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Medicine

PARASITES- A RED FLAG FOR THE FUTURE RESPIRATORY DISEASES

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ABSTRACT The parasites Ascaris lumbricoides, Ancylostoma duodenale, Necator americanus, Strongyloides stercoralis, Wuchereria bancrofti, Schistosoma haematobium, Schistosoma japonicum, Paragonimus westermani, Echinococcus granulosus, Echinococcus multilocular , Leishmania donovani, Plasmodium vivax, Plasmodium falciparum, and Toxoplasma gondii, are responsible for causing parasitic lung diseases. Ascaris lumbricoides and parasitic worms produce various like 2-methylbutanamide, which are thought to be related to the worm's carbohydrate metabolism. Intermediary metabolites like lactate, citrate, and succinate can change significantly during different stages of the parasitic worm's development. Biochemical research on diethyl succinate, conducted on human airway epithelial cells, studied the effect of hypoxia. The clinical presentation may be in the form of focal or cystic lesions, and pleural effusion. Many intestinal parasites consume glucose and secrete lactate as a byproduct of their metabolism. Some parasites can alter the host's glucose metabolism, leading to hypoglycemia and lactic acidosis. Specifically, they rely on glycolysis, a metabolic pathway that breaks down glucose into pyruvate, which is then converted to lactate. Excessive or abnormal levels of pyruvic acid or its derivatives, like lactic acid, can contribute to lung inflammation and damage.

KEYWORDS : Ascaris lumbricoides, Giardia lamblia, Entamoeba histolytica, Loeffler's syndrome, Tropical ulmonary eosinophilia, Parasites-pneumonia

INTRODUCTION

According to the World Health Organization, soil-transmitted helminth infections are estimated to affect 1.5 billion people globally, which accounts for approximately 24% of the world's population (1)

Common helminth infections of the gut include ascariasis, trichuriasis, strongyloidiasis, enterobiasis, and schistosomiasis (2).

Majorly intestinal-associated protozoan infections include cryptosporidiosis, cyclosporiasis, balantidiasis, giardiasis, and amebiasis (3)

Researchers have emphasized that common eukaryotic parasites colonize the intestine alongside bacterial gut microbiota (BGM).(4)

Intestinal helminths (multicellular worms) and protozoan parasites are responsible for the prevalent parasitic infections in developing countries.(5)

Acute schistosomiasis (Katayama fever) usually occurs among nonimmune travellers and is associated with fever, malaise, fatigue, headache, cough, abdominal pain, and urticarial rash. (6)

Although high morbidity and mortality due to intestinal parasites have been reported in endemic countries (especially in children). (7)

Intestinal parasites and parasitic secretions have been shown to stimulate and train the innate and adaptive immune regulatory pathways, modulating the immune responses (8)

TES is a type of hypersensitivity reaction to a few parasitic agents. The reaction is usually directed towards microfilaria of W. bancrofti and Brugia malayi.(9)

Schistosoma may cause an acute or a chronic pulmonary disease, or the lung could be involved in Katayama fever (10)

The gut microbiota probably impacts the manifestation and development of amebiasis through immunity (11)

Giardiasis can cause disaccharidase deficiency due to loss of absorptive surface and impair sodium-dependent D-glucose and water absorption, but can cause chloride hypersecretion(12)

Cryptosporidium affects the small bowel mucosa, but the distal jejunum and ileum are more severely affected. (13)

The trophozoites of E. histolytica compete with colonic microbiota and adhere to the colonic mucus layer through their galactose/galactose/N-acetyl-D-galactosamine (Gal/GalNAc) lectin (14)

Subsequently, they break the protective mucus layer through their various glycosidases, glycoside hydrolase β-amylase and cysteine proteinases (15)

E. histolytica causes dysbiosis in the human gut by feeding on preferred bacteria like Lactobacillus ruminus and SCFA-producing bacteria like Bifidobacterium longum. (16)

The pathogenicity of E. histolytica depends on the pathogen-associated molecular pattern of E. histolytica as well as the host's innate immune response to recognize and eliminate E. histolytica (17)

Ascaris lubricoides can block the biliary tree or pancreatic duct, causing cholangitis, cholecystitis, and pancreatitis (18)

The patient may also develop pneumonitis and eosinophilia (Loeffler syndrome) during the migration of larvae into the lungs (19).

