

Magnetic Resonance Angiography as a Radiation-Free Alternative for Pulmonary Embolism: A Longitudinal Case Report

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AUTHORS' CONTRIBUTIONS

Joel McKenzie: was the primary author who collected patient data, obtained consent, performed the literature review, and drafted the initial manuscript.

Manuela Aschauer: provided senior clinical oversight, contributed to interpretation of findings, revised the manuscript for important technical details, and approved the final version.

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DISCLOSURES

None.

CONSENT

Yes, written consent was obtained.

HUMAN AND ANIMAL RIGHTS

No human or animal experiments were conducted.

ABSTRACT

Pulmonary embolism is life-threatening and is diagnosed with computed tomography pulmonary angiography (CTPA), involving ionizing radiation and iodinated contrast. This case describes a pulmonary embolism diagnosed with magnetic resonance angiography (MRA) in 2004 and 2025, providing a longitudinal comparison of MRA's reproducibility in pulmonary embolism and venous thromboembolism diagnosis in this patient.

A 65-year-old female with prior pulmonary embolism and chronic venous insufficiency presented with dyspnea, pleuritic chest pain and leg edema. Due to patient concerns about radiation from CTPA, MRA was employed first-line, revealing multiple pulmonary emboli, lower limb deep vein thromboses and infarct-related pneumonia. The patient was treated with anticoagulation and antibiotics.

This case shows MRA can diagnose pulmonary embolism while avoiding radiation. It underscores MRA's role as a safe diagnostic modality and supports its uptake for broader populations.

CASE REPORT

BACKGROUND

Pulmonary embolism is commonly diagnosed with computed tomography pulmonary angiography (CTPA), despite significant associated exposure to ionizing radiation and iodinated contrast. Magnetic resonance angiography (MRA) offers a radiation-free alternative but remains underutilized due to historical technical limitations and variable diagnostic confidence. This case provides a rare longitudinal comparison of MRA for pulmonary embolism in the same patient over a 21-year

interval, demonstrating reproducible diagnostic performance across different generations of magnetic resonance imaging (MRI) technology and supporting the role of contemporary MRI as a viable alternative in selected patients.

CASE REPORT

A 65-year-old female presented to the Emergency Department with two days of progressive breathlessness on

a background of chronic venous insufficiency and a personal history of pulmonary embolism (PE). Her first PE occurred in 2004, three days after a long-haul flight, where she experienced dyspnea. She was treated with low-molecular-weight heparin (LMWH) and was advised the use of compression stockings.

In June 2025, the patient again experienced an episode of progressive exertional dyspnea following a period of prolonged immobility, without wearing her usual compression stockings. She reported mild dehydration, dyspnea, leg edema and significant unilateral pleuritic chest pain. There was no leg pain or hemoptysis in either episode.

On presentation, the patient was hemodynamically stable but tachypneic. There was no tachycardia, no hypoxia and the patient was afebrile. Respiratory examination demonstrated dyspnea without wheeze or crackles. Cardiovascular examination was normal, and there were no peripheral signs of right heart strain. She is functionally independent, highly active, a non-smoker, takes no regular medications and underwent a total knee replacement in January 2025, which was unlikely to be contributory.

Imaging Findings

Relevant laboratory results included elevated C-reactive protein (135 mg/L [reference <5]) and D-dimer (5.34 mcg/mL [reference <0.5]). Due to patient preference, MRI was used as the frontline imaging modality. Gadolinium contrast was administered.

MRA of the pulmonary arteries revealed a 17mm thrombus in the right lower lobe artery (Figure 1) and two smaller thrombi in the left lower lobe arteries (Figure 2).

Additional findings included infarct-related pneumonia in the left lung (Figure 3) and a left-sided pleural effusion (Figure 4)

Magnetic resonance venography of the lower limbs demonstrated extensive thrombotic deposits along the deep femoral vein with proximal extension into the superficial femoral vein (Figure 5). Abdominal MRI showed no paraneoplastic process. An incidental simple renal cyst (Figure 6) was reported without malignant features.

