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The reversed halo sign with a reticulonodular pattern as unusual findings of pulmonary infarct in acute pulmonary embolism: case report and literature review

Antonio Pierro[1], Antonio Totaro[2,3*], Gianluca Testa[3], Biagio Francesco Pio Apollonio[1], Stefano Carafa[1], Attilio Bontempo[4], Antonio Vallo[5], Savino Cilla[6] and Raffaella Basilico[7]

Abstract

Background The reversed halo, also known as the atoll sign, is a distinct sign with ring-shaped consolidation and central lucency. The reversed halo sign, initially emerging in cryptogenic organizing pneumonia, has been observed in various pulmonary diseases, including pulmonary embolism. The presence of this sign in the subpleural, posterior basal parts of the lower lobes, predominantly when solitary, should raise the possibility of other causes, such as pulmonary infarction.

Case presentation We present a case of acute pulmonary embolism with pulmonary infarction discovered on a CT pulmonary angiogram in our emergency department, where the pulmonary infarction appears as a reverse halo sign with a reticulonodular pattern. The reticular nodular pattern in the halo sign is not typical of a pulmonary infarct presenting with a reverse halo sign.

Conclusions To our knowledge, this is the first case of pulmonary infarction in acute pulmonary embolism with the appearance of a reverse halo sign with a reticulonodular pattern.

Keywords Reversed halo sign, Pulmonary infarct, Pulmonary embolism, CT pulmonary angiography

Background

One frequent and potentially fatal side effect of venous thromboembolic illness (VTE) is acute pulmonary embolism (PE) [1].

Computed tomography pulmonary angiography (CTPA) is the current non-invasive imaging modality of choice to assess acute PE. Its advantages include accuracy, speed of image acquisition, and wide availability [2].

Filling defects in the pulmonary artery detected in CTPA examination represent direct signs of PE. Due to the intricate nature of the clinical diagnosis, specific individuals who are afflicted with an undetected pulmonary embolism may be subjected to unenhanced computed tomography of the thorax to assess various other cardiopulmonary ailments.

*Correspondence:
Antonio Totaro
antonio.totaro@unimol.it
[1] Radiology Department, "S. Timoteo" Hospital, Termoli, Italy
[2] Department of Cardiovascular Disease, Responsible Research Hospital, Campobasso, Italy
[3] Department of Medicine and Health Sciences "V. Tiberio", University of Molise, Via F. De Sanctis 1, 86100 Campobasso, Italy
[4] Emergency and Urgency Department, "S. Timoteo" Hospital, Termoli, Italy
[5] Department of Surgery, "S. Timoteo" Hospital, Termoli, Italy
[6] Medical Physics Unit, Responsible Research Hospital, Campobasso, Italy
[7] Department of Neurosciences, Imaging and Clinical Studies, "Gabriele D'Annunzio" University, Chieti, Italy

Patients exhibiting cardiopulmonary symptoms that do not indicate a pronounced clinical stigma of PE may benefit from an unenhanced thoracic CT scan in specific clinical situations. This supports the need to focus on non-obvious PE or pulmonary infarction (PI) signals on unenhanced CT [3].

The mosaic perfusion pattern or PI as the classic appearance of wedge-shaped, pleural-based consolidation without air bronchograms inside or the spontaneous hyperdense thrombus inside pulmonary arteries in an unenhanced study could be indirect signs of pulmonary embolism on unenhanced CT [3].

Reversed halo sign (RHS) was observed in 18% of patients with pulmonary embolism who had a lower-lung predominance, subpleural involvement, and pleural effusion. Researchers have also described RHS as a morphological manifestation of pulmonary infarction [3].

In immunocompromised patients, infections are more likely to cause RHS than non-infectious processes. In contrast, the reticular RHS pattern—rather than the nodular RHS pattern—typically correlates with PI in immunocompetent patients, resulting from a thromboembolic condition.

