRODUCTION

Rasmussen's aneurysm is a pseudoaneurysm associated with tuberculosis. It is known to cause life-threatening complications such as massive hemoptysis from the rupture.(1) As a result, this condition needs to be handled properly and appropriately. Infection is the etiology of both true aneurysms and pseudoaneurysms. More virulent infections like *staphylococcus* cause damage to all three layers of the vessel wall and lead to true aneurysm formation, but less virulent infections typically cause pseudoaneurysms.

Tuberculosis is a disease caused by *Mycobacterium tuberculosis* or, in rare cases, by *Mycobacterium bovis*.(2) *Mycobacterium tuberculosis* is included in the Mycobacteriaceae family and is an acid-fast bacterium (AFB).(2) Tuberculosis can attack any part of the body. Therefore, tuberculosis can be categorized into pulmonary tuberculosis and extra-pulmonary tuberculosis.

Aspergillosis, in the form of aspergilloma, is one of the complications of a preexisting cavity due to pulmonary tuberculosis. Aspergilloma can also cause complaints of hemoptysis in afflicted patients.(3)

There are several lessons to be learned from the problems of our case. The first is exploring the role of chest CT angiography as a diagnostic tool and management guidance for Rasmussen's aneurysm. The second is identifying the complications of pulmonary

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tuberculosis and its radiological findings. The third is finding the cause of hemoptysis in this case.

CASE DESCRIPTION

A 38-year-old male working as a farmer came with a history of hemoptoe of approximately 500 mL for 4 days long accompanied by shortness of breath. The patient had a history of pulmonary tuberculosis. At the hospital, his condition was described as weak with a Glasgow Coma Scale of E4M6V5, blood pressure of 110/70 mmHg, heart rate of 92 x/minute, respiratory rate of 38 x/minute, and oxygen saturation of 100% using a non-rebreathing oxygen mask at 10 liters/minute.

Upon initial laboratory examination (December 24, 2021) there was an insignificant increase in the leukocyte count (12.31 x 10^3/µL) with a diff count leading to neutrophilia (79%) accompanied by an increase in C-reactive protein (CPR) with a value of 3.55 mg/dL. There was no increase in liver or kidney function. There was no increase in blood procalcitonin levels. At the time of hospitalization (January 5, 2022) there was a decrease in hemoglobin levels (8.6 g/dL) with an MCV of 84.6 fL, MCH of 26.9 pg, and MCHC of 31.8 g/dL, because the patient was still experiencing hemoptysis and the urinalysis bacteria level was 148.6 x 10^3/mL.

Based on conventional chest radiographs, there was ground-glass opacity with partial consolidation and fibrosis in the upper, middle, and lower zones of the left lung. There was also a thickening of the left apex of the pleura (Schwarte). This supports the feature of pulmonary tuberculosis (Figure 1).

Chest CT showed a tree-in-bud pattern in segments 2, 3, 4, 5, 6, 7, and 8 of the right lung and all segments of the left lung, fibro-calcification in segments 1, 2, and 3 of the right lung, fibrosis of segments 1/2, 3, 4, and 5 of the left lung and both-sided pleural thickening of the apex, leading to pulmonary tuberculosis. In addition, there was also partial consolidation with the cavity in it and part of the cavity with a fungus ball forming an air crescent sign on segments 1/2, 3, 4, 5, and 6 of the left lung, which supported the feature of aspergilloma. Paraseptal emphysema was also seen in segments 1 and 2 of the right lung (Figure 2).

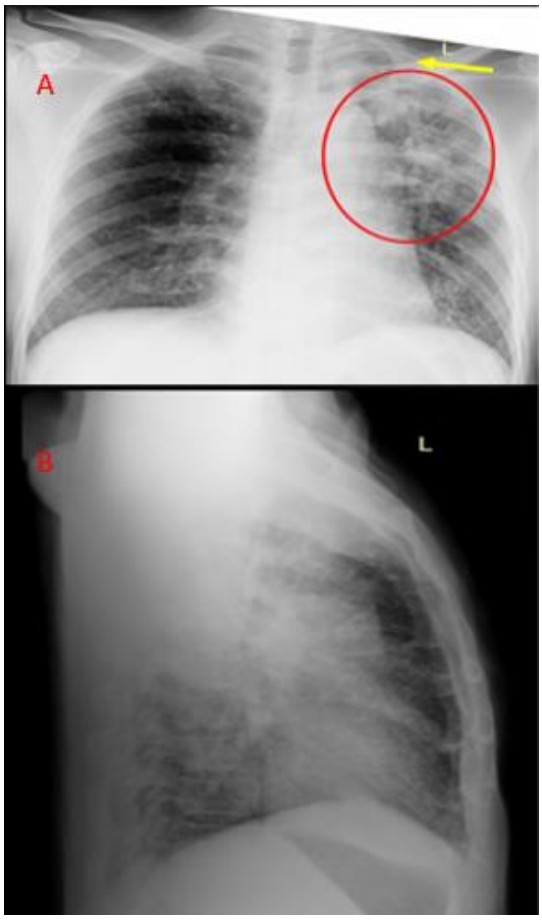

Figure 1. Chest X-Ray at the Anteroposterior and Lateral Position.