MRA was also employed during the patient's 2004 presentation. In these studies, a thrombus was noted in the left lung, also demonstrating areas of decreased perfusion (Figure 7). Lower leg studies confirmed thrombotic deposits in the deep veins of the calf and popliteal vein (Figure 8).

Management

PE was diagnosed based on the above findings. The patient was treated with LMWH (1 mg/kg subcutaneously twice daily), followed by apixaban 10 mg oral twice daily for 7 days, then 5 mg oral twice daily. Amoxicillin/clavulanate 500 mg oral twice

daily for 10 days was prescribed for infarct-related pneumonia. Compression stockings and supportive lifestyle measures were recommended.

Follow-up

The patient was discharged in good health without dyspnea. Her mobility and exercise tolerance returned to baseline levels. Ongoing anticoagulation and compression therapy were prescribed.

DISCUSSION

PE is a potentially fatal condition caused by pulmonary artery obstruction, most often from venous thromboembolism [1]. Currently, CT Pulmonary Angiography (CTPA) is the first-line imaging modality, supported by risk-stratification tools including the Wells score and PE Rule-out Criteria (PERC) [2]. Ventilation-perfusion (V/Q) scanning is used in some cases (including in pregnancy and contrast allergy); but its lower radiation dose is offset by limited diagnostic efficacy as it assesses perfusion defects rather than direct visualization of thrombi. Given this, the utility of V/Q scanning is limited and frequently necessitates further imaging [3, 4].

CTPA is accurate but exposes patients to radiation and iodinated contrast, both of which carry population-level and individual risks [5, 6]. MRI has emerged as a promising alternative that avoids radiation and iodinated contrast, with test sensitivity and specificity comparable to CTPA in multiple studies [7-9]. Despite these advantages, MRA has not been widely adopted as a first-line investigation for pulmonary embolism. Earlier literature describes MRA as more expensive, time-consuming, susceptible to artefact, and technically inadequate at times [10]. These limitations, however, largely reflect older scanner technology, acquisition protocols, and patient selection.

This case challenges these concerns by demonstrating successful diagnostic accuracy across a 21-year interval, using both a Siemens Symphony 1.5T ® in 2004, compared with a Siemens MAGNETOM Vida 3T ® in 2025 with consistent identification of PE. This longitudinal comparison highlights both the reproducibility of MRA in an individual patient and the substantial improvements in image quality achievable with contemporary MRI technology.

Etiology & Demographics

PE has increased in incidence over the past two decades, partly due to increased use of CTPA and a growing burden of comorbidities such as malignancy, obesity, and ageing populations and increased international travel [11]. Most emboli originate from proximal lower-limb deep veins with significant risk factors including recent surgery, trauma, immobility, or cardiac disease. The pathophysiology of PE develops through venous stasis, hypercoagulability, endothelial injury, and inflammation [12]. In recent years, survival rates of PE have

improved owing to better risk stratification and adherence to evidence-based treatment [13].

Clinical & Imaging Findings

Common symptoms of PE include sudden dyspnea, pleuritic chest pain, limb swelling, tachycardia and occasionally hemoptysis [14]. As clinical findings are non-specific, risk-stratification methods such as the Wells Score and the PERC guide imaging [2].

Although CTPA is readily available and rapid, it exposes patients to ionizing radiation, with dose varying by study parameter [15]. Table 1 summarizes radiation doses from common imaging modalities used in PE assessment. In comparison, MRA offers radiation-free evaluation, providing direct visualization of intraluminal thrombus, while perfusion MRI assesses regional pulmonary blood flow.

CTPA also requires iodinated contrast, which can cause nephrotoxicity and allergic reactions [6]. MRA uses gadolinium-based contrast agents, which have lower rates of both. Although nephrogenic systemic fibrosis (NSF) and gadolinium deposition have been reported as complications of gadolinium-based agents, there is no reported risk of NSF with cyclic gadolinium molecules like Gadobutrol [16]. Furthermore, while gadolinium deposition is well documented, no adverse clinical effects have been demonstrated [17].