PI typically appears in the juxta pleural location and the lower lobes (81.8%) [4–6]. The presence of RHS on unenhanced pulmonary CT scans in the lower lobes' juxta pleural posterior location, mainly when it is solitary, should prompt a suspicion for conditions other than infection or typical cryptogenic organizing pneumonia, like pulmonary infarction [7].

We reported a case of pulmonary embolism with pulmonary infarction with the reversed halo sign and internal reticulo-nodulation pattern.

Our case thus suggests that the RHS can offer the possibility of a pulmonary infarction presence in an adequate clinical environment, and consequently, it indicates the need to advance towards an angiographic CT imaging study of the pulmonary arteries.

Case presentation

A 47-year-old patient with glioblastoma, who was undergoing chemotherapy cycles, presented to our hospital's emergency room with complaints of bilateral chest pain and dyspnea.

There were no clinical signs of hypoxia (SpO_2 of 97% in ambient air), tachycardia (74 bpm), or hypertension/hypotension (105/70 mmHg). The Wells score results indicated a low risk of PE.

The results of the laboratory tests ruled out a compromised immune system and revealed elevated levels of fibrinogen (722 mg/dl), C-reactive protein (8 mg/dl), and D-dimer (1.904 ng/ml).

A large saddle embolus and extensive bilateral defects in the lobar artery filling were found on CT pulmonary angiography (Fig. 1), and the lung CT window revealed two reversed halo signs: one in the lower left lobe, with a juxta pleural location and an elliptical shape, and another in the lower right lobe, with a subpleural location (Fig. 2).

As pulmonary infarcts, the reverse halo areas on CT pulmonary angiography did not exhibit perfusion (Fig. 3).

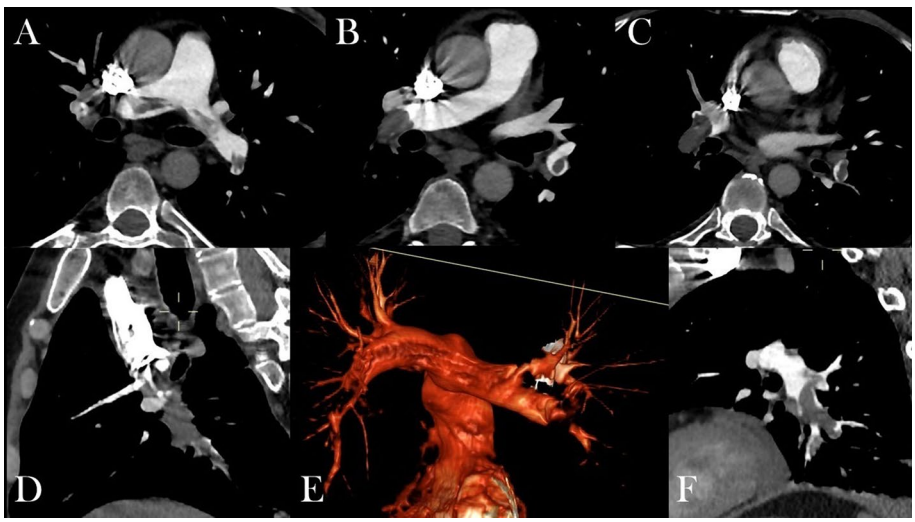

Fig. 1 Axial (**A**, **B**, and **C**) and sagittal (**D** and **F**) CT angiography of pulmonary arteries shows extensive filling defects straddling the bifurcation of the pulmonary trunk, extending into the left and right pulmonary arteries. A volume rendering image of the pulmonary artery (**E**) shows amputation affecting the pulmonary artery in its lobar inferior branches bilaterally and an impression that straddles the bifurcation of the pulmonary trunk