A.) Chest X-ray at Anteroposterior and B.) Lateral view: Ground- glass opacity with partial consolidation and fibrosis in the left lung (red circle). Pleural thickening (Schwarte) (yellow arrow).
Source: Radiology Information System, Saiful Anwar Hospital, Malang

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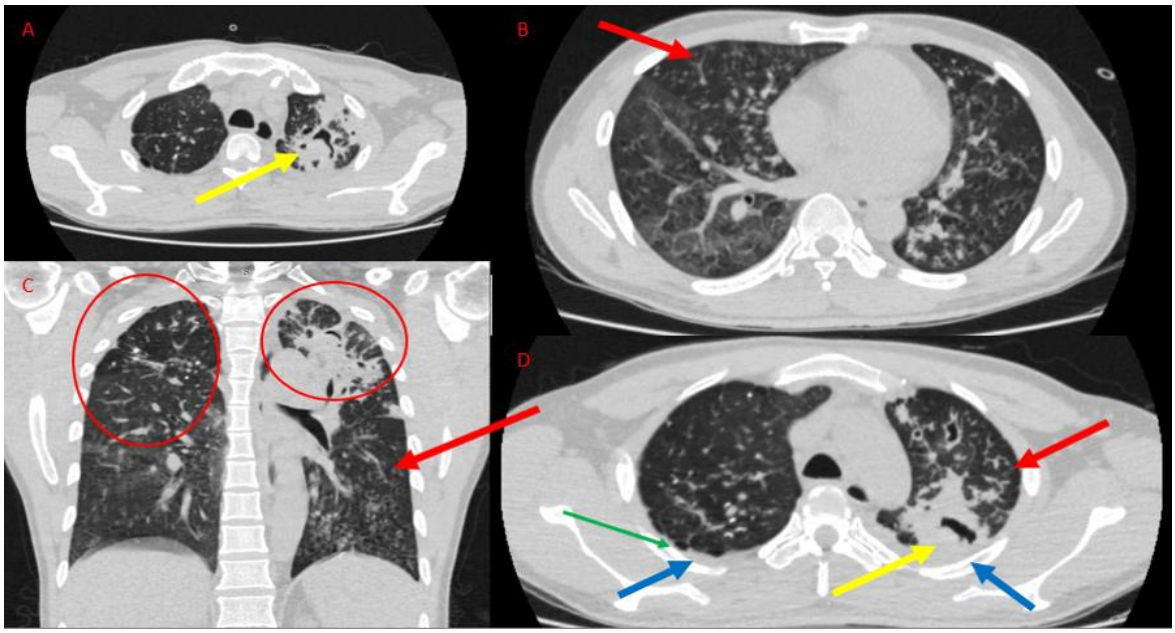

Figure 2. Chest Computed Tomography: A Depiction of Pulmonary Tuberculosis with Aspergilloma.

A./B./D.) Axial and C.) coronal chest CT lung window shows a tree-in-bud pattern (red arrow), fibro-calcification (red circle), a cavity with fungus ball (yellow arrow), pleural thickening (blue arrow), paraseptal emphysema (green arrow).
Source: Radiology Information System, Saiful Anwar Hospital, Malang

The result of the chest CTA revealed a saccular aneurysm with a dome width of 1.0 cm, a dome height of 1.5 cm, and a neck width of 3.4 mm in the anastomoses between the left thyrocervical trunk branch, the left bronchial artery, and the left apicoposterior branch of the left pulmonary artery (Figure 3).

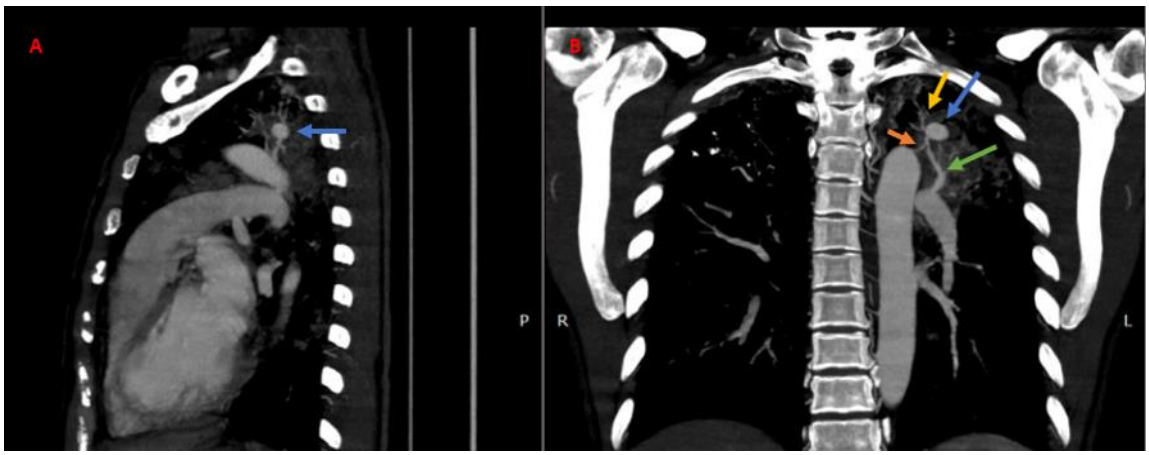

Figure 3. Chest CT Angiography Depicts Rasmussen's Aneurysm.

