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MINISYMPOSIUM: PEDIATRIC INFECTIOUS DISEASE IN LATIN AMERICA

Contribution of imaging in the diagnosis of three neglected diseases in the Southern Cone: Leishmaniasis, Dengue, and Chikungunya

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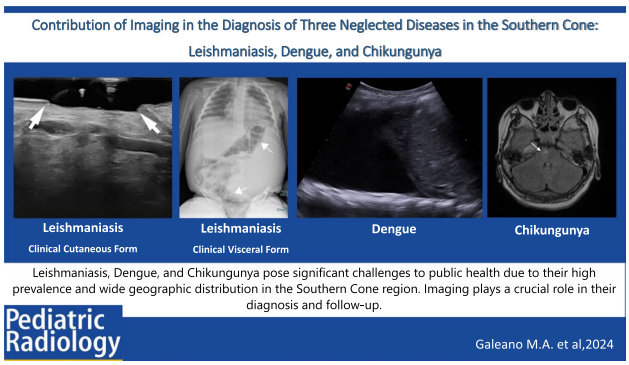
Abstract

Neglected diseases such as leishmaniasis, dengue, and chikungunya pose significant challenges to public health due to their high prevalence and wide geographic distribution in the Southern Cone region. These diseases are transmitted through insect bites, which serve as natural reservoirs. While their imaging findings are not always conclusive, they can play a crucial role in the diagnosis and monitoring. This review provides a concise overview of the clinical manifestations, epidemiological context, and imaging findings associated with these diseases. The primary purpose of this article is to share our experience and offer valuable insights into the use of imaging for the diagnosis and monitoring of patients suspected to have these diseases.

Graphical Abstract



Keywords Chikungunya · Children · Dengue · Leishmaniasis · Ultrasound · Pediatric · Latin America

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Introduction

Neglected diseases such as leishmaniasis, dengue, and chikungunya pose a significant challenge to public health due to their high prevalence, wide geographic distribution, and profound impact on overall well-being in the Southern Cone region. These diseases are transmitted through vectors, with sandflies being responsible for transmitting leishmaniasis, and *Aedes* genus mosquitoes transmitting dengue and chikungunya. The importance of addressing neglected diseases like leishmaniasis, dengue, and chikungunya is underscored by their disproportionate impact on vulnerable populations living in tropical and subtropical regions. These diseases tend to affect the poorest communities, exacerbating existing health disparities and hindering socio-economic development in these areas [1]. The use of imaging in this context not only facilitates decision-making regarding treatment in endemic areas but also enables the referral of patients to more specialized health centers for the evaluation of potential acute and late complications.

Leishmaniasis

The Pan American Health Organization (PAHO) has documented a total of 1,105,545 cases of cutaneous and mucosal leishmaniasis in the region of the Americas from 2001 to 2021. On average, approximately 50,000 new cases are reported to PAHO each year [1]. This disease is transmitted through a zoonotic cycle, with dogs, hares, or rodents acting as reservoir hosts while humans serve as incidental hosts [2, 3]. In the Americas, dipterans of the *Phlebotomus* species, belonging to the *Lutzomyia* genus, serve as responsible vectors. Their larvae are commonly found in soil or decomposing organic matter near residential areas [1, 4]. The causative parasites are protozoa of the *Leishmania* genus, with 22 identified species in the Americas [2], whose life cycle includes two morphological forms: the non-flagellated amastigote and the flagellated promastigote [3, 5, 6]. Children without prior exposure and immunity to *Leishmania* can manifest all clinical forms of leishmaniasis [6, 7]. In the initial stage, macrophages phagocytize the parasites and accumulate in the dermis. The infection can present as cutaneous, mucosal, mucocutaneous, or visceral lesions, depending on the species of *Leishmania* [4, 8]. The diversity of clinical presentations may stem from differences in parasite virulence, other inherent traits, and variations in the host immune response [9].

Clinical cutaneous forms

After inoculation, an erythematous lesion develops, which progresses into a growing papule that enlarges and develops into a plaque-like lesion ultimately undergoing central ulceration with raised and hardened margins, thus defining the characteristic lesion of *localized* cutaneous leishmaniasis [2, 8, 10, 11] (Fig. 1). Occasionally, these lesions can evolve into chronic forms such as diffuse cutaneous leishmaniasis, characterized by acneiform, nodular, papular, or ulcerative lesions [8, 10, 12]. Another chronic form is disseminated leishmaniasis (DL), which is characterized by multiple nodules and papules infiltrating the dermal layers of the body, loaded with parasites without affecting the mucosa [2, 10, 11, 13].

Mucocutaneous leishmaniasis primarily affects the upper airway and can potentially cause partial or total destruction of the nasal lining. Less frequently, it may also affect the oral cavity, mouth, and throat, and even more rarely, the anal region [10, 14, 15]. This disease is highly disfiguring and poses a potential life-threatening risk [2, 11, 14] (Fig. 2).

Purely lymphatic manifestations (lymphatic leishmaniasis) have been documented in children [16].

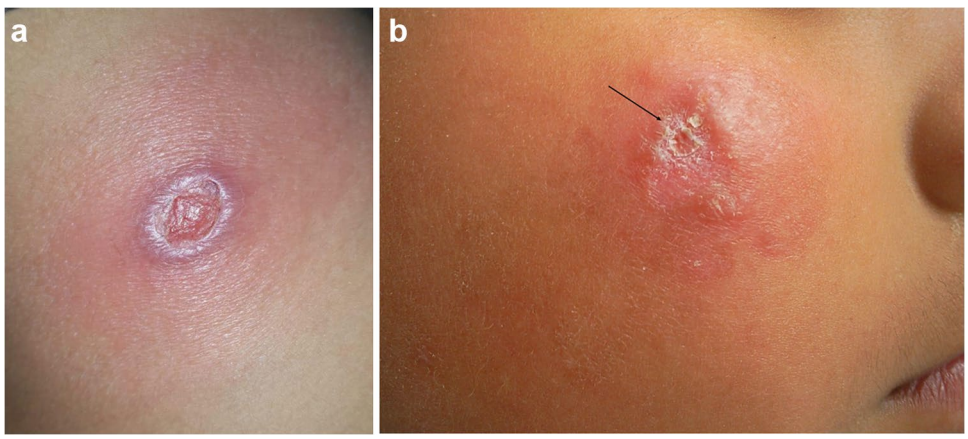

Fig. 1 A 2-year-old boy with leishmaniasis skin lesions in different locations. **a** Indurated lesion on the right lateral back tissues, characterized by a violaceous plaque and a central ulcer with raised, hardened edges. **b** Another characteristic lesion on the right cheek of this child, displaying a red plaque with a hyperkeratotic surface and central ulcer with raised edges. A scab can be observed within the ulcerated area (*arrow*)