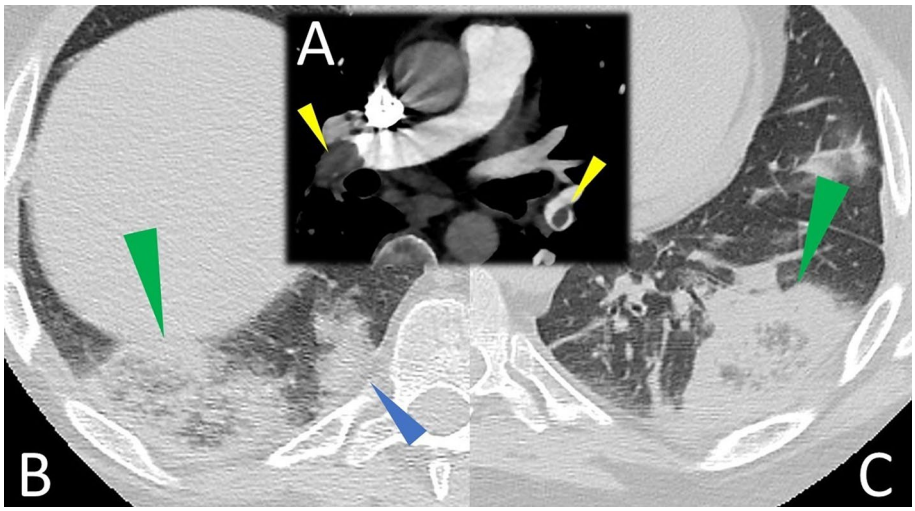

Fig. 2 Axial (**A**) CT angiography of the pulmonary artery shows filling defects in the left and right pulmonary arteries (yellow arrowheads). An axial HRCT scan of the lung base reveals two reversed halo signs: (**B**) one in the lower right lobe, with an elliptical shape and subpleural location (green arrowhead), and another (**C**) in the lower left lobe, with a wedge-shaped and juxtapleural location (green arrowhead). A nodular reticulum-type pattern is appreciable within both areas of RHS (**B** and **C**). In the right lower lung lobe, a pulmonary infarction without aspects of RHS is also evident (blue arrowhead in **B**)

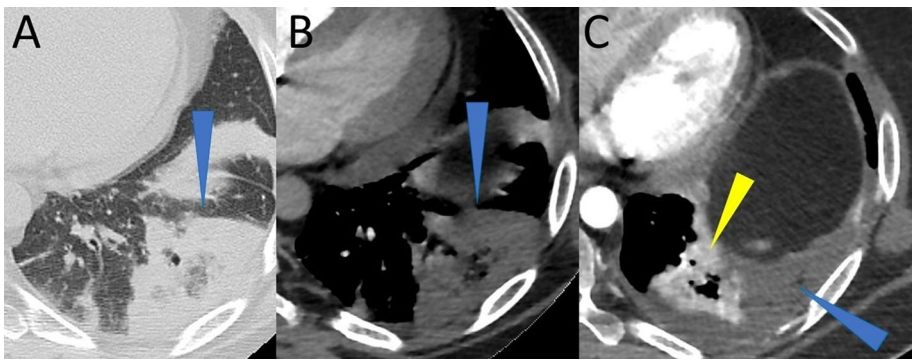

Fig. 3 Axial CT images with parenchymal (**A**) and mediastinal (**B** and **C**) settings. RHS (blue arrowhead in **A**, **B**, and **C**) represents pulmonary infarction. The pulmonary infarction showed no enhancement after the contrast medium was introduced (blue arrowhead in **B** and **C**). At the same time, the neighbouring parenchyma with partial and lamellar atelectasis is vascularized (yellow arrowhead in **C**)

Within the reverse halo areas, a micronodular-reticulonodular pattern was visible in the ground-glass opacity (Fig. 4). Neither a pleural nor pericardial effusion was present. The remaining pulmonary parenchyma of both lungs shows no other significant alterations (Fig. 5).

Discussion

The third most common cardiovascular condition is pulmonary artery embolism (PE), with acute right heart failure and/or lung infarction as a significant consequence [8].

Since lung consolidations suggestive of infarction may be the initial sign of acute PE, timely diagnosis of pulmonary infarction during life is crucial.

A cushion-like or hemispherical consolidation along the pleura strongly indicates pulmonary infarction, but when establishing a differential diagnosis, other conditions, such as pneumonia or lung cancer, must also be considered.