A.) Sagittal and B.) coronal view of chest CT angiography. Rasmussen's aneurysm (blue arrow), the left bronchial artery (orange arrow), the thyrocervical trunk branch (yellow arrow), and the apicoposterior branch of the left pulmonary artery (green arrow).
Source: Radiology Information System, Saiful Anwar Hospital, Malang

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From the chest DSA, we performed selective systemic arteriography first, followed by pulmonary arteriography. The result showed that there was a saccular aneurysm in the left thyrocervical trunk branch, the left bronchial artery and the left apicoposterior branch of the left pulmonary artery (Figure 4).

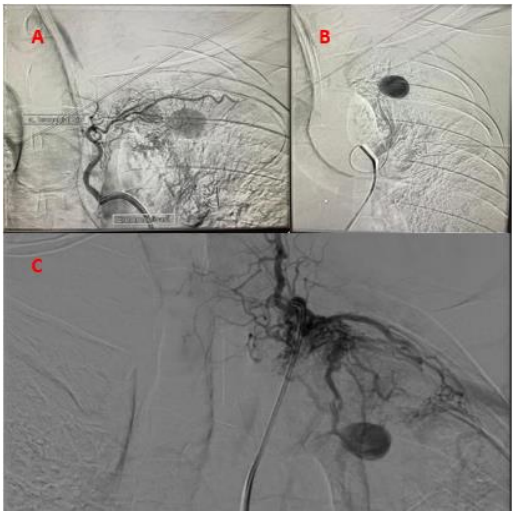

Figure 4. Digital Subtraction Angiography Depicts Rasmussen's Aneurysm.

A. The feeder artery comes from the left bronchial artery
B. The feeder artery comes from the apicoposterior branch of the left pulmonary artery
C. The feeder artery comes from the left thyrocervical trunk branch

Source: Radiology Information System, Saiful Anwar Hospital, Malang

This patient was embolized on the left thyrocervical trunk branch leading to the aneurysm and the left bronchial artery leading to the aneurysm (from the systemic artery). However, during observation, the patient still experienced hemoptoe for about 3 hours as much as 500 mL 4 days after the embolization. Because grade IV hemoptoe was still found, embolization was performed on the left apicoposterior segmental artery which is a branch of the left pulmonary artery (Figure 5).

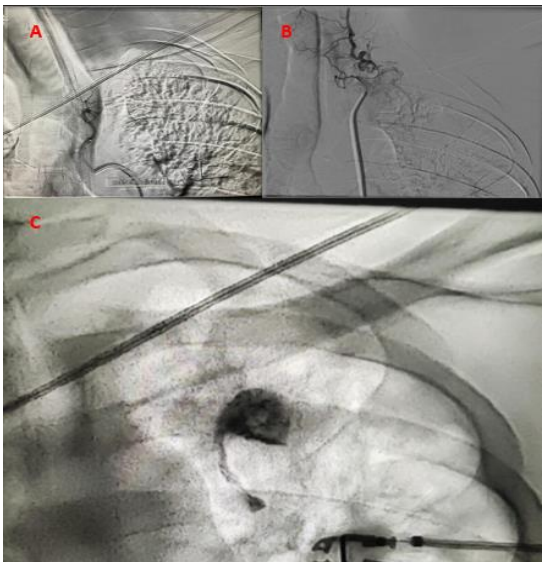

Figure 5. Digital Subtraction Angiography: Post Systemic and Pulmonary Arteries Embolization of Rasmussen's Aneurysm.

A. There is no blushing in the left bronchial artery
B. There is no blushing in the thyrocervical trunk branch
C. Pooled contrast media with an embolic agent into the Rasmussen's aneurysm after embolization approach from the apicoposterior branch of the left pulmonary artery.

Source: Radiology Information System, Saiful Anwar Hospital, Malang

One day after embolization, no hemoptoe was found. Then, an evaluation was carried out using chest CT without contrast to ensure that the embolic agent was at the target location and there was no embolic agent outside the target. Before becoming an out patient, a chest X-ray was performed with the result showing that the embolic agent opacity was found in the superior zone of the left lung (Figure 6).