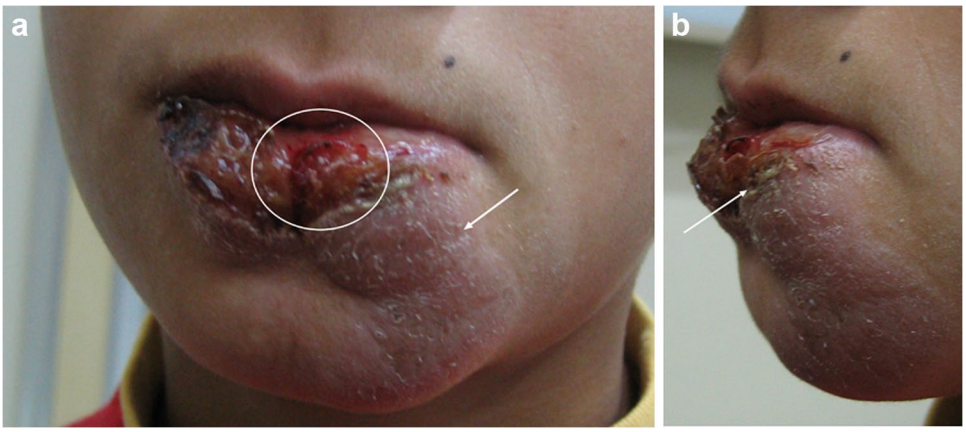

Fig. 2 A 12-year-old boy with mucocutaneous leishmaniasis involving the lip and chin. **a** The lesion on the lip and chin is characterized by a mucocutaneous granulomatous base that is indurated, erythematous, and with hyperpigmented edges (*arrow*). In the center, an ulcer is observed, causing partial destruction of the labial mucosa (*white circle*). **b** In the profile photograph, a depression at the mucocutaneous junction is visible, which is covered by a very painful scab (*arrow*)

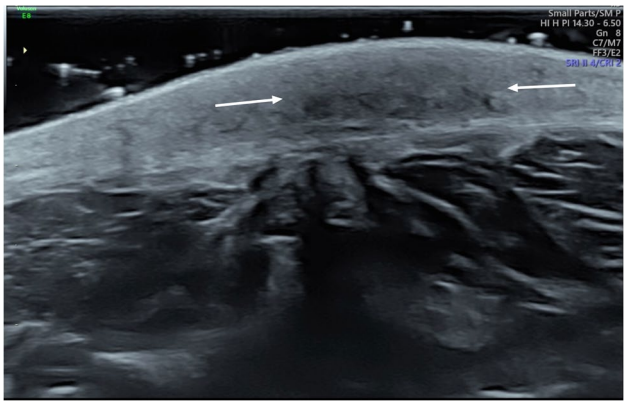

Fig. 3 A 10-year-old boy with cutaneous leishmaniasis on the right thigh. Transverse ultrasound image obtained with a high-frequency linear transducer (56 Hz) shows relatively focal, heterogeneous, predominantly hypoechoic dermal-hypodermal thickening (*between arrows*)

Imaging evaluation

Although there are no specific imaging findings for this clinical form, ultrasound can play an important role in diagnostic support and patients' monitoring [17].

High-frequency ultrasound, with a minimum frequency of 15 MHz, allows for the visualization of superficial layers of the skin [18]. In the case of localized cutaneous leishmaniasis lesions, ultrasound provides important information such as the location, extent, echotexture, lesion edges, hypodermal involvement, and vascular pattern [17].

In our experience, we have observed certain ultrasound characteristics. These include a thickened, irregular, hypoechoic dermis; non-ulcerated plaques or nodules; hypodermal inflammation with diffusely increased echogenicity (Fig. 3); a heterogeneous dermoepidermal junction; and the identification of panniculitis with increased vascular

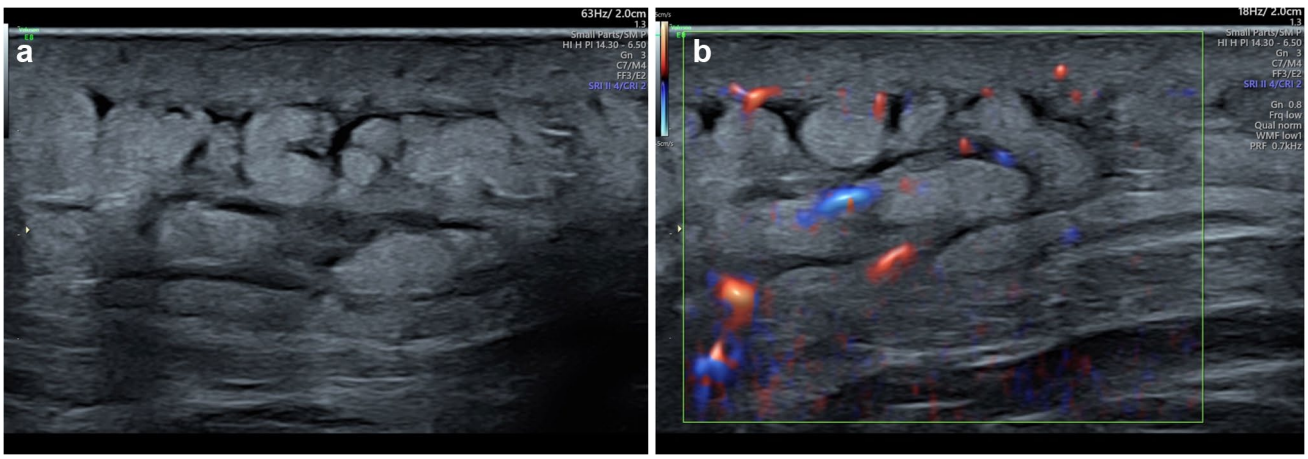

Fig. 4 A 14-year-old child with localized cutaneous leishmaniasis of the left leg. Ultrasound images obtained using a high-frequency linear transducer. **a** Transverse ultrasound image shows thickening, increased echogenicity, and cobblestoning of the hypodermis consistent with panniculitis. **b** Corresponding color Doppler image in longitudinal plane shows increased vascularity

flow (Fig. 4). Two common lesion patterns have been described in the literature for *localized cutaneous* leishmaniasis, which we have also observed in our patients: the inflammatory pattern, characterized by a lesion of mixed, heterogeneous echogenicity with poorly defined borders, increased vascularity, the presence of ulcerations, and granulation tissue with raised edges (Fig. 5), and the pauci-inflammatory pattern, which exhibits well-defined lesions of decreased echogenicity and reduced or absent vascularity [17] (Fig. 6).

Radiography, specifically paranasal sinus radiographs, may be useful in advanced cases of mucocutaneous lesions affecting the upper airway in mucocutaneous leishmaniasis [12] and can reveal erosion or loss of the nasal septum.

