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Leishmaniasis in humans and small animals: Updates and insights through a one health

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Abstract

Leishmaniasis is neglected infectious disease caused by a type of microscopic parasite called *Leishmania spp*. This disease can affect both humans and animals, as well as sandflies. There are more than 90 species of sandflies that can transmit Leishmania parasites, with Lutzomyia being the primary transmitter in the Americas and Phlebotomus being the primary transmitter elsewhere. The disease, prevalent in tropical and subtropical regions, including southern Europe, poses a significant global health concern due to increasing outbreaks spurred by climate change and heightened human and animal mobility. Leishmaniasis is categorized into three main forms: cutaneous, visceral (kala-azar), and mucocutaneous. These forms vary in clinical presentation, ranging from skin lesions to severe systemic involvement of internal organs and mucosal damage. The treatment of leishmaniasis is complex and depends on factors such as the disease type, parasite species, geographic region, and the host's health status. This review adopts a One Health approach, integrating human, animal, and environmental perspectives to provide a comprehensive update on leishmaniasis. It synthesizes recent advances in understanding the epidemiology, clinical manifestations, diagnostic techniques, and treatment strategies of cutaneous, mucocutaneous, and visceral leishmaniasis in humans and small animals. Understanding interconnection between animals and humans requires a holistic approach such as One Health perspective. This framework emphasizes the need for coordinated research, innovative treatments, and integrated prevention strategies to combat its growing global burden.

1. Introduction

Parasitic diseases remain a major global health issue affecting billions of people worldwide (Ikeogu et al. 2020). Leishmaniasis is an infectious illness caused by a type of microscopic parasite from the *Trypanosomatidae* family (Gambino and Otero 2021). It is transmitted by a vector and can cause cutaneous, mucocutaneous, and visceral symptoms. The disease is complex and can be caused by multiple subspecies, leading to confusion even among experts (Mann et al. 2021). Visceral leishmaniasis (VL), also known as kala-azar, represents the most severe form of the disease, while cutaneous leishmaniasis (CL) is the most frequently encountered (Pradhan et al. 2022). Visceral leishmaniasis was first documented in India in 1903 by William Leishman and Charles Donovan, working independently (Dutta 2008). The parasite *Leishmania infantum*, also referred to as *Leishmania chagasi*, is the primary causative agent of visceral leishmaniasis, transmitted by sandflies of the *Phlebotomus* and *Lutzomyia* genera (Macedo-Silva et al. 2014).

***Fig. 1**: Sand fly (Phlebotomus) (Bilgic-Temel et al. 2019)*

The prevalence of the disease is increasing among individuals with compromised immune systems, such as those who have undergone bone marrow or organ transplants, or have received treatment with biologic drugs. Additionally, an increasing number of cases of cutaneous disease have been observed in military troops deployed to endemic areas or in people who travel to those areas (Antinori, Schifanella et al. 2012). In the last decade, significant scientific advancements have been made in the treatment, diagnosis, and prevention of leishmaniasis (Georgiadou et al. 2015). This review aims to provide an updated synthesis of the current knowledge on leishmaniasis, focusing on its epidemiology, clinical manifestations, diagnostic methods, and treatment options in both humans and animals. By adopting a One Health perspective, this review also explores the role of zoonotic reservoirs and environmental factors in the disease's transmission and highlights key areas for future research to mitigate its growing global burden.

2. Epidemiology of Leishmaniasis

This ailment can affect various species, including dogs, cats (less frequently), humans, rodents, wild canids, horses, and marsupials. Additionally, there have been instances of travel-related infections in non-endemic regions across the globe (Sykes 2022). Leishmaniasis is traditionally categorized into two major syndromes based on their geographic distribution - Old World leishmaniasis and New World leishmaniasis. Old World leishmaniasis is comprised of two distinct clinical forms: cutaneous leishmaniasis (CL) and visceral leishmaniasis (VL). This type of leishmaniasis is prevalent in certain parts of Asia, the Middle East, Africa (mainly in tropical regions and North Africa), and southern Europe, but it is not found in Australia or the Pacific Islands. Cutaneous leishmaniasis and mucocutaneous leishmaniasis are the primary clinical forms of New World leishmaniasis (WHO 2010; Kobets et al. 2012). This illness is found in specific areas of Mexico, Central America, and South America, but it is not present in Chile and Uruguay (Inceboz 2019).

