CHEST

Pictorial Review of Thoracic Parasitic Diseases

A Radiologic Guide

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Parasitoses are infectious diseases of global distribution, with predominance in areas of poor sanitation. Parasites cause damage through direct tissue injury and the inflammatory response generated by their migration and establishment in various organs. Thoracic involvement by parasitic disease can generate both specific and nonspecific clinical, laboratorial, and radiologic manifestations, which often makes their diagnosis challenging. The correct diagnosis is crucial for definition of treatment, which sometimes requires rapid intervention. Based on a literature review of the last few decades, this article aimed to characterize the main radiologic findings related to thoracic manifestations of parasitic diseases, correlating them with radiographic and tomographic images of patients with confirmed diagnosis of such pathologies. The included parasitic diseases are malaria, Chagas disease, toxoplasmosis, amoebiasis, ascariasis, toxocariasis, strongyloidiasis, dirofilariasis, cysticercosis, echinococcosis, schistosomiasis, and paragonimiasis.

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Human parasitic infections affect > 1.5 billion people worldwide, predominantly in developing countries, and are generally associated with poverty and poor sanitation[1-3] (Fig 1). The increasing number of immunocompromised patients, such as those with AIDS and solid organ transplant recipients, in addition to rising migration and global travel, has reshaped the burden of parasitic diseases even in developed countries.[3-6] Parasites can lead to respiratory system injuries during their migration and establishment on the pulmonary parenchyma usually due to direct tissue destruction, mass effect, and secondary inflammatory reactions. The clinical, radiologic, and laboratory findings can vary depending on the parasite and its life cycle.[3-5]

Radiologic findings of the chest are commonly nonspecific, making the diagnosis challenging.[6] Some imaging features may be very similar to those of TB and neoplasms;

ABBREVIATIONS: ELISA = enzyme-linked immunosorbent assay; PCR = polymerase chain reaction

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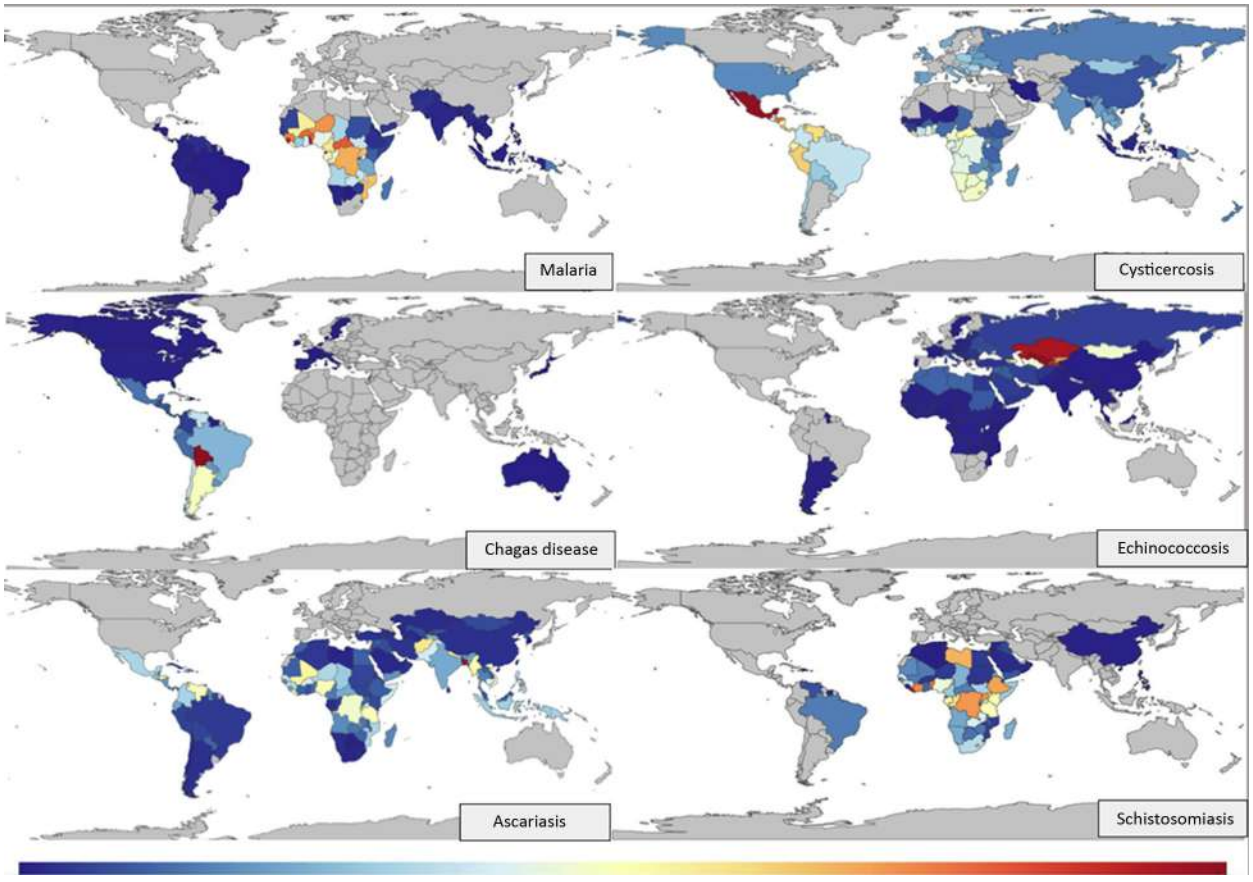

Figure 1 – *Thoracic parasitic diseases and their epidemiology in the world. (Adapted from https://vizhub.healthdata.org/gbd-compare/.[2])*

parasitic infections should therefore be considered as differential diagnoses on approach of these common diseases, mainly in endemic regions, especially because a great number of these infections can easily be treated with oral medication alone.[4]

The objective of the current article was to discuss the specific and nonspecific chest features of common parasitic diseases, illustrating them with a series of radiographic and CT studies and correlating them with clinical and laboratorial findings.

Protozoa

Malaria

Malaria is an infectious disease caused by various species of *Plasmodium* protozoa and transmitted by the *Anopheles* mosquito. According to the World Health Organization, in 2017, approximately 219 million people were infected, and the disease was responsible for nearly 435,000 deaths worldwide.[7] The parasites develop within erythrocytes and lead to hemolysis at different time intervals, resulting in characteristic fever patterns related

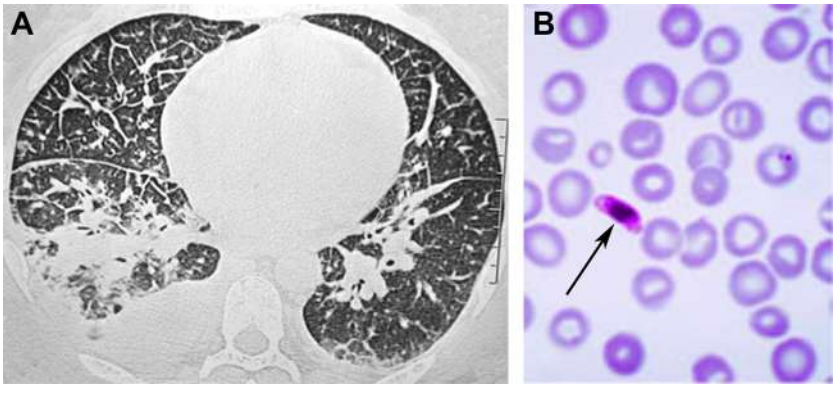

Figure 2 – *A, Axial CT scan (lung window) shows dependent consolidations in the right lung, bilateral pleural effusions, and smooth interlobular septal thickening suggesting pulmonary edema, in a 38-year-old man presenting with dyspnea, chills, hematuria, and fever. B, Blood smear analysis revealed gametocytes of* Plasmodium falciparum *(arrow).*

