

**Review Article**

**TROPICAL PARASITIC LUNG DISEASES**

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**ABSTRACT**

Protozoa and helminthes can affect the lung as a primary site, or a complication. Some parasites have a migration cycle through the lung (larva migrans), inducing blood and tissue eosinophilia. Clinical manifestations of lung involvement could be acute: asthma-like syndrome, or Loeffler's syndrome, with dyspnea, wheezing, cough; or chronic such as hemoptysis or right heart failure signs. Acute manifestations depend on immunological reaction (hypersensitivity), and chronic feature relay on the mechanical action of pathogen on the vessels and tissues. (vg: schistosoma eggs in the pulmonary artery and pulmonary hypertension). The lung is important organs which affected by parasitic diseases in tropical area, e.g. Protozoal parasites that cause pulmonary diseases are *Entamoeba histolytica*, *Leishmania donovani*, malarial parasites, *Toxoplasma gondii*, *Babesia microti* and *Babesiadivergens*. and also, some helminthes such as Helminths: Cestodes (*Pulmonary hydatid cyst*; *Trematodes (Pulmonary schistosomiasis, Pulmonary paragonimiasis)*; *Nematodes (Pulmonary ascariasis, Pulmonary ancylostomiasis, Pulmonary strongyloidiasis)*; *Tropical pulmonary eosinophilia, Pulmonary dirofilariasis*; *Visceral larva migrans*; *Pulmonary trichinellosis*. The perfect diagnosis for parasitic lung diseases very important to prevent the distribution of parasites between patient in tropical and subtropical area. Health education must be done. The main target of this study is to focus on some tropical parasitic lung diseases.

**Keywords:** Asthma Complication, Helminthes, Lung diseases, Pneumonia, Protozoa, Tissue eosinophilia, Tropical.

**INTRODUCTION**

Parasitic diseases are distributed worldwide, with a higher prevalence in developing countries, especially in areas with inadequate sanitation. Some of these diseases are restricted to tropical and subtropical regions. Clinical manifestations of lung involvement could be acute: asthma-like syndrome, or Loeffler's syndrome, with dyspnea, wheezing, cough [1-2]; or chronic such as hemoptysis or right heart failure signs. Acute manifestations depend on immunological reaction (hypersensitivity), and chronic feature relay on the mechanical action of the pathogen on the vessels and tissues. (vg: schistosoma eggs in the pulmonary artery and pulmonary hypertension)[3].

Parasitic diseases represent one of the most common types of human infection throughout the world and are still the cause of much human morbidity and mortality. Epidemics of parasitic diseases (e. g., malaria) have devastated large populations and pose a serious barrier to progress in many developing countries. Profound economic and social changes over the past decades are stimulating rural-to-urban migration in most endemic areas; consequently, parasitic diseases that are more common in rural areas are no longer entirely absent in the urban population. In industrialized countries, risk groups for parasitic diseases include travelers, recent immigrants, institutionalized populations, and patients with acquired immunodeficiency syndrome (AIDS).

The lung is important organs which affected by parasitic diseases in tropical area, e. g. Protozoal parasites that cause pulmonary diseases are *Entamoeba histolytica*, *Leishmania donovani*, malarial parasites (*Plasmodium vivax*, *P. falciparum*, *P. malariae* and *P. ovale*), *Toxoplasma gondii*, *Babesia microti* and *Babesiadivergens*. and also, some helminthes such as Helminths: Cestodes (*Pulmonary hydatid cyst* *Echinococcus granulosus*, *Echinococcus multilocularis*); *Trematodes (Pulmonary schistosomiasis Schistosoma haematobium, Schistosoma mansoni, Schistosoma japonicum, Pulmonary paragonimiasis Paragonimus westermani)*; *Nematodes (Pulmonary ascariasis Ascaris lumbricoides, Pulmonary ancylostomiasis Ancylostoma duodenale, Necator americanus, Pulmonary strongyloidiasis Strongyloides stercoralis)*; *Tropical pulmonary eosinophilia (Wuchereria bancrofti, Brugia malayi, Pulmonary dirofilariasis Dirofilaria immitis, Dirofilaria repens)*; *Visceral larva migrans (Toxocara canis, Toxocara cati)*; *Pulmonary trichinellosis (Trichinella spiralis)*.

**Normal Lung (anatomy and physiology)**

When you breathe, your lungs take in oxygen from the air and deliver it to the bloodstream. The cells in your body need oxygen to work and grow. During a normal day, you breathe nearly 25,000 times. People with lung disease have difficulty breathing [4].

**The respiratory system-glossary**

Nasal cavity: Interior area of the nose; lined with a sticky mucous membrane and contains tiny, surface hairs called cilia.; Nose hairs: Located at the entrance of the nose, these hairs trap large particles that are inhaled.; Paranasal sinuses: Air spaces within the skull.; Pharynx: The throat.; Epiglottis: A flap of cartilage that prevents food from entering the trachea.; Larynx: Voice box.; Trachea: Tube through which air passes from the nose to the lungs (also known as the windpipe); Bronchi: The two main air passages into the lungs [5].

Lungs: The two organs that extract oxygen from inhaled air and expel carbon dioxide in exhaled air. Heart: The muscular organ that pumps blood throughout the body. Diaphragm: The main muscle used for breathing; separates the chest cavity from the abdominal cavity. Muscles: Intercostals' muscles: Thin sheets of muscle between each rib that expands (when air is inhaled) and contract (when air is exhaled). Muscles attached to the diaphragm: These muscles help move the diaphragm up and down for breathing; Abdominal muscles; Muscles in the neck and collarbone area. Ribs: Bones attached to the spine and central portion of the breastbone, which supports the chest wall and protect the heart, lungs, and other organs in the chest [6].

**The lung disease**

The term lung disease refers to many disorders affecting the lungs, such as Acute-Disease or condition characterized by the rapid onset of severe symptoms [7]. Chronic-Disease or condition characterized by slow onset over a long period of time.

The lung may be diseased by two ways First: affected upper Respiratory System such as: 1-Rhinitis is an inflammation of the mucus membrane in the nose, due to a common cold, allergies, etc [8]. 2-Pharyngitis is a sore throat, which could be due to a viral infection such as the common cold or flu or a bacterial infection such as *Streptococcus pyogenes* [9]. 3-Laryngitis is an inflammation of the vocal cords in which the person partially or totally loses his/her voice [10].