Clinical visceral form

After inoculation, approximately 50% of children will develop the active form of the disease within 2 to 8 months [5, 8]. The disease spreads through the reticuloendothelial system or other organs, leading to immunosuppression. Common symptoms associated with this form of the disease include fever of unknown origin, anemia, bleeding due to thrombocytopenia, weight loss, abdominal distension or pain, night sweats, and hepatosplenomegaly [18–20]. Normocytic and normochromic anemia due to hemolysis can occur. Other possible findings include leukopenia, eosinopenia, or absence of eosinophils, thrombocytopenia, and hypergammaglobulinemia [19]. The parasites have a strong

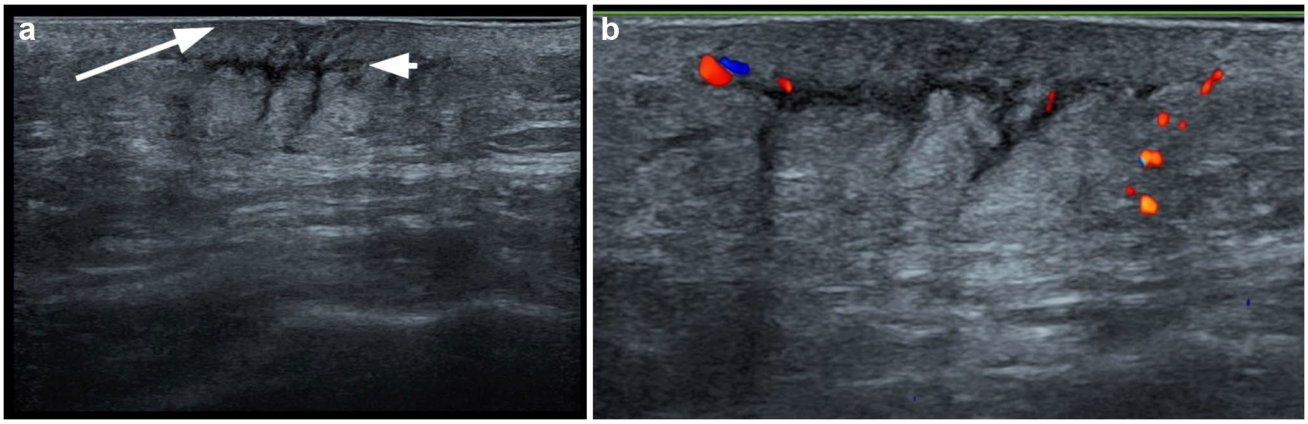

Fig. 5 Ultrasound performed with a high-frequency linear transducer in a 9-year-old patient with cutaneous leishmaniasis located in the anterior portion of the left thigh. **a** Longitudinal US image shows thickening of the dermis (*long arrow*) and hypodermis (*short arrow*) with poorly defined borders with heterogeneous echotexture and cobblestoning. **b** Corresponding color Doppler ultrasound image demonstrates increased peripheral vascularity in the area

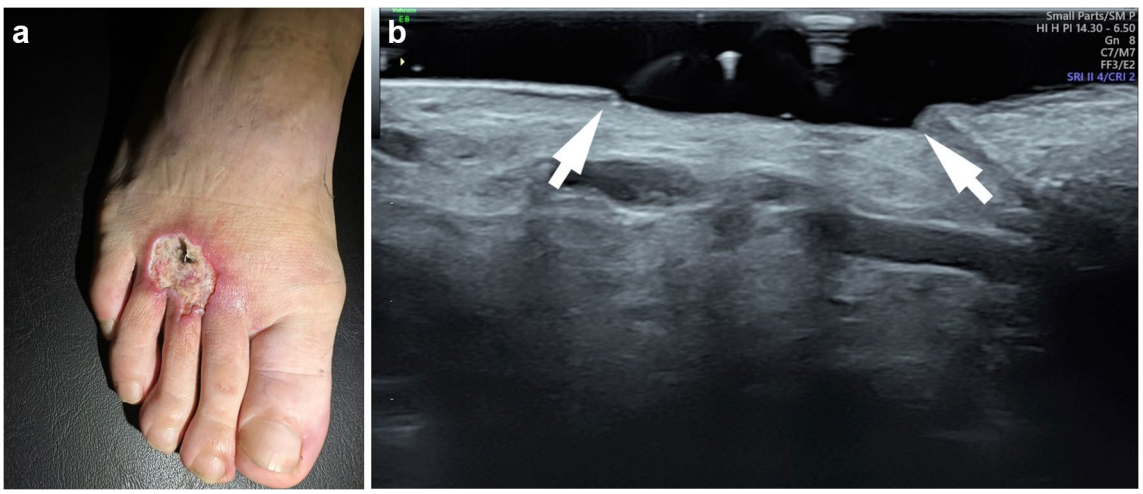

Fig. 6 A 14-year-old male patient with an ulcerated skin lesion on the right foot. **a** Note the loss of integrity of the skin of the right forefoot at the base of the 3rd and 4th toes. **b** Grayscale ultrasound image obtained with a high-frequency linear transducer shows localized epidermal disruption (between *arrows*) and extension of the lesion without involvement of deep planes

affinity for the monocyte-macrophage system, triggering a granulomatous process that occasionally results in lymph node necrosis [19, 21], potentially leading to lung infections, interstitial pneumonitis, and intestinal parasitic infestations [8, 22].

In advanced stages of the disease, the liver, spleen, and bone marrow are affected. Key signs at this stage include darkening of the skin, hepatosplenomegaly, jaundice, severe anemia, and severe pancytopenia [6, 19]. A rare but relevant complication that often develops in patients under 2 years of age with visceral leishmaniasis is hemophagocytic lymphohistiocytosis (HLH), usually requiring prolonged hospitalization and intensive care. HLH is characterized by an uncontrolled activation of lymphocytes, macrophages, and cytotoxic T cells, leading to an overproduction of proinflammatory cytokines [23, 24]. It can be complicated by secondary bacterial, respiratory, and gastrointestinal infections, presenting symptoms such as malabsorptive diarrhea, peripheral edema due to low albumin levels, and ultimately cachexia [19, 21, 24]. Additionally, individuals infected with the human immunodeficiency virus (HIV) have a higher risk of developing visceral leishmaniasis, which accelerates the progression of HIV to acquired immunodeficiency syndrome (AIDS), the advanced stage of the disease [6]. Furthermore, cases of epididymitis or orchitis have been recorded in patients affected by visceral leishmaniasis and chronic granulomatous disease [25].

Imaging evaluation

Imaging plays a crucial role in the diagnosis and monitoring of visceral leishmaniasis.