Epidemics of leishmaniasis pose a significant public health challenge, particularly where environmental, socioeconomic, and health factors intersect to create ideal conditions for the spread of the disease (Negera et al. 2008; Oryan and Akbari 2016). Epidemics have been reported across endemic areas of Europe (Carrillo et al. 2013), South Asia (Azian et al. 2016), East Africa (Ngure et al. 2009; Jones and Welburn 2021), and Latin America (Silveira et al. 2002; Vélez et al. 2012) and have been triggered by situations such as population displacement due to war, deforestation, urbanization, and ineffective vector control measures (Alawieh et al. 2014). For instance, during refugee crises in Sudan and Syria, leishmaniasis outbreaks surged due to overcrowding, poor sanitation, and the collapse of healthcare infrastructure (Alawieh et al. 2014). Climate change has also emerged as a significant driver of outbreaks, with rising temperatures and changed rainfall patterns causing the expansion of sandfly habitats into new, previously unprotected territories, such as Argentina and Algeria (Salomón et al. 2012; Saadene et al. 2023). Such outbreaks have a disproportionate effect on marginalized and immunocompromised populations, demonstrating the imperative for improved surveillance systems, diagnostic and therapeutic tools, and coordinated control strategies. Addressing the root causes and drivers of outbreaks, the global health community can better prepare and respond to leishmaniasis as an emerging public health crisis (Palatnik-de-Sousa and Day 2011; Ruiz-Postigo et al. 2020). An outbreak of cutaneous leishmaniasis has been reported in Afghanistan and Pakistan, while India and Sudan are experiencing an outbreaks of visceral leishmaniasis (Murray et al. 2005).

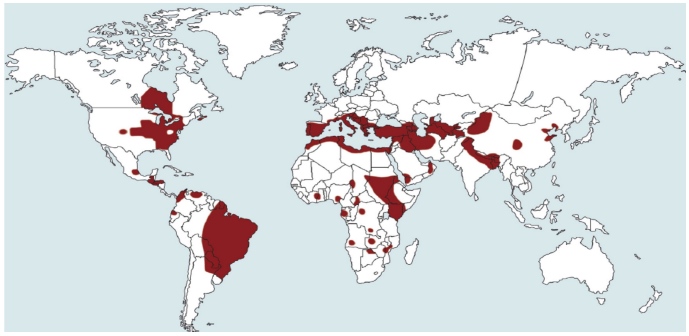

***Fig. 2**: The illustration shows the worldwide spread of visceral leishmaniasis in both humans and dogs (Sykes 2022)*

Leishmania spp. can infect around 70 different animal species, including humans, who serve as the natural reservoir hosts (Esteva et al. 2017). Several factors, including the type of parasite and sand fly, local ecological conditions, human exposure, and behavior, can significantly impact the epidemiology of leishmaniasis. The main way Leishmania parasites are transmitted is through the bites of infected female phlebotomine sand flies (Cecílio et al. 2022). These sand flies get the parasite by feeding on the blood of an infected animal or person, which they then take in as an amastigote into their digestive tract. Upon ingestion, the amastigote changes into a promastigote in the sand fly's digestive tract, and is later transmitted to a susceptible host during the fly's next feeding. After being ingested by sand flies, the promastigote form of *Leishmania spp.* infects the host's macrophages and transforms into amastigotes (Kaye et al. 2020). Sand flies are most active during the hours of twilight, evening, and night. Because of their limited flying capabilities, sand flies tend to stay near their breeding areas and remain close to the ground. Although sand flies are less active during the hottest parts of the day, they may still bite if disturbed, such as when a person accidentally comes into contact with their resting sites, like the trunk of a tree. Sand flies often go unnoticed by people due to their small size (about a quarter the size of mosquitoes), lack of noticeable sound, and typically painless bites.

Certain species of Leishmania parasites can be transmitted through contaminated needles or blood transfusions. Additionally,

***Fig. 3**: The geographical distribution of the primary Leishmania species and their main reservoirs (Abadías-Granado et al. 2021)*

there have been reports of congenital transmission from pregnant women to their babies (Boehme et al. 2006). People at high risk for leishmaniasis include travelers, ecotourists, soldiers, ornithologists, and field epidemiologists who are exposed to areas where the disease is common (Magill 2005).

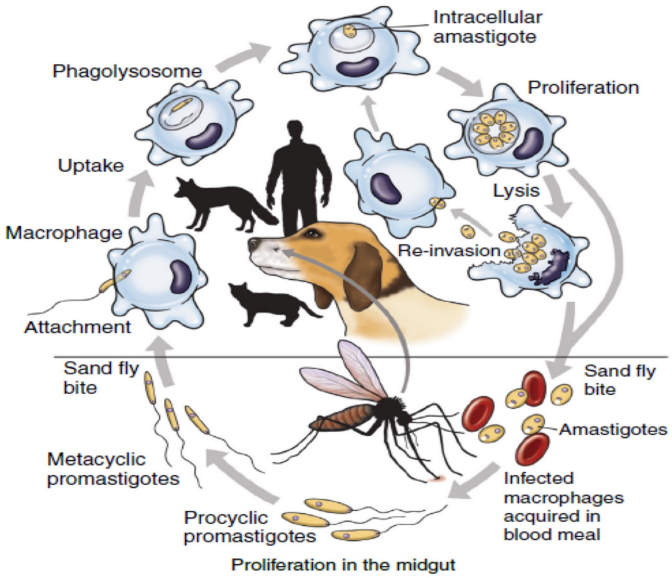

***Fig. 4**: Leishmania infantum undergoes a specific life cycle. When bitten by a sand fly, dogs, cats, and humans can become infected with this parasite (Sykes 2022)*