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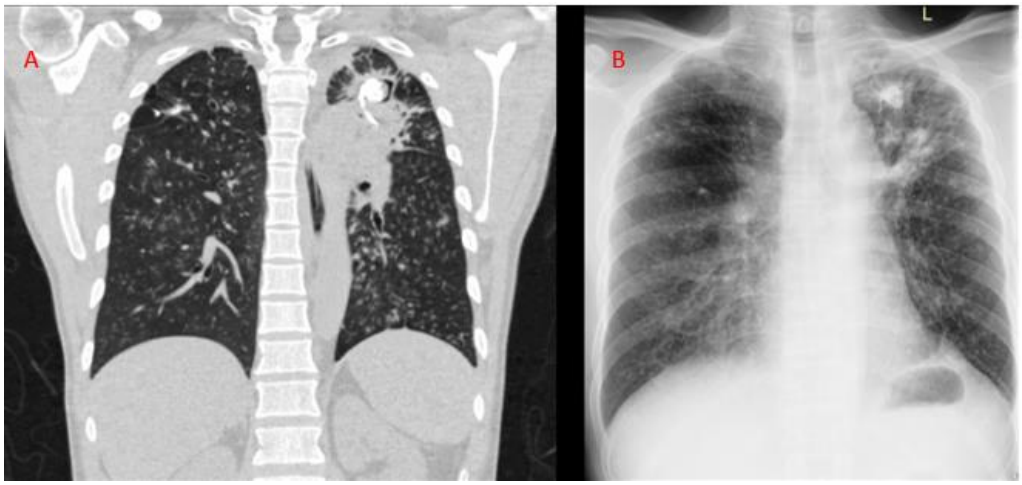

Figure 6. Imaging Follow-Up during Hospitalization

A. Coronal chest CT without contrast shows the location (apical segment of the left lung) and size of the embolic agent
B. Chest X-ray, before becoming an out-patient, showing that the location and size of the embolic agent are the same as the previous examination
Source: Radiology Information System, Saiful Anwar Hospital, Malang

Four months later, a follow-up was performed. There were no complaints of hemoptoe and a chest X-ray examination revealed an opacity of the embolic agent in the superior zone of the left lung with a fixed size. Eight months later, a third follow-up was performed. There were no complaints of hemoptoe and a chest X-ray examination revealed an opacity of the embolic agent in the superior zone of the left lung with a minimally decreased size (Figure 7).

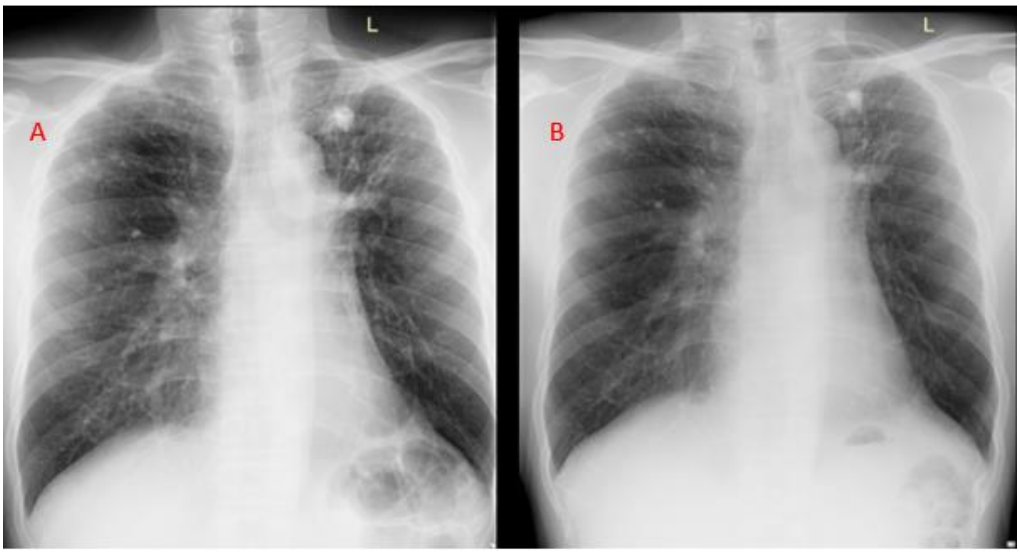

Figure 7. Follow-Up Chest X-Ray

A.) Chest X-ray 4 months after embolization, B.) Chest X-ray 8 months after embolization, which shows that the embolic agent is at the same location but with a minimally decreased size.
Source: Radiology Information System, Saiful Anwar Hospital, Malang

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DISCUSSION

In our case the risk factors for pulmonary tuberculosis comprise the male sex, living in rural areas, and a previous history of tuberculosis. A cross sectional study of the elderly population in China in 2013 suggested that the male sex has an odd ratio (OR) 3.26 (2.34–4.55), older age (age 75-84 OR 1.59 (1.17–2.17); age ≥85 OR 2.05 (1.25–3.36)), living in rural areas OR 2.65 (1.81–3.88), underweight (<18.5 OR 1.55 (1.09–2.22)), diabetes OR 1.83 (1.08–3.10), close contact with pulmonary TB (PTB) (living with a new active PTB case for at least 7 days, 3 months before diagnosis) OR 7.30 (2.15–24.82) and previous TB history OR 9.23 (6.16–13.83) are all risk factors for TB.(4) In our case the risk factors comprised the male sex, living in rural areas, and a previous history of tuberculosis.