Although radiological findings are nonspecific in visceral leishmaniasis, conventional radiography remains a useful tool for the initial assessment of the thoracoabdominal region, particularly in resource-limited areas [26, 27]. Chest radiographs may reveal bilateral interstitial infiltrates (Fig. 7) or consolidations [21, 27]. Abdominal radiographs can show mass effect with displacement of bowel loops due to hepatosplenomegaly, which may be massive and extend into the pelvic region (Fig. 8). Air-fluid levels may be present in cases of gastrointestinal superinfections associated with visceral leishmaniasis. Radiographs of the extremities may show diffuse osteopenia related to bone marrow abnormalities [24, 25] (Fig. 9).

Abdominal ultrasound can provide valuable information regarding splenomegaly and hepatomegaly. It can also reveal free fluid and heterogeneous lymphadenopathy at the hepatic hilum and/or mesentery [28] (Fig. 10). The considerably enlarged spleen [24, 26, 29] might display multiple, heterogeneous, focal lesions of varying sizes ranging from 2 to 23 mm [28]. The lesions may be either hypoechoic with internal hyperechoic foci or hyperechoic

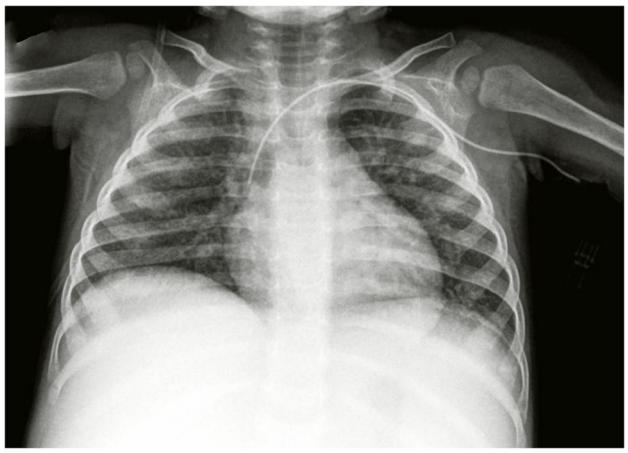

Fig. 7 Chest radiograph of a 2-year-old girl with visceral leishmaniasis. Note the interstitial prominence within both lung fields

with surrounding hypoechoic halos [28]. These focal lesions may vary in shape, being round, oval, coalescent, or poorly defined [30] (Fig. 11). The hepatic parenchyma may appear granular, homogeneous, and hyperechoic or heterogeneous, with slightly hyperechoic or hypoechoic nodular lesions [29, 30], some with hypoechoic halos. Additionally, ultrasound can also detect signs of portal hypertension [25].

In the chest, ultrasound can be a valuable tool for the diagnosis and guidance of procedures, such as pleural drainage or biopsies [22, 30].

Significant hepatosplenomegaly with multiple hypodense lesions with diameters ranging between 10 and 20 mm can be observed on contrast-enhanced CT exams. In some cases, these lesions may appear hypovascular or may exhibit mild ring enhancement [29].

Thoracic CT on inspiration reveals consolidations, ground glass opacities, pleural effusion, and airway involvement. Additional images on expiration or lateral decubitus in younger children can show air trapping (Fig. 12). As the disease progresses, high-resolution CT can be used to identify in detail the increase in lung lesions [22, 31].

Although the use of MRI for visceral leishmaniasis is supported by the medical literature, in our clinical experience, we have not utilized MRI for this specific purpose. However, as documented in the literature, splenic MRI may reveal heterogeneous, hypointense nodules on T2-weighted sequences, altering the morphology of the spleen. These nodules may exhibit a concentric ring with a central area of high signal and a peripheral ring of low signal intensity. Additionally, these lesions may demonstrate diffusion restriction on diffusion-weighted images (DWI). Usually, they tend to enhance after contrast administration or display a hypovascularization pattern [27, 31].

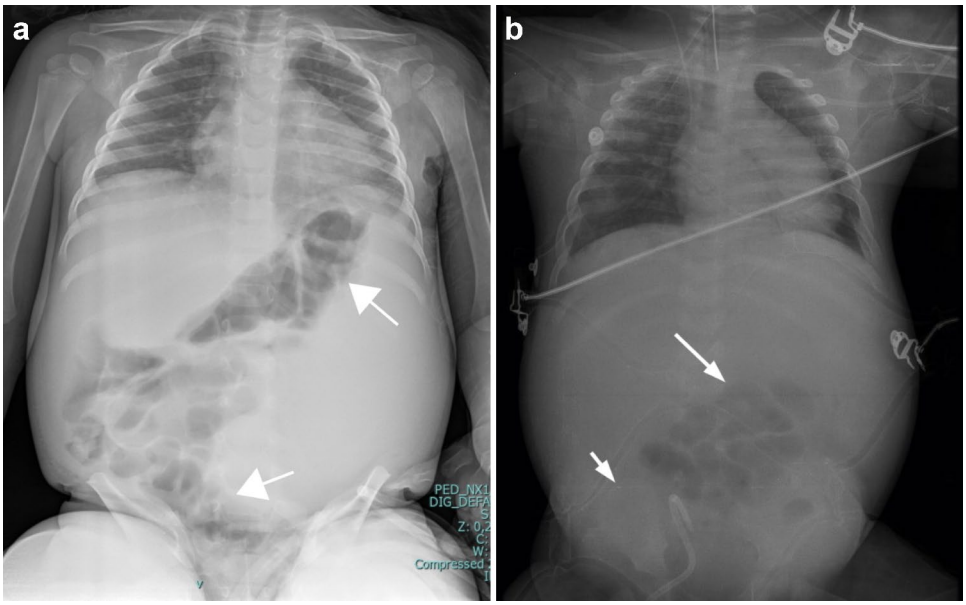

Fig. 8 A 2-year-old girl with visceral leishmaniasis. **a** Frontal thoracoabdominal radiograph in sitting position shows massive splenomegaly (*arrows*) displacing the bowel loops to the contralateral side. **b** Thoracoabdominal radiograph in the supine position shows mass effect on the bowel (*arrows*) as a result of hepatomegaly. The liver edges reach the iliac crest