Entamoeba histolytica, the most common extra-intestinal manifestation is an amebic liver abscess in 4% of patients with amebic colitis(20)

Intestinal parasitic infections have been shown to affect approximately 3.5 billion people worldwide and pose a significant health and economic burden on both a personal and global scale (21).

According to the WHO, soil-transmitted helminth infections are estimated to affect 1.5 billion people globally, which accounts for approximately 24% of the world's population (22)

Common helminth infections of the gut include ascariasis , trichuriasis, strongyloidiasis enterobiasis and schisto-somiasis (23,24)

Giardia Duodenalis

Giardia duodenalis (also known as Giardia lamblia or Giardia intestinalis) is a flagellate parasite that is a major cause of epidemic or sporadic diarrhoea worldwide. (25)

In the developed world, it is the most common cause of parasitic diarrhoea (26).

Giardia trophozoites damage the brush border epithelium, shorten the microvilli, and disrupt the epithelial barrier function (27)

Rarely can they cause intraepithelial lymphocytosis, crypt hyperplasia, and villous atrophy. There can be neutrophilic and eosinophilic infiltrates in the epithelial layer as well. All these changes lead to nutrient malabsorption, diarrhoea, and steatorrhea (28)

Giardiasis can cause disaccharidase deficiency due to loss of absorptive surface and impair sodium-dependent D-glucose and water absorption, but can cause chloride hypersecretion (29)

Blastocystis Hominis

Blastocystosis is the infection caused by Blastocystis spp. (previously called Blastocystis hominis). Blastocystis is a strict anaerobic enteric protozoan of unknown pathogenic potential. It is the most common protozoan in human fecal samples (30)

- It is widely distributed throughout the world, but the prevalence is much higher in developing countries (about 50%) than in developed countries (about 20%) (31)
- Blastocystis spp. is found chiefly adhered to the colonic epithelium (32).
- The protozoa produce cysteine proteases that break down the tight junction protein of epithelial cells, increasing intestinal permeability, degrading IgA, and inducing an inflammatory response in the colon (33)
- Blastocystis spp. can also activate complements, releasing anaphylatoxins which can activate mast cells and produce urticaria (34)

Entamoeba Histolytica

- Entamoeba histolytica is a protozoan that causes intestinal amebiasis as well as extraintestinal manifestations (35)
- The pathogenesis of infection by trophozoites is due to the adherence of colonic epithelial cells through a specific galactose-N-acetylgalactosamine lectin. Through the direct adherence of trophozoites to the colonic epithelial cells, the colonic epithelial cells die off through cytolysis and apoptosis, which results in the release of interleukin-1α and precursor interleukin-1β. IL-1β activates NF-κB in distal cells to produce cytokines and other inflammatory mediators such as COX-2, interleukin-1, and interleukin-8.
- Amoebic cysteine proteinases can also convert precursor IL-1β to active IL-1β, which can further facilitate the process. These cytokines and inflammatory mediators subsequently attract neutrophils and macrophages. Neutrophils can be damaged by direct contact with trophozoites, which can cause more damage to colonic epithelial cells, resulting in the release of more mediators. Macrophages release other mediators as well, such as TNFα, which further contributes to inflammation.(36)

The pathological range includes mucosal inflammation, thickening, ulcers, and necrosis, leading to perforation. Amoebic cysteine proteinases can also contribute to trophozoites' ability to suppress a host's immune response by being able to cleave and inactivate anaphylatoxins C3a, C5a, IgA, and IgG. Trophozoites can reach other areas of the body, most commonly the liver, which can cause tissue necrosis and abscess formation.(37)