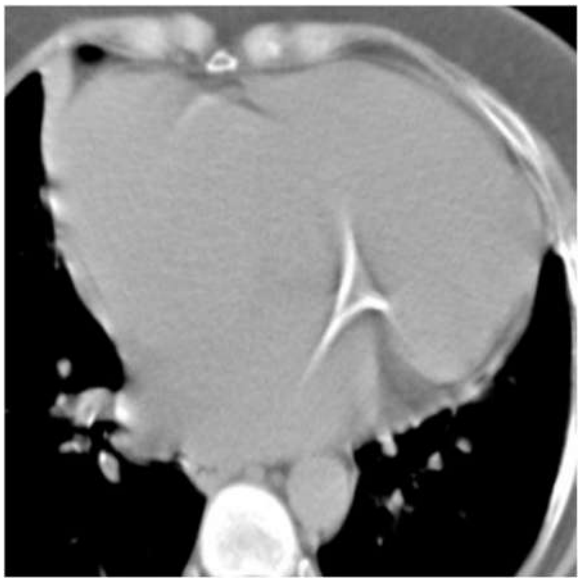

Figure 3 – *Axial CT scan demonstrates a right heart enlargement in a 51-year-old patient with systemic congestion symptoms and confirmed Chagas disease serologic findings.*

to the parasitemia.[8,9] *Plasmodium vivax* and *Plasmodium ovale* infections result in fever spikes occurring every 48 hours while *Plasmodium malariae* fever occurs at 72-hour intervals. *Plasmodium falciparum* usually leads to more severe infections with fever spikes at irregular intervals. Clinical and laboratorial manifestations include fever, chills, leukopenia, splenomegaly, and anemia.[3,9]

The most important pulmonary manifestations of human malaria are ARDS and pulmonary edema, which affects up to 25% of adults with severe malaria. The pathophysiology of pulmonary involvement in malaria is mainly attributed to sequestration of infected erythrocytes in the pulmonary microcirculation and a host immune response to this event leading to inflammation and capillary fluid leakage.[10] The identification of infected erythrocytes in blood smear analysis confirms the diagnosis.[10,11] When available, a rapid diagnostic test is also useful. The high lethality of severe malaria makes early diagnosis and treatment crucial.[10]

Radiologic examinations may reveal features of noncardiogenic pulmonary edema and ARDS.[3,10,11] Bilateral pulmonary interstitial infiltrates are radiographic findings often described,[10,11] although consolidations, diffuse interstitial edema, and pleural effusion have also been seen on chest radiograph and CT imaging (Fig 2).[3,5,11]

Chagas Disease

Chagas disease, endemic in Latin America and responsible for a great burden of morbidity and mortality, affects nearly 8 to 10 million people worldwide.[12] The disease is caused by the flagellate protozoa *Trypanosoma cruzi* and is acquired through contact with feces from an infected triatomine bug. Although less common, vertical transmission, food-borne disease, and transfusion- and transplantation-related transmission have been reported. Acute clinical manifestations include facial or palpebral swelling (Romaña's sign) and fever. Rarely, myocarditis leading to acute heart failure can occur. Chronic disease is characterized by multiorgan involvement, including cardiac and GI tract disease. Direct visualization of trypomastigotes in blood smear analysis and polymerase chain reaction (PCR) are the diagnostic methods used during the acute phase; serologic tests are used in the assessment of chronic disease.[3,12,13]

Almost 20% to 40% of patients with chronic Chagas disease will develop Chagas cardiomyopathy, which may manifest as heart failure, cardiac arrhythmia, and thromboembolism.[12,14] Earlier cardiac involvement, related to asymptomatic cardiomyopathy, may be suggested by abnormalities in ECG, echocardiography, and cardiac magnetic resonance. Cardiomegaly, with or without signs of pump dysfunction, as shown on chest radiography and CT imaging (Fig 3), is related to late

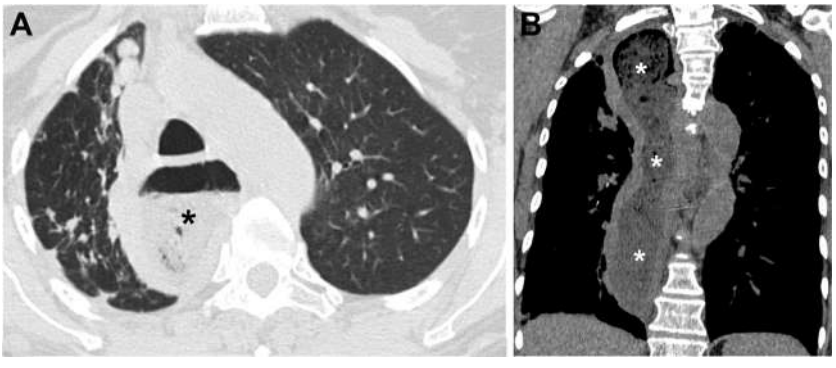

Figure 4 – *Axial lung window (A) and coronal mediastinal window (B) CT imaging show a megaesophagus, filled with fluid, air, and food content (asterisks), in a 66-year-old patient with a serologic test positive for* Trypanosoma cruzi.

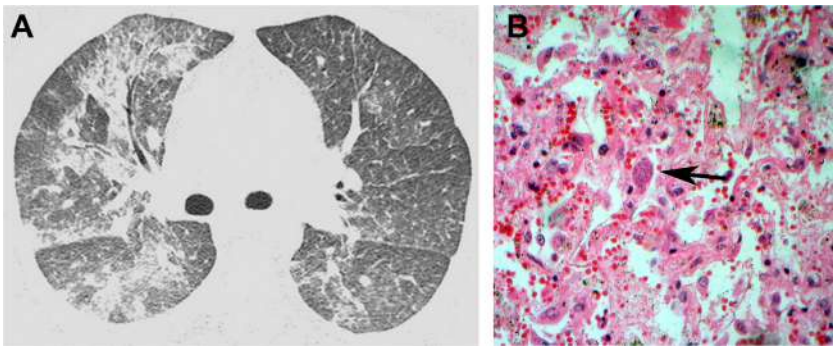

Figure 5 – *A, CT scan of the chest in a 34-year-old female patient who had undergone bone marrow transplantation days earlier, with dry cough, dyspnea, and fever for 3 days. The scan shows bilateral smooth interlobular septal thickening, along with ground-glass and nodular densities, predominantly in the right lung. The respiratory symptoms worsened, and the patient died a few days later. B, Lung autopsy revealed multiple cysts of* Toxoplasma gondii *(arrow).*

stages and is considered a poor prognostic indicator.[3,12,14]

Moreover, chronic esophagopathy will affect about 10% of the patients,[14] which may manifest as signs of achalasia and megaesophagus on chest imaging (Fig 4). Tracheomegaly and bronchiectasis have also been reported, albeit rarely.[3]