3. Primary risk factors for leishmaniasis

The impact of climate change can lead to the spread of leishmaniasis into regions that were previously unaffected. Variations in temperature, rainfall, and humidity can have a significant impact on the number of vectors and reservoir hosts by influencing where they are found, their ability to survive, and their population size. Moreover, droughts, famines, and floods can result in the substantial movement and relocation of people to regions with a high risk of Leishmania transmission. Inadequate nutrition during these events could also weaken individuals' immune systems (Ready 2008; Dereure et al. 2009).

Canine leishmaniasis is a widespread zoonotic disease caused by *Leishmania infantum*, with its prevalence varying significantly across endemic regions. A pooled global prevalence of 15.2% (95% CI 13.6–16.9), with higher rates observed in rural dogs (19.5%) and owned dogs (16.5%) (Priolo et al. 2024). Inadequate housing and unhygienic conditions, such as the absence of proper waste disposal or open sewage systems, can encourage the proliferation of sand fly breeding and resting areas, as well as their proximity to humans. Participating in certain human activities, like sleeping outdoors or on the ground, can increase the chances of being bitten by sand flies (Hewawasam et al. 2020). The combination of Leishmania, HIV, and transmission among drug users can result in a rise in the number of cases in countries where drug abuse is prevalent (Alvar et al. 2008; Lindoso et al. 2016; Cunha et al. 2020). This is especially concerning in areas where the diseases are already prevalent and there is no effective vaccine available. Additionally, the problem may worsen due to climate change leading to the spread of the diseases to new areas.

4. Clinical Manifestations and Pathogenesis

While some people may have asymptomatic infections, those who show clinical symptoms of leishmaniasis may display one or more of the three forms described below. Cutaneous leishmaniasis is the most prevalent form of leishmaniasis, identified by the appearance of skin lesions, particularly ulcers. These ulcers resemble a volcano, with raised edges and a central crater, and typically occur on the exposed areas of the body (Ayele and Seyoum 2016; Bilgic-Temel et al. 2019). In severe instances, the presence of these lesions can result in permanent scarring, leading to significant impairment or social stigma. The incubation period for cutaneous leishmaniasis can vary from two weeks to several months, with rare cases even reporting an incubation period of up to three years. Around 95% of cases are detected in regions such as the Americas, the Mediterranean, the Middle East, and Central Asia (Salman et al. 1999).

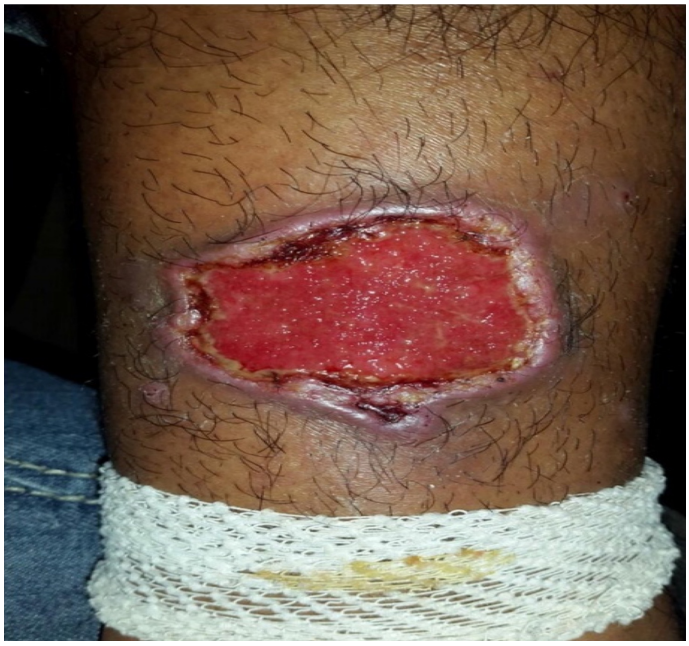

***Fig. 5**: The image depicts a typical arm ulcer in a patient with L. panamensis, which is indicative of cutaneous leishmaniasis (Mann et al. 2021)*

***Fig. 6**: Dogs with leishmaniasis may exhibit alopecic cutaneous lesions. Image A shows a neutered male husky mix, 8 years old, with leishmaniasis, presenting periocular alopecia and crusting. This dog was examined in northern California and had a history of traveling to Spain. The dog also had lesions on its muzzle and ears. Image B depicts a standard exfoliative facial dermatitis with hair loss at the tips of the ears (Sykes 2022).*

Mucocutaneous leishmaniasis Also referred to as espundia, is characterized by an incubation period of 1-3 months (Marsden 1986). However, it is important to note that this form of the disease can manifest years after the initial healing of a cutaneous ulcer. Mucocutaneous leishmaniasis can result in partial or total harm to the mucous membranes in the nose, mouth, and throat. In severe instances, it can cause eating difficulties and raise the risk of secondary infections, which can result in substantial mortality. Over 90% of cases of mucocutaneous leishmaniasis are documented in Bolivia, Brazil, Ethiopia, and Peru (Aghakhani et al. 2023).