## Second: affected lower respiratory system, such as: 1-Bronchitis

Bronchitis is an inflammation of the bronchi, causing them to over-secrete mucus, which in turn, causes coughing to get it up. Acute bronchitis is usually caused by a viral infection, but can also be caused by a bacterial infection and can heal without complications [11]. Chronic bronchitis is a sign of serious lung disease that may be slowed but cannot be cured [12]. Cystic fibrosis: A genetic condition causing poor clearance of mucus from the bronchi. The accumulated mucus results in repeated lung infections [13].

Chronic obstructive pulmonary disease (COPD) — A term used to describe chronic lung diseases, like Chronic bronchitis and Chronic asthmatic bronchitis [14]. Chronic bronchitis may progress to emphysema, or both diseases may be present together. 2-Emphysema -emphysema involves the destruction of air sac walls to form abnormally large air sacs that have reduced gas exchange ability and that tend to retain the air within the lungs. Symptoms include labored breathing, the inability to forcefully blow air out of the lungs, and an increased susceptibility to respiratory tract infections [15]. 3-Pleurisy is an infection of the pleural membranes lining the inside of the chest cavity and coating the lungs. Normally these membranes are very slippery, aiding in breathing, but when they become infected, they don't slide over each other as well, and breathing becomes painful [16]. 4-Asthma is an allergic reaction that causes constriction of the bronchiole muscles, thereby reducing the air passages, thus the amount of air that can get to the alveoli. Interestingly, many of the treatments for asthma are similar to treatments used for hypoglycemia. That and the fact that diabetics rarely also have asthma have led some authors to suggest that asthma may be related to hypoglycemia, and that a hypoglycemia diet may aid in alleviation of asthma symptoms [17]. 5-Infections: Influenza, Pneumonia and Tuberculosis, Lung cancer, and many other Breathing problems. Some lung diseases can lead to Respiratory failure [18]. A steady flow of blood in the small blood vessels that surround your air sacs is vital for gas exchange. Long periods of inactivity or surgery can cause a blood clot called a pulmonary embolism (PE) to block a lung artery, and reduce or block the flow of blood in the small blood vessels and hinder gas exchange.

### Pulmonary hypertension

Various conditions can lead to high blood pressure in the pulmonary arteries. This can cause shortness of breath and chest pain. When no cause is identified, the condition is called idiopathic pulmonary arterial hypertension.

### Pulmonary edema

Fluid leaks out of the small blood vessels of the lung into the air sacs and the surrounding area. One form is caused by heart failure and back pressure in the lungs' blood vessels; in another form, direct injury to the lung causes the leakage of fluid [19].

**Lung cancer** has many forms, and may develop in any part of the lungs. Most often, this is in the main part of the lung, in or near the

air sacs. The type, location, and spread of lung cancer determines the treatment options [20].

### Lung diseases affecting the interstitium

The interstitium is the microscopically thin, delicate lining between the lungs' air sacs (alveoli). Tiny blood vessels run through the interstitium and allow gas exchange between the alveoli and the Various lung diseases affect the interstitium. A broad collection of lung conditions affecting the interstitium. Sarcoidosis [21]. idiopathic pulmonary fibrosis [22]. Autoimmune disease [23]. Pneumonias and pulmonary edemas can also affect the interstitium blood.

### Lung diseases affecting the pleura

#### 1. Pleural effusion

Fluid collects in the normally tiny pleura space between the lung and the chest wall. Pneumonia or heart failure is usually responsible. If large, pleural effusions can impair breathing, and should be drained. The volume of the lung is reduced because of the collection of fluid around the lung [24].

#### 2. Pneumothorax

Air may enter the space between the chest wall and the lung, collapsing the lung. To remove the air, a tube is typically inserted through the chest wall [25].

#### 3. Mesothelioma

A rare form of cancer that forms on the pleura. Mesothelioma tends to emerge several decades after asbestos exposure [26].

### Lung diseases affecting the chest wall

The chest wall also plays an important role in breathing. Muscles connect the ribs to each other, helping the chest to expand. The diaphragm descends with each breath in, also causing chest expansion [27].

### Obesity hypoventilation syndrome

Extra weight on the chest and abdomen makes it difficult for the chest to expand. Serious breathing problems can result [28].

### Neuromuscular disorders

Poor function in the nerves controlling the respiratory muscles causes difficulty breathing. Amyotrophic lateral sclerosis and myasthenia gravis are examples of neuromuscular lung disease.

Typical symptoms include a cough, chest pain, fever, and difficulty breathing. Diagnostic tools include x-rays and culture of the sputum. Vaccines to prevent certain types of pneumonia are available. Treatment depends on the underlying cause. Presumed bacterial pneumonia is treated with antibiotics. If the pneumonia is severe, the affected person is generally admitted to the hospital. Pneumonia fills the lung's alveoli with fluid, hindering oxygenation. The alveolus on the left is normal, whereas the one on the right is full of fluid from pneumonia [29].

**Table 1: Tropical parasitic lung diseases [31-32]**

	Diseases	Parasites
Protozoa	Pulmonary amoebiasis	<i>Entamoeba histolytica</i>
	Pulmonary leishmaniasis	<i>Leishmania donovani</i>
	Pulmonary malaria	<i>Plasmodium vivax, Plasmodium falciparum Plasmodium malariae Plasmodium ovale</i>
	Pulmonary toxoplasmosis	<i>Toxoplasma gondii</i>
	Pulmonary babesiosis	<i>Babesia microti, Babesia divergens</i>
Helminths Cestodes <i>Trematodes</i>	Pulmonary hydatid cyst	<i>Echinococcus granulosus Echinococcus multilocularis</i>
	Pulmonary schistosomiasis	<i>Schistosoma haematobium Schistosoma mansoni Schistosoma japonicum</i>
	Pulmonary paragonimiasis	<i>Paragonimus westermani</i>
<i>Nematodes</i>	Pulmonary ascariasis	<i>Ascaris lumbricoides</i>
	Pulmonary ancylostomiasis	<i>Ancylostoma duodenale Necator americanus</i>
	Pulmonary strongyloidiasis	<i>Strongyloides stercoralis</i>
	Tropical pulmonary eosinophilia	<i>Wuchereria bancrofti Brugia malayi</i>
	Pulmonary dirofilariasis	<i>Dirofilaria immitis Dirofilaria repens</i>
	Visceral larva migrans	<i>Toxocara canis Toxocara cati</i>
	Pulmonary trichinellosis	<i>Trichinella spiralis</i>

## Parasitic lung diseases

Parasitic diseases, though prevalent predominantly in tropical and subtropical regions, have been reported from other countries as well due to globalization and travel across the continents. Pulmonary involvement is frequently observed in many protozoal and helminthic infections. Parasitic pneumonia occurs as the larval stages of some of these parasites pass through the lungs. Pneumonia can also result from direct extension from contiguous sites or sequestration of parasite in the pulmonary capillaries.

