Abstract:
Pediatric patients in resource-limited settings are often at high risk of severe manifestations or complications of tropical infectious diseases. Health care providers in these settings often lack access to basic diagnostic imaging. Point-of-care ultrasound is one modality that may improve the care of these children by bringing portable imaging technology to the bedside. To use ultrasound effectively, the clinician must have both the ability to obtain and interpret images and an understanding of the context and presentation of the disease in question. We discuss the utility of point-of-care ultrasound in a variety of pediatric tropical infectious diseases with dual purposes: first, to introduce practitioners with prior ultrasound experience to ways to apply preexisting knowledge in different contexts and, second, to introduce providers in low-resource settings to a diagnostic modality that can be easily learned with discrete protocols and may improve their care of vulnerable patients.

Keywords:
point-of-care ultrasound; POCUS; pediatrics; children; tropical disease; malaria; tuberculosis; pneumonia; dengue; schistosomiasis; rheumatic heart disease; tropical pyomyositis; resource-limited settings

*Department of Emergency Medicine, Medical College of Georgia, Augusta University, Augusta, GA; †Department of Emergency Medicine, University of Alabama at Birmingham, Birmingham, AL.
Reprint requests and correspondence: Daniel Kaminstein, MD, DTMH, 1120 15th St, Augusta, GA 30912.
dakaminstein@augusta.edu

1522-8401

Perspectives on Point-of-Care Ultrasound Use in Pediatric Tropical Infectious Disease

Daniel Kaminstein, MD, DTMH*, W. Ted Kuhn, MD, RMDS*, Deborah Huang, MD*, Samuel L. Burleson, MD†

Access to advanced imaging plays a major role in the health care gap that exists between the wealthiest and poorest countries. High-resource countries routinely rely on computed tomography and magnetic resonance imaging, whereas many clinicians in resource-limited settings (RLS) do not have access to basic radiographic capabilities. The portable ultrasound (US) machine bridges the gap by bringing more advanced imaging technology to the patient's bedside. US is not a panacea, and those of us who advocate for its widespread use must realize that new technological tools must be applied appropriately. Knowing how a technology will function in the context where it is being applied is a vital part of maximizing benefit and preventing harm.

There is a growing body of literature on the use of US in RLS for the adult patient,[1-7] including for tropical infectious diseases.[1,2,8]

There is also an increasing body of literature documenting the use of point-of-care ultrasound (POCUS) in the pediatric population.[9-12] Very little addresses the unique challenges and opportunities for POCUS use in children where tropical infectious diseases are endemic. A pediatric focus on tropical diseases in RLS is worth addressing for several reasons. An increasing number of practitioners are receiving pediatric-focused POCUS training in high-resource countries and are interested in applying that training to patient care in RLS. Many of those who teach POCUS for pediatrics in RLS are less familiar with the tropical disease implications of specific US findings. Finally, equipping clinicians who are working full-time in areas of tropical diseases requires a degree of familiarity with some of the common conditions that they are likely to encounter.

The goal of this article is to 2-fold. For those with prior POCUS experience, it is intended to be a primer for specific diseases presentations in areas where tropical diseases are endemic. It is also meant to be a guide for clinicians who live and work in RLS to highlight how US might apply to their daily clinical work. Therefore, we have structured the article around the use of US for infectious diseases that have unique or predominant pediatric implications.

This is not meant to be the definitive work on pediatric US or tropical disease. We present a perspective on how US might be contextualized and conceptualized differently based on the diseases that plague children around the world. We hope that this will advance the discussion in asking not just what US can do but how it can more clearly help clinicians in RLS make the best decisions for their patients given the burden and prevalence of disease.

The topics covered are a result of our combined experiences over the past 30 years, performing, teaching, and researching US use in RLS. These topics address common pediatric infectious disease challenges in RLS and the evaluation of these diseases based on previously established POCUS protocols (Table 1). There are not many new US skills to be learned; rather, the unique US appearance of these disease presentations must be recognized. In the end, we hope to encourage pediatric POCUS application and highlight context-specific teaching based on the local needs of the population where it is being used.

TABLE 1. Selected pediatric tropical infectious diseases and associated point-of-care US examination.