Pneumonic consolidations during the early stages of the disease or resolution may manifest as a more central consolidation at a distance from the pleura. At the same time, infarcts remain organized peripherally alongside the pleural surface.

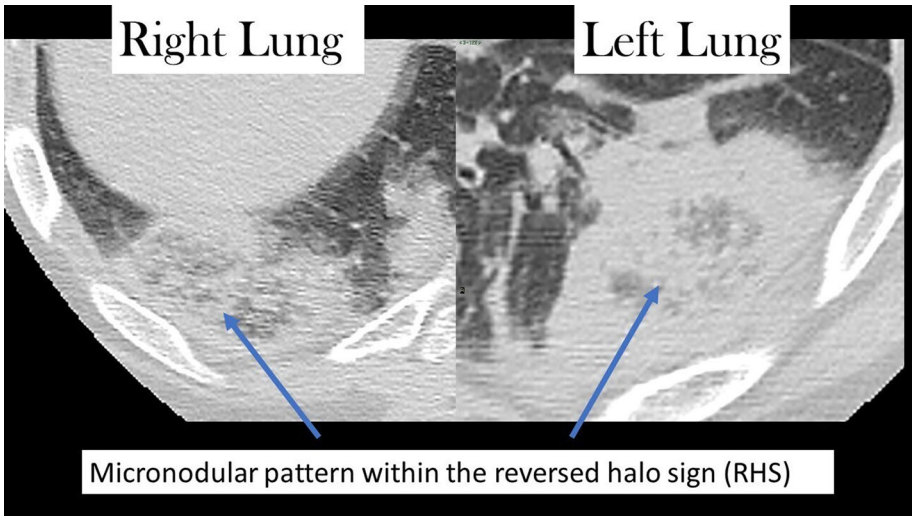

Fig. 4 On the CT lung window, in both areas of RHS, a micronodular pattern is evident in the ground-glass opacity inside the pulmonary infarcted area on lung window CT images

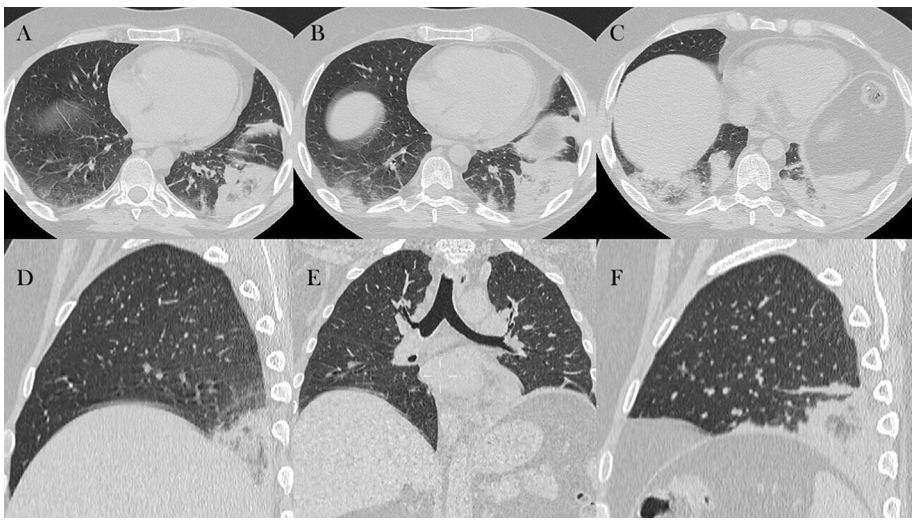

Fig. 5 The CT windows of both lungs evaluated entirely in the axial (**A**, **B**, and **C**), sagittal (**D** and **F**), and coronal (**E**) planes do not show other significant parenchymal alterations

Likewise, tumour masses are frequently situated at some distance from the pleura.

Sadly, the widely held misconception that a pulmonary infarction should only be triangular, with the apex pointing towards the pulmonary hilum, causes pulmonary infarctions to frequently be mistaken for pneumonia, granulomatous disease, or neoplasia [9].