In this case, MRA demonstrated multiple intraluminal thrombi in bilateral lower lobe arteries, infarct-related pneumonia, pleural effusion and lower-limb deep vein thrombosis (DVT), providing a complete radiation-free diagnostic picture.

Treatment & Prognosis

Standard treatment for acute PE involves anticoagulation, most commonly with LMWH or direct oral anticoagulants. Prognosis is generally favorable when treated promptly, depending on severity [2].

MRI findings did not alter the management pathway but enabled diagnosis without radiation or iodinated contrast. The patient recovered to baseline function following anticoagulation and treatment of infarct-related pneumonia.

Differential Diagnoses

The differential diagnoses for dyspnea and pleuritic chest pain are broad. Pneumonia, pneumothorax, and pericarditis may present with pleuritic features, although these typically demonstrate characteristic parenchymal, pleural, or pericardial findings on imaging. Musculoskeletal chest pain can mimic pleuritic discomfort but is often localized and reproducible on examination. Another critical differential diagnosis is the rapidly fatal aortic dissection. Given its severity, dissection requires prompt diagnosis, of which MRA has been shown to have excellent diagnostic accuracy [18]. Malignancy-

related thromboembolism also remains a key consideration, particularly in cases of unprovoked PE [19]. In this patient, MRI of the abdomen and pelvis demonstrated no evidence of intra-abdominal malignancy, an important exclusion given that occult cancer accounts for approximately 17% of unprovoked cases of PE [20].

TEACHING POINT

MRA can reliably detect pulmonary arterial thrombi, associated parenchymal changes, and concomitant DVT without ionizing radiation or iodinated contrast. As evidence grows and technology advances, MRI may take on a larger role in the diagnostic pathway for PE, potentially emerging as a frontline imaging option in selected patients.

QUESTIONS

Question 1: What is the most common source of pulmonary emboli?

1. Cardiac thrombus from atrial fibrillation
2. Proximal lower-limb deep veins (applies)
3. Pulmonary artery wall inflammation
4. Upper-limb veins after intravenous cannulation
5. Distal lower-limb veins

Explanation for question: [Most emboli originate from proximal lower-limb deep veins with significant risk factors including recent surgery, trauma, immobility, or cardiac disease].

Question 2: How can magnetic resonance angiography (MRA) diagnose pulmonary emboli?

1. Via direct visualization of intraluminal thrombus (applies)
2. By detecting calcium deposits in the pulmonary arteries
3. Through evaluation of regional pulmonary perfusion (applies)
4. By measuring oxygen levels in the blood
5. By detecting areas of lung inflammation or infection

Explanation: [MRA provides direct visualization of intraluminal thrombi, while perfusion MRI evaluates regional pulmonary blood flow. Magnetic resonance venography also assists in the planning and evaluation of vena cava filter insertion to reduce the risk of subsequent acute pulmonary embolism [22]].

Question 3: How does the diagnostic accuracy of magnetic resonance imaging (MRI) compare to computed tomography pulmonary angiography (CTPA) for diagnosing pulmonary embolism?

1. MRI has a higher sensitivity and specificity compared to CTPA in all settings
2. MRI has been shown to have a comparable diagnostic accuracy compared to CTPA (applies)
3. CTPA has a higher sensitivity and specificity compared to MRI in all settings
4. There is no available research that compares the two imaging modalities

5. There is no difference in diagnostic accuracy between the two imaging modalities

Explanation: [MRI has emerged as a promising alternative that avoids radiation and iodinated contrast, with test sensitivity and specificity comparable to CTPA in multiple studies [7-9]].

Question 4: Which of the following statements regarding gadolinium-based contrast agents in magnetic resonance imaging (MRI) is true?

1. Gadolinium contrast always causes nephrogenic systemic fibrosis (NSF)
2. Gadolinium contrast is more nephrotoxic than iodinated contrast used in computed tomography (CT)
3. There is no documented risk of NSF with newer gadolinium agents (applies)
4. Gadolinium cannot be used in patients with any renal impairment
5. Gadolinium deposition in tissues always leads to clinical symptoms

Explanation: [Although NSF and gadolinium deposition have been reported as complications of gadolinium-based agents, there is no reported risk of NSF with newer gadolinium agents such as Gadobutrol [16]. Furthermore, while gadolinium deposition is well documented, no adverse clinical effects have been demonstrated [17]].

