Received:
23 March 2015

Revised:
1 August 2015

Accepted:
1 September 2015

doi: 10.1259/bjr.20150246

Cite this article as:

Menna Barreto M, Marchiori E, de Brito A, Escuissato DL, Hochegger B, Souza AS, et al. CT morphological features of the reversed halo sign in pulmonary paracoccidioidomycosis. *Br J Radiol* 2015; **88**: 20150246.

FULL PAPER

CT morphological features of the reversed halo sign in pulmonary paracoccidioidomycosis

¹MIRIAM MENNA BARRETO, MD, PhD, ¹EDSON MARCHIORI, MD, PhD, ²ANDREA DE BRITO MD, ³DANTE LUIZ ESCUISSATO, MD, PhD, ⁴BRUNO HOCHHEGGER, MD, PhD, ⁵ARTHUR SOARES SOUZA, MD, PhD and ^{1,6}ROSANA SOUZA RODRIGUES, MD, PhD

¹Department of Radiology, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil

²Department of Radiology, National Institute of Oncology, Rio de Janeiro, Brazil

³Department of Radiology, Federal University of Paraná, Curitiba, Brazil

⁴Department of Radiology, Santa Casa de Porto Alegre, Porto Alegre, Rio Grande do Sul, Brazil

⁵Department of Radiology, Medical School of Rio Preto and Ultra X, São José do Rio Preto/SP, Brazil

⁶D'Or Institute for Research and Education, Rio de Janeiro, Brazil

Address correspondence to: Professor Edson Marchiori

E-mail: edmarchiori@gmail.com

Objective: The purpose of this study was to identify morphological characteristics of the reversed halo sign (RHS) on chest CT in patients with pulmonary paracoccidioidomycosis (PCM) that may aid the diagnosis of this fungal disease.

Methods: We retrospectively reviewed chest CT images from 23 patients with proven pulmonary PCM who demonstrated the RHS. Two chest radiologists analysed the morphological characteristics of the lesions and reached decisions by consensus.

Results: We identified 64 RHSs on CT images from the 23 patients. Multiple lesions were observed in all cases, with middle and lower lung zone predominance occurring in 17 patients (73.9% of cases). 34 (53.1%) RHSs were round and 30 (46.9%) were oval. Outer borders of the RHSs were smooth in 32 (50%) lesions, nodular in 16 (25%)

lesions and irregular/spiculated in 16 (25%) lesions. Ground-glass opacity was observed inside 63 (98.4%) lesions.

Conclusion: Our data suggest that morphological characteristics of the RHS on chest CT, such as the presence of multiple lesions, middle and lower lung zone predominance and a spiculated RHS ring, as well as the association with other parenchymal patterns, should lead radiologists to include PCM in the differential diagnosis of PCM in endemic areas.

Advances in knowledge: This is the largest series of patients with RHS due to PCM and is also the first study to report RHS lesions with spiculated or irregular walls. The study adds information regarding morphological characteristics of the RHS that may raise suspicion of PCM on chest CT, particularly in endemic areas of the disease.

INTRODUCTION

Paracoccidioidomycosis (PCM) is an inflammatory granulomatous systemic disease caused by the dimorphic fungus *Paracoccidioides brasiliensis*. It is the most frequent endemic systemic mycosis in Latin America, particularly in Brazil, Venezuela, Colombia and Argentina.¹ Several cases of PCM have also been reported in Europe and North America, mainly among immigrants and travellers.²

The disease predominantly affects males between the ages of 30 and 60 years from rural areas and is only transmitted from contact with contaminated soil, the fungus habitat.³ Inhalation of infectious particles develops into primary infection that may progress to severe pulmonary involvement. The disease may present in two forms: the acute or subacute (juvenile) form, which is more

aggressive, and the chronic (adult) form, which is more common.⁴

Lung infection in the adult form is the leading cause of morbidity and mortality from the disease,^{4,5} and active pulmonary disease and residual fibrotic lesions have been reported in 80% and 60% of patients with PCM, respectively.³