Parasitic diseases are neglected tropical diseases and are considered 'poverty-promoting conditions'. These diseases are therefore major public health concerns in many developing countries. This review deals with the recent developments in the diagnosis and management of parasitic pneumonias [30].

### Protozoa

#### Amebiasis

The lung is the most frequent site of extra-intestinal invasion. Thoracic amebiasis with pleural manifestations is suspected in patients from endemic areas with or without an obvious liver abscess. Stool examination is of limited value because (a) cysts or trophozoites are seen in only 15%–33% of patients with extraintestinal amebiasis [32], and (b) many pleuropulmonary manifestations may be unrelated to *E. histolytica*, even if parasites are present in the feces. The classic "anchovy sauce" content can be obtained from an amebic hepatic abscess or from expectorate that has traveled through a hepatobronchial fistula.

Clinical symptoms are related to the hepatic and intrathoracic implications. General symptoms including fever, right upper quadrant pain, cough, chest pain are frequent in the lung amoebiasis. Pleural effusion could develop, following hepatobronchial fistula. The parenchymal disease can present as pulmonary abscess with characteristic chocolate pus and airspace consolidation at chest radiograph. Elevation of right hemidiaphragm is an earlier radiographical feature in liver abscess.

Diagnosis of thoracic amoebiasis is suggested by the findings of elevated hemidiaphragm, tender hepatomegaly, pleural effusion and basal pulmonary involvement. Active trophozoites of *E. histolytica* can be demonstrated in sputum or pleural pus. Microscopic examination of stool samples may reveal cysts or trophozoites of amoebae. The presence of amoeba in the stool does not signify that the disease is due to *E. histolytica* as other two non-pathogenic species found in humans (*E. dispar* and *E. moshkovskii*) are indistinguishable morphologically. A single-round polymerase chain reaction (PCR) assay has been developed as an accurate, rapid and effective diagnostic method for the detection and discrimination of these three Entamoeba species [33, 34]. Other diagnostic tests include culture of *E. histolytica* and serological tests [indirect haemagglutination test (IHA), enzyme linked immunosorbent assay (ELISA) and indirect fluorescent antibody test (IFAT)]. A combination of serological tests with detection of the parasite by antigen detection or PCR is the best approach for diagnosis. Serologic analysis is helpful for the diagnosis of invasive disease in nonendemic populations [35].

#### Treatment

Metronidazole is the treatment of choice and widely used, with established effectiveness. Lactoferrin and lactoferricins combined to low metronidazole doses has been proposed as an alternate therapeutic option.

#### Malaria

Adult respiratory distress syndrome (ARDS) is the primary manifestation of malaria in the lung and was included in 1990 by the World Health Organization as a criterion for the definition of both severe and complicated malaria. The pulmonary manifestations range from cough to severe and rapidly fatal non-cardiogenic pulmonary oedema and acute respiratory distress syndrome (ARDS). It has also been reported that ARDS can occur in vivax malaria [36]. There has been no convincing evidence for the

existence of true malarial pneumonitis and if it occurs, it may be due to viral and secondary bacterial infections. Gas transfer was significantly impaired in patients with severe malaria [37].

#### Diagnosis

Systemic symptoms of malaria are: fever, myalgia, headache, loss of appetite, nausea, vomiting. Severe respiratory symptoms may be observed, following the onset of edema and respiratory distress syndrome. Light microscopy of thick and thin stained blood smears are the Gold standards for the diagnosis of malaria. Thin smears allow identification of malaria species. Radiological Chest findings in severe *falciparum* malaria include lobar consolidation, diffuse interstitial edema, pulmonary edema, or hemorrhages and pleural effusion. CT findings are consistent with noncardiogenic pulmonary edema. Pleural effusion, diffuse interstitial edema, and lobar consolidation may also be seen [38-40].

Occasionally, bronchiolitis obliterans organizing pneumonia has been reported [41]. Eosinophilic pneumonia with bilateral patchy consolidation has also been described in association with the use of pyrimethamine. Polymerase chain reaction detection of Plasmodium falciparum in human urine and saliva samples has been described [42].

#### Treatment

Parenteral quinine is the drug of 1<sup>st</sup> choice for the treatment of severe malaria. Artemisinin derivatives are an alternative in case of contra-indications. Adjunctive therapy with clindamycin or doxycycline has been proposed in complicated malaria [43-46].

General resuscitation measures could be indicated in life threatening cases.

Antivectorial eradication, using insecticide treated bed-nets is widely utilized in endemic regions.

#### Pulmonary leishmaniasis

Visceral leishmaniasis is caused by *Leishmania donovani* and the infection is transmitted by various species of Phlebotomus, the sand fly [47]. Pneumonitis, pleural effusion and mediastinal adenopathy are reported in patients coinfecting with human immunodeficiency virus. *Leishmania* amastigotes can be found in the alveoli, pulmonary septa and bronchoalveolar lavage (BAL) fluid [48-49]. Visceral leishmaniasis has also been reported in lung transplant patients, and it has been suggested that serological testing for latent infection due to *Leishmania* spp may be included in the pre-transplantation screening from endemic regions [50].

The drugs for the treatment of leishmaniasis include pentavalent antimonials, amphotericin B especially the liposome formulations and pentamidine. An oral drug, miltefosine is now available [51].

#### Pulmonary toxoplasmosis

The disease caused by the Protozoan parasite, *Toxoplasma gondii* infects the man, after ingestion of cyst-contaminated food raw or undercooked meat, vegetables or milk products. Cats are the primary carriers of the organism [52]. The symptoms of toxoplasmosis are flue-like syndrome, enlarged lymph nodes or myalgia. Infection in early pregnancy can cause foetal death, and chorioretinitis and neurologic symptoms in the newborn. Chronic toxoplasmosis can cause chorioretinitis, jaundice, encephalitis and convulsions. Pulmonary toxoplasmosis has been reported with increasing frequency in patients with HIV infection. *Toxoplasma* pneumonia can manifest as interstitial pneumonia/diffuse alveolar damage or necrotising pneumonia [53]. Immunocompromised individuals are at higher risk of developing toxoplasmosis with the central nervous system involvement as the most common complication.