Question 5: What is a key advantage of using magnetic resonance angiography (MRA) for the diagnosis of pulmonary embolism?

1. MRA can replace the need for therapeutic anticoagulation in selected patients
2. MRA is less expensive and faster than computed tomography pulmonary angiography (CTPA) in all settings
3. MRA eliminates the need for clinical risk stratification tools like the Wells score
4. MRA can directly dissolve pulmonary emboli during imaging
5. MRA can reliably detect pulmonary emboli, associated parenchymal changes and lower-limb deep vein thrombosis (DVT) without ionizing radiation or iodinated contrast (applies)

Explanation: [MRI, particularly MRA, can reliably detect pulmonary arterial thrombi, associated parenchymal changes, and concomitant DVT without ionizing radiation or iodinated contrast. As evidence grows and technology advances, MRI may take on a larger role in the diagnostic pathway for PE, potentially emerging as a frontline imaging option in selected patients].

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FIGURES

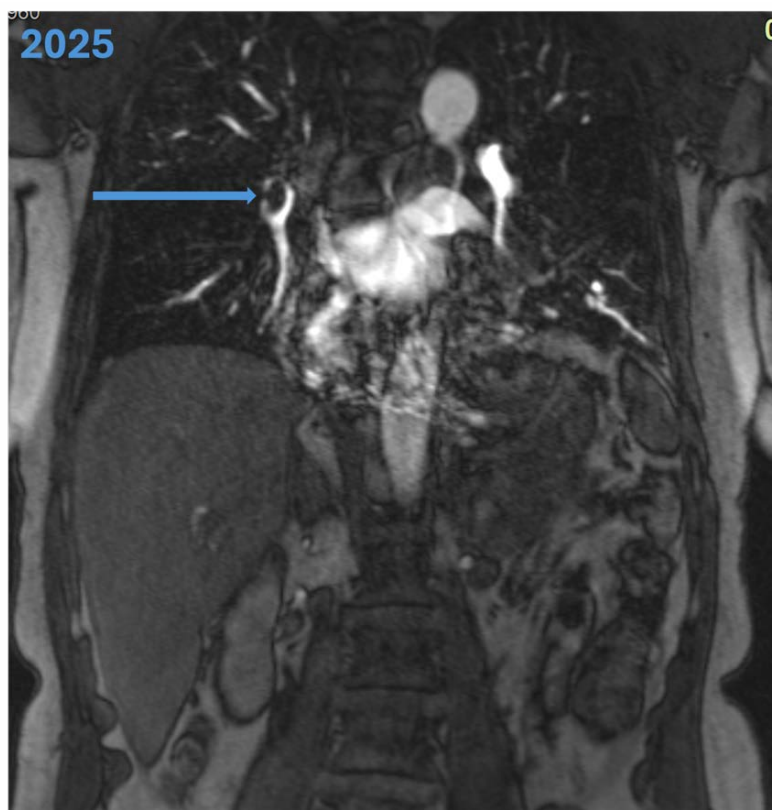


Figure 1: 65-year-old female with right-sided PE.

FINDINGS: 2025 MRA revealed a 17mm thrombus in the right lower lobe artery of the lung (blue arrow).

TECHNIQUE: T1 weighted coronal MRA using Flash 3D Angio sequence after 15mL of GADOVIST® contrast. Magnet strength = 3T, TR/TE/Flip angle = 2.9ms/1.03ms/16°; slice thickness = 2.3mm.