CT findings of pulmonary PCM are characterized by a large variety of non-specific abnormalities, including ground-glass opacities, small centrilobular nodules, cavitated nodules, parenchymal bands, paracatricial emphysema and the reversed halo sign (RHS), which has been reported in approximately 10% of patients with PCM.^{3,5,6}

Figure 1. 45-year-old male with paracoccidioidomycosis. Axial CT image shows an oval reversed halo sign (RHS) with a smooth ring and ground-glass opacity inside the halo located in the lower lobe of the right lung (arrows). Note also a smaller round RHS (arrowheads). Associated parenchymal ground-glass opacities are visible in both lungs.

The RHS is a CT pattern defined as a focal rounded area of ground-glass opacity surrounded by a complete or nearly complete ring of consolidation.⁷ In 1996, Voloudaki et al⁸ initially described this CT finding in patients with organizing pneumonia (OP); Kim et al⁹ suggested the term “reversed halo sign” in 2003. The RHS was considered specific for the diagnosis of OP until 2005, when Gasparetto et al⁵ reported this finding in 15 patients with PCM. Although other authors have further described the presence of the RHS in several pulmonary diseases, only recently have specific characteristics of this sign been recognized as useful in narrowing differential diagnoses. The presence of small nodules in the wall or inside the RHS lesion indicates active granulomatous disease,^{6,10,11} and reticulation in the centre of the halo suggests diseases or conditions that cause pulmonary infarction, such as invasive pulmonary aspergillosis and pulmonary embolism (PE).^{12,13} The recognition of specific characteristics of the RHS associated with pulmonary PCM has important clinical implications that may enable the early institution of treatment.¹⁴ The purpose of this study was to identify morphological characteristics of the RHS in patients with pulmonary PCM that may raise suspicion of the disease on chest CT.

METHODS AND MATERIALS

Patient selection

Our institutional review board approved this study and waived the requirement for informed patient consent. All data used in this study were anonymized.

We retrospectively reviewed the CT images and medical records of 278 consecutive patients with proven pulmonary PCM. The patients were examined between 2000 and 2013 in five hospitals in Brazil. 23 (8.3%) of these patients demonstrated the RHS on CT examination. All patients had the chronic (adult) form of the disease with pulmonary involvement. Cough, expectoration and dyspnoea were the most commonly reported respiratory

symptoms. The diagnosis of PCM was confirmed by the identification of *P. brasiliensis* by direct microscopy and/or culture of the fungus in clinical specimens (sputum and/or bronchoalveolar lavage fluid). Tissue biopsy samples were also obtained from laryngeal lesions, cervical lymph nodes or lung. The Grocott-Gomori methenamine silver stain technique reveals the typical pattern of multiple budding around the mother cell. Serological tests, especially double immunodiffusion, were also performed. This test is most readily available in clinical practice, and its sensitivity and specificity are >80% and 90%, respectively.^{3,15,16}

Image acquisition

Chest CT was performed in the participating hospitals using a variety of scanners. All CT examinations were performed with 1- to 2-mm slice thickness and 1- to 5-mm intervals and reconstructed using standard and high-spatial-frequency algorithms. The acquisition time was 0.5–1 s per rotation, peak voltage was 120 kVp, modulated tube current was 100–400 mA and pitch was 1. All images were acquired at full inspiration in the craniocaudal direction.

Image analysis

Two chest radiologists with more than 15 years of experience retrospectively and independently reviewed all images. In this phase of the study, the level of agreement (κ value) was 0.78. Discordant interpretations were then reviewed, and the final results were based on consensus achieved through discussion with a third reviewer.

All chest CT images were analysed initially using parenchymal window settings (width, 1200 to 1600 HU; level, –500 to –700 HU) and subsequently reviewed with mediastinal window settings (width, 35 to 450 HU; level, 10 to 20 HU). The readers were asked to assess the number of RHSs and their morphological characteristics, such as size, shape (oval, round, triangular or other), wall appearance (smooth, nodular or spiculated/irregular) and internal characteristics (nodular, reticular or ground glass).