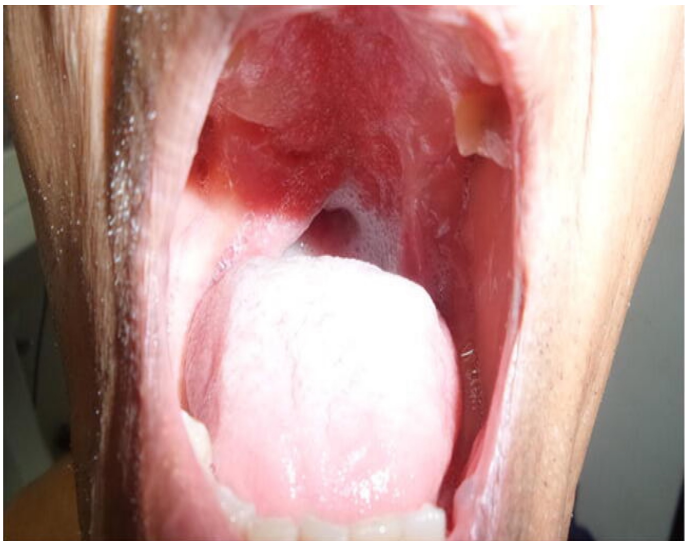

***Fig. 7**: The picture shows a patient with mucocutaneous leishmaniasis caused by L. panamensis infection (Mann et al. 2021)*

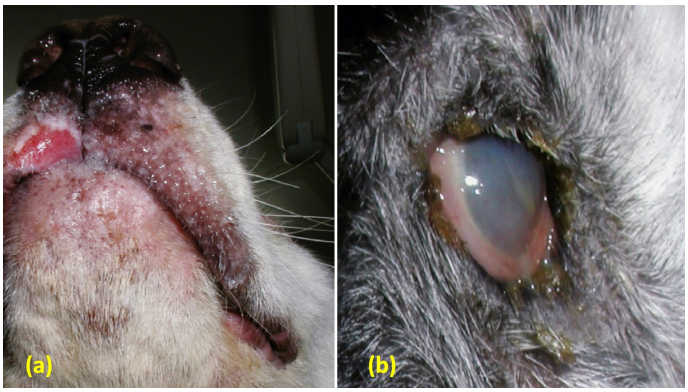

***Fig. 8**: (a) A dog with leishmaniosis is experiencing damage to the mucocutaneous tissues, resulting in ulcers forming. (b) A dog suffering from leishmaniosis is exhibiting inflammation of the conjunctiva and the uvea in the eye (Sykes 2022)*

Visceral leishmaniasis, also referred to as kala-azar, is a disease with an incubation period that typically ranges from 3 to 8 months (Manson-Bahr et al. 1963). The disease is characterized by recurring episodes of fever, weight loss, and anemia, along with hepatosplenomegaly (enlargement of the spleen, often more pronounced than the liver). Skin pigmentation may also occur, which is why the disease is referred to as "kala-azar," meaning "black disease." Most cases of visceral leishmaniasis are reported in Brazil, East Africa, and India. If left untreated, this form of leishmaniasis is fatal in over 95% of cases (Piscopo and Mallia 2006). Post-kala-azar dermal

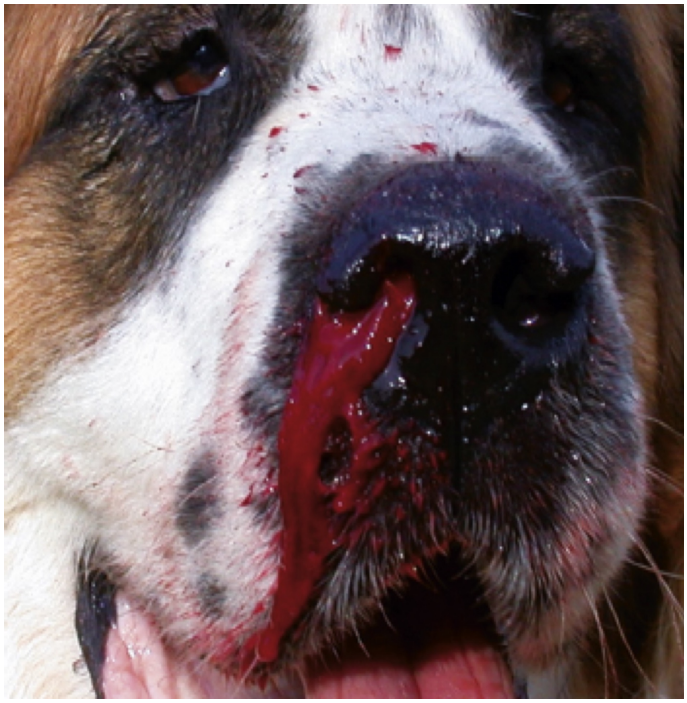

***Fig. 9**: A St. Bernard dog with leishmaniasis is experiencing epistaxis (nosebleed) despite the absence of dermal lesions (Sykes 2022)*