Diagnosis of toxoplasmosis is based on the detection of the protozoa in body tissues. Antibody levels can be increased without active disease. A real-time PCR based assay in bronchoalveolar lavage (BAL) fluid has been reported in immunocompromised HIV-positive patients [54].

Toxoplasmosis can be treated with a combination of pyrimethamine and sulfadiazine.

### Pulmonary babesiosis

Babesiosis is caused by hemoprotozoan parasites, *Babesia microti* and *Babesia divergens* [55]. Humans get the infection by the bite of an infected tick, *Ixodes scapularis* but can also be infected from a contaminated blood transfusion. Co-infection with ehrlichiosis and Lyme disease is an important characteristic of these tick-borne illnesses [56].

The parasites attack the red blood cells and can be misdiagnosed as Plasmodium. The symptoms are fever, drenching sweats, tiredness, loss of appetite, myalgia and headache. Acute respiratory distress syndrome occurring a few days after initiation of the medical therapy is the important pulmonary manifestation [57]. Specific diagnosis is made by the examination of a Giemsa-stained thin blood smear, DNA amplification using PCR or detection of specific antibody.

Treatment is with a combination of clindamycin (600 mg every 6 hrs) and quinine (650 mg every 8 hrs) or Atovaquone (750 mg every 12 hrs) and azithromycin (500-600 mg on first day and 250-600 mg on subsequent days) for 7-10 days [58].

### Trypanosomiasis

Bronchopathy has rarely been described when denervation of the bronchial walls occurs. Although the pathogenesis of bronchopathy is not well understood, this disease entity seems to have a small clinical impact. Serologic tests are preferred for the diagnosis of chronic forms.

Pulmonary manifestations (pleural effusion, edema), are linked to heart involvement. Tracheomegaly and bronchiectasis have been infrequently encountered [59]. Acute manifestations consist of flu-like syndrome and facial edema [60].

Radiologic findings reflect the aforementioned clinical features. Acute myocarditis can cause acute heart failure. Severe cardiomegaly with or without signs of chronic heart failure (septal lines, pulmonary edema, pleural effusion) is frequently seen in dilated cardiomyopathy. Achalasia and megacolon are usually confirmed with barium studies when appropriate clinical data suggest these diagnoses. Bronchiectasis and tracheomegaly are rarely seen [61, 62]. Serological diagnosis is helpful in chronic forms.

### Nematodes

#### Ascariasis

Parasites migrate from the small intestine to the pulmonary circulation, where they mature and produce destruction of capillaries and alveolar walls with subsequent edema, hemorrhage, and epithelial cell desquamation, causing chemotaxis of neutrophils and eosinophils [63].

In the lung, the larvae produce a hypersensitivity reaction. This may result in peribronchial inflammation, increased mucus production in the bronchi and bronchospasm. In addition to peripheral blood and tissue eosinophilia. *Ascaris* infection produces both specific and polyclonal IgE [64]. Elevated levels of antibodies (IgG4) to *Ascaris lumbricoides* have also been reported [65].

Pulmonary migration of larvae is usually asymptomatic. Symptomatic pulmonary disease may range from mild cough to a Loeffler's syndrome [66]. This syndrome associates respiratory symptoms (dry cough, wheezing, dyspnoea) with blood and lung eosinophilia, and chest radiograph with fleeting infiltrates. General symptoms such as fever, loss of appetite, myalgia can be observed.

The respiratory symptoms include chest pain, cough with mucoid sputum, haemoptysis, shortness of breath and wheezing. There may be rapid respiratory rate and rales can be heard on auscultation. Leucocytosis particularly eosinophilia is an important laboratory finding. Chest radiographs demonstrate unilateral or bilateral, transient, migratory, non-segmental opacities of various sizes. These opacities are often peripherally situated and appear to be pleural based [67]. And CT demonstrate migratory, patchy alveolar infiltrates that characteristically clear within 10 days.

Sputum may show Charcot-Leyden crystals and the chest radiograph may reveal fleeting pulmonary infiltrates. Because of the occurrence of respiratory symptoms during larval pulmonary migration, stool examination usually does not show *Ascaris* eggs and stool samples may be negative until two to three months after respiratory symptoms occur, unless the patient was previously infected.

However, larvae can sometimes be demonstrated in respiratory or gastric secretions [68] and may be in stool examination may show eggs or adult worms.

It has been suggested that measurement of *Ascaris* specific IgG4 by ELISA may be useful in the serodiagnosis of ascariasis [69].

#### Treatment

Pulmonary disease due to ascariasis usually does not require any treatment, as it is a self-limiting disease, but the treatment aims to eradicate intestinal colonization responsible for recurrent respiratory episodes. However, the persistence of gastrointestinal ascariasis may result in repeated episodes of respiratory symptoms due to larval migration.

In order to eradicate *Ascaris lumbricoides* from the intestine, specific anti-helminthic treatment is given. Mebendazole (100 mg twice a day for three days, or 500 mg one day) and Albendazole (400 mg, single dose) are the drugs of choice. Pyrantel Pamoate, Levamisole, and Piperazine are alternative choices. Ivermectine, an antifilarial drug has shown efficacy in the treatment of ascariasis.

#### Toxocariasis

The main symptoms in patients with visceral larva migrans are fever, cough, wheezing, seizures, anemia and fatigue. Pulmonary manifestations are reported in 80% of cases and patients may present with severe asthma. Scattered rales and rhonchi are heard on auscultation. There will be intense blood eosinophilia. Chest radiograph may reveal focal patchy infiltrates. In some cases, severe eosinophilic pneumonia may lead to respiratory distress [71, 72].

Non specific changes include hypergamma-globulinemia and elevated isohemagglutinin titers to A and B blood group antigens. Serological tests by ELISA method using excretory-secretory proteins obtained from cultured *T. canis* may be useful in the diagnosis [72].

Cross-reactivity with other helminths limits the usefulness of this test in endemic areas. Detection of IgE antibodies by ELISA and toxocara excretory-secretory antigens by Western blotting procedure have also been reported for diagnosis [73].

However, serodiagnostic procedures can not distinguish between past and present infections. Histopathological examination of lung or liver biopsy specimens may demonstrate granulomas with eosinophils, multinucleated giant cells and fibrosis [74]. Treatment Visceral larva migrans is a self-limiting disease and there may be spontaneous resolution. Therefore, mild to moderately symptomatic patients need not require any drug therapy. Patients with severe VLM can be treated with thiabendazole, mebendazole or diethylcarbamazine. Treatment with anthelmintics may exacerbate the inflammatory reactions in the tissues due to the killing of larvae. a roundworm of dog and cat can infect human, who is an intermediate host, and determine a Loeffler's like syndrome caused by larva migrans as with *Ascaris* [75].