Toxoplasmosis

Toxoplasma gondii infects nearly one-third of the world's population, predominantly in developing countries.[15-17] Toxoplasmosis is acquired by ingestion of oocysts from contaminated cat feces and improperly cooked meat from intermediate hosts. It produces a wide spectrum of disease phenotypes depending on the host immunity and microorganism strain.[9]

Acute toxoplasmosis in immunocompetent individuals is usually subclinical or manifests as a benign mononucleosis-like syndrome.[9,16] Pneumonia is another clinical presentation, demonstrated by fever, dyspnea, and nonproductive cough.[15] The disease in immunosuppressed hosts, characteristically patients with HIV, manifests more commonly with neurologic symptoms related to tissue parasite reactivation. Severe multisystemic disease with pulmonary involvement is also mostly seen in the immunocompromised population, although uncommon; this presentation in immunocompetent individuals is extremely rare and may be related to specific strains of *T gondii.*[15,17,18] Cases of disseminated toxoplasmosis in hematopoietic stem cell transplant recipients display an aggressive form of disease with obscure prognosis.[15]

PCR of body tissues/fluid, histopathologic analysis, and BAL showing tachyzoites contribute to the diagnosis. Increased serum lactic dehydrogenase levels can be a useful laboratorial marker.[15-17] Serology test results with high serum titers are present in most cases of pulmonary toxoplasmosis but are not well validated.[17]

Chest radiograph often demonstrates bilateral interstitial infiltrates (63%), associated or not with nodular opacities, isolated multiple pulmonary nodular opacities (12%), and, more rarely, pleural effusion or pneumothorax, reported by a case series of patients infected with HIV and pulmonary toxoplasmosis.[18] CT findings include bilateral

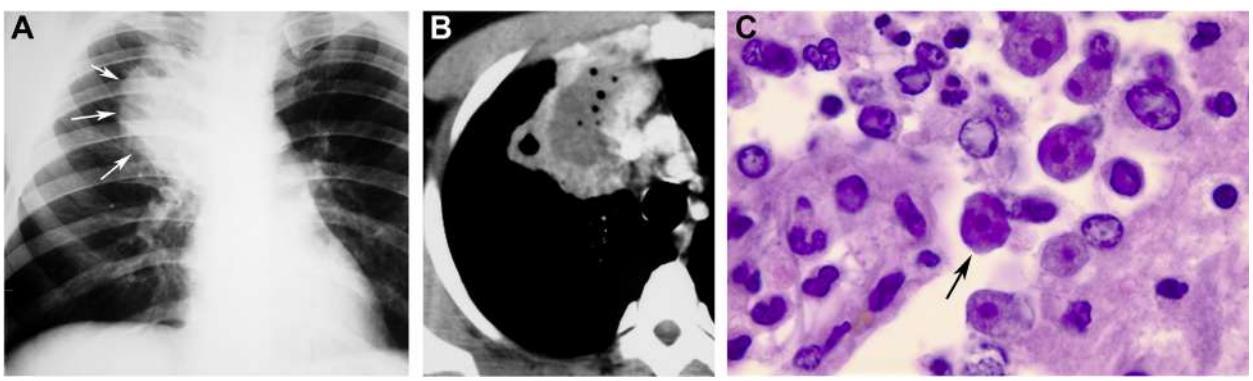

Figure 6 – *Right-sided pulmonary abscess in a 28-year-old male patient. A, The chest radiograph reveals an expansive opacity projected in the upper half of the right hemithorax (arrows). B, Axial CT scan in the mediastinal window presents an organized collection, with thick walls and internal foci of air, located in the upper right lobe and corresponding to an amoebic abscess, which was confirmed by the presence of* Entamoeba *trophozoites in* microbiologic analysis (C) (arrow).

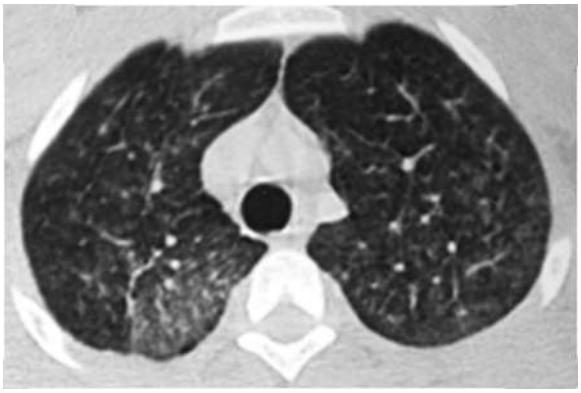

Figure 7 – *Axial CT scan in the lung window shows centrilobular ground-glass nodules predominantly in the left upper lobe of a 33-year-old male patient with mild respiratory symptoms and marked eosinophilia.* Ascaris lumbricoides *larvae were accidentally identified in feces, and the diagnosis was confirmed.*

interstitial thickening, ground-glass attenuation, and random pulmonary nodules (Fig 5).[17] These features are mostly reported in immunosuppressed patients, although they may manifest similarly in individuals with a preserved immune system.[15]

Amoebiasis

Amoebiasis is a global disease with a high incidence in tropical and subtropical regions, mainly in developing countries located in Central America, South America, Africa, and Asia.[9,19] Like most parasitic diseases, transmission of *Entamoeba histolytica* occurs through the fecal-oral route, and its manifestations are mainly GI and hepatic.[4] The thorax is the most common extra-abdominal site affected by amoebiasis, due to direct extension of hepatic abscesses, hematogenous dissemination, or even aspiration of the parasites. Usual symptoms of the thoracic disease are cough, pleuritic pain, and dyspnea.

Microbiologic analysis of the abscess aspirate, sputum, or pleural fluid samples can detect trophozoites, although PCR provides better sensitivity.[4,20] Results of immunologic tests are often positive at the presentation of the disease and can also aid the diagnosis in nonendemic areas or in travelers with suspicion of disease. Moreover, neutrophilia is another nonspecific laboratorial marker. Stool study results are generally negative in extra-intestinal amoebiasis.[19,20]

Pleuropulmonary involvement is most commonly associated with dissemination by contiguity of amoebic liver abscesses. Thus, the abnormalities are often localized in the right hemithorax and in the lower and middle lobes. Pleural effusion (62.5%), consolidation (60%), with or without cavitation, and elevation of the right diaphragmatic dome, usually of the anterior aspect (50%), are the main imaging findings on chest radiographs[20]; these findings are better characterized on CT imaging. Pulmonary parenchyma and mediastinum can also be involved directly by abscesses, even in locations other than the right lower hemithorax, which may indicate hematogenous dissemination (Fig 6).[3,4,20]

Nematodes

Ascariasis

Ascariasis has global distribution and is the most common helminthic infection in the world. The transmission of *Ascaris lumbricoides* nematodes is fecal-oral, explaining the large prevalence of infected individuals in countries with poor sanitation. Generally, during the second week of infection, the most common pulmonary symptoms (expectoration, dyspnea, and fever) are caused by worm migration and tissue invasion, which can induce granuloma formation, eosinophilia, and hypersensitivity reactions.[4,5] The diagnosis can be confirmed by identification of larvae in sputum or suggested by *Ascaris* eggs in stool.[3-6]