leishmaniasis (PKDL) commonly occurs as a consequence of visceral leishmaniasis. PKDL manifests as a rash that can take the form of flat spots (macules), raised lesions (papules), or solid bumps (nodules). The rash primarily affects the face, upper arms, and trunk, although it can also involve other areas of the body (Zijlstra et al. 2003; Kumar et al. 2021). PKDL is primarily found in East Africa and the Indian subcontinent. It affects approximately 5-10% of people who have kala-azar. This condition is generally associated with being infected by the specific cluster of *L. donovani*. It can appear anytime between 1 month to several years after someone appears to have recovered from kala-azar. It is crucial to understand that individuals with PKDL are regarded as potential carriers of Leishmania infection (Ghosh et al. 2021).

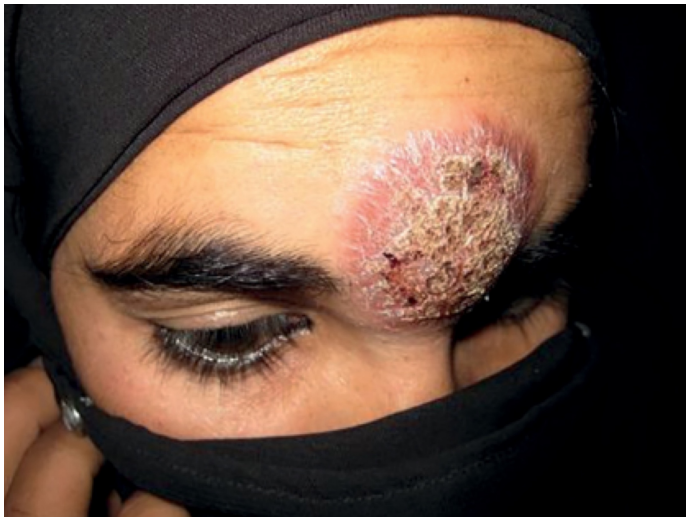

***Fig. 10**: The patient is suffering from a highly debilitating skin lesion resulting from post-kala-azar dermal leishmaniasis (Burza et al. 2018)*

Prominent clinical indications of leishmaniasis in dogs encompass weight loss, decreased appetite, scaling and/or ulcerative non-itchy skin lesions, excessively long nails, inflammation of the cornea and conjunctiva, inflammation of the uvea, swollen lymph nodes, enlarged liver and spleen, pale appearance, lameness, and signs of kidney failure (Sykes 2022).

5. Diagnosis of Leishmaniasis

Diagnosing leishmaniasis can be challenging, especially in low-resource areas. It requires direct parasitological or indirect immunological methods, though these are not always accessible. Clinicians must rely on patient history, travel to endemic areas, and symptoms. A painless sore on the face or limbs may suggest cutaneous leishmaniasis, while persistent fever, fatigue, weight loss, anemia, and an enlarged liver or spleen in individuals from visceral leishmaniasis-endemic regions could indicate infection. These symptoms may also overlap with conditions like HIV, tuberculosis, or cancer, making prompt medical evaluation crucial (Mann et al. 2021). To diagnose visceral leishmaniasis, a combination of clinical symptoms and tests involving the detection of parasites or antibodies in the body are employed. Serological tests have limited usefulness in diagnosing cutaneous and mucocutaneous leishmaniasis. Diagnosis of these conditions is primarily based on clinical signs and symptoms, as well as parasitological tests to confirm the presence of the parasite. Microscopic examination or the utilization of serological and molecular tests can be employed to analyze tissue samples taken from bone marrow (for visceral leishmaniasis) or skin sores (for cutaneous leishmaniasis) in order to detect the presence of the parasite. In some cases, the parasite can be grown in the laboratory from tissue samples that appear parasite-free when observed under a microscope. This can be achieved by using specialized media like Novy, McNeal, Nicolle (NNN) medium, or by introducing the samples into experimental animals like mice or hamsters (Romero et al. 2001; de Vries et al. 2015; Reimão et al. 2020). Maia et al reported that: The *rK39* protein is the best choice for efficient serodiagnosis of VL, whether implemented through a strip test or an ELISA, followed by DAT (Maia et al. 2012).