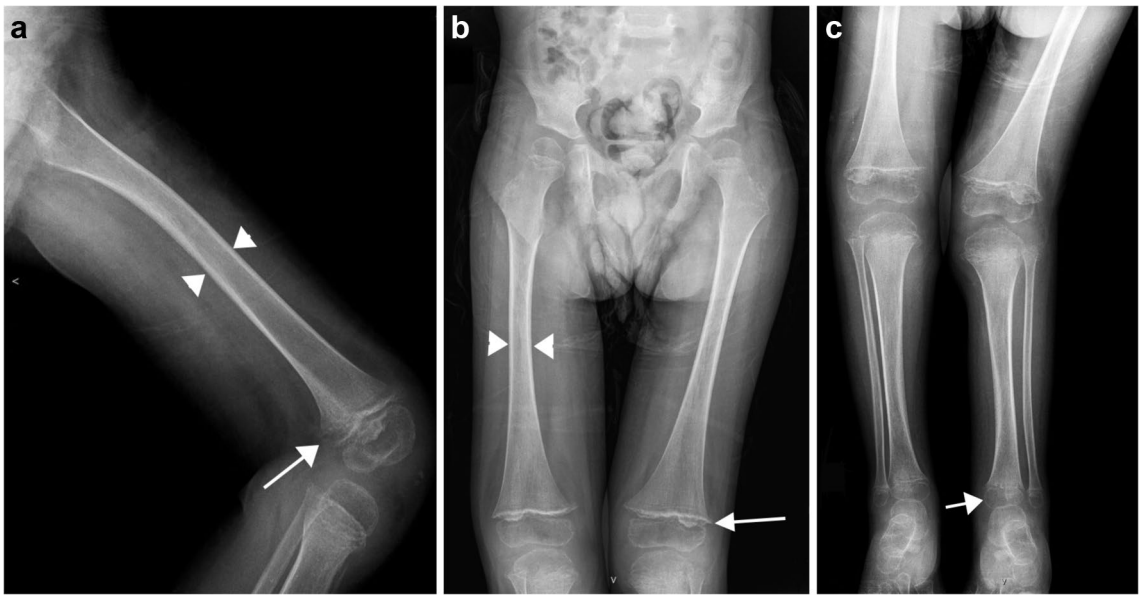

Fig. 9 Lateral radiograph of the femur and frontal view of the bilateral lower extremities of a 6-year-old girl with visceral leishmaniasis. **a**, **b** Thinning of the femoral cortex (*arrowheads*) **a, b** Bone demineralization of the femoral epiphyses and **c** distal tibiofibular epiphyses (*arrows*)

Dengue

Dengue is a viral disease with a significant impact on global public health.

In the Americas' region, the year 2023 witnessed a notable surge in dengue cases, totaling 4,569,464 reported instances. Among these cases, 7,665 were categorized as severe, resulting in 2,363 fatalities, as reported to the Pan American Health Organization (PAHO), which is the regional office for the Americas of the World Health Organization (WHO) [32–34].

The virus is mainly transmitted to humans through the bite of infected mosquitoes, primarily *Aedes aegypti* mosquitoes [34]. *Aedes aegypti* mosquitoes are widely distributed across the Americas, with only Canada and continental Chile being free from dengue and its vector [33]. There are four closely related but serologically distinct serotypes of this RNA virus: DENV-1, DENV-2, DENV-3, and DENV-4. An initial infection provides temporary immunity against

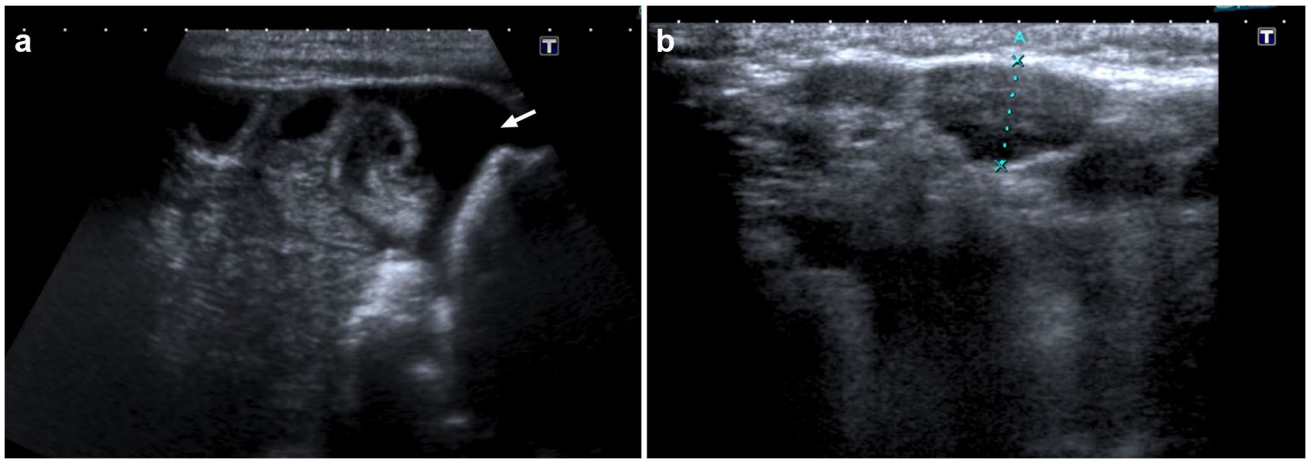

Fig. 10 A 5-year-old girl with visceral leishmaniasis. **a** Longitudinal ultrasound image of the left lower quadrant obtained using a high-frequency linear transducer shows a small amount of free abdominal fluid (*arrow*). **b** A cluster of a few, small lymph nodes (*between calipers*) was noted in the right lower quadrant

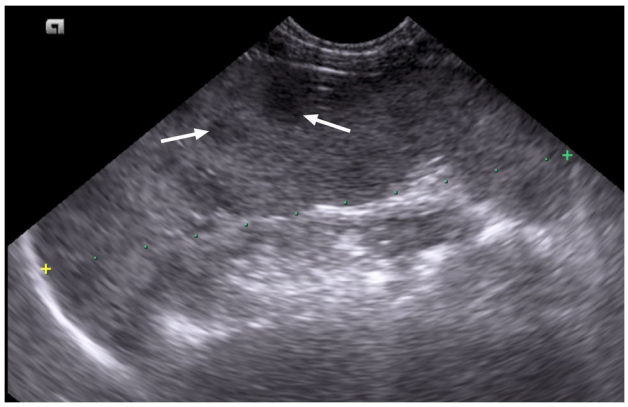

Fig. 11 Abdominal ultrasound of a 2-year-old male with visceral leishmaniasis shows an enlarged spleen measuring 10.5 cm with multiple hypoechoic, relatively well-defined nodular lesions (*arrows*) of varying sizes

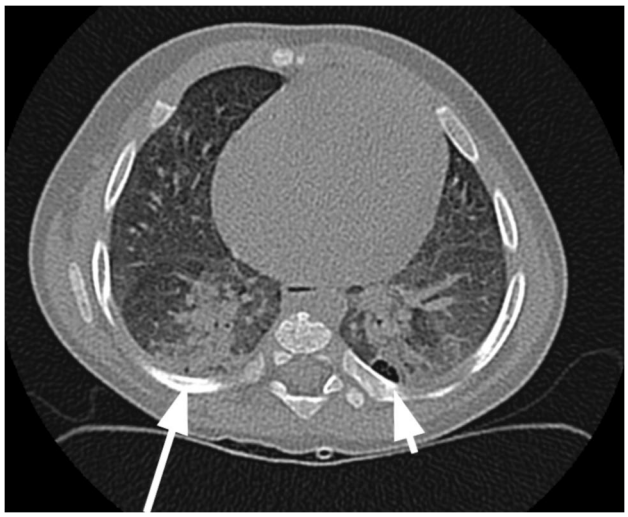

Fig. 12 CT image of a 1-year-old girl with visceral leishmaniasis shows a small area of paraseptal emphysema (short arrow) and scattered areas of consolidation and/or atelectasis (long arrow)

the specific serotype, but a second infection with a different serotype can increase the risk of severe disease [34].