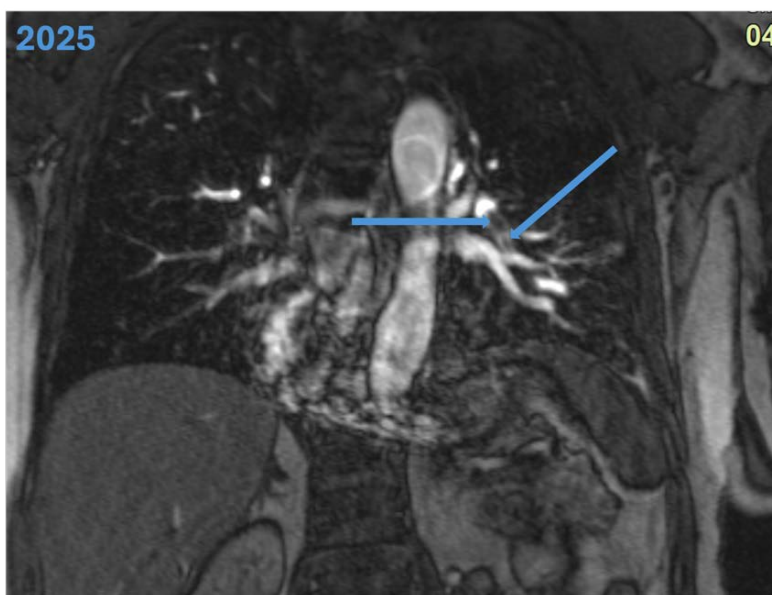


Figure 2: 65-year-old female with left-sided PE.

FINDINGS: 2025 MRA revealed two smaller thrombi in the left lower lobe arteries of the lung (blue arrows).

TECHNIQUE: T1 weighted coronal MRA using Flash 3D Angio sequence after 15mL of GADOVIST® contrast. Magnet strength = 3T; TR/TE/Flip angle = 2.9ms/1.03ms/16°; slice thickness = 2.3mm.

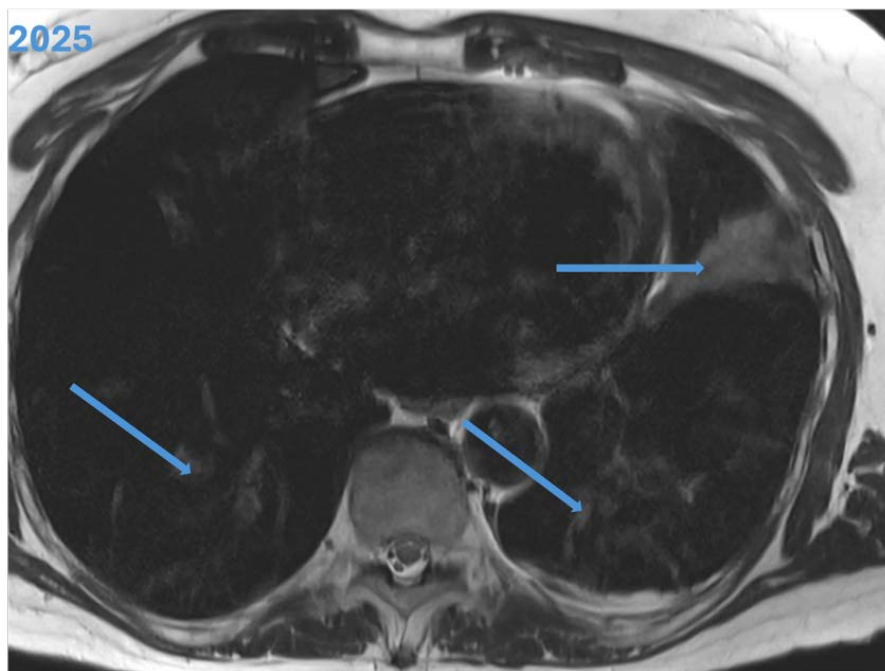


Figure 3: 65-year-old female with infarct-related pneumonia.

FINDINGS: 2025 MRA revealed infarct-related pneumonia throughout the left lung and developing in the right lung (blue arrows).

TECHNIQUE: T2 weighted axial MRI using a HASTE sequence. Magnet strength: 3T; TR/TE/Flip Angle = 800ms/93ms/120°; slice thickness = 4mm.