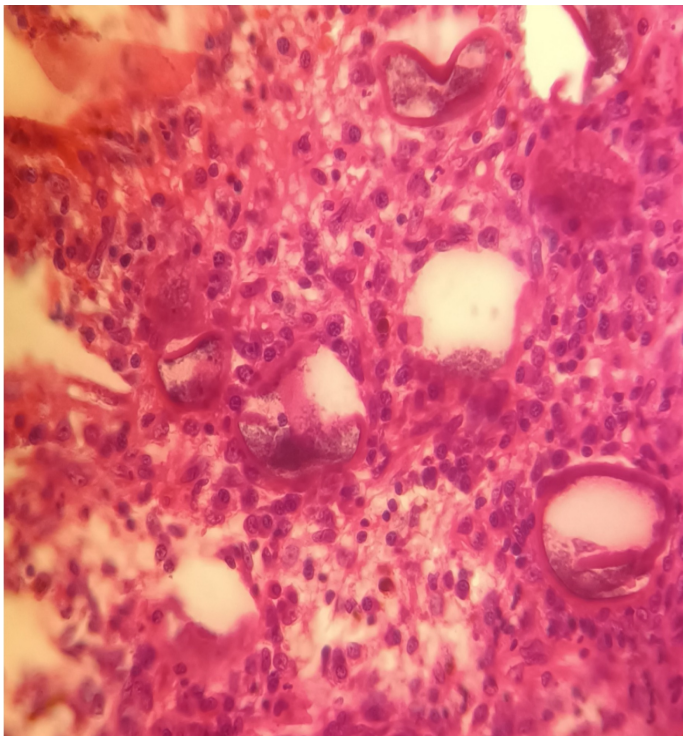

***Fig. 11**: Histopathological image of Cutaneous leishmaniasis showing infiltration of inflammatory cells, primarily histiocytes and plasma cells. An oval Leishmania amastigote can be seen in the center of the image, existing inside a macrophage (H&E X 400)*

There are several other potential illnesses that could be the cause of systemic disease in dogs, including conditions like canine monocytic ehrlichiosis, babesiosis, histoplasmosis, brucellosis, hemic neoplasia, other metastatic neoplasms, and primary autoimmune diseases such as systemic lupus erythematosus. Possible causes of skin lesions in dogs include demodectic mange, pyoderma, Malassezia dermatitis, cutaneous vasculitis, and pemphigus foliaceus. The potential causes of skin lesions in cats may include cutaneous neoplasia, cutaneous vasculitis, herpes viral dermatitis, and dermatophytosis. When it comes to American tegumentary leishmaniosis, the primary differential diagnosis is sporotrichosis (Sykes 2022).

6. Treatment and Control Strategies

The treatment approach for leishmaniasis can vary based on several factors, including the type of disease, concurrent health conditions, parasite species, and geographic location. In many instances, the skin sores resulting from cutaneous leishmaniasis can heal without treatment, although this process may take several months or even years and could result in noticeable scarring (Berman 1997). If left untreated, cutaneous leishmaniasis can progress to the mucocutaneous form of the disease. This can lead to the appearance of sores in the mucous membranes of the mouth, nose, or throat, as the infection spreads from the skin. However, timely and appropriate treatment for the cutaneous form of the disease can help prevent the development of mucosal leishmaniasis. In contrast to cutaneous leishmaniasis, mucosal leishmaniasis does not resolve on its own and can result in ongoing destruction, disfigurement, and potentially death, often due to aspiration pneumonia or respiratory obstruction (Mann et al. 2021). Patients diagnosed with visceral leishmaniasis need immediate and comprehensive treatment, as severe cases of this disease are usually fatal if not treated (El Hajj et al. 2018). While leishmaniasis can be treated and cured, it is important to note that medication cannot completely eliminate the parasite from the body. This means that there is a possibility of the disease reoccurring, especially in cases where the immune system is weakened. The treatment of canine leishmaniosis is less effective compared to human leishmaniosis, and it is uncommon for all Leishmania organisms to be eradicated using the currently available medications (Baneth and Shaw 2002; Noli and Auxilia 2005). For many years, pentavalent antimonials have been the main medication used to treat leishmaniosis in both dogs and humans. These drugs specifically target the enzymes in the parasite that are necessary for glycolysis and fatty acid oxidation. The primary antimonial used to treat dogs is meglumine antimoniate. The suggested amount of this medication to be taken is between 75 and 100 mg per kilogram per day, administered subcutaneously for a duration of 4 to 8 weeks. However, there is a risk of developing skin cellulitis or abscesses at the injection site, and it also has the potential to cause kidney damage (Sykes 2022). There are new and promising treatments for leishmaniasis that are gaining attention. These include miltefosine for cutaneous leishmaniasis, paromomycin for visceral leishmaniasis, and a combination of drugs for treating leishmaniasis (Antinori et al. 2012). Singh and Sivakumar (2004) have identified miltefosine as the most