The pathogenesis of dengue virus infection and the development of severe dengue manifestations are highly complex and not yet fully understood. The leakage of plasma and deranged hemostasis are the physiopathological hallmarks. Despite being aware of this plasma leakage phenomenon for the past five decades, the exact mechanism behind this manifestation still remains unclear [35].

Clinical manifestations

The clinical course of dengue infection is unpredictable. In most cases, dengue triggers mild symptoms or can be asymptomatic, typically resolving within 1 week or 2 weeks after infection. Symptoms include high fever, intense headaches, retro-orbital pain, myalgias, arthralgias, nausea, vomiting, lymphadenopathy, and skin rashes on the hands and feet [36].

In its severe form, dengue can present with acute abdominal pain, persistent vomiting, bleeding, extreme weakness, paleness, hypothermia, and general asthenia. Young children are more susceptible to *dengue* shock due to their lesser capacity to compensate for the loss of fluids [36, 37]. The critical stages of dengue can cause capillary leakage resulting in hemoconcentration and can trigger dengue shock syndrome. Warning signs include severe and constant abdominal pain, persistent vomiting, bleeding

from mucous membranes, drowsiness, sudden increase in hematocrit, and rapid decrease in platelets [37].

During the recovery phase following the critical phase, patients experience rapid clinical improvement, although they may present with fatigue for several months. Manifestations such as petechiae, relative bradycardia, and multisystem involvement, including hepatic, cardiac, neurological, and renal manifestations, can arise at different stages of the disease [37].

According to the new classification guidelines, dengue fever is no longer categorized as dengue hemorrhagic fever and dengue shock syndrome. Instead, the severity of dengue fever is now described based on the presence of warning signs. The revised classification system, introduced by the World Health Organization (WHO) in 2009, divides symptomatic cases of dengue into three categories: dengue without warning signs, dengue with warning signs, and severe dengue [35].

Laboratory analyses reveal leukopenia, thrombocytopenia, and hemoconcentration, associated with fever and a positive tourniquet test with high predictive value for diagnosing *dengue* [38–40].

Imaging evaluation

Ultrasound is a valuable diagnostic tool to differentiate mild cases of dengue from those at risk of poor outcomes. It can identify significant findings associated with the severity of dengue. During the critical phase, ultrasound can detect and assess serous effusions, which are the result of capillary leakage. However, while the WHO guidelines suggest using ultrasound for diagnosis, there is still insufficient evidence regarding its performance and prognosis [41].

In the abdomen, ultrasound allows visualization of homogeneous splenomegaly, hepatomegaly, sometimes with focal necrotic areas, and intraparenchymal and subcapsular hemorrhages. Acalculous cholecystitis, characterized by a distended and thickened gallbladder wall without gallstones, is a predictor of severe dengue [42, 43] (Fig. 13).

In the chest, ultrasound is highly sensitive for identifying pleural effusions [41] (Fig. 14).

Chest radiography, whether performed in standing or sitting position, may reveal the presence of pleural effusion. Occasionally, it may also suggest the presence of pericardial effusion and interstitial infiltrates. However, it is important

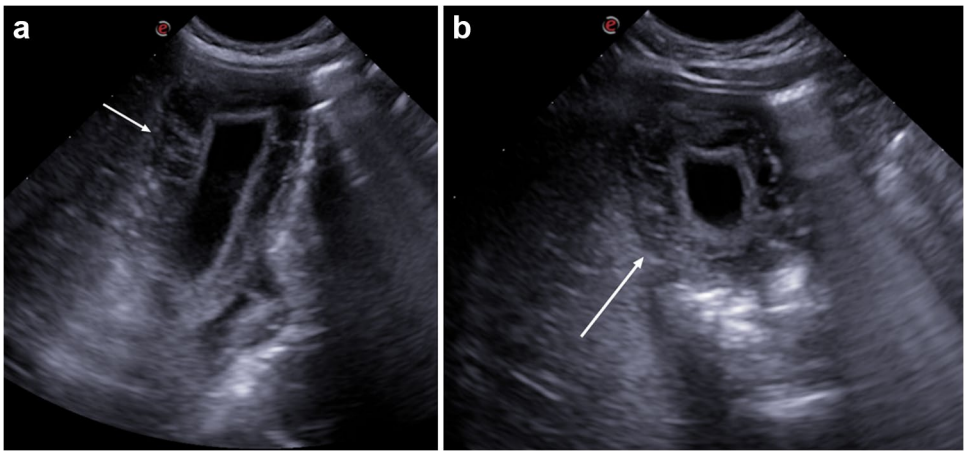

Fig. 13 A 12-year-old girl with dengue. **a** Longitudinal and (**b**) transverse US images of the gallbladder show marked, diffuse gallbladder wall thickening (*arrows*)

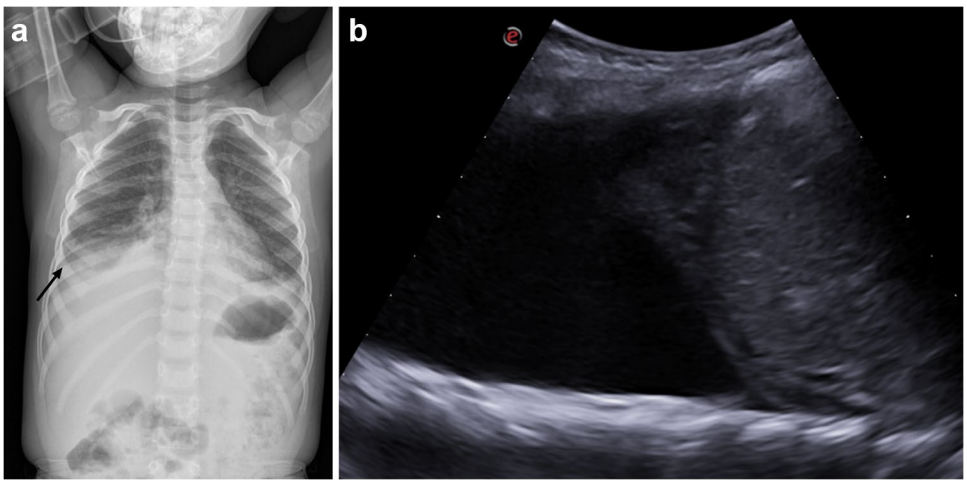

Fig. 14 A 3-year-old female presenting with a 5-day history of fever and 48 h of respiratory distress, admitted in a poor general condition. **a** Frontal chest radiograph shows right lung base airspace opacification with obliteration of the right costophrenic sulcus suggestive of a small pleural effusion (*arrow*). **b** Longitudinal ultrasound image of the right chest shows a large, simple-appearing pleural effusion

to note that chest radiography has limitations in terms of its sensitivity [43] (Fig. 14).