The infection is classically described as a cause of simple eosinophilic pneumonia, also known as Löffler

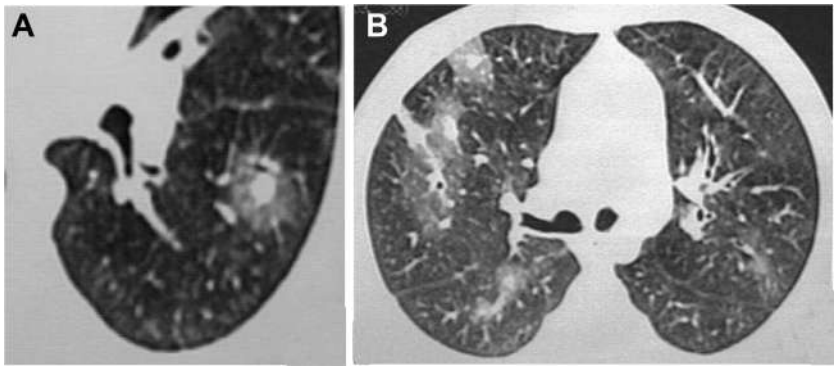

Figure 8 – *Axial CT scan in the lung window (A and B) of a 38-year-old man reveals ground-glass opacities in both lungs, with and without solid components ("halo sign"). Toxocariasis was confirmed by results of serologic testing.*

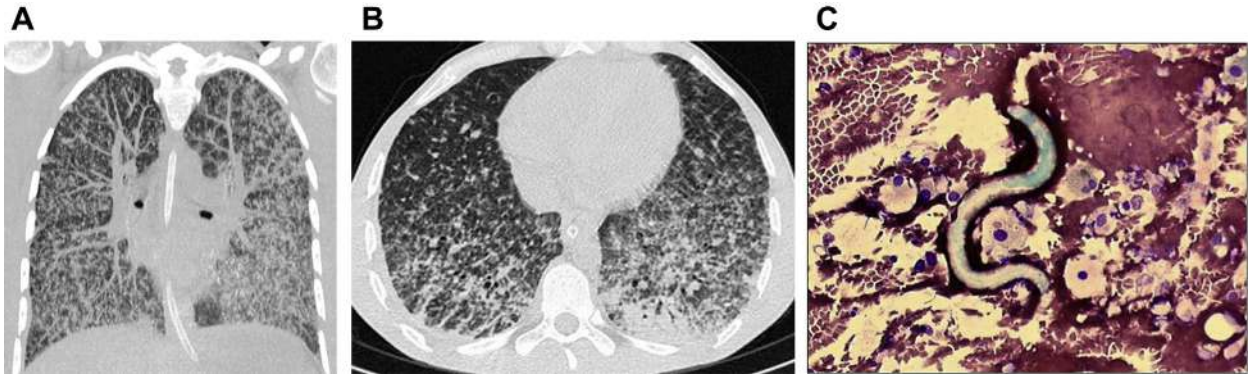

Figure 9 – *Coronal (A) and axial (B) CT images of a 73-year-old man, presenting with a serpiginous pruritic abdominal rash, showed bilateral multiple random pulmonary micronodules, with coalescent areas and septal thickening. BAL was performed, and* Strongyloides stercoralis *filariform larvae were obtained, confirming the diagnosis (C).*

syndrome, an entity characterized by migratory and transient pulmonary opacities on radiographs, serum eosinophilia, minimal or absent respiratory symptoms, and spontaneous resolution.[4-6,21] CT imaging usually shows ground-glass attenuation areas, consolidations, and pulmonary nodules (Fig 7), which may be present

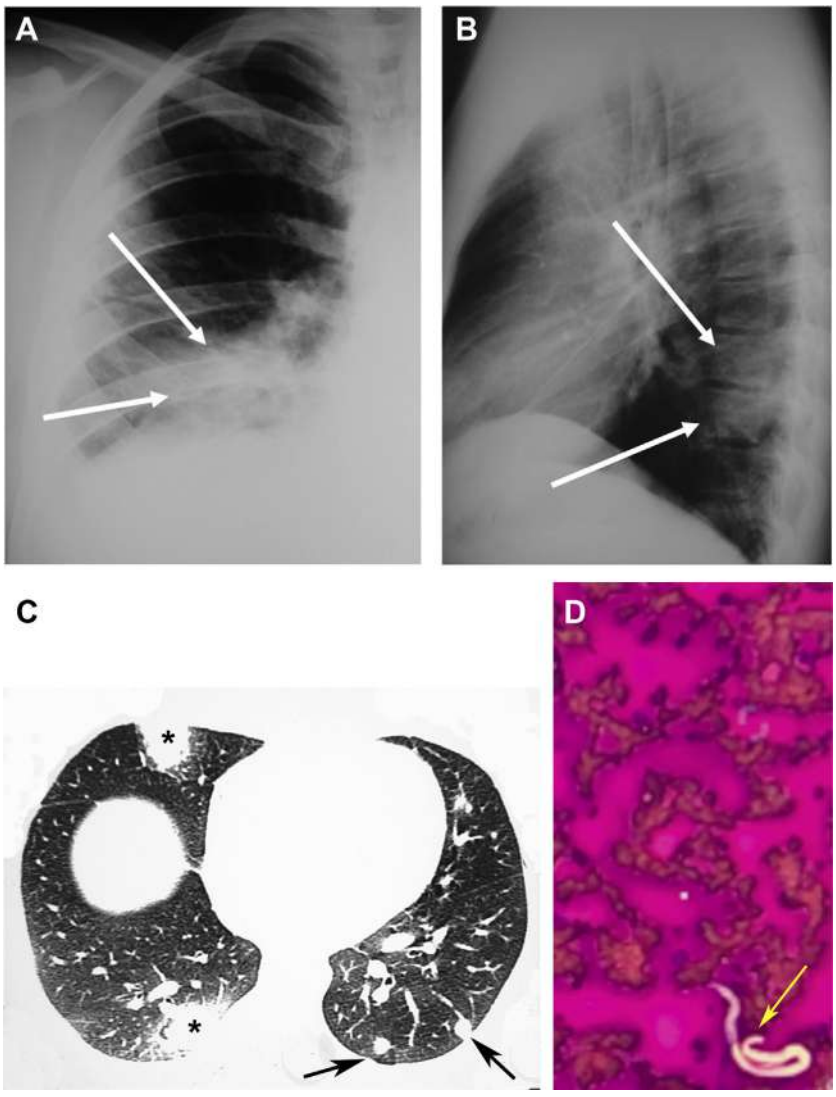

Figure 10 – *Frontal (A) and lateral (B) chest radiograph views show an ill-defined opacity in the right lower lobe (arrows) of a 27-year-old male patient with cough, chest pain, and hemoptysis on emergency admission. CT image of the same patient (C) revealed pulmonary consolidations surrounded by ground-glass attenuation in the right lung (asterisks), one of them cavitated, and two well-defined nodules were identified in the left lower lobe (arrows). D, Biopsy of a nodule revealed fragments of* Dirofilaria immitis *(arrow).*