Figure 2. 54-year-old male with pulmonary paracoccidioidomycosis. Axial CT image shows an oval reversed halo sign (RHS) lesion with nodular walls in the lower lobe of the right lung (arrows). Note also another RHS in the left lower lobe.

Figure 3. 53-year-old male with pulmonary paracoccidioidomycosis from a rural area in Brazil. Axial CT image shows a reversed halo sign lesion with irregular walls in the lower lobe of the right lung. Associated ground-glass opacities, focal consolidations and signs of architectural distortion are visible in the left lower lobe.

For patients with three or more lesions, only the three largest lesions were analysed. The presence of associated lung abnormalities, including air-space consolidation, ground-glass opacities, bronchiectasis, cavities, paracatricial emphysema, large (>1 cm) and small (<1 cm) nodules, and signs of architectural distortion, was also noted. The definition of these patterns followed the glossary of terms for thoracic imaging proposed by the Fleischner Society.⁷

The predominant anatomic distribution of lesions in the cranio-caudal direction was characterized as upper (above aortic arch), middle (aortic arch to carina) or lower (below carina) zones. The distribution was noted to be peripheral when abnormalities were predominant in the outer third of the lung, in contact with the pleural surface, and central when abnormalities were predominant in the inner two-thirds of the transverse plane.⁴ Laterality and symmetry of the abnormalities were also noted.

RESULTS

Among the 23 patients with PCM; 20 males and 3 females; median age, 49 years; mean age, 49.7 (range, 27–69) years, a total of 64 RHSs were found. 18 (78.3%) patients had three or more lesions and 5 (21.7%) patients presented with two lesions. No patient had a single RHS. 30 (46.9%) RHSs had diameters of 3.1–5 cm, 21 (32.8%) ranged from 5.1 to 10 cm, 11 (17.2%) had diameters ≤ 3 cm and 2 (3.1%) lesions had diameters >10 cm. 34 (53.1%) RHSs were round, and 30 (46.9%) RHSs were oval. The outer borders of RHSs were smooth (Figure 1) in 32 (50%), nodular (Figure 2) in 16 (25%) and spiculated/irregular (Figure 3) in 16 (25%) cases. Ground-glass opacity within the RHS was observed in 63 (98.4%) cases (Figure 4). In one (1.6%) case, small nodules were observed inside the halo. No reticulation was observed in the central areas of the RHS lesions (Table 1).

The lesions were equally distributed in the peripheral and central zones of the lungs in 14 (60.9%) cases, they predominated in the lung periphery in 5 (21.7%) patients and in the central zones in 4 (17.4%) patients. Along the longitudinal plane, the upper, middle and lower lung zones were concomitantly affected in 11 (47.8%) cases; in 6 (26.1%) patients, the lesions affected the middle and lower zones. Middle zone predominance was observed in three (13%) patients, lower predominance was observed in two (8.7%) patients and upper zone predominance was observed in one (4.4%) patient. RHSs were found in both lungs in 20 (87%) cases and were unilateral in 3 (13%) cases.

Other parenchymal abnormalities found in association with the RHS were ground-glass opacity ($n = 22$, 95.6%), small nodules ($n = 18$, 78.3%), reticular opacities ($n = 13$, 56.5%), large nodules ($n = 8$, 34.8%), bronchiectasis ($n = 8$, 34.8%), consolidations ($n = 6$, 26.1%), architectural distortion ($n = 6$, 26.1%), cavitation ($n = 6$, 26.1%) and paracatricial emphysema ($n = 4$, 17.4%) (Figures 5 and 6; Table 2).