Ascaris Lumbricoides

Ascaris lumbricoides is a nematode, or roundworm, that parasitizes the human gastrointestinal tract. Worldwide, ascariasis is among the most common helminthic human infections, with an estimated 800 million to 1.2 billion people infected. (38,39)

Ascariasis is considered one of the "neglected tropical diseases." (40)

The fact that A. lumbricoides can produce copious numbers of eggs that can survive extreme environmental conditions has made it one of the most prevalent and geographically well-distributed parasitic worms in impoverished socioeconomic regions across the world (41)

In the United States, the occurrence of ascariasis is attributed to immigration from, and travel outside the country to, areas with high prevalence of infection. However, the southeastern region of the United States, due to its temperate, humid climate, has the highest burden of the disease (42)

Trichuris Trichiura,

It is also known as the human whipworm, is a roundworm that causes trichuriasis in humans. It is referred to as the whipworm because it looks like a whip with wide handles at the posterior end. The whipworm has a narrow anterior esophagus and a thick posterior anus.

Some recent studies show that people with certain chromosome traits may be predisposed or have increased susceptibility to acquiring trichuriasis.(43)

Ancylostoma Duodenale

It is a parasitic, blood-feeding nematode that primarily inhabits the small intestine of its host, typically birds or mammals (44)

A. duodenale causes ancylostomiasis, which primarily results in iron-deficiency anaemia, protein malnutrition, impaired cognitive development, stunted growth, and low physical fitness, especially in children (45).

Immunity--

Immunology in Entamoeba Histolytica

Histolytica trophozoites secrete potent chemokines, such as IL-8, resulting in immune cell recruitment (51)

Neutrophils are activated by interferon gamma (IFN-gamma) (52,53)

Depletion of neutrophils with anti-Gr-1 antibodies resulted in exacerbated intestinal disease in murine models, supporting the protective role of neutrophils in amebiasis (54)

Macrophages also play a crucial role in the host response against intestinal amebiasis (55,56)

Several amebic antigens are known to activate these cells via pattern recognition receptors. Entamoeba. Histolytica triggers pro-inflammatory cytokine production via NF-kB activation. Macrophages that lack TLR2 and TLR-4 displayed impaired response to Entamoeba. Histolytica (57,58)

Additionally, Entamoeba histolytica DNA can activate macrophages through interacting with TLR-9 39 Amebicidal activity of macrophages is contributed to by the production of nitric oxide (NO) from L-arginine, which is mediated by macrophage nitric oxide synthase (59,60)

Immunology in Ascaris Lumbricoides

A partial immunity may be acquired by man, induced by the larvae, and produce protective antibodies which lower the worm burden and play a part in the immune response.Specific antibodies can be demonstrated in Ascaris lumbricoides infection. Hypersensitivity to Ascaris is demonstrated by skin test (61)

Immunology in Schistosoma Haematobium

Mouse models have been used extensively to investigate the protective immune response to schistosome infection, primarily with S. mansoni as the infecting species (62)

A single exposure to attenuated cercariae induces partial protection, primarily associated with the production of IFN-γ. Treatment of infected mice with praziquantel confers similar levels of resistance to reinfection (63)

4. Immunology in Parasitic Infections

It has long been recognized that parasite infections are often accompanied by blood eosinophilia. It is due to the immunological process. It is highly common in intestinal roundworms. Including tropical eosinophilia and hydatid disease. In these conditions, there is ample opportunity for prolonged absorption of antigenic materials from the parasites, which can give rise to hypersensitivity reactions

Metabolites

E. Histolytica

Studies have shown that the host microbiota shapes virulence and stress adaptation in E. histolytica. Increasing evidence suggests that metabolites from the microbiota mediate communication between the parasite and the microbiota (64)

Increasing evidences support the role of SCFAs, which are exclusively produced by the gut microbiota from the catabolism of carbohydrates of dietary origin in the regulation of global histone acetylation and methylation in the host (65)