Symptoms that appear in patients with pulmonary tuberculosis vary; two-thirds of patients will be asymptomatic and only one-third will be symptomatic. Symptoms most often appear in the form of gradual low-grade fever but can reach a body temperature of 39 degrees Celsius and last about 14 to 21 days. Twenty-five percent of TB patients may present with pleuritic pain, shortness of breath and, rarely, fatigue, cough, arthralgia, and pharyngitis.(5,6) Our patient presented with symptoms of hemoptoe, but there were no other symptoms that support tuberculosis. The hemoptoe in this patient could arise due to complications of TB in the form of aspergilloma or Rasmussen's aneurysm, which we will discuss future in this study. Several references stated that hemoptysis can happen in pulmonary tuberculosis that bleeds from the cavity, endobronchial tuberculosis (TB), post-TB bronchiectasis, aspergilloma, or rupture of Rasmussen's aneurysm.(7)

Laboratory findings in this patient included leukocytosis with diff count neutrophilia, which indicated the presence of an acute infection, accompanied by the presence of bacteriuria and an increase in C-reactive protein, which suggested urinary tract infection. Because there was new bleeding in the form of hemoptysis, this patient also had normochromic normocytic anemia with a Hb of 8.6 g/dL.

Radiographic findings of pulmonary tuberculosis can be in the form of 4 main entities, namely lymphadenopathy, parenchymal disease (features of lung lesions), miliary disease (presence of angioinvasive process), and pleural effusion. Based on the pathophysiology, it can be divided into primary tuberculosis, secondary (reactivation) tuberculosis in immunocompetent patients (post-primary tuberculosis), TB with HIV coinfection, highly ARV therapy and immune restoration syndrome, miliary tuberculosis, multidrug-resistant tuberculosis, and extensively drug-resistant tuberculosis.(8)

The main findings in secondary tuberculosis are consolidation and a cavity dominant in segments 1, 2 (segment 1/2 of the left lung), and 6, as an endogenous reactivation of past infection that can be explained by higher oxygen tension and lower blood flow, or higher ventilation/perfusion (V/Q) ratio than the base lung fields.(8,9) Segmental consolidation or fibronodular opacity can be happened. Cavities can be found in 12-45% of secondary TB cases, sometimes showing an air-fluid level. If it responds to the administration of anti-tuberculosis, then the cavity wall will be thinner (Figure 8).

Fibrosis is a fairly frequent finding in about 20-40% of cases. Tuberculomas with well-defined and smooth margins, 0.5 to 4.0 cm in size, can be found in about 5% of secondary TB cases. On FDG-PET examination, tuberculoma also showed uptake, but it could be distinguished from the SUV cut-off of 1.05. Another finding is a dominant tree-in-bud pattern in the lower lung zone, which is the result of endobronchial spread. Mediastinal lymphadenopathy is rare in patients with secondary TB and is found in only about 5% with a size >2 cm. Lymphadenopathy is

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associated with extensive consolidation. Active lymphadenopathy is characterized by necrosis in the form of hypodense lesions on the central side. Pleural effusion is also a finding in secondary tuberculosis.(8,10,11)

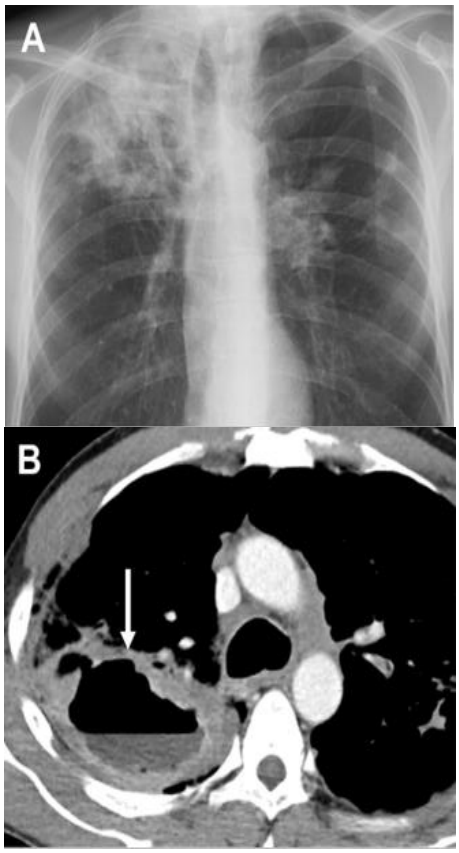

Figure 8. Features in Secondary Tuberculosis.