DISCUSSION

In this series, all patients presenting with RHS due to proven pulmonary PCM^{5,10,17} had multiple lesions; all the RHSs were round or oval shaped, with diameters mostly >3 cm. RHS rims were nodular or spiculated/irregular in half of the patients, an uncommon finding for the RHS^{9,10,12,14,18}. The middle and/or lower lung zones were affected in 95% of cases, and RHSs were often bilateral. Our data suggest that the morphological characteristics of the RHS on chest CT may help radiologists to suspect the diagnosis of this endemic fungal infection.

Similar to our finding that all patients presented with multiple RHSs, Gasparetto et al⁵ reported that most RHSs found in

Figure 4. 60-year-old male with pulmonary paracoccidioidomycosis. Axial CT image shows a reversed halo sign lesion with irregular walls and ground-glass opacity in the inner area of the halo in the upper lobe of the right lung. Note also the ground-glass opacity with a partial ring of consolidation in the left upper lobe.

Table 1. Number, size and main tomographic characteristics of the reversed halo sign (RHS) in patients with paracoccidioidomycosis

RHS characteristic	Number (%) of patients (n = 23)
Number of lesions	
1	0 (0%)
2	5 (21.7%)
3 or more	18 (78.3%)
RHS diameter	
≤3 cm	11 (17.2%)
3.1–5 cm	30 (46.9%)
5.1–10 cm	21 (32.8%)
>10 cm	2 (3.1%)
Tomographic characteristics	Number (%) of RHSs (n = 64)
Shape	
Round	34 (53.1%)
Oval	30 (46.9%)
RHS ring	
Smooth walls	32 (50%)
Nodular walls	16 (25%)
Irregular/spiculated	16 (25%)
Central area	
Ground-glass opacity	59 (92.2%)
Normal parenchyma	4 (6.2%)
Small nodules	1 (1.6%)
Reticulation	0 (0%)

15 patients with PCM were multiple; in another study of 79 patients with the RHS, all 14 patients with PCM had multiple lesions.¹⁰ Single RHSs have frequently been described in patients with diseases that cause pulmonary infarction; Marchiori et al¹⁰ described single RHSs in all 6 patients with invasive pulmonary aspergillosis and Casullo and Semionov¹³ observed them in 10 of 12 patients with PE. The majority of infectious and non-infectious diseases, however, presents with multiple RHSs. Several authors have attempted to document the presence of multiple RHSs in a wide spectrum of diseases, such as cryptogenic OP (COP), tuberculosis, sarcoidosis, invasive fungal infections and granulomatosis with polyangiitis.^{10,12,17–20} Nevertheless, in a study comparing RHS characteristics in tuberculosis and COP,¹⁸ solitary and multiple lesions were observed in both diseases. Indeed, although multiple RHSs were found in all patients with PCM in our study, this finding is not specific.

In an attempt to better characterize the RHS in PCM, we evaluated its shape. Although a RHS is round by definition,⁷ the image readers were asked to evaluate this variable because

chronic pulmonary PCM is associated with architectural distortion and an atypical shape would give the sign greater specificity. However, half of the lesions in our sample were oval and the other half were round. The triangular form (described in RHS associated with infarction) and other shapes were not found in our series.

Nearly half of the 64 RHS lesions seen in our study had diameters of 3.1–5.0 cm and one-third had diameters of 5.1–10 cm. Lesions in our series were larger than those described by Gasparetto et al,⁵ who found RHS sizes ranging from 1.0 to 5.0 cm (average, 2.0 cm) in 15 patients with PCM. Little overall information about RHS dimensions in PCM or other diseases that present this sign is available in the literature.