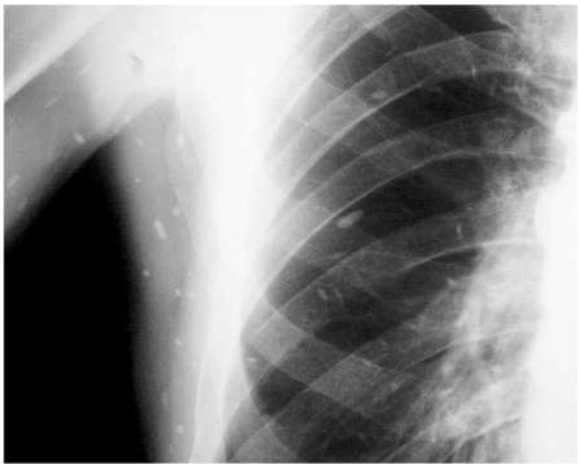

Figure 11 – *Coned-down frontal chest radiograph of 37-year-old male farmer, probably with chronic exposure to* Taenia solium *eggs, presenting with seizures of unknown origin. The "rice-grain" calcifications projected over the right hemithorax and proximal arm correspond to the characteristic radiologic appearance of cysticercus in soft tissues.*

in 100%, 58%, and 42% of the cases, respectively. There is a predilection for upper lobes.[4,21,22]

Simple eosinophilic pneumonia may be caused by several entities, such as other parasitosis, drug reactions, or pulmonary aspergillosis.[21] The proven cases of pulmonary ascariasis in the literature are restricted to isolated reports, and spontaneous pneumothorax and alveolar hemorrhage have been described in addition to the findings described here.[3,4]

Toxocariasis

Toxocariasis is a parasitic infection with global distribution, occurring more frequently in tropical and rural regions. Seroprevalence of *Toxocara canis* in the United States has been estimated to be as high as 13%, with prevalence rates even higher in developing countries.[23] The disease is acquired through the ingestion of infective eggs from contaminated soil or encysted larvae from paratenic hosts, producing presentations based on the involved organs, classically categorized as visceral larva migrans and ocular larva migrans.[9,23]

The visceral syndrome may involve the lungs and manifests as cough, wheezing, bronchiolitis, asthma, and even presenting itself as a simple eosinophilic pneumonia.[23-25] The diagnosis is generally based on clinical manifestations, peripheral eosinophilia, and enzyme-linked immunosorbent assays (ELISAs). Eventually, isolation of the larvae in the sputum or in the affected organ according to histologic examination provides the definitive diagnosis.[4,9,24]

Radiologic findings of pulmonary toxocariasis consist of ill-defined ground-glass opacities, with or without solid components (84%), multiple solid pulmonary nodules (29%), and patchy consolidations (21%) (Fig 8). In addition, focal linear opacities are less frequently reported (19%).[25] Pulmonary involvement is usually bilateral, with subpleural areas and the lower lobe being the most affected topography, a finding probably related to larval migration.[24,25]

Strongyloidiasis

Strongyloidiasis is a soil-transmitted neglected tropical disease that affects > 30 million people worldwide; it is more prevalent in South America, Africa, Asia, and Australia.[26,27] The disease is acquired when infective filariform larvae of *Strongyloides stercoralis* penetrate the skin or mucous membranes and migrate to the small intestines to mature.[4] Hyperinfection ensues in immunocompromised patients (notably those with AIDS or undergoing prolonged corticosteroid therapy) from the massive increase in infective parasite load, leading to widespread migration of worms outside of the parasite's ordinary pattern.[3,4]

Clinical and laboratorial manifestations of hyperinfection syndrome include marked eosinophilia,

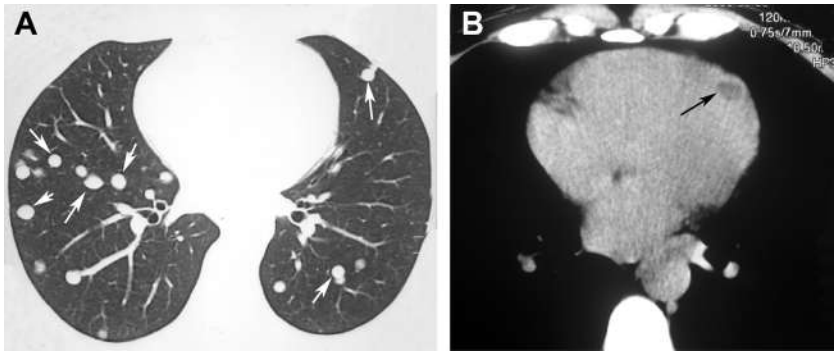

Figure 12 – *A 39-year-old male farmer with dyspnea, progressive low visual acuity, multiple subcutaneous nodules, and history of seizures. A, CT scan in lung window shows multiple randomly distributed pulmonary nodules (arrows). B, There was also a hypoattenuated nodule in the myocardium, demonstrated on soft tissue window (arrow). Results of a biopsy of a cutaneous nodule confirmed disseminated cysticercosis.*

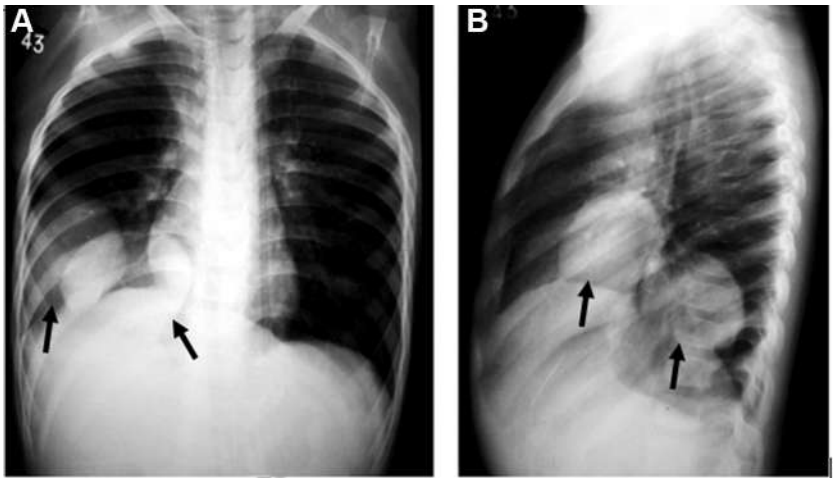

Figure 13 – *Two rounded masses on the chest radiograph of a 55-year-old farmer. Posteroanterior (A) and lateral (B) projections of the chest radiograph show two large opacities with circumscribed wall, on the basal segments of the right lung (arrows). Results of histologic testing were positive for* Echinococcosis.

abdominal pain, diarrhea, skin involvement, and severe pulmonary symptoms such as diffuse alveolar hemorrhage, pneumonia, and ARDS, which often lead to death.[3-5] Larvae can be isolated in stool, sputum, or duodenal aspirate. Furthermore, serologic testing is sensitive but unspecific due to cross-reactions with other helminths, and false-negative findings can occur in immunosuppressed patients.[4]

Radiologic findings include pulmonary ground-glass opacities and septal thickening, which can be found in up to 89% and 67% of patients submitted to CT imaging, respectively. Patchy migratory consolidations have also been reported. Widespread pulmonary airspace opacities associated with other features of ARDS in imaging are found in up to 53% of clinically severe cases.[28] Although uncommon, miliary pulmonary micronodule distribution on chest CT imaging has also been described (Fig 9). In addition, secondary bacterial infections and hemorrhagic features may often overlap with the underlying disease.[3,4,29]