A. Frontal chest X-ray shows a cavity within the consolidation in the upper lobe of the right lung and lymphadenopathy in the left hilum.
B. Axial contrast-enhanced CT shows an irregular cavity with an air-fluid level in the right lung (arrow).(8)

This patient, aged 38 years, had radiographic findings of ground-glass opacity with partial consolidation and fibrosis in the left lung. There was also a thickening of the left apex of the pleural (Schwarte). Chest CT showed a tree-in-bud pattern in the right and left lung, fibro-calcification in the upper lobe of right lung, fibrosis of the upper lobe of the left lung and both-sided pleural thickening of the apex. These findings are more suggestive of secondary tuberculosis.

One of the co-infections of tuberculosis is aspergillosis. Aspergillosis is a fungus that vegetates in the soil. The fungus can reach the respiratory tract and lungs but will not manifest and only manifest if the host's immune or lung conditions are poor.(3)

Aspergillosis spectrum can be divided into 4 based on the pathophysiology (Table 1,Table 2).

Aspergilloma or mycetoma spectrum, emphasizes the non-invasive Aspergillus fungal infection and forms a fungus ball image. The immune status of the patient in this study was normal, but there was already damage to the lungs, especially in the form of cavities mainly due to preexisting tuberculosis infection, sarcoidosis, pneumatocele, pulmonary sequestration, or a bronchogenic cyst. The most common manifestation of this spectrum is hemoptysis. Conventional radiographic findings include pleural thickening at the apex, a cavity with a fungus ball that moves when changing position (Monad's sign) or an air crescent sign in which the fungus ball does not move with a change of position (Figure 9). Treatment of hemoptysis can be bronchial artery embolization with an embolic agent or surgical resection.(3) Surgery allows concurrent eradication of the fungus ball, underlying cavity, and surrounding unhealthy parenchyma. The goals of surgery are to avoid life-threatening hemoptysis and the development of an invasive clinical form, pulmonary fibrosis, or any complication due to chronic inflammation.(12)

Our patient had left apex pleural thickening on his conventional radiograph and a cavity with a fungus ball that formed an air crescent sign in the left superior lobe of the left lung with left apex pleural thickening on his chest CT, which support the features of aspergilloma.

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Table 1. The Spectrum of Aspergillosis.(3)

Immunity status	Lung condition	Disease spectrum
Hyperimmune	Normal	Hypersensitivity Pneumonitis/Allergic Bronchopulmonary Aspergillosis (ABPA)
Normal	Preexisting damage	Mycetoma (Aspergilloma)
Immunosuppressed	Normal	Semi invasive Invasive (Airway invasive/ Angioinvasive)

Table 2. Radiographic Findings on the Spectrum of Aspergillosis.(3)

Condition	Synonyms	Radiographic findings
Allergic Bronchopulmonary aspergillosis (ABPA)	Saprophytic aspergillosis	Finger-in-glove Central bronchiectasis High attenuation mucoid impaction
Aspergilloma	Mycetoma	Mass in a cavity Air crescent sign
Semi-invasive Aspergillosis	Chronic necrotizing aspergillosis	Consolidation Cavity Tree-in-bud nodules
Invasive Aspergillosis	(Angio-invasive or Airway-invasive)	Angio-invasive: Halo sign Airway-invasive: airway thickening, tree-in-bud

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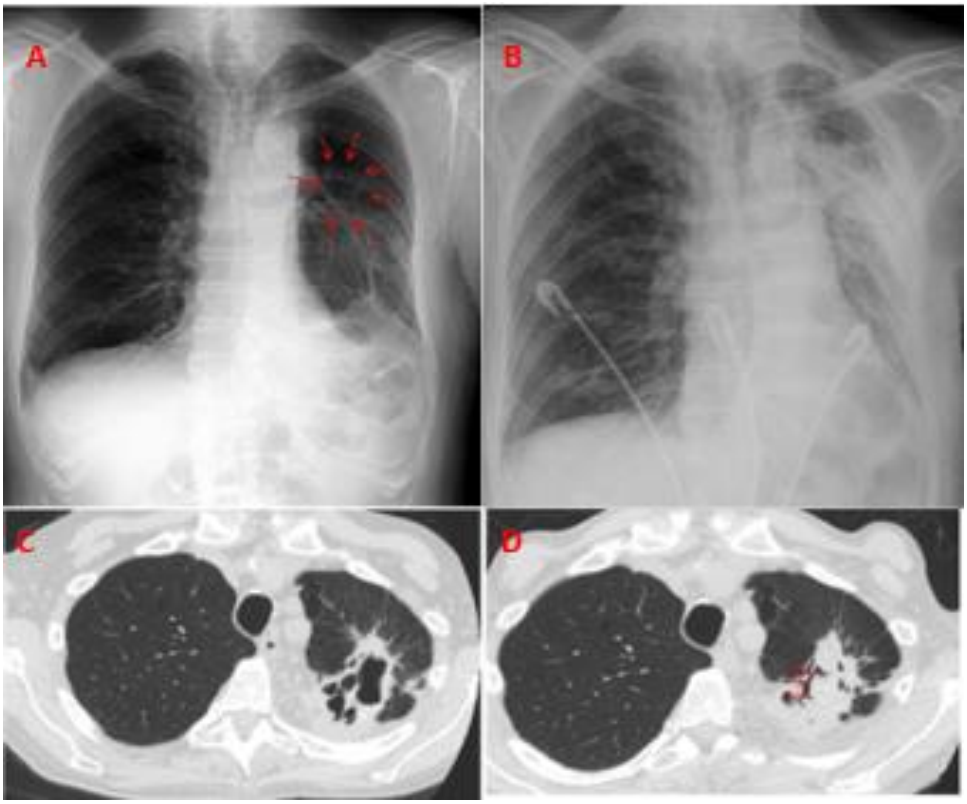