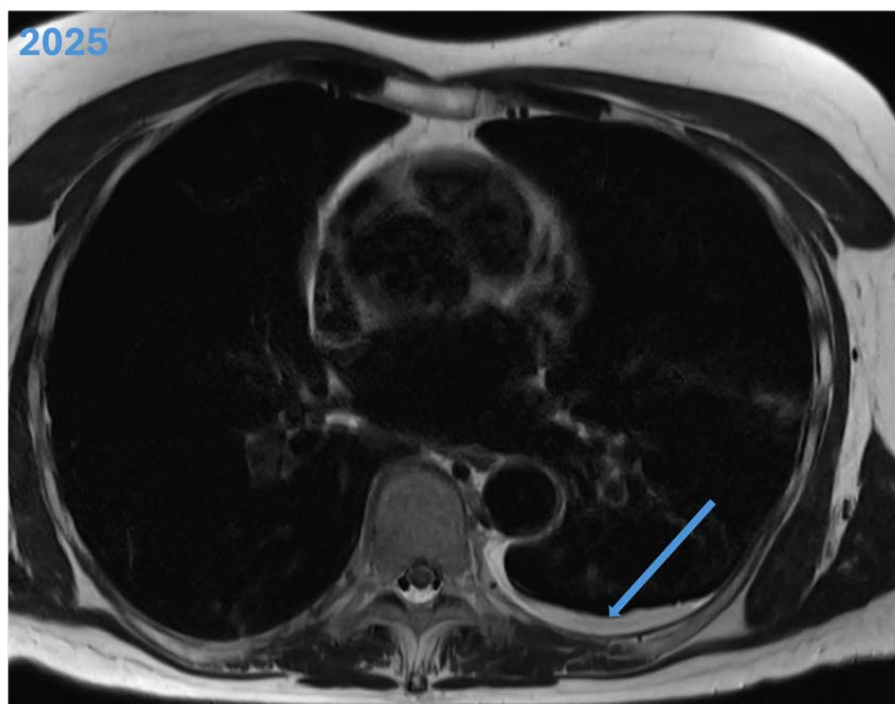


Figure 4: 65-year-old female with left-sided pleural effusion in 2025.

FINDINGS: 2025 MRA revealed a moderate left-sided pleural effusion (blue arrow). There is no evidence of septations or additional consolidation apart from previously described infarct-related pneumonia.

TECHNIQUE: T2 weighted axial MRI using a HASTE sequence. Magnet strength: 3T; TR/TE/Flip Angle = 800ms/93ms/120°; slice thickness = 4mm.

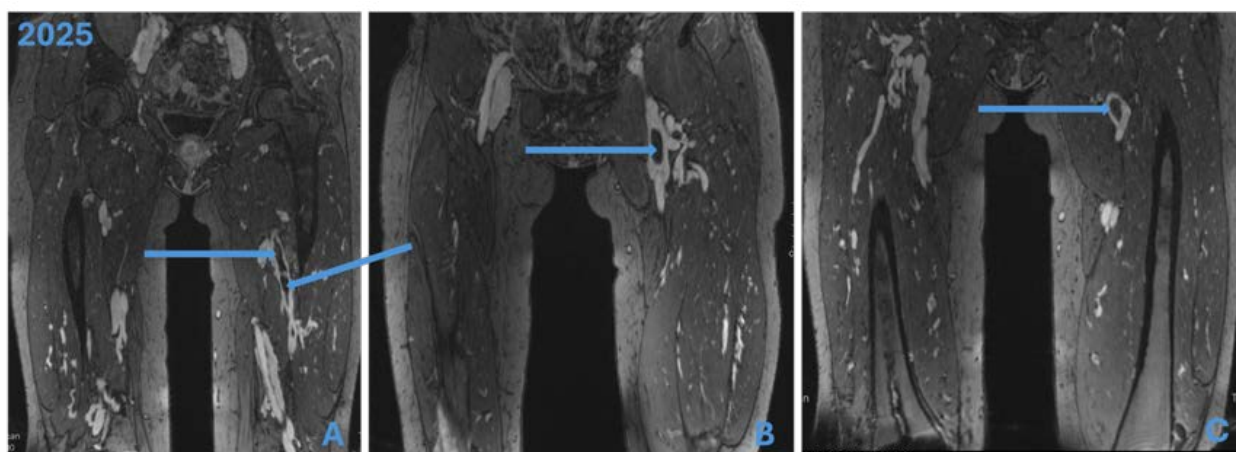


Figure 5A, B, and C: 65-year-old female with deep vein thromboses.