Dirofilariasis

Dirofilariasis is a canine parasitic disease, caused by the nematodes *Dirofilaria immitis* and *Dirofilaria repens*, that occasionally infects humans, causing pulmonary and subcutaneous/ocular involvement, respectively. *D immitis* predominates in the Americas (mainly the United States and Brazil), Japan, and Australia, whereas *D repens* is mostly found in Europe, Russia, and Sri Lanka.[30] The disease is transmitted by mosquitoes from dogs to humans, which in turn serve as incidental hosts. The immature larvae gain access to the bloodstream through peripheral veins and ultimately lodge in small-caliber pulmonary arteries, eventually leading to pulmonary infarctions. Clinical manifestations of pulmonary dirofilariasis, although mostly asymptomatic, include cough, chest pain, and hemoptysis.[9,31]

The most common radiologic presentation is a solitary pulmonary nodule, mimicking lung cancer. The CT image shows a well-defined pulmonary nodule usually 1 to 3 cm in diameter (Fig 10). These lesions may be accompanied by pulmonary infarction and can contain central areas of necrosis. Histopathologic analysis of excised nodules is diagnostic.[4,31]

In one of the largest case series available in the current literature, the authors described a right lung (75%) and lower lobes (58%) predominance of pulmonary dirofilariasis in 39 patients, with 41 lung lesions, who

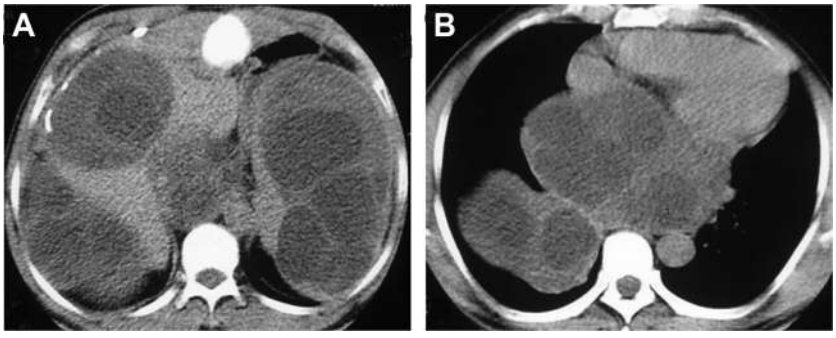

Figure 14 – *Axial CT scans of a 32-year-old male patient with a confirmed polycystic echinococcosis. The study shows multiple large cysts in the liver, spleen, and mediastinum, some with endocysts (A), which extend farther to the right lung and superior mediastinum (B), generating the compressive symptoms reported by the patient.*

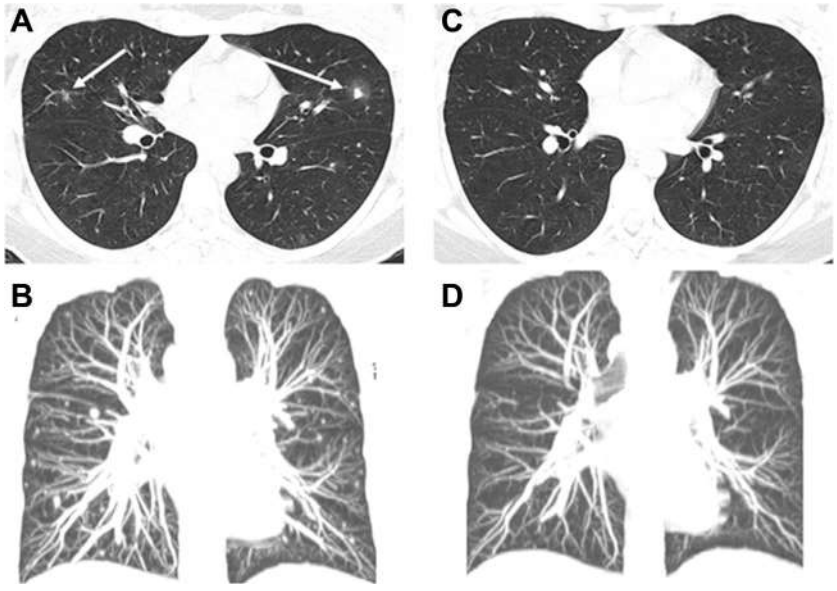

Figure 15 – *A-D, A 22-year-old woman, who traveled recently to an endemic area, presented with fever, dyspnea, arthralgias, and eosinophilia. CT studies with lung window revealed multiple pulmonary nodules (arrows), with "halo sign," on an acute onset of the disease (A, B) and their reduction 20 weeks following treatment on a follow-up study (C, D). Diagnosis of schistosomiasis was confirmed by using enzyme-linked immunosorbent assay.*

underwent chest radiographs.[32] A more recent study also described a similar pattern of anatomic predilection in 13 patients.[33]

Cestodes

Cysticercosis

Cysticercosis is a consequence of ingesting *Taenia solium* eggs shed from an asymptomatic tapeworm carrier or from contaminated water and food. The disease affects > 50 million people worldwide and is more prevalent in South America, Mexico, Asia, and Africa.[34-37] Cysticercosis is usually asymptomatic until cysticerci begin to degenerate, losing their ability to evade the immunologic system. The diagnosis can be confirmed by histopathological analysis of the nodules. Positive ELISA result, serum, and pleural fluid eosinophilia are other possible markers in cases of disseminated disease.[36]

The lesions are radiologically demonstrated as well-defined nodules distributed in any part of the body, mostly found in the skeletal muscles and in the CNS.[35,36] These hypoattenuated nodules can contain a typical central hyperattenuation on CT imaging, corresponding to the parasite head.[37] In addition, they may calcify and be shown on plain radiographs as characteristic "rice-grain" or "cigar-shaped" calcifications in soft tissues (Fig 11).[38]

Disseminated cysticercosis is a very rare entity, described in approximately 60 cases worldwide, and its epidemiologic data remain scarce.[36,39] Pulmonary involvement in disseminated cysticercosis is featured by multiple random pulmonary nodules on CT imaging (Fig 12A), associated or not with cavitation and pleural effusion. Intracardiac muscle may also contain cysticerci (Fig 12B).[35-37]

Echinococcosis

Echinococcus granulosus, Echinococcus multilocularis, and *Echinococcus vogeli* are responsible for cystic lesions in the liver and lungs of humans. *E granulosus* is associated with the most common presentation, unilocular cysts; it has a ubiquitous distribution around

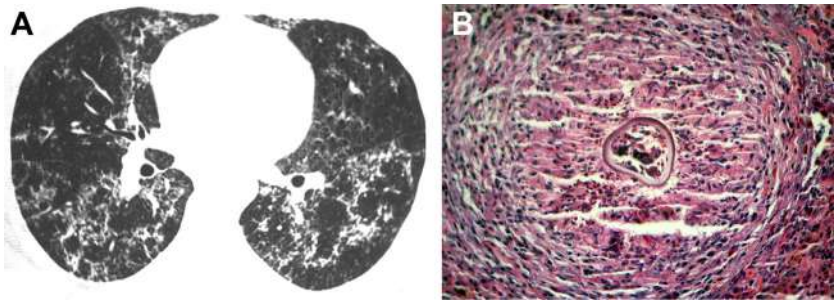

Figure 16 – *CT scan shows bilateral small nodules, ground-glass opacities, interlobular septal thickening, and intralobular interstitial thickening in a 35-year-old man (A), who presented with cough, dyspnea, myalgia, and fever for 5 days. The laboratorial investigation was inconclusive; the patient then underwent a pulmonary biopsy, the results of which showed* Schistosoma mansoni *eggs with granulomatous inflammation (B).*