Figure 9. Conventional Chest X-Ray and CT of Aspergilloma.

A./B. Frontal Chest X-Ray, A. Pre-existing cavity in the middle zone of the left lung, B. Opacity that is developed in a pre-existing cavity (fungus ball) and pleural thickening
C./D. Axial lung window Chest CT, C. Pre-existing cavity in segment 2 of the left lung, D. Fungus ball developing in a pre-existing cavity with an air-crescent sign.(3)

Rasmussen's aneurysm is a peripheral pulmonary pseudoaneurysm that occurs as a focal dilatation of the pulmonary artery branch due to erosion of the wall secondary to chronic inflammation of the tuberculous cavity. They are generally located in the peripheral zone of the lung, because the branch of the pulmonary artery affected is medium-to-small in size and adjacent to or within a tuberculous cavity.(13–16)

The occurrence of Rasmussen's aneurysm is a result of progressive weaknesses in the pulmonary artery wall due to the presence of granulation tissue infiltration into the tunica adventitia and media. The granulation tissue will gradually be replaced by fibrin; this results in thinning of the pulmonary arterial wall.(14,15,17,18)

In addition to conventional imaging to establish the presence of pulmonary tuberculosis, especially with the findings of a cavity, multidetector chest CT Angiography with a 3D reconstruction is very necessary. It can provide anatomic information including the source of the aneurysm, the pathway to bleeding places, and orthotopic bronchial arteries. This is both to enforce the presence of Rasmussen's aneurysm or for management in the form of super-selective embolization (road map).(17,18) Another aim is to depict the anterior spinal artery that could help prevent spinal cord ischemia.(17) The predilection of Rasmussen's aneurysm is in previous cavities and is located in the upper lobe and peripheral zone of the lungs.(13–15) The feeder artery comes from the bronchial or non-bronchial systemic artery and from a branch of the pulmonary artery. This is

because infectious lung disease-related pulmonary artery pseudoaneurysm can be perfused through the bronchial and pulmonary arterial circulations. Based on bronchial and pulmonary angiographic findings, Shin et al. classified infectious lung disease-related pulmonary artery pseudoaneurysm (PAPs) into 4 types:

1. Type A PAPs can be visualized on non-selective pulmonary angiography.
2. Type B PAPs can be visualized on selective pulmonary angiography only.
3. Type C PAPs can be depicted on bronchial and non-bronchial systemic collateral arterial angiography through a bronchial to pulmonary arterial shunt, without visualization of the feeding pulmonary arteries on selective pulmonary angiography.
4. Type D PAPs can be depicted only by pulmonary CT angiography and not by catheter-directed angiography.(16)

First-line management in the case of Rasmussen's aneurysm consists of endovascular embolization due to its convenience and less-invasive nature. Rebleeding in cases of aneurysms carried out by embolization can occur, especially in cases of chronic tuberculosis, mycetoma, and cancer. The adverse effect of this action may include ischemic myelopathy because the embolic agent is loose to the spinal artery. Surgery, such as lobectomy, can be used as an option if the aneurysm is only in 1 lobe, the patient's condition is operable, a radiology interventionist is not available, and the presence of other conditions that cause damage to the lungs, such as *Coccodioides immits* infections or aspergilloma. The advantage of surgery permits a definitive treatment of hemoptysis because it removes the source of bleeding, but it has a high mortality rate of 20% with post operative complications of around 50%.(16,17)

The standard treatment for hemoptysis is bronchial artery embolization (BAE) because it usually originates from the bronchial artery or, less frequently, from a non-bronchial systemic artery. Hemoptysis that originated from a branch of the pulmonary artery only accounts for 10% of cases. On the other hand, Rasmussen's aneurysm requires combined embolization via the bronchial and pulmonary arteries. One method involves BAE followed by selective pulmonary artery embolization in case pulmonary angiography shows a residual aneurysm. The other method involves selective pulmonary artery embolization followed by BAE when a residual aneurysm is detected on bronchial angiography. The first method (BAE) has been a popular method for controlling hemoptysis, especially for type C Rasmussen's aneurysm. However, in some cases of Rasmussen's aneurysm, the bronchial artery is tortuous with interconnecting branches, making it difficult to approach the aneurysm. For such cases, the approach may be easy with the use of the second method (pulmonary artery embolization first), because the pulmonary artery is usually short and straight (Figure 10).(16)