FINDINGS: 2025 MRA revealed extensive thrombotic deposits through the deep femoral vein of the left leg (blue arrows).

TECHNIQUE: T1 weighted coronal MRA using Flash 3D Angio sequence after 15mL of GADOVIST® contrast. Magnet strength: 3T; TR/TE/Flip angle = 2.9ms/1.03ms/16°; slice thickness = 2.3mm.

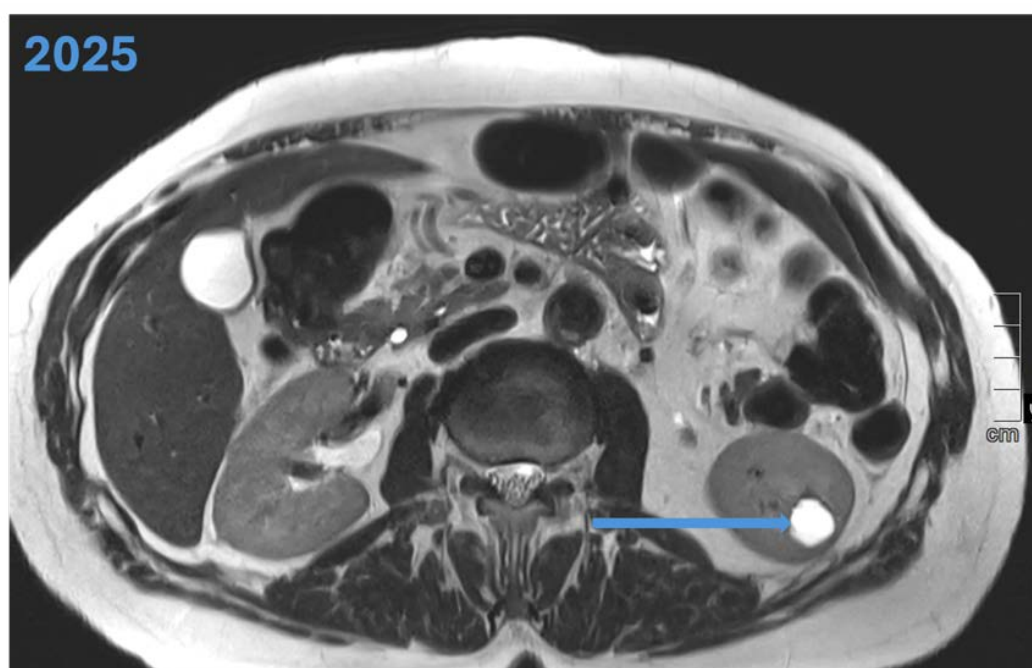


Figure 6: 65-year-old female with a simple renal cyst.

FINDINGS: 2025 MRA revealed no paraneoplastic findings and a benign renal cyst (blue arrow). This is an important aspect of diagnosing pulmonary embolism, as intra-abdominal malignancies may often precipitate the disease

TECHNIQUE: T2 weighted axial MRI using a HASTE sequence. Magnet strength: 3T; TR/TE/Flip Angle = 800ms/93ms/120°; slice thickness = 4mm.