Severe respiratory syndromes (ARDS) have rarely been observed, while asthma-like symptoms are currently reported among pulmonary manifestations.

Defects in neutrophil function have been reported in children with visceral larva migrans. This defect should be explained by the neutrophilic adherence to larvae illustrated elsewhere in animal model [76].

Exacerbations of inflammatory reactions during anthelmintic treatment emphasize the need of combination with corticosteroids.

### Strongyloidiasis

The filariform larvae can penetrate directly through the skin, invade the tissues, penetrate into the venous or lymphatic channels and are carried by the blood stream to the heart and then to the lungs. They pierce the pulmonary capillaries and enter the alveoli. These larvae, then, migrate to the bronchi, trachea, larynx and epiglottis and are swallowed back into the intestine. In the duodenum and jejunum, they develop into sexual forms to continue the life cycle [77].

During migration of filariform larvae through the lungs, bronchopneumonia and haemorrhages in the alveoli can occur. These areas are infiltrated with eosinophils. This is associated with elevated IgE and eosinophilia in the blood. The inflammation that follows such invasion of larvae leads to disseminated strongyloidiasis and this is usually fatal. It has been suggested that hyperinfection syndrome and disseminated strongyloidiasis can be distinguished from each other [78]. In hyperinfection syndrome, severe symptoms are referable to the organs usually involved in parasitic life cycle, the lung and the intestine. In this situation, the larval load is very high in faeces and sputum. In disseminated strongyloidiasis, there is widespread involvement of organs that are not ordinarily part of the life cycle [79]. Syndrome of inappropriate secretion of antidiuretic hormone [80] and pulmonary microcalcifications [81].

In the lung, massive pulmonary bleeding can occur due to alveolar microhaemorrhages. As a result of invasion of bacteria along with larvae, diffuse and patchy bronchopneumonia and pulmonary abscess can occur. Other risk factors include chronic lung disease, use of histamine blockers or chronic debilitating illness [82].

Strongyloidiasis is a chronic relapsing illness of mild to moderate severity characterised by gastrointestinal complaints (diarrhoea, pain, tenderness, nausea, vomiting), peripheral blood eosinophilia and hypoalbuminemia [83-84]. Cough, dyspnoea, wheezing and haemoptysis are frequent during lung involvement. Eosinophilic pleural effusion have been reported among pulmonary manifestations of strongyloidiasis; and rare cases of acute respiratory failure due to respiratory muscle paralysis have been observed [85]. In patients at high risk for strong yloidiasis, adult respiratory distress syndrome and septicemia due to intestinal transmural migration of bacteria can occur as a result of pulmonary hyperinfection or disseminated strongyloidiasis [86-89]. In addition, acute anemia, acute renal failure and systemic inflammatory response syndrome are also reported in hyperinfection [90]. Strongyloidiasis can manifest as eosinophilic pleural effusion in both immunocompetent and immune compromised individuals [91, 92]. Lung strongyloidiasis is commonly asymptomatic in immunocompetent individuals, or present with mild symptoms.

Exacerbations of chronic obstructive pulmonary disease [93] and worsening of symptoms in idiopathic pulmonary fibrosis [94] have also been reported in *Strongyloides stercoralis* infection. In disseminated disease, larvae and adult parasites can be seen in sputum, urine, bronchoalveolar lavage fluid and other body fluids as pulmonary secretions, duodenal juice, may be contributive for parasite identification [95, 96].

A serological test using enzyme immunoassay (EIA) for detection of antibodies to strongyloidiasis was found to have a sensitivity of 94.6% in patients with proven infection [97].

Physiopathologic events in *S. stercoralis* involving the lung are similar to those seen in ascariasis and correspond with the imaging findings: ill-defined, patchy, migratory airspace consolidation that typically resolves in 1-2 weeks. Hyperinfection syndrome can manifest with extensive pneumonia, alveolar hemorrhage, and ARDS. Although rare, a milary pattern has also been described. Pleural effusion and secondary superimposed bacterial infection with cavitation and abscess formation are not uncommon findings [98-101].

### Treatment

Thiabendazole (25 mg/kg, twice a day for two days), Albendazole (400 mg, twice a day/5 days), Ivermectine (200 microgr/kg for one

or two days) are recommended. As treatment with thiabendazole is effective only in about 70% of patients, it has to be repeated. In immunocompromised individuals with disseminated strong yloidiasis, the dose of thiabendazole has to be doubled and the duration of treatment may be several weeks. In addition, appropriate treatment of bacterial infection as a result of intestinal transmural migration of bacteria has to be instituted. A paradoxical therapeutic response of asthma to glucocorticosteroids, in which bronchial asthma symptoms worsened after treatment with parenteral corticosteroids, has been described in patients with *Strongyloides* super infections [102].

### Pulmonary ancylostomiasis

These larvae reach pulmonary circulation through the lymphatics and venules. The larvae then pierce the alveolar walls and ascend the bronchi, trachea, larynx and pharynx and are ultimately swallowed to reach the upper part of small intestine. The interval between the time of skin penetration and laying of eggs by adult worms is about six weeks. Bronchitis and bronchopneumonia can occur when the larvae break through the pulmonary capillaries to enter the alveolar spaces. The lung migration can elicit blood eosinophilia as for other larva migrans. Larvae release low molecular weight proteins with anticoagulant properties [103], favoring blood loss during the intestinal capillaries destruction. Anemia with iron deficiency is often associated with this infection. Chronic blood loss can result in iron deficiency anemia. Pulmonary larval migration can elicit peripheral blood eosinophilia. During pulmonary larval migration, patients may present with fever, cough, wheezing and transient pulmonary infiltrates in chest radiographs. This is associated with blood and pulmonary eosinophilia. Clinical, immunological and radiological manifestations of Loeffler's syndrome can be observed during larval migration through the lung. A polymerase chain reaction (PCR) to differentiate between *A. duodenale* and *N. americanus* has been developed. Stool examination may demonstrate the presence of eggs, blood samples may identify eosinophilia and iron deficient anemia [104].

### Treatment

Mebendazole is given as 100 mg twice daily for three days and albendazole is given as a single dose of 400 mg. Pyrantel pamoate at a dose of 11 mg/kg orally (maximum 1g) as a single dose has also been found to be useful. Recent studies have demonstrated that ivermectin can also be used in the treatment of hookworm infections as an alternative. Anemia can be treated with oral ferrous sulphate tablets.