Our analysis of the RHS ring demonstrated a smooth appearance in half of the lesions. This smooth appearance has been described in a variety of diseases,^{9,12,14,19} especially in OP, which is the most common cause of this sign.¹⁸ Hence, this feature alone cannot be used to distinguish PCM from OP. Nodular walls were observed in 25% of RHSs in our series. In a previous study, this aspect was noted in 21.4% of patients with PCM,¹⁰ in agreement with our results. Nodular walls or nodules inside the halo of the RHS are highly suggestive of active granulomatous diseases, especially tuberculosis and sarcoidosis.^{10,11,18,21}

Histopathological analysis has revealed the presence of granulomas within the ring portion of and/or inside the RHS.^{12,18} Hence, this RHS characteristic is attributed to the presence of multiple granulomas and may be useful in differential diagnosis.¹⁸ Neither pattern (nodular walls or internal nodularity) has been described in any patient with OP.^{12,18} Although active tuberculosis is highly suspected in patients presenting the RHS with nodular walls, especially in association with centrilobular nodules and endobronchial spread,^{10,11,14} PCM should be

Figure 5. 69-year-old male with pulmonary paracoccidioidomycosis. Axial CT image shows a reversed halo sign with smooth rings and ground-glass opacity inside the halo in the upper lobe of the left lung (arrow). Note associated nodules and focal ground-glass opacities in both lungs.

Figure 6. 59-year-old male with pulmonary paracoccidioidomycosis. Coronal (a) and sagittal (b) reformatted CT images. (a) A small reversed halo sign (RHS) with smooth borders is visible in the lower lobe of the left lung (arrow). (b) An oval RHS is visible in the right upper lobe (arrows). Note the multiple associated lesions with consolidation in both lungs, signs of architectural distortion, irregular nodules and a cavitated lesion in the right upper lobe (arrowhead in a).

included in the differential diagnosis, particularly in patients from endemic areas. Special attention should be paid to the possibility of PCM associated with tuberculosis. Clinical and radiological aspects of those diseases may be similar, as both evolve with fibrosis in the chronic phase. Clinicians should recognize that pulmonary tuberculosis may precede, follow, or occur simultaneously with PCM.²²

Recently, emphasis has been given the RHS rims.^{11,12,14,18} In our series, RHS rims were nodular or spiculated/irregular in half of the patients. We observed that 25% of RHS lesions presented with spiculated or irregular walls. This is the first study to report this finding, which may possibly be associated with the fibrotic pattern observed in chronic PCM, which consists of dense areas of fibrosis with prominent collagen deposition.^{3,4}

The central area of the RHS was composed of ground-glass opacities in almost all lesions in our series. Surgical lung biopsy specimens have shown that the central ground-glass area of the RHS in PCM corresponds to inflammatory infiltrate of alveolar septa, whereas the peripheral ring of consolidation consists of dense and homogeneous intra-alveolar inflammatory infiltrate.⁵ Small nodules inside the halo were found in only one case in our series. Reticulation inside the RHS area was not observed in our study. This finding, associated with pleural effusion, strongly suggests the diagnosis of pulmonary infarction, and may be associated with PE or with invasive fungal infection in a severely immunocompromised host.^{17,19}

Most RHS lesions in our series were bilateral, with no central or peripheral zones predominance. Almost half of the lesions showed diffuse distribution along the upper, middle and lower lobes.

As reported in previous studies of CT aspects in PCM,¹⁻⁴ associated findings such as ground-glass opacities, small nodules, reticular opacities, large nodules, bronchiectasis, consolidations, architectural distortion, cavitation and paracatricial emphysema were common. In our series, ground-glass opacities occurred in

95.6% of patients, frequently associated with nodules, reticulation and bronchiectasis.

Our study has some limitations. Its retrospective nature limited clinical data correlation. In addition, CT techniques varied over the 14-year study period and among participating institutions. We do not believe, however, that this variation altered our observations or results. Despite these limitations, our study involved the largest reported series of patients with confirmed PCM and RHS on chest CT.

In conclusion, the RHS is increasingly recognized as a valuable imaging finding in several lung diseases, and its morphological characteristics may help to narrow the differential diagnosis. Our data suggest that specific morphological characteristics of the RHS on chest CT, such as the presence of multiple lesions, middle and lower lung zone predominance and spiculated RHS ring, as well as the association with other parenchymal patterns, should lead radiologists to include PCM in the differential diagnosis of RHS in endemic areas.