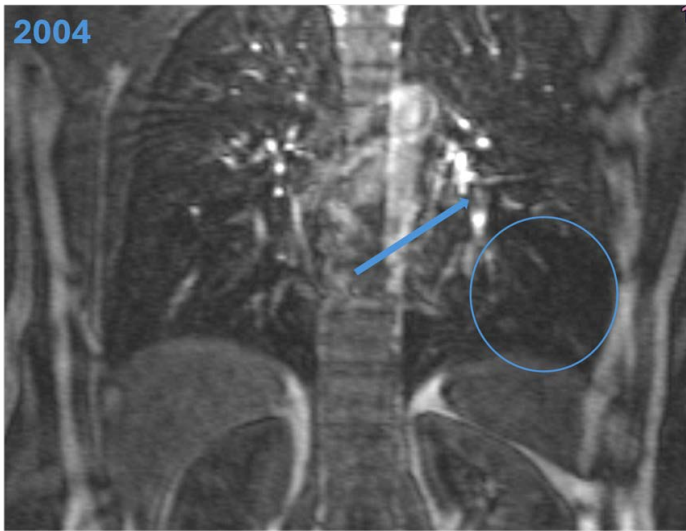


Figure 7: Historical study of a 65-year-old female with left-sided PE.
FINDINGS: 2004 MRA revealed a thrombus in the left descending pulmonary artery (blue arrow) with area of reduced lung perfusion (blue circle).
TECHNIQUE: T1 weighted coronal MRA using FLASH 3D Angio sequence after 30mL of MAGNEVIST ® contrast. Magnet strength: 1.5T; TR/TE/Flip Angle = 2.4/1.04ms/20°; slice thickness = 3mm.

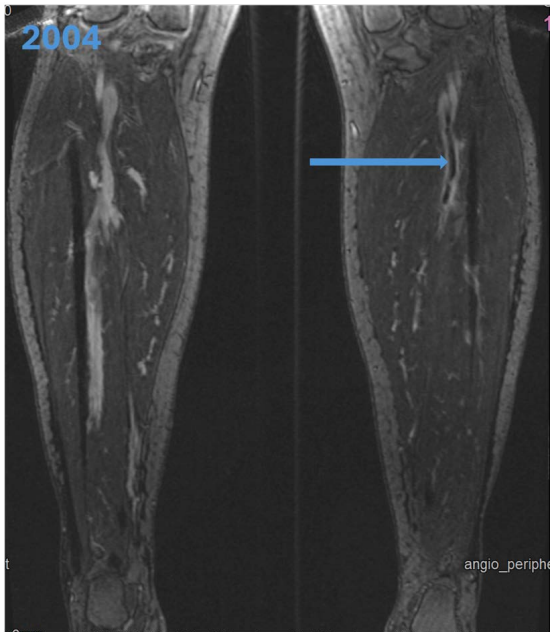


Figure 8: Historical study of a 65-year-old female with left-sided DVT (blue arrow).
FINDINGS: 2004 MRA revealed an intraluminal thrombus within the left popliteal vein and veins of the calf.
TECHNIQUE: T1 weighted coronal MRA using FLASH 3D Angio sequence after 30mL of MAGNEVIST ® contrast. Magnet strength: 1.5T; TR/TE = 4.45ms/1.58ms; slice thickness = 1mm.

Table 1: This Table compares effective radiation doses in mSv for imaging modalities associated with the diagnosis of pulmonary embolism. It is worth noting that the effective radiation dose varies depending on the parameters of the study.

Study	Approximate effective radiation dose
Computed Tomography (CT) examinations	
Chest	7mSv [21]
Chest pulmonary angiogram (CTPA)	10mSv [21]
Nuclear medicine scan	
Ventilation-perfusion (V/Q) scan	1.2mSv [4]
Magnetic resonance (MR) imaging	
MR angiography (MRA)	0.0mSv

KEYWORDS

Pulmonary embolism; Venous thromboembolism; Deep vein thrombosis; Magnetic resonance angiography; Magnetic Resonance Imaging; Gadolinium-based contrast agents; Infarct-related pneumonia

ABBREVIATIONS

CT = Computed Tomography
MRI = Magnetic Resonance Imaging
MRA = Magnetic Resonance Angiography
PE = Pulmonary Embolism
LMWH = Low Molecular Weight Heparin
CTPA = Computer Tomography Pulmonary Angiography
PERC = Pulmonary Embolism Rule-Out Criteria
NSF = Nephrogenic Systemic Fibrosis
DVT = Deep Vein Thrombosis

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