Chikungunya

Chikungunya (CHIKV) is a viral disease that was first identified during an outbreak in southern Tanzania in 1952. Since then, it has affected millions of people worldwide and has caused epidemics in several countries. The disease is endemic in Southeast Asia, Africa, and Oceania, and it was introduced into the Americas in 2013, leading to major outbreaks in different countries [44, 45]. According to epidemiological data from 2022, a total of 271,176 cases of chikungunya, with 95 deaths, were reported in 13 countries and territories in the region of the Americas. This figure is higher than that reported during the same period in 2021. In the first weeks of 2023, 30,707 cases and 14 deaths from chikungunya were reported [44].

Chikungunya virus (CHIKV) is an RNA virus that belongs to the *Alphavirus* genus of the Togaviridae family. It is mainly transmitted through mosquitoes of the *Aedes* genus, such as *Aedes aegypti* and *Aedes albopictus*. Mosquitoes can transmit the virus to a susceptible individual after biting an infected person during their viremic period. This transmission can occur throughout the lifespan of the mosquito. There is also a risk of vertical transmission to newborns, if the mother develops viremia during delivery, with a transmission risk of up to 49% [44–46]. Once individuals are exposed to the virus, they acquire long-lasting immunity that protects them from reinfection. During epidemic outbreaks, humans serve as the primary reservoir for the chikungunya virus [47].

Clinical manifestations

After an incubation period of 1 to 12 days, chikungunya causes high fever, particularly in children, and presents with a wide range of symptoms including arthralgia, skin, and neurological and hemorrhagic disorders including thrombocytopenia and lymphopenia [46, 47]. The disease can manifest in acute, subacute, or chronic forms.

Chikungunya-related arthritis is acute in 50–60% of cases, confirmed through serological tests, and can occur at any age, with a higher prevalence among children.

A pruritic or vesicular maculopapular rash typically appears 2 to 5 days after the fever and spreads throughout the body along with joint pain [48].

Nausea, vomiting, and conjunctivitis may also occur in this acute phase. While arthralgia is the most typical joint symptom, arthritis with significant synovitis can be observed at any stage of the disease [49]. In the subacute phase, joint stiffness with a limited range of motion is observed between the second and third months following the onset of the disease. In the chronic variant, joint pain persists for more than 3 months and can last up to 2 or 3 years, according to some studies [50]. Chikungunya-associated arthritis is debilitating and can affect small, medium, and large joints, with a predilection for distal, symmetrical, and oligo- or polyarticular involvement, particularly in the hands, wrists, and ankles. In rare cases, it may affect the elbows, knees, shoulders, hips, and temporomandibular joint. There is a high incidence of persistent joint symptoms, resembling rheumatoid arthritis with a migratory pattern.

Carpal tunnel syndrome and cases of myositis of the soleus muscle or flexor hallucis longus, as well as calcaneal bursitis, have been reported in the literature [49]. The chronic course of the disease shows two different patterns: one with polyarthralgias and tendinopathies, and the other, less common, with chronic inflammatory changes resulting in synovitis and potentially destructive arthritis [50, 51].

Although chikungunya virus is primarily associated with arthralgia, it can also cause neurological disorders that have long-term consequences [52]. Neurological signs that have been observed include altered level of consciousness, auditory and/or visual hallucinations, stiff neck, tense fontanel, seizures, headaches, and focal neurological signs [53]. The disease can manifest in various forms, ranging from severe cases such as encephalitis to moderate forms like complex febrile seizures and acute encephalopathies, and even mild forms such as simple febrile seizures and meningeal syndromes [53].

In addition, some patients may experience transient peripheral vascular, cardiovascular, and ocular disorders such as uveitis, retinitis and episcleritis, renal disorders, chronic fatigue, weakness, and depression.

It is possible for a patient to have both dengue and chikungunya fever simultaneously. Compared to dengue, chikungunya infection causes more intense pain localized to joints and tendons, and has a more acute onset and shorter duration of fever. Severe shock or hemorrhage is rare with chikungunya [50].

Imaging evaluation

Ultrasound has proven to be an excellent tool for both diagnosing and monitoring chikungunya. Ultrasound is particularly useful for assessing arthralgia, the most common joint symptom, as it can visualize arthritis with synovitis at any stage of the disease. Ultrasound can detect joint capsule distension, fluid accumulation, and synovial thickening [54, 55] (Fig. 15). In carpal tunnel syndrome, ultrasound can show synovial tendon sheath thickening [55, 56] and color Doppler can reveal hypervascularity of the thickened synovial membranes [49, 54].

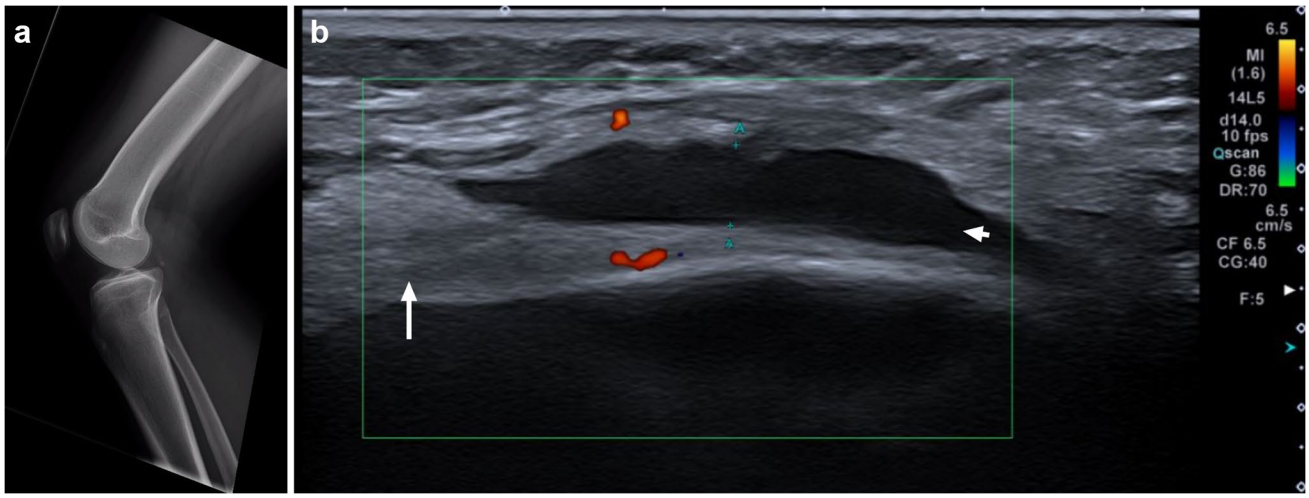

Fig. 15 A 14-year-old male presents with high fever, severe right knee pain, and positive serology for chikungunya. **a** Lateral knee radiograph shows no bone abnormality and a questionable suprapatellar joint effusion. **b** Transverse ultrasound image shows a small, anechoic, suprapatellar joint effusion (*short arrow*) with very mild synovial thickening (*long arrow*). Color Doppler shows only a slight increase in vascularity

In children with neurological manifestations and a patent fontanelle, ultrasound may show a normal examination, brain edema, lenticulostriate vasculopathy, and increased echogenicity of the periventricular white matter [53].