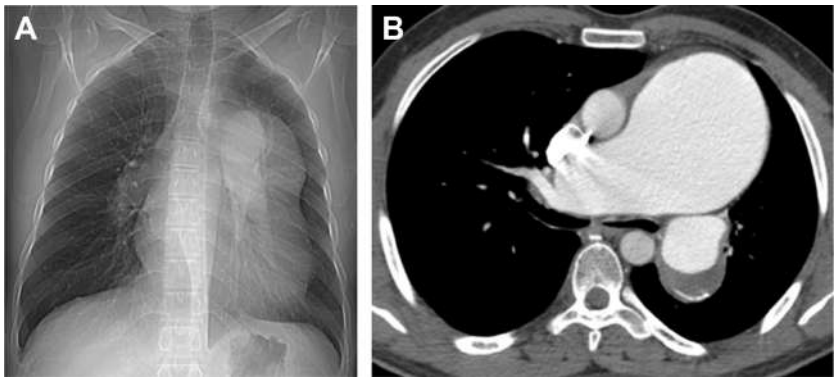

Figure 17 – *Marked enlargement of the right cardiac chambers, pulmonary trunk, and pulmonary arteries, secondary to pulmonary hypertension, shown on scout image (A) and axial CT cut in mediastinal window setting (B), in a 49-year-old man who lived in Brazil, a country endemic for schistosomiasis. Other causes of pulmonary hypertension were excluded, and the diagnosis of chronic schistosomiasis was established by the concomitant presence of prehepatic portal hypertension with periportal fibrosis and* Schistosoma mansoni *eggs in rectal biopsy.*

the globe, being especially prevalent in South America, Africa, Russia, China, New Zealand, the Mediterranean region, and the Middle East.[3,4] Transmission is due to ingestion of foods and fluids containing contaminated feces, and the parasites migrate to the lung by transdiaphragmatic or hematogenous spread.[9] Although often asymptomatic, onset of symptoms can take years and is associated with organ compression and inflammatory response or secondary infection generated by cyst rupture. The ruptured cysts can lead to anaphylactic reactions.[4,5]

Serum eosinophilia may be present, mainly when there is cyst rupture, and serologic test results are positive in approximately one-half of the cases.[3] Histologic analysis of the cysts is diagnostic.[3-5]

The lesions shown on chest radiographs are well-defined, rounded opacities in either lung parenchyma or the mediastinum (Fig 13). These are better characterized on CT imaging as cysts.[40] Eventually, a calcified wall and endocysts can be found on imaging studies (Fig 14). Cyst rupture can lead to complications, such as pleural effusion, pneumothorax, or cavity formation.[3-5]

In a case series of 43 patients with pulmonary hydatid cysts on CT imaging and radiography studies, the authors found a predilection of the disease to the right lung (62.9%) and lower lobes (70,4%). A solitary cyst was found in 81.4% of the cases, whereas the disease was bilateral in only 7% of patients.[41] A more recent study found similar results in the pediatric population: a predominance of solitary cysts (70.6%) along with involvement of the right lung and lower lobes (44.1% and 58,6%, respectively), and an uncommon bilateral manifestation (7.6%) on CT imaging.[42]

Trematodes

Schistosomiasis

Schistosomiasis is an endemic tropical disease infecting $>$ 200 million people worldwide.[3] *Schistosoma mansoni, Schistosoma haematobium, and Schistosoma japonicum* are the most common agents, and their transmission is via contaminated water exposure. The cercariae penetrate skin and gain access to the circulatory system, where they invade the heart, the lungs, and the portal venous system to mature.[4]

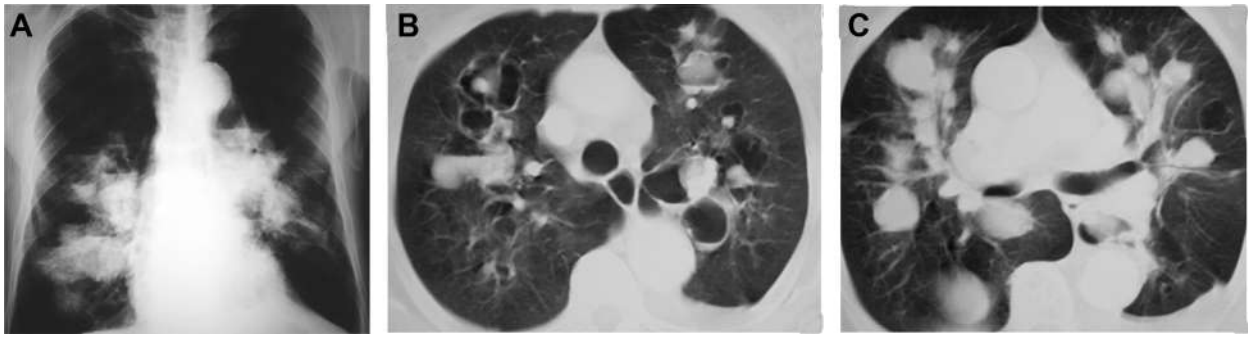

Figure 18 – *Chest radiograph of an 86-year-old patient with paragonimiasis showing perihilar nodular opacities bilaterally, some of them with air-fluid levels (A). CT scan with lung window setting (B, C) showing multiple nodules, distributed in a peribronchovascular pattern along with associated several cysts, predominantly on the perihilar regions of the lungs. The patient is a South American man; sputum examination revealed* Paragonimus *species eggs.*

TABLE 1] Thoracic Parasitic Diseases and Their Corresponding Imaging Findings, in Addition to Characteristics That Could Be Correlated to Discriminate Them and Guide the Diagnostic Approach

Parasitic Disease	Main Radiologic Manifestations of Thoracic Involvement	Other Characteristics and Findings That Could Help the Diagnosis
Malaria	• Septal thickening	The findings are related to pulmonary edema and ARDS
	• Consolidation	
	• Pleural effusion	
Chagas	• Cardiomegaly	Multiorgan chronic disease, which affects mainly the heart, but only the late stages are seen on radiograph or CT imaging
	• Megaesophagus	
	• Tracheomegaly	
	• Bronchiectasis	
Toxoplasmosis	• Septal thickening	Interstitial and ground-glass opacities are the most common features seen, associated or not with pulmonary nodules. The findings may be similar in immunosuppressed and immunocompetent patients
	• Ground-glass opacity	
	• Pulmonary nodules	
	• Pleural effusion	
	• Pneumothorax	
Amoebiasis	• Pleural effusion	The right diaphragm elevation, pleural effusion, and consolidation are the main features, which predominate on the right lower part of the thorax and represent liver abscess complications
	• Consolidation	
	• Right diaphragm elevation	
	• Abscess	
	• Pulmonary cavitation	
Ascariasis	• Ground-glass opacity	Migratory, transient, and patchy opacities on radiographs. There is a certain predilection for the upper lobes
	• Consolidation	
	• Pulmonary nodules	
	• Pneumothorax	
Toxocariasis	• Ground-glass opacity	The characteristic distribution is in bilateral lower lobes and in subpleural areas
	• Consolidation	
	• Pulmonary nodules	
	• Linear opacity	
Strongyloidiasis	• Ground-glass opacity	Patchy migratory consolidations and miliary micronodule distribution are less common manifestations. Secondary bacterial infections and hemorrhage may often overlap the other features. ARDS is found in severe cases
	• Septal thickening	
	• Consolidation	
	• Miliary pulmonary micronodules	
Dirofilariasis	• Pulmonary nodule	It is often presented as a solitary pulmonary nodule (well defined, measuring 1-3 cm, with or without central necrosis), predominating in right lung and lower lobes. It may be associated with pulmonary infarction and necrosis
Cysticercosis	• Small nodules in soft tissues	Characteristic "rice-grain" soft tissue calcifications on radiograph. Well-defined hypoattenuated nodules, with or without central hyperattenuation (parasite head) on CT imaging. Multiple random pulmonary nodules feature lung involvement in disseminated cysticercosis