Table 2. Associated CT findings

Associated finding	Number (%) of patients (<i>n</i> = 23)
Ground-glass opacity	22 (95.6%)
Small nodules ^a	18 (78.3%)
Reticular opacities	13 (56.5%)
Large nodules ^a	8 (34.8%)
Bronchiectasis	8 (34.8%)
Consolidations	6 (26.1%)
Architectural distortion	6 (26.1%)
Cavity	6 (26.1%)
Paracatricial emphysema	6 (26.1%)

^aLarge (>1cm) and small (<1cm) nodules.

REFERENCES

1. Souza AS Jr, Gasparetto EL, Davaus T, Escuissato DL, Marchiori E. High-resolution CT findings of 77 patients with untreated pulmonary paracoccidioidomycosis. *AJR Am J Roentgenol* 2006; **187**: 1248–52. doi: [10.2214/AJR.05.1065](https://doi.org/10.2214/AJR.05.1065)
2. Marchiori E, Valiante PM, Mano CM, Zanetti G, Escuissato DL, Souza AS Jr, et al. Paracoccidioidomycosis: high-resolution computed tomography-pathologic correlation. *Eur J Radiol* 2011; **77**: 80–4. doi: [10.1016/j.ejrad.2009.06.017](https://doi.org/10.1016/j.ejrad.2009.06.017)
3. Barreto MM, Marchiori E, Amorim VB, Zanetti G, Takayasu TC, Escuissato DL, et al. Thoracic paracoccidioidomycosis: radiographic and CT findings. *Radiographics* 2012; **32**: 71–84. doi: [10.1148/rg.321115052](https://doi.org/10.1148/rg.321115052)
4. Funari M, Kavakama J, Shikanai-Yasuda MA, Castro LG, Bernard G, Rocha MS, et al. Chronic pulmonary paracoccidioidomycosis (South American blastomycosis): high-resolution CT findings in 41 patients. *AJR Am J Roentgenol* 1999; **173**: 59–64. doi: [10.2214/ajr.173.1.10397100](https://doi.org/10.2214/ajr.173.1.10397100)
5. Gasparetto EL, Escuissato DL, Davaus T, de Cerqueira EM, Souza AS Jr, Marchiori E, et al. Reversed halo sign in pulmonary paracoccidioidomycosis. *AJR Am J Roentgenol* 2005; **184**: 1932–4. doi: [10.2214/ajr.184.6.01841932](https://doi.org/10.2214/ajr.184.6.01841932)
6. Marchiori E, Zanetti G, Meirelles GS, Escuissato DL, Souza AS Jr, Hochegger B. The reversed halo sign on high-resolution CT in infectious and noninfectious pulmonary diseases. *AJR Am J Roentgenol* 2011; **197**: W69–75. doi: [10.2214/AJR.10.5762](https://doi.org/10.2214/AJR.10.5762)
7. Hansell DM, Bankier AA, MacMahon H, McLoud TC, Müller NL, Remy J. Fleischner Society: glossary of terms for thoracic imaging. *Radiology* 2008; **246**: 697–722. doi: [10.1148/radiol.2462070712](https://doi.org/10.1148/radiol.2462070712)
8. Voloudaki AE, Bouros DE, Froudarakis ME, Datsis GE, Apostolaki EG, Gourtsoyiannis NC. Crescentic and ring-shaped opacities. CT features in two cases of bronchiolitis obliterans organizing pneumonia (BOOP). *Acta Radiol* 1996; **37**: 889–92.
9. Kim SJ, Lee KS, Ryu YH, Yoon YC, Choe KO, Kim TS, et al. Reversed halo sign on high-resolution CT of cryptogenic organizing pneumonia: diagnostic implications. *AJR Am J Roentgenol* 2003; **180**: 1251–4. doi: [10.2214/ajr.180.5.1801251](https://doi.org/10.2214/ajr.180.5.1801251)