effective drug for treating Leishmaniasis. This compound, which belongs to the alkylphosphocholine group and was originally developed as an anticancer drug, has undergone both experimental and clinical trials and has shown an efficacy rate of 94% to 97%. Although this medication can be effective, it is not recommended for use during pregnancy and may cause significant gastrointestinal side effects. Additionally, the cost of the medication may pose a barrier to its use (Singh and Sivakumar 2004). These medications have some disadvantages including their high toxicity, need for administration through injection, and most importantly, the development of resistance in certain parasite strains (Registre, Soares et al. 2023). There have been reports of *L. infantum* strains in France, Spain, and Italy developing resistance to pentavalent antimonials, which is a significant concern for both veterinary and public health purposes (Carrió et al. 2001; Gradoni et al. 2003). PCR testing for species identification can guide therapy for cutaneous disease patients at risk of ML (Mann et al. 2021). It is essential to carefully observe patients who have been successfully treated for any clinical manifestation of leishmaniasis, in order to detect any potential signs of recurrence. If a recurrence occurs, it is recommended to undergo repeated treatment, typically using liposomal amphotericin B. Additionally, longer treatment durations should be considered (Aronson et al. 2017). Unfortunately, drug resistance testing is not easily accessible commercially, and it is generally not recommended to undergo repeat biopsies and serological testing. Nanoparticles containing drugs are also utilized in the management of Leishmaniasis (Registre et al. 2023). The most commonly used and highly effective treatment for the leishmaniasis in dogs is a combination of meglumine antimoniate and allopurinol. The treatment plan consists of administering the combination therapy for a period of 4 to 8 weeks, followed by the use of allopurinol alone for at least 12 months. When dogs are seriously ill, particularly if they have severe renal failure, it may be necessary to first correct any fluid and acid-base imbalances before administering antileishmanial medications. The prognosis of leishmaniosis is determined by the extent of damage to the dog's body systems at the time of diagnosis, as well as the individual response and progression of the disease (Sykes 2022). The prognosis for leishmaniasis can differ based on different factors and can range from mild to severe, depending on variables such as the type of leishmaniasis, the person's immune system, overall health, and prompt diagnosis and treatment. Canine leishmaniosis (CanL) is a long-lasting and possibly life-threatening illness. The outlook for CanL is determined by the seriousness of the symptoms and clinicopathological irregularities observed in the dog when diagnosed (Pereira et al. 2020).

Successful control and eradication of cutaneous and visceral leishmaniasis face many challenges. The disease is still endemic in poverty-stricken and war-torn areas. Leishmania is unique among parasites in that it can be grown easily in cell-free media. The simplicity of cultivation, along with the use of killed parasites as skin-test antigens (known as leishmanin) for human diagnosis over the past several decades, has led scientists to explore the use of killed parasites as vaccines or for immunotherapy, either alone or with adjuvants (Modabber 1995). Numerous research studies have concentrated on creating vaccines for Leishmania, which can effectively manage the infection it causes. In most human cases, natural infection typically results in strong immunity. In dogs, first generation vaccines like *Leishmune*® and *CaniLeish*® have shown to provide strong protective immunity. Recombinant vaccines, such as *Leish-F1*, may provide a level of protection against natural Leishmania infection in humans. Another promising vaccine, the ChAd63-KH DNA vaccine, has recently demonstrated effectiveness in preventing Leishmania infection. However, additional evaluation is needed for this vaccine in other clinical trials (Moafi et al. 2019). To prevent and manage leishmaniasis, a combination of intervention strategies is necessary. Vector control programs are essential in reducing or interrupting the transmission of the parasite by targeting sand flies. Measures to control leishmaniasis include insecticide spraying, the use of nets treated with insecticide, environmental management, and personal protection for individuals living in areas where the disease is endemic. In areas where sand flies are typically found indoors after feeding (known as endophilic), spraying insecticide inside homes is an effective way to reduce the risk

Table 1 Comprehensive treatment methods for treating Leishmaniasis in both humans and small animals

Treatment	Description	Species	Efficacy	Side effects	Key points
Miltefosine	Oral antileishmanial drug	Humans, Dogs	High (94-97% cure in humans, 90-95% in dogs)	Gastrointestinal issues, hepatotoxicity	First-line oral medication
Amphotericin B	Antifungal that binds to parasite cell membranes	Humans, Dogs	Very effective (90-98% cure in humans, 80-90% in dogs)	Fever, chills, nephrotoxicity (improved with liposomal formulation)	Available as a less toxic liposomal formulation
Paromomycin	Aminoglycoside antibiotic	Humans, Dogs	Good (85-90% cure in humans, 70-80% in dogs)	Ototoxicity, nephrotoxicity, injection site pain	Used topically and systemically
Pentavalent Antimonials	Metal compounds affecting parasite metabolism	Humans, Dogs	Generally effective (80-90% cure in humans, 70-80% in dogs)	Cardiotoxicity, liver issues	Traditional first-line treatment in some regions
Allopurinol	Inhibits parasite nucleic acid synthesis	Dogs	Moderate (60-70% improvement)	Renal issues, hypersensitivity	Often used with other drugs
Domperidone	Dopamine antagonist with immune-boosting effects	Dogs	Variable	Gastrointestinal problems, potential hormonal effects	Used to enhance immune response
Liposomal Amphotericin B	Encapsulated form of Amphotericin B	Humans	High efficacy	Reduced nephrotoxicity compared to standard form	Preferred for severe cases
Topical Treatments	Creams/ointments with antileishmanial drugs	Humans	Effective for cutaneous leishmaniasis	Local irritation	Useful for localized skin lesions
Combination Therapy	Using two or more drugs together	Humans, Dogs	Improved outcomes	Depends on drugs used	Reduces resistance and improves efficacy