(Continued)

TABLE 1] *(Continued)*

Parasitic Disease	Main Radiologic Manifestations of Thoracic Involvement	Other Characteristics and Findings That Could Help the Diagnosis
	• Pulmonary nodules	
	• Pulmonary cavitation	
	• Pleural effusion	
Echinococcosis	• Pulmonary cysts	Cysts can contain endocysts and calcified walls. There is a predilection to right lung and lower lobes. Pleural effusion, pneumothorax, and cavitation are associated with rupture. Mediastinal, hepatic, or splenic cysts may be found simultaneously
	• Pleural effusion	
	• Pneumothorax	
	• Pulmonary cavitation	
Schistosomiasis	• Pulmonary nodules	Ill-defined nodules, reticulonodular infiltrate, ground-glass opacities in acute form; fibrosis and pulmonary hypertension signs in chronic form
	• Septal thickening	
	• Ground-glass opacity	
	• Fibrosis	
	• Pulmonary hypertension signs	
Paragonimiasis	• Pulmonary nodules	Radiologic findings vary according to the endemic location and the stage of the disease. Consolidations are generally seen in the early stage, while nodules or cysts are seen in the late stage
	• Consolidation	
	• Pulmonary cysts	
	• Atelectasis	
	• Pneumothorax	
	• Pleural effusion	
	• Linear opacities in lung	

S mansoni is frequently found in Latin America (especially Brazil, Venezuela, and Puerto Rico), Africa, and Western Asia; *S japonicum* is found exclusively in East Asia; and *S haematobium* predominates in Africa (especially the Nile Valley), Asia, and southern Portugal.[3,9]

Pulmonary manifestations can be divided into acute and chronic forms. Acute pulmonary schistosomiasis, also known as Katayama fever, is generally self-limited and sometimes asymptomatic. However, nonimmune patients traveling to endemic regions can develop severe presentations. The most common acute phase symptoms are fever, dyspnea, arthralgia, and rash.[6] Radiologic findings of acute disease consist of ill-defined pulmonary nodules (most common), reticulonodular infiltrates, and bilateral diffuse ground-glass opacities (Figs 15 and 16).[3,4,43]

In a case series of eight patients with confirmed *S mansoni* and *S haematobium* acute infection, the authors found that seven patients presented with ill-defined nodular lesions on chest radiographs, and one patient also presented with reticulonodular infiltrates. In this same study, four patients underwent CT scanning that revealed a bilateral diffuse interstitial ground-glass pattern with ill-defined nodules in all cases.[44]

Chronic disease is associated with granulomatous reactions to parasite eggs affecting mainly the pulmonary vasculature. This inflammatory reaction can lead to fibrosis, pulmonary hypertension, and cor pulmonale; thus, the clinical and radiologic features are related to those consequences (Fig 17).[3,4]

Serum eosinophilia, abnormal liver function test results, and elevated serum IgE are possible findings at the acute phase, whereas serologic test results according to ELISA are positive after 6 to 12 weeks.[4,5] Another diagnostic method is the identification of parasite eggs in stool,

sputum, or BAL, usually detected following 6 weeks of infection. In some cases, open lung or rectal biopsy may be helpful.[3-5,43]

Paragonimiasis

Paragonimiasis is associated with the ingestion of *Paragonimus* species (mainly *Paragonimus westermani*) metacercariae from uncooked crustaceans. It occurs primarily in Asian countries, including South Korea, Japan, and Lao People's Democratic Republic (Laos), although it can also be less frequently found in Africa, Central America, and South America. The disease mainly affects the lungs, leading to inflammation and fibrosis. Patients usually present with hemoptysis and malaise. Expectorated material is of a characteristic chocolate brown color and contains blood, inflammatory cells, and parasite eggs.[45] The eggs can also be detected in pleural fluid and feces, and the larvae may often be isolated at BAL, confirming the diagnosis. Another useful marker is the increased eosinophil count in blood, pleural fluid, or BAL. Moreover, serologic testing, when available, can help the diagnosis.[3,4] Radiologic findings vary according to the endemic location and the stage of the disease. Pulmonary consolidations are generally associated with early stages, whereas solitary or multiple pulmonary nodules or cysts are seen following consolidation resolution (Fig 18). Pleural effusion and pneumothorax have been described simultaneously with the other findings. Linear opacities on radiologic studies can be a sign of peripheral atelectasis or worm migration. The main radiologic diagnostic considerations are malignancies and TB.[3,4,45]

A comparative report studied the chest imaging findings of patients in two endemic countries; it found that patients in Laos presented mainly with multiple small cysts (90%) of perihilar and lower lobes predominance, whereas patients from a previous South Korean study presented mainly with nodular opacities (39%). Pleural effusion was also more likely to be seen in those from Laos.[45] In a more recent North American case series of eight patients with confirmed *Paragonimus kellicotti* infection, pleural effusion was the main imaging finding (100%), followed by isolated linear opacities (62.5%) and nodules with pleural tracks (50%). The variability of radiologic features between different endemic and nonendemic countries may be related to the specific causative *Paragonimus* species or even to the differences in health-care access and delayed diagnosis.[45,46]

Conclusions

Parasitic pulmonary diseases present with overlapping radiologic manifestations, requiring clinical, epidemiologic, and laboratorial correlation (Table 1). Despite the nonspecific presentation, imaging patterns contribute to increased or decreased suspicion of specific entities, guiding physicians in the clinical workflow.

This article serves as a quick guide for radiologists in the obscure field of parasitosis, aiming to encourage them to add these diseases to their differential diagnosis, especially for patients who live in or who have traveled recently to endemic regions. Although most of these parasites cause mainly GI manifestations, the thorax should be remembered as one of the most relevant extra-abdominal sites.

Little progress has been made in the medical literature on the subject of parasitic disease with pulmonary manifestations in the last decades, possibly due to its predominance in tropical and lower income countries, where epidemiologic data are often scarce. However, the rise of HIV and the expansion of the number of drug-induced immunosuppressed patients are changing the epidemiologic pattern of parasitic diseases, with re-expansion to developed countries. Thus, further studies are needed to develop novel imaging-based forms and approaches to the diagnosis of parasitic infections to provide the correct treatment to less-assisted populations.

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