### Tropical pulmonary eosinophilia (TPE)

Tropical pulmonary eosinophilia, one of the main causes of pulmonary eosinophilia in the tropical countries, is prevalent in filarial endemic regions of the world especially SouthEast Asia [105, 106].

TPE is caused by a type 1 hypersensitivity reaction to filarial antigens (*W. bancrofti* or *B. malayi*). It presents as an eosinophilic alveolitis with an airway component. With the passage of time, the presenting symptom is breathlessness on exertion and the lung shows a mixed cell reaction. Later on in untreated patients well-marked fibrosis occurs. Lung function shows increasing restriction. The peripheral eosinophilia may wane so that the end result may not be recognized as TPE unless the patient was observed in the early part of the natural history.

Tropical pulmonary eosinophilia, an occult form of filariasis, is endemic in the Indian subcontinent, SouthEast Asia and South Pacific islands. It has been estimated that at least 120 million persons are infected with mosquito-borne lymphatic filariasis worldwide [107]. The hypersensitivity reaction to filarial antigens induces a strong eosinophilic inflammatory response in the lungs. The microfilariae in lymphatics invade the pulmonary circulation and parenchyma with further granulomatous and fibrosing pattern. The concentration of eosinophils in the lung has been shown to be more significant than in the peripheral blood suggesting the compartmentalisation, and a prominent role of these cells in the pulmonary involvement and clinical manifestations [106].

Epidemiological data state a male predominance in TPE (sex ratio M/F; 4:1), a disease of children and young adult (15-40 yrs).

Tropical pulmonary eosinophilia (TPE) is characterized by cough, dyspnoea and nocturnal wheezing, diffuse reticulo-nodular infiltrates in chest radiographs and marked peripheral blood eosinophilia [108-109]. The syndrome results from immunologic hyperresponsiveness to human filarial parasites, *Wuchereria bancrofti* and *Brugia malayi*. TPE is seen in only less than 1% of filarial infections [110].

As the number of individuals traveling from filarial endemic areas to other parts of the world has increased tremendously, TPE is being increasingly reported from countries which are not endemic to filarial infection [111, 112].

Therefore, TPE should be considered in the differential diagnosis, if a patient traveling from a filarial endemic region presents with "asthma-like" symptoms. A positive filarial complement fixation test (FCFT) and a positive immediate reaction to intradermal skin tests with *Dirofilaria immitis* antigens have been reported in patients with TPE [113].

Histopathological examinations had demonstrated microfilariae in the lungs, liver and lymph nodes of patients with TPE [114, 115]. The microfilariae were sheathed and had the anatomical features of *Wuchereria bancrofti* [116].

Open lung biopsy studies have demonstrated that three types of histopathological reactions can be seen in TPE: (i) interstitial, peribronchial and perivascular exudates consisting of histiocytes in patients with a short duration of symptoms (less than three weeks), (ii) acute eosinophilic infiltrations of interstitial, peribronchial and perivascular tissues leading to the formation of eosinophilic abscesses and eosinophilic bronchopneumonia, and granuloma with foreign body type giant cells in those with 1-3 months of disease, and (iii) a mixed cell type of infiltration consisting of histiocytes, eosinophils and lymphocytes with well marked interstitial fibrosis after six months. A predominant histiocytic response developed two years after the onset of the disease and ultimately progressed to fibrosis with marked scarring. In the end stage, a picture resembling fibrosing alveolitis with honeycombing might develop in some cases, if untreated [117].

Lung biopsies after one month's treatment with diethylcarbamazine demonstrate incomplete histological regression, although symptoms subside within seven days of therapy and peripheral eosinophilia return to normal. Bronchoalveolar lavage (BAL) studies have demonstrated that TPE is characterised by intense eosinophilic inflammatory process in the lower respiratory tract.

Electron microscopic examination of lung eosinophils had shown marked alterations consisting of severe degranulation with loss of both the cores and the peripheral portions of the granules, suggesting that eosinophils were in an activated state.

The bronchospasm in TPE may result from leukotrienes released by the eosinophils. Patients with TPE show striking elevations of total IgE, IgG (Hypergammaglobulinemia) and filarial specific IgG, IgM and IgE antibodies in peripheral blood and lung epithelial lining fluid (ELF).

Bronchoalveolar lavage fluid of patients with TPE contains IgE antibodies that recognise *Brugia malayi* antigen, Bm23-25. Patients with TPE usually present with respiratory symptoms that include paroxysmal cough, breathlessness, and wheeze and chest pain. The symptoms occur predominantly at night, but can persist during the day. Severe cough can lead to fractured ribs. Sputum is usually scanty, viscous and mucoid. The sputum often shows clumps of eosinophils, and rarely Charcot-Leyden crystals are observed [115, 118].

Leucocytosis is common in TPE, with marked peripheral blood eosinophilia; and elevated erythrocyte sedimentation rate is often reported. Serological examinations may reveal high level of specific IgG or IgE antibodies to microfilariae. Stool examination is very important to determine co-infection with other helminths. The chest radiograph may show miliary nodules mimicking miliary

tuberculosis. Histopathological analysis of lung biopsies may illustrate microfilariae

### Treatment

Diethylcarbamazine (6 mg/kg/day for 3 weeks), a current treatment of filariasis, has been successfully indicated in patients with TPE.

Steroids have shown additional improvement of symptoms in TPE patients.

### Pulmonary dirofilariasis

Human dirofilariasis is increasingly been reported worldwide [119, 120]. Pulmonary dirofilariasis is a zoonotic infection caused by filarial nematodes, *Dirofilaria immitis* and *Dirofilaria repens*. Though the parasite has been named as "dog heart worm", there are evidences that *D. immitis* is a vascular parasite. Nearly 50% of the subjects infected with dirofilariasis are asymptomatic. Clinical symptoms are chest pain, cough, fever, haemoptysis and dyspnoea.

Humans are accidental hosts of this parasite which is transmitted to man by the mosquito. An immature adult worm unable to mature in the accidental human host can reach a peripheral vein and travel in the bloodstream until it lodges in a pulmonary vein [121, 122]. Once the parasite lodges in a pulmonary vein, an infarction can originate. Frequently, there are no symptoms, although cough, pain, and haemoptysis have been described on rare occasions. The parasites are usually seen in the pulmonary artery where they produce an embolism ultimately leading to the formation of a pulmonary nodule or "coin lesion". A solitary pulmonary nodule 3 cm or less in diameter is the most common radiologic finding [123, 124]. Serologic tests are available but are not very helpful. A PCR-based diagnosis of *D. repens* in human pulmonary dirofilariasis has been reported [125].