of contracting cutaneous leishmaniasis (González et al. 2015). When engaging in outdoor activities, it is recommended to minimize exposed skin and use suitable insect repellent. Efficient disease surveillance is vital for monitoring and responding to epidemics. Early diagnosis and treatment can greatly decrease the disease's prevalence, prevent disabilities and deaths, and aid in monitoring the disease's impact. Treating patients successfully, especially those with PKDL, in regions where anthroponotic transmission is prevalent (such as India), has proven effective in controlling parasite transmission (Kumar et al. 2023).

7. One Health Perspective in Leishmaniasis

The One Health philosophy emphasizes the interrelatedness of human, animal, and environmental Health for the sake of effective disease control, and as such, is particularly applicable to zoonotic diseases such as leishmaniasis. For example, successful Brazilian case studies have emphasized the synergy between veterinary and human health interventions, whereby simultaneous public health campaigns, such as dog culling, vaccination, and the use of insecticides, heavily decreased visceral leishmaniasis in endemic regions (Hong et al. 2020; Rupasinghe et al. 2022; Cosma et al. 2024). Human and canine case spatial mapping has also assisted in identifying high-risk areas, allowing for targeted interventions like vector control using insecticides, public education campaigns, and enhanced diagnostic efforts (Bueno et al. 2016; Su et al. 2019). These efforts highlight the imperative contribution of cooperative approaches to lowering the disease burden among animals and humans.

Domestic dogs and wild animals like rodents and foxes are the key zoonotic reservoirs responsible for maintaining the leishmaniasis transmission cycle. Dogs serve as the main reservoirs of Leishmania infantum, which they transmit to humans through sandflies (Hong et al. 2020; Alcover et al. 2021). Surveillance and monitoring systems like molecular diagnostic tools and marking infected animals have effectively detected high-risk animal populations (Cosma et al. 2024). Mass dog vaccination programs have been experimented with in nations such as Brazil and Iran, with initial success in decreasing disease rates in human and animal reservoirs (Palatnik-de-Sousa et al. 2009). Animal health drives, including treatment regimens in infected animals and involving insecticide-impregnated collars in dogs, have shown potential in reducing zoonotic transmission (Marcondes and Day 2019; Morales-Yuste et al. 2022). Veterinary-human health collaborations continue to be invaluable in responding to the load of zoonotic reservoirs through cost-efficient, sustainable measures (Alemayehu and Alemayehu 2017). Climate change introduces an added layer of complexity to the control of leishmaniasis, affecting the density and distribution of sandfly vectors. Increased humidity, temperature rise, and environmental changes have promoted the migration of significant vectors, especially Phlebotomus species, to non-endemic areas (Ready 2008). Southern Europe, for instance, has seen the northward expansion of leishmaniasis, primarily due to climate changes that promote vector breeding (Morillas-Márquez et al. 2010). Evidence from recent research also underscores the link between urbanization and leishmaniasis outbreaks through habitat encroachment and ecosystem modification (Costa 2008). Environmental and ecological data-driven predictive models are being used increasingly to project future disease spread and develop region-based response plans (Artun 2019; Rupasinghe et al. 2022). These models highlight the necessity of integrating climate-resilient interventions into One Health approaches for more accurate forecasting and prevention of leishmaniasis outbreaks in susceptible areas.

8. Conclusion and future perspective

Leishmaniasis is a complex infection that often requires potentially toxic treatments or expensive drugs with fewer side effects. Nevertheless, the introduction of newer oral agents has the potential to revolutionize the management of this disease. When immunosuppression is present, there is a risk of relapse, and it is necessary to administer secondary prophylaxis to prevent it. Over the last few years, a number of techniques and tools have been created to detect, measure, and recognize the parasite belonging to the genus Leishmania. Although there have been significant advancements in these methods, which have improved the accuracy and precision of leishmaniasis diagnosis, there are still some challenges that need to be addressed. Thanks to advancements in vaccine development, diagnosis, reporting, and treatment, it is now feasible to prevent substantial illness and death caused by this disease.

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