10. Marchiori E, Zanetti G, Escuissato DL, Souza AS Jr, Meirelles GS, Fagundes J, et al. Reversed halo sign: high-resolution CT scan findings in 79 patients. *Chest* 2012; **14**: 1260–6. doi: [10.1378/chest.11-1050](https://doi.org/10.1378/chest.11-1050)
11. Marchiori E, Zanetti G, Barreto MM, de Andrade FT, Rodrigues RS. Atypical distribution of small nodules on high resolution CT studies: patterns and differentials. *Respir Med* 2011; **105**: 1263–7. doi: [10.1016/j.rmed.2011.02.010](https://doi.org/10.1016/j.rmed.2011.02.010)
12. Marchiori E, Zanetti G, Hochegger B, Irion KL, Carvalho AC, Godoy MC. Reversed halo sign on computed tomography: state-of-the-art review. *Lung* 2012; **190**: 389–94. doi: [10.1007/s00408-012-9392-x](https://doi.org/10.1007/s00408-012-9392-x)
13. Casullo J, Semionov A. Reversed halo sign in acute pulmonary embolism and infarction. *Acta Radiol* 2013; **54**: 505–10. doi: [10.1177/0284185113475797](https://doi.org/10.1177/0284185113475797)
14. Godoy MC, Viswanathan C, Marchiori E, Truong MT, Benveniste MF, Rossi S, et al. The reversed halo sign: update and differential diagnosis. *Br J Radiol* 2012; **85**: 1226–35. doi: [10.1259/bjr/54532316](https://doi.org/10.1259/bjr/54532316)
15. Shikanai-Yasuda MA, Telles Filho FQ, Mendes RP, Colombo AL, Moretti ML. Guidelines in paracoccidioidomycosis. [In Portuguese.] *Rev Soc Bras Med Trop* 2006; **39**: 297–310.
16. Do Valle AC, Costa RL, Fialho Monteiro PC, Von Helder J, Muniz MM, Zancopé-Oliveira RM. Interpretation and clinical correction of serological test in paracoccidioidomycosis. *Med Mycol* 2001; **39**: 373–7. doi: [10.1080/714031038](https://doi.org/10.1080/714031038)
17. Maturu VN, Agarwal R. Reversed halo sign: a systematic review. *Respir Care* 2014; **59**: 1440–9. doi: [10.4187/respcare.03020](https://doi.org/10.4187/respcare.03020)
18. Marchiori E, Zanetti G, Irion KL, Nobre LF, Hochegger B, Mançano AD, et al. Reversed halo sign in active pulmonary tuberculosis: criteria for differentiation from cryptogenic organizing pneumonia. *AJR Am J Roentgenol* 2011; **197**: 1324–7. doi: [10.2214/AJR.11.6543](https://doi.org/10.2214/AJR.11.6543)
19. Marchiori E, Marom EM, Zanetti G, Hochegger B, Irion KL, Godoy MC. Reversed halo sign in invasive fungal infections: criteria for differentiation from organizing pneumonia. *Chest* 2012; **142**: 1469–73. doi: [10.1378/chest.12-0114](https://doi.org/10.1378/chest.12-0114)
20. Wahba H, Truong MT, Lei X, Kontoyiannis DP, Marom EM. Reversed halo sign in invasive pulmonary fungal infections. *Clin Infect Dis* 2008; **46**: 1733–7. doi: [10.1086/587991](https://doi.org/10.1086/587991)
21. Marchiori E, Grando RD, Simões Dos Santos CE, Maffazzoli Santos Balzan L, Zanetti G, et al. Pulmonary tuberculosis associated with the reversed halo sign on high-resolution CT. *Br J Radiol* 2010; **83**: e58–60. doi: [10.1259/bjr/22699201](https://doi.org/10.1259/bjr/22699201)
22. do Valle AC, Guimarães RR, Lopes DJ, Capone D. Thoracic radiologic aspects in paracoccidioidomycosis. [In Portuguese.] *Rev Inst Med Trop Sao Paulo* 1992; **34**: 107–15.