Effective embolic agents, such as gelatin sponge, coils, and n-Butyl-2-Cyanoacrylate (NBCA) can be used. NBCA may be the most feasible material to use, because its liquid form in an appropriate concentration, enables embolization of both inflow and outflow arteries, including the aneurysm, and less rupture risk during filling of the aneurysmal sac, compared with that using coil. However, NBCA is a highly operator-dependent material to use and its behavior is difficult to estimate, especially if there is retrograde flow. Consequently, non-target embolization can pose dangerous and serious lung ischemic complications. Some authors use a modified second method using either a coil or balloon microcatheter placed proximal to the aneurysm.(16)

In this case, we used the systemic artery embolization method (from the proximal part of the left bronchial artery and the proximal part of the thyrocervical trunk branch), followed by intra-aneurysm embolization via the apicoposterior branch of the left pulmonary artery. After the

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embolization procedure, the follow-up result did not show any complaints of hemoptysis. Therefore, it can be concluded that the cause of hemoptysis, in this case, is the presence of Rasmussen's aneurysm. In addition, there were no complications such as spinal ischemia or lung ischemia.

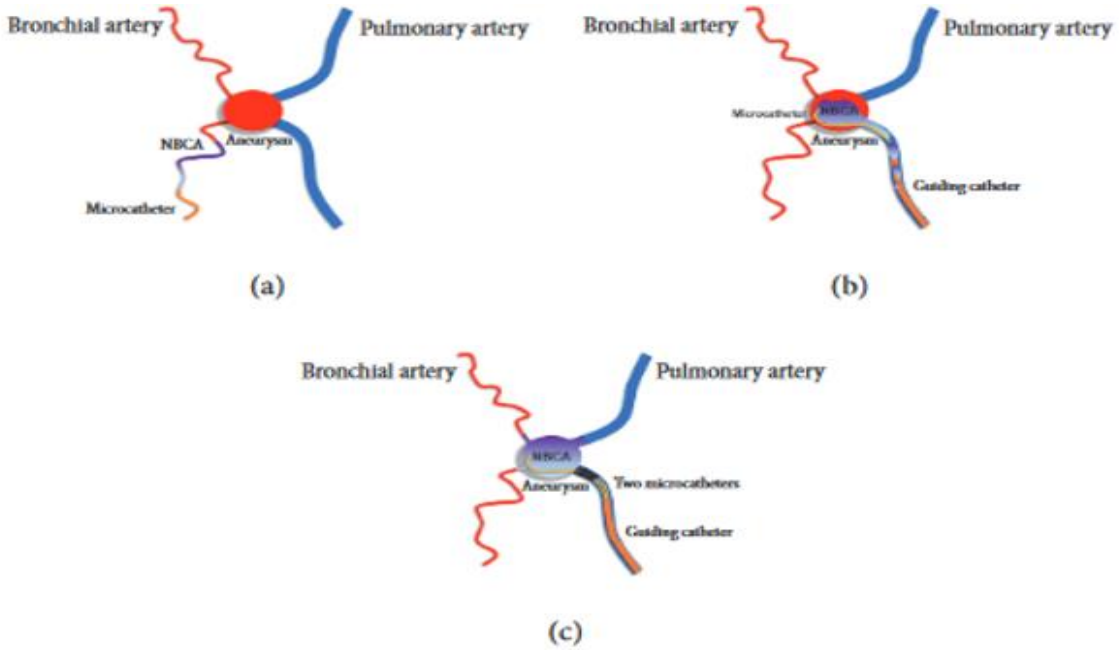

Figure 10. A Schematic Diagram of the Different Approaches to Rasmussen's Aneurysm Embolization.

a) Via the bronchial artery (first method). Only proximal embolization may be achieved because the inflow artery is small and tortuous. (b) Using the conventional approach via the pulmonary artery (second method). Selective catheterization of the aneurysm may be easy, but an unintended reflux of the NBCA cast and subsequent incomplete embolization of the aneurysm may occur with the retrograde flow. (c) Modified second method. Proximal coil blocking via the pulmonary artery prevents unintended reflux of the NBCA cast and allows continuous retrograde retention of the NBCA in the aneurysm, as well as in the inflow and outflow arteries. NBCA, n-butyl-2-cyanoacrylate.

CONCLUSION

Appropriate chest CT angiography procedures can help diagnose Rasmussen's aneurysm and to become a road map for embolization. Transarterial catheter embolization from bronchial or non-bronchial systemic artery and pulmonary artery can be used as the treatment modality of choice for Rasmussen's aneurysm in pulmonary tuberculosis with aspergillosis co-infection in the form of aspergilloma.

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