Radiological findings are often subtle, but can be helpful in detecting atypical manifestations, such as pneumonia and its complications including pleural effusion [57] (Fig. 16). Magnetic resonance imaging (MRI) plays an important role in the documentation of joint involvement, hands' and wrists' tenosynovitis, and ankles' abnormalities [55].

In the evaluation of neurological disorders, MRI may show normal findings or may demonstrate edema and increased T2 signal in the periventricular white matter and within the bilateral centrum semiovale, cingulate gyri, and limbic areas, as well as intraparenchymal areas of hemorrhage above and below the tentorium [58, 59]. Diffusion-weighted images may show diffusion restriction in the bilateral frontal, parietal, and temporal white matter and in the bilateral centrum semiovale, corpus callosum, and posterior limbs of the internal capsules, and in the optic radiations [58] (Fig. 17). Following intravenous administration of gadolinium, the lesions usually show no enhancement [53].

Conclusion

In conclusion, we have presented a comprehensive review of the clinical manifestations and epidemiology of these neglected diseases, highlighting the contributions of imaging in their diagnosis and monitoring. Our aim is to enhance understanding and raise awareness among physicians, health

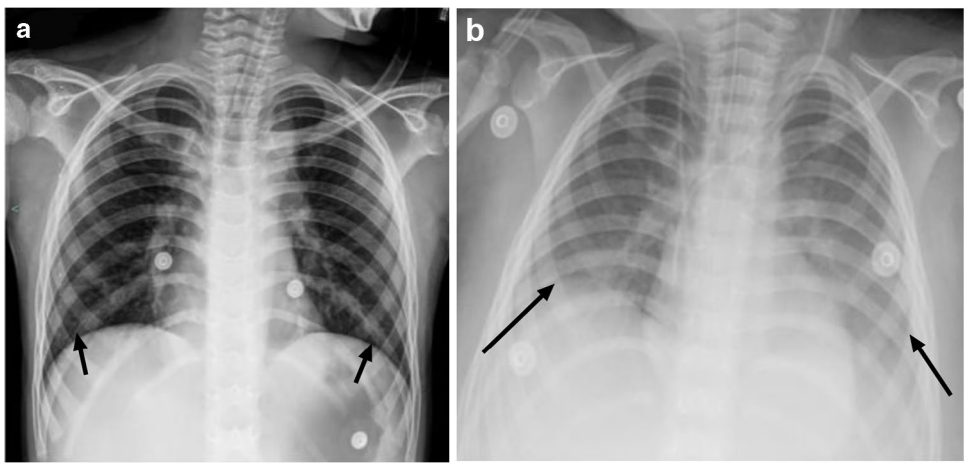

Fig. 16 Chest radiographs of an 8-year-old boy presenting with fever, fatigue, and progressive respiratory distress. All laboratory tests and serologies were negative except for chikungunya. **a** Initial chest radiograph shows very mild, bibasilar peribronchial thickening (*short arrows*). **b** Subsequent chest radiograph obtained the following day shows bibasilar areas of ground glass opacification

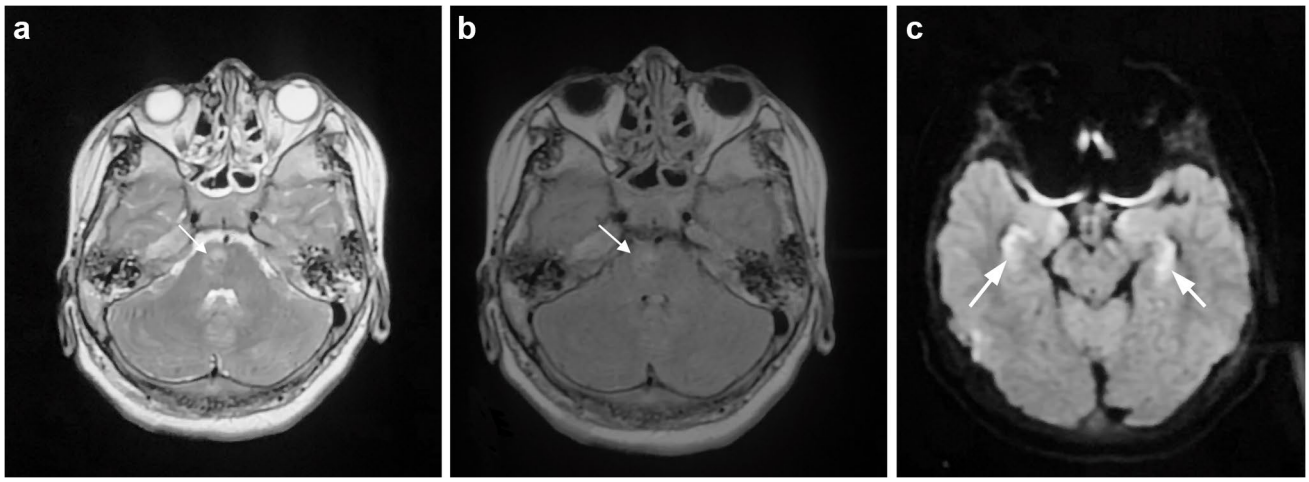

Fig. 17 A 14-year-old boy with positive chikungunya serology diagnosed on the 5th day after the onset of symptoms. He was afebrile and presented with severe headache and nonfocalized seizures. **a** Axial T2-weighted and (**b**) axial FLAIR MR images show a heterogeneous right pontine lesion (*arrows*). **c** Axial DWI shows diffusion restriction in both hippocampal regions (*arrows*)

policymakers, and researchers, with the goal of fostering future research and clinical advancements to effectively manage and control these diseases. We emphasize the significance of ultrasound as a crucial tool, particularly in primary care and emergency settings.

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Declarations

Data confidentiality The authors state that they have followed the protocols of the patients' originating institution regarding data publication, and the document does not contain data that could identify them.

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