Definitive diagnosis is usually made at histopathologic analysis of the excised nodule and, sporadically, with aspiration of the nodule and demonstration of fragments of the parasite [126, 127].

Computed tomographic scan may show a well-defined nodule with smooth margin connected to an arterial branch [128]. Positron emission tomography (PET) scan can demonstrate hyper-metabolic activity in a pulmonary infarct secondary to dirofilariasis [129]. Thoracic imaging (TTDM) shows well delimited nodule neighbouring an arterial branch. Histopathological analysis of pulmonary biopsies is strongly contributive for the diagnosis of this disease lacking specific treatment.

A definitive histopathological diagnosis of pulmonary dirofilariasis can be made in tissue specimens obtained by wedge biopsy, videoassisted thoracoscopy or rarely by fine needle biopsy [130, 131].

There is no specific treatment for human dirofilariasis.

### Pulmonary trichinellosis

Man is infected after ingesting partially or cooked or raw meat, and the larvae develop in the gut into adult worms, when infected pig's muscle containing larval *trichinellae* is eaten by man.

Pulmonary symptoms include dyspnea due partially to the involvement of diaphragm, cough and pulmonary infiltrates [132].

Leucocytosis, eosinophilia and elevated levels of serum muscle enzymes (LDH enzyme) suggest muscle involvement (creatinine phosphokinase, lactate dehydrogenase, aldolase and amino transferase) are important laboratory findings.

An enzyme-linked immunosorbent assay (ELISA) for detection of anti-*Trichinella* antibodies using excretory/secretory antigens may be useful in the diagnosis of *T. spiralis* [133]. Elevated IgE level are depending on Th-2 cytokines released by TCD4 cells recruited by parasitic antigens.

A definitive diagnosis can be made by muscle biopsy. Larvae may be also identified in striated muscle biopsies (usually deltoid muscle) that may demonstrate larvae of *T. spiralis* [134].

## Treatment

Symptomatic treatment of trichinellosis includes analgesics and corticosteroids. Specific treatment is with mebendazole 200 to 400 mg three times a day for three days followed by 400 to 500 mg three times a day for 10 days. Albendazole can be given in a dosage of 400 mg per day for three days followed by 800 mg per day for 15 days.

## Cestodes

### Pulmonary hydatid disease

The parasite species that cause hydatid disease in man are *Echinococcus granulosus* and *Echinococcus multilocularis*. Hydatid cysts are formed mainly in the liver and lungs.

Pulmonary symptoms are non specific and resemble asthma manifestations. Pulmonary symptoms include cough, fever, dyspnea and chest pain. Signs and symptoms can occur due to compression of adjacent tissue by the cysts. Mechanical compression by hydatid cysts may influence clinical features. Rupture of Cysts in the bronchi could explain haemoptysis or excretion of cyst fluid containing parasite membrane, and may lead to anaphylaxis. Pneumothorax, pleural effusion, persistent pneumonia, sepsis and emphysema are possible lung presentation [135, 136]. Eosinophilia and elevated IgE levels are seen when the hydatid cyst ruptures [137].

Chest radiographs show solitary or multiple round opacities mimicking lung tumours [138]. Ultrasonography using a portable ultrasound scanner has been found as reliable, inexpensive and rapid technique in community-based screening surveys for cystic echinococcosis [139].

The crescent sign, Cumbo's sign (onion peel sign), water-lily sign and air-fluid level are seen on chest radiography and computed tomography (CT) [140]. Inverse crescent sign, signet ring sign and serpent sign are recognised as features of pulmonary hydatid cysts in computerized tomographic scans [141]. Serodiagnosis is helpful by detection of specific antibodies.

### Unilocular cystic echinococcosis

*E granulosus* is responsible for unilocular cystic echinococcosis. Thoracic involvement may occur via a transdiaphragmatic route (0.6%–16% of cases of hepatic disease) or by means of hematogenous spread. The former results from the migration of the parasite from the liver to the pleural cavity. Pulmonary parenchymal involvement and chronic bronchial fistula can also be found. Hematogenous dissemination directly to the lung can occur, the lung being the second most common site of involvement (after the liver) in adults (10%–30% of cases) and the most common site in children [142].

Infection remains asymptomatic for months to years. When affecting the lung, it may manifest with cough, hemoptysis, biliptysis, pneumothorax, pleuritis, lung abscess, parasitic pulmonary embolism, anaphylaxis secondary to cyst rupture, or cyst superinfection. Indirect hemagglutination and enzyme-linked immunosorbent assay (ELISA) tests in association with abdominal ultrasonography can be used as screening tools in high-risk populations. The most relevant radiographic and CT feature is the presence of cystic lesions, which can be solitary (60% of cases) or multiple, can be unilateral or bilateral (20%–50%), are predominantly found in the lower lobes (60%), and have a diameter between 1 and 20 cm. The coexistence of liver and lung disease is present in only 6% of patients. Uncomplicated cysts may be seen as round or oval masses that have well-defined borders, enhance after contrast material injection, and have a low-opacity or hypoattenuating content relative to the capsule. The "meniscus sign," or "crescent sign," which is characterized by the presence of air between the pericyst and the laminated membrane, appears as growth continues and the cysts erode adjacent bronchioles. Rupture can be associated with consolidation adjacent to the cyst. Radiographic and CT findings in transdiaphragmatic dissemination include pleural effusion, hemidiaphragm elevation, pulmonary consolidation, laminar basal atelectasis, pleural cysts, and, rarely, emphyema. Other less common thoracic manifestations of the disease

include invasion of the mediastinum, pericardium, chest wall, cardiovascular system, or inferior vena cava, the latter being associated on occasion with recurrent pulmonary embolism [143].

### Alveolar echinococcosis and polycystic echinococcosis

Less frequent than in unilocular cystic echinococcosis, results from metastatic dissemination or direct extension. Infection becomes symptomatic after 5–15 years secondary to local compression or dysfunction of the affected organ, usually the liver. Nonspecific signs and symptoms such as fatigue, weight loss, cough, and hemoptysis can be present. A mass of fibrous tissue containing several scattered cavities of widely varying diameters with necrotic areas is frequently seen, as are calcifications. Definitive diagnosis can be made with immunohistochemical and histologic analysis. Serologic tests are also available and are important for early detection of asymptomatic cases [144].