SCFA has a direct effect on E. histolytica by promoting its encystation

By consuming SCFA-producing flora, the parasite may control its entry into encystation through a modulation of its HDAC. It is important to note that SCFA has the opposite effect on the encystation of Entamoeba invadens, a reptile parasite (66)

The abundances of SCFA depend on the composition of the microbiota, with the dominant SCFA-producing bacteria being Faecalibacterium prausnitzii and Roseburia intestinalis(67)

Butyrate, another SCFA, inhibits HDACs by binding to $Zn^{+2,}$ which is located in their active site. Gut microbiota dysbiosis is associated with many intestinal and extra-intestinal disorders, including bowel disease, metabolic syndrome, obesity, cardiovascular disease, and neurodegenerative disorders(68)

Loeffler's Syndrome

The initial syndrome was associated with pulmonary infiltrates and peripheral eosinophilia as a result of transbronchial migration of Ascaris species

Additionally, the syndrome may result from a hypersensitivity reaction to the transient parasitic immigration into the lungs. It is also known as simple pulmonary eosinophilia, as it lacks pulmonary symptoms or is only associated with mild symptoms (69)

It is characterised by a transient pulmonary infiltrate that spontaneously resolves within 2–4 weeks. Patients may have peripheral eosinophilia, severe bronchospasm, fatigue, and fever (70).

The major causes of Loeffler's syndrome are Ascaris lumbricoides, Ancylostoma duodenale, Necator americanus, and Strongyloides stercoralis.A special form of Loeffler's syndrome is caused by S. stercoralis in immunocompromised patients, such as those on steroid treatment with superinfection (71)

Tropical Pulmonary Eosinophilia

TES is a type of hypersensitivity reaction to a few parasitic agents. The reaction is usually directed towards microfilaria of W. bancrofti and Brugia malayi.

Cutaneous Larva Migrans

It manifests as an erythematous, serpiginous, pruritic cutaneous eruption caused by accidental percutaneous penetration and subsequent migration of larvae of various nematode parasites. Cutaneous larva migrans is most commonly found in tropical and subtropical geographic areas and the southwestern United States. (72).

Pulmonary Schistosomiasis

Acute and chronic schistosomiasis result in nodular pulmonary lesions, and the disease is likely related to eggs laid by adult worms during their migration in the chronic phase. In addition, the pulmonary nodules formed during Katayama fever (syndrome) are secondary to a systemic immune-allergic reaction. The distinction between acute and chronic schistosomiasis is based on an arbitrary cut-off time frame of 10–12 weeks from the time of exposure (73)

Today's Research, Tomorrow's Innovation

The complex relationship between parasitic infections and lung cancer. Notably, a study detected Toxoplasma gondii DNA in 100% of lung tissue samples from 72 lung cancer patients, with active parasite stages observed in 95.8% of cases, suggesting a potential association between T. gondii infection and lung cancer development.

Parasites-pneumonia

Parasites such as Paragonimus westermani (lung fluke) can cause paragonimiasis, presenting with chronic cough, fever, hemoptysis, and radiographic features mimicking bacterial pneumonia or tuberculosis. Migratory parasites like Ascaris lumbricoides and Strongyloides stercoralis may induce eosinophilic pneumonia during their pulmonary migration (Löffler's syndrome). In immunocompromised patients, Strongyloides can cause severe, disseminated pneumonia (hyperinfection syndrome) with high mortality. Recognizing parasitic causes is crucial in endemic areas or patients with eosinophilia and atypical pneumonia presentations.