Fleischner, Hampton, and Castleman subsequently noted that this is erroneous since sufficient collateral blood flow safeguards the apical region of an embolized lung from infarction [9].

Acute PE may result in partial or total blockage of the pulmonary vasculature, but the latter may also cause PI. On CTPA, PI manifests as ground-glass opacity with reticular changes or as a wedge-shaped consolidation with the truncated apex directed towards the hilum and the base towards the pleural surface (Hampton hump) without the presence of an air bronchogram [10]. Infarcts are usually multiple and, in 87%, unilateral [9]. Eighty-five per cent of them are located in the lower lobes, and the remaining fifteen per cent are equally split between the other lobes. In 82% of the cases, focal central

hyperlucencies (bubbly consolidation) within the infarction have been observed [9, 10].

In addition to being linked to various pulmonary conditions, reversed halo sign (RHS) has also been linked to pulmonary infarction [11].

By using computed tomography angiography (CTA) of the pulmonary arteries, Mancano et al. described the incidence of the reversed halo sign (RHS) in patients with pulmonary infarction (PI) caused by acute pulmonary embolism (PE). They also described the RHS's main morphological features, including areas of low attenuation and a typical single oval lesion in the right lower lobe subpleural location [4].

Marchiori et al. have demonstrated that lower lung predominance and pleural effusion also suggest PI and that a single RHS with low-attenuation areas inside the halo, with or without reticulation, highly suggest PI [5].

On the other hand, the patient's immune status and the overall clinical presentation should be considered when interpreting reticulation inside the RHS halo. The RHS with reticulation in an immunocompromised patient highly suggests invasive fungal infection (IFI), especially angioinvasive pulmonary aspergillosis or pulmonary zygomycosis. In an immunocompetent patient, this feature is highly suggestive of PI [5]. It is crucial to remember that nodules on the halo's wall or inside (nodular RHS) typically indicate active granulomatous diseases like sarcoidosis and tuberculosis to aid in differential diagnosis [12]. Reticulations within the reverse halo sign, which characterize the reticular pattern, have been linked to pulmonary infarctions in immunocompetent patients or invasive fungal diseases in immunocompromised patients [13]. Therefore, the nodular pattern is not typical or expected in pulmonary infarction.

Surprisingly, our case report found two pulmonary infarctions with the reverse halo sign involving the right and left lower lobes, with one presenting an oval and the other a triangular shape. Moreover, it is noteworthy that in both instances, the internal region of the RHS displayed a nodular reticulum pattern in an immunocompetent patient who had a pulmonary embolism, as shown by CT angiography of the pulmonary arteries.

Conclusions

The reversed halo sign on lung CT could indirectly indicate pulmonary infarction. Traditionally associated with pneumonia organization, the localization and distribution of RHS can suggest alternative diagnoses. In a pertinent clinical setting, identifying RHS on HRCT may indicate pulmonary infarction and require additional investigations, preferably with CT pulmonary angiography.

In immunocompetent patients, a micronodular or reticule-micronodular pattern within the RSH may indicate a pulmonary infarction rather than exclusively an active granulomatous disease; this awareness could help triage patients with RHS.

Abbreviations

VTE	Venous thromboembolic illness
PE	Pulmonary embolism
CTPA	Computed tomography pulmonary angiography
RHS	Reversed halo sign
PI	Pulmonary infarction
IFI	Invasive fungal infection
HRCT	High-resolution computed tomography

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None.

Author contributions

AP was involved in the conceptualization, supervision, investigation, and writing—original draft. AT contributed to the conceptualization, supervision, writing—original draft. BFPA assisted in the Investigation. SCa, AB and AV contributed to the investigation. SCi, GT and RB were involved in the supervision. All authors read and approved the final manuscript.

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Availability of data and materials

Available on request.

Declarations

Ethics approval and consent to participate

This study does not require institutional review board approval.

Consent for publication

Informed consent is not available.

Competing interests

None of the authors have any relevant conflict of interest or industry support related to this report.

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