CT and magnetic resonance imaging are the imaging modalities of choice for better defining the location and extent of pulmonary disease, which invariably coexists with liver infection. Metastatic lung disease and chest wall compromise are commonly seen. Calcifications may develop as the disease progresses (33%–100% of cases). Secondary lung compromise by direct extension may mimic a lung cancer. A rare form of right atrial metastasis can cause recurrent episodes of pulmonary embolism.

Treatment of hydatid cyst is primarily surgical. Parenchyma preserving surgery (cystotomy alone or cystotomy and capitonnage) is the preferred treatment. Radical surgery including pneumonectomy, lobectomy and segmentectomy should be avoided. Pharmacotherapy with albendazole or mebendazole has also been found to be useful especially in recurrent and multiple cysts. The treatment of AE is radical surgical resection of the entire parasitic lesion. In inoperable cases, pharmacotherapy with mebendazole, albendazole or praziquantel is given continuously for many years [145].

## Trematodes

### Schistosomiasis

Pulmonary schistosomiasis can manifest clinically as an acute form and a chronic form. Pulmonary compromise is divided into early and late forms. Early pulmonary schistosomiasis (3–8 weeks after parasitic penetration) [146, 147], results from immunologic (type 3) reaction, in which eosinophils are sequestered in the lungs. Common clinical findings include shortness of breath, wheezing, and dry cough. The diagnosis is suggested in patients who live in or have traveled to endemic areas and who present with eosinophilia. Patients may have both clinical and radiologic manifestations after the onset of treatment.

In Katayama fever, pulmonary symptoms coincide with febrile illness, and this condition is thought to be an immunologic reaction to the parasite eggs [148]. Associated symptoms include urticaria, arthralgia, hepatosplenomegaly, hepatitis, eosinophilia, and pulmonary disease. Small nodular lesions with ill-defined borders or, less commonly, a reticulonodular pattern or bilateral diffuse areas of ground-glass increased opacity or hyperattenuation may be seen at radiography and CT. Asymptomatic cases that manifest with abnormal radiologic findings may also be seen, but their real prevalence is unknown.

Chronic pulmonary disease results from granulomatous (type 4) reaction to eggs deposited in the pulmonary vasculature, which leads to intimal fibrosis, pulmonary hypertension, and cor pulmonale. It is often preceded by liver involvement by portal hypertension, which allows the eggs to shunt from the portal system into the pulmonary vasculature. The clinical picture includes dyspnea, chest pain, fatigue, palpitations, cough, and, lately, right-sided heart failure [149]. Radiographic and CT findings are also consistent with these clinical findings and include cardiomegaly and pulmonary arterial enlargement. Diagnosis is made by identifying eggs in stool or urine samples or at rectal biopsy. Serologic tests are not very helpful because they cannot help differentiate a former infection from current disease [150–152].

Local inflammation occurs at the penetration site, while the onset of pulmonary manifestations may be acute or chronic. Pulmonary inflammatory reaction may induce a cytotoxic reaction to migrating agents, and facilitate the secretions of chemiotactic mediators for eosinophils, involved in the *schistosoma* immunity [153].

Diagnosis of chronic schistosomiasis is based on the demonstration of eggs in stool or urine by direct microscopy or rectal/bladder biopsy. Peripheral blood eosinophilia with mild leucocytosis, abnormal liver function test and elevated IgE levels are reported during this phase. Hepatosplenomegaly due to portal hypertension has been reported in patients infected with *S. mansoni* or *S. japonicum*.

#### Treatment

Acute schistosomiasis at presentation can be treated with corticosteroids alone followed by praziquantel (20-30 mg/kg orally in two doses within 12 hours). Praziquantel can be repeated several weeks later to eradicate the adult flukes. Artemether, an artemisinin derivative has also found to be useful in acute form as the drug has been found to act on juvenile forms of the schistosomes. Chronic schistosomiasis can also be treated with praziquantel with the same dosage [154].

#### Paragonimiasis

The food-borne zoonosis is more frequent in Asia, affecting ± 20 million people [153]. Subacute or chronic lung manifestations are described. The lung is the target organ, although cutaneous and cerebral paragonimiasis have also been described. The agent *Paragonimus westermani* lives in the lung, and eggs are eliminated in the sputum or faeces. Miracidia develop into cercariae in the snail before infecting the second intermediate host, the crabs. The man get infection after eating partially cooked or raw crabs. Clinical manifestations are not specific, and chest radiograph may demonstrate cavitations as in tuberculosis [155]. Patients present with fever, chest pain, and respiratory symptoms such as chronic cough and hemoptysis [156]. Pleural effusion or pneumothorax are frequently seen in paragonimiasis [157].

Computed tomographic scan may show single or multiple nodules in the lung parenchyma or pleura. *P. westermani* adult excretory-secretory products were composed of cysteine proteases and these molecules are involved in immunological events during infection [153]. Immunoglobulin G4 (IgG4) antibodies to an excretory-secretory product of *P. heterotremus* had accuracy, sensitivity, specificity and positive and negative predictive values of 97.6%, 100%, 96.9%, 90% and 100%, respectively [155]. Peripheral blood eosinophilia and elevated serum IgE levels are seen in more than 80% of patients with paragonimiasis [155].

Diagnosis is confirmed by detecting parasite eggs in the sputum, pleural fluid, or feces; in addition, larvae can often be found at bronchial brushing. Intradermal and serologic tests are also available. Tuberculosis is the main alternative in the differential diagnosis [156, 157].

Once the parasites get to the lung, patchy airspace consolidation can occur, a phenomenon that reflects the presence of an exudative or hemorrhagic pneumonia which can cavitate. Linear areas of increased opacity or hyperattenuation indicate peripheral atelectasis or worm migration. Worm cysts, whose diameters range from 0.5 to 1.5 cm, are better visualized after the consolidation resolves and manifest as either solitary or multiple nodules or gas-filled cysts depending on their content and their communication with the airway. Chest radiographic and CT findings include a ring shadow usually less than 3 mm thick and a crescent-shaped area of increased opacity or hyperattenuation within the cyst that represents worms attached to the wall [156, 160].

#### Treatment

Paragonimiasis can be treated with praziquantel (the first choice) (75 mg/kg/day for three days), bithionol (30 to 40 mg/kg in 10 days on alternate days), niclofolan (2 mg/kg as a single dose) or triclabendazole (20 mg/kg in two equal doses) [160].

#### CONFLICT OF INTERESTS

Declared None

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