Parasites-lung Fibrosis

Parasitic infections can contribute to pulmonary fibrosis

through direct tissue invasion and immune-mediated inflammation. For instance, Schistosoma species can induce granulomatous lung inflammation, leading to fibrosis and pulmonary hypertension, a condition known as bilharzial pulmonale. Similarly, Paragonimus westermani infections may result in chronic lung inflammation and fibrosis, mimicking tuberculosis. Additionally, tropical pulmonary eosinophilia, caused by filarial infections, can lead to interstitial fibrosis if not treated promptly. These findings underscore the importance of considering parasitic infections in the differential diagnosis of interstitial lung diseases, especially in endemic regions or among travellers

Acute Lung Injury in Malaria

Malaria is an important treatable cause of acute lung injury (ALI) and acute respiratory distress syndrome (ARDS) in the tropics and the returning traveller in non-endemic areas. Increased alveolar capillary permeability, resulting in intravascular fluid loss into the lungs, appears to be the key pathophysiologic mechanism. Patients present with an acute onset of dyspnoea that can rapidly progress to respiratory failure.(74)

Human Pulmonary Dirofilariasis (HPD)

It is a rare zoonotic disease caused by Dirofilaria immitis, the nematode responsible for canine cardiopulmonary dirofilariasis (dog heartworm). Most patients are asymptomatic and present with an incidental pulmonary nodule that mimics primary or metastatic pulmonary malignancy. Some patients suffer from pulmonary and systemic symptoms in the acute phase of pneumonitis caused by pulmonary arterial occlusion by the preadult worms, resulting in pulmonary infarction and intense inflammation. These patients may have an ill-defined pulmonary infiltrate on chest radiology. Pulmonary nodules represent the result of initial pneumonitis(75)

Parasites--Reflection of Facts

Parasitic Lung Disease as a Mimicker of Malignancy or TB

Parasitic pulmonary lesions—especially hydatid cysts or paragonimiasis—can mimic radiologic findings of lung tumors or tuberculosis, often leading to misdiagnosis and inappropriate treatments.

Parasitic Infections in Immunosuppressed Hosts

Strongyloides hyper infection syndrome can be life-threatening in immunocompromised individuals (e.g., corticosteroid use or transplant recipients) and presents as severe pulmonary haemorrhage or ARDS.

Reactivation of Latent Parasitic Infections Post-COVID or Post-Steroid Therapy

Post-COVID steroid therapy has been linked to reactivation of dormant parasitic infections (especially Strongyloides), underlining the need for pre-emptive screening in endemic areas.

Drug Resistance in Parasites and Its Impact on Lung Disease

Rising resistance to albendazole and ivermectin in parasitic populations (e.g., Strongyloides, Ascaris) could result in chronic pulmonary manifestations due to prolonged larval migration.

Airborne Transmission Risk of Parasitic Spores

Though traditionally faecal-oral or vector-borne, emerging hypotheses suggest that Cryptosporidium oocysts and certain protozoal cysts might be aerosolized in immunocompromised hospital settings.

Autoimmune-like Pulmonary Responses Triggered by Parasites

Some parasites stimulate autoantibody production (e.g., antinuclear antibodies), leading to misdiagnosis as autoimmune ILD, especially in patients with mixed eosinophilic patterns.

Parasites as Triggers for Chronic Airway Inflammation

Chronic exposure to parasitic antigens may sensitize airways, increasing susceptibility to asthma and airway hyperresponsiveness through persistent Th2 skewing.

Pulmonary Hypertension Due to Parasitic Emboli

Schistosomiasis and filarial infections can lead to obliterative pulmonary vascular disease and severe pulmonary hypertension—often irreversible and underdiagnosed.

Parasitic Antigens in BAL Fluid as Diagnostic Clues

PCR and antigen-detection assays on BAL samples can detect parasite DNA/proteins (e.g., Strongyloides, Paragonimus), allowing non-invasive diagnosis of unexplained eosinophilic pneumonitis.

Eosinophilic Exudative Pleural Effusions in Parasitosis

Parasitic pleural effusions are often misattributed to malignancy or TB. High eosinophil count in pleural fluid should prompt evaluation for helminths, especially in endemic regions.

Epigenetic Modulation of Host Lung Cells by Parasites

Parasites like *E. histolytica* and *Toxoplasma* can modulate host histone acetylation, impacting gene expression in alveolar epithelial cells—potentially influencing fibrotic responses.