Infectious Disease	POCUS Examination
Tuberculosis	FASH, thorax
Pneumonia	Thorax
Dehydration	Inferior Vena Cava
Dengue	FAST, right upper quadrant
Malaria	Ocular
Schistosomiasis	Urinary, right upper quadrant
Rheumatic Heart Disease	Cardiac
Tropical Myopyositis	Skin and soft tissue

TUBERCULOSIS

Pediatric tuberculosis (TB) perhaps best epitomizes the diagnostic dilemma of an infectious disease presentation in RLS. Although uncommon in high-resource settings, TB is the single leading infectious cause of death worldwide.[13] An estimated 1 million children developed TB in 2017, and children are at higher risk of rapid dissemination and death, especially if young, malnourished, or immunocompromised.[13-15] Early diagnosis and treatment are the mainstay of TB control, but diagnosis is a particular challenge in children. As opposed to adults, children with TB present with vague signs and symptoms. Children have more difficulty producing adequate sputum samples, and when the sputum is analyzed with molecular techniques, it is less likely to be positive even when children are infected.[13,16,17] As a result, diagnosis often relies on clinical, historical, and radiologic findings.[15,17,18] There is a small but growing body of literature documenting the utility of POCUS for children with pulmonary TB (PTB) and extrapulmonary TB (EPTB).

Although PTB remains the major focus of most adult and pediatric TB efforts, the traditional distinction between PTB and EPTB is less clear in children.[19] Recent studies indicate that findings of abdominal TB can be present in up 40% of children with clinical TB and an inconclusive chest radiograph, which is a very common occurrence in high-prevalence TB settings.[16,19,20] This means that, in many cases where TB is suspected clinically, US imaging demonstrating signs of EPTB can help providers diagnose and treat more appropriately.

The Focused Assessment with Sonography in HIV-associated TB (FASH) examination is a POCUS protocol designed to detect signs of EPTB in adult patients co-infected with HIV.[21] It was modeled on the focused assessment with sonography for trauma (FAST) examination and looks for common findings (Table 2) in abdominal and disseminated TB.[21] It can be taught rapidly to clinicians in RLS who have limited prior US experience.[22] In adult populations,

TABLE 2. Ultrasonographic findings on FASH examination suggestive of EPTB in populations with high prevalence of HIV and TB.

Ultrasonographic Finding
Pleural effusion
Pericardial effusion
Hepatic or splenic microabscesses
Ascites
Periaortic lymphadenopathy

the FASH examination is primarily helpful in patients with known HIV and suspected TB co-infection.[21] In children with PTB, FASH has demonstrated utility, regardless of HIV status.[16,19,20] Children with confirmed or suspected PTB have an increased rate of FASH findings, most commonly pleural effusion and abdominal lymphadenopathy (Figure 1), relative to those in whom TB is not suspected.[20]

In pediatrics, the FASH is an encouraging adjunct to TB care. Many children with negative FASH imaging will still have isolated pulmonary TB with the associated diagnostic challenges. Thoracic US findings in PTB vary widely and overlap with those of pneumonia.[23-25] In one of the few studies specifically examining chest US in pediatric patients with suspected TB, consolidations and pleural interruptions were the most common finding. Children with confirmed TB were more likely to have unilateral pleural effusions, and consolidations were less likely to resolve after initial treatment.[17] Unfortunately, based on studies to date, US findings are not specific enough to clearly differentiate children with pneumonia from PTB. In those with high clinical suspicion for TB, unilateral effusions, and persistent consolidation, TB should be strongly considered, specifically in those with unilateral US findings. Thoracic US evaluation for TB in RLS has many applications for future research to identify more specific findings in high-risk patients.[26]

One way to increase the yield of thoracic US in TB may be mediastinal evaluation. Mediastinal lymphadenopathy with or without parenchymal findings is the hallmark of pediatric primary TB.[27] Up to two thirds of pediatric TB patients with a negative chest x-ray (CXR) result may have lymphadenopathy on US, and a simplified POCUS protocol for mediastinal lymphadenopathy was recently described.[28,29] Use of this specific protocol needs to be evaluated further but, it may improve pediatric PTB diagnosis.[30]

POCUS use in children with suspected TB has high interreader reliability, is feasible, can be taught and learned quickly, and may be a useful adjunct in the diagnosis and treatment of children with mediastinal, pulmonary, and especially EPTB.[17,20,21,31] Children with suspicion for PTB should undergo POCUS evaluation for mediastinal and EPTB where possible. Additionally, because US findings seem to resolve with adequate treatment, POCUS may be useful in assessing response to therapy.[20,28]