Parasitic Components as Immunotherapy Targets or Adjuvants

Parasitic molecules (e.g., helminth-derived IL-10 mimetics) are being explored as immunomodulators for treating asthma, COPD, and even cancer, highlighting their double-edged role.

Zoonotic Parasites and Occupational Lung Risks

Vets, abattoir workers, and pet handlers are at risk for pulmonary zoonoses (e.g., hydatid disease, toxocariasis), necessitating occupational health protocols and serologic screening.

Exhaled Volatile Organic Compounds (VOCs) as Biomarkers

Emerging breath omics research shows that parasites release unique VOCs—potentially allowing early, non-invasive diagnosis of parasitic lung diseases via breath analysis.

Coinfections with Respiratory Viruses and Parasites

Parasitic infections may modulate ACE2 or TMPRSS2 expression in the respiratory tract, potentially enhancing viral replication (e.g., SARS-CoV-2), thus compounding disease severity.

Biofilm-like Colonies in Lung Parenchyma

Some helminths and protozoa can form protective biofilm-like matrices in tissues, resisting immune clearance and contributing to chronic granulomatous lung inflammation.

Parasitic Induction of Lung Microbiome Dysbiosis

Emerging evidence shows that parasites disrupt local lung microbiota—altering bacterial-fungal balance and contributing to secondary infections or immune dysregulation.

Increased Risk of Parasitic Pneumonias Post-Bariatric Surgery

Altered gut immunity and micronutrient deficiency post-bariatric surgery can predispose to severe parasitic infections, including disseminated strongyloidiasis affecting the lungs.

Parasitic Associations with Interstitial Lung Disease (ILD)

Paragonimus and Strongyloides have been linked with chronic interstitial patterns on HRCT—mimicking NSIP or chronic eosinophilic pneumonia, but responding differently to steroids.

Environmental Change–Driven Emergence of Novel Pulmonary Parasites

Climate change and urbanization are shifting vector patterns, introducing previously unknown lung parasites (e.g., *Angiostrongylus*, *Gnathostoma*) into new geographic areas.

Diagnostic Tests

1. Imaging:

- Chest X-ray/CT scan:
- Transient or migratory infiltrates (Löffler's syndrome)
- Cystic lesions (hydatid)
- Cavitations (paragonimiasis)
- Diffuse nodular/reticulonodular opacities (TPE)

2. Laboratory:

- Peripheral blood eosinophilia (often pronounced)
- Elevated IgE levels
- Stool exam: ova/larvae (e.g., Ascaris, Strongyloides)
- Sputum exam: larvae or eggs (Paragonimus, Strongyloides)
- Serology (ELISA, IFA): useful for Echinococcus, Paragonimus, Toxocara
- BAL fluid: may show eosinophils or larvae
- PCR/antigen tests: in specialized settings

Treatment

1. Antiparasitic therapy (based on organism):

- Albendazole – for Echinococcus, Ascaris, Toxocara
- Ivermectin – for Strongyloides, filariasis
- Praziquantel – for Paragonimus, Schistosoma
- Diethylcarbamazine (DEC) – for tropical pulmonary eosinophilia (TPE)

CONCLUSION

Parasites can cause a variety of lung diseases, ranging from asymptomatic conditions to severe life life-threatening infections. The most common manifestation is unexplained radiological abnormalities, often with or without solitary pulmonary nodules. Symptoms can include coughing, fever, shortness of breath, and rapid breathing. Some parasitic lung diseases, like Löffler's syndrome, can be triggered by the body's reaction to the parasites or mechanical damage to the lungs.

Parasitic diseases of the lung are caused by various types of parasites, including nematodes, trematodes, and protozoa. These gut parasites release metabolites. These metabolites cause pulmonary disease. Pulmonary and pleural amebiasis is an uncommon disease, usually occurring on the right side of the lung compared to the left side, and rarely causes respiratory failure. The most common manifestations involve radiographic abnormalities, with the possible occurrence of solitary pulmonary nodules. The clinical presentation may be in the form of focal or cystic lesions, pleural effusion, or diffuse pulmonary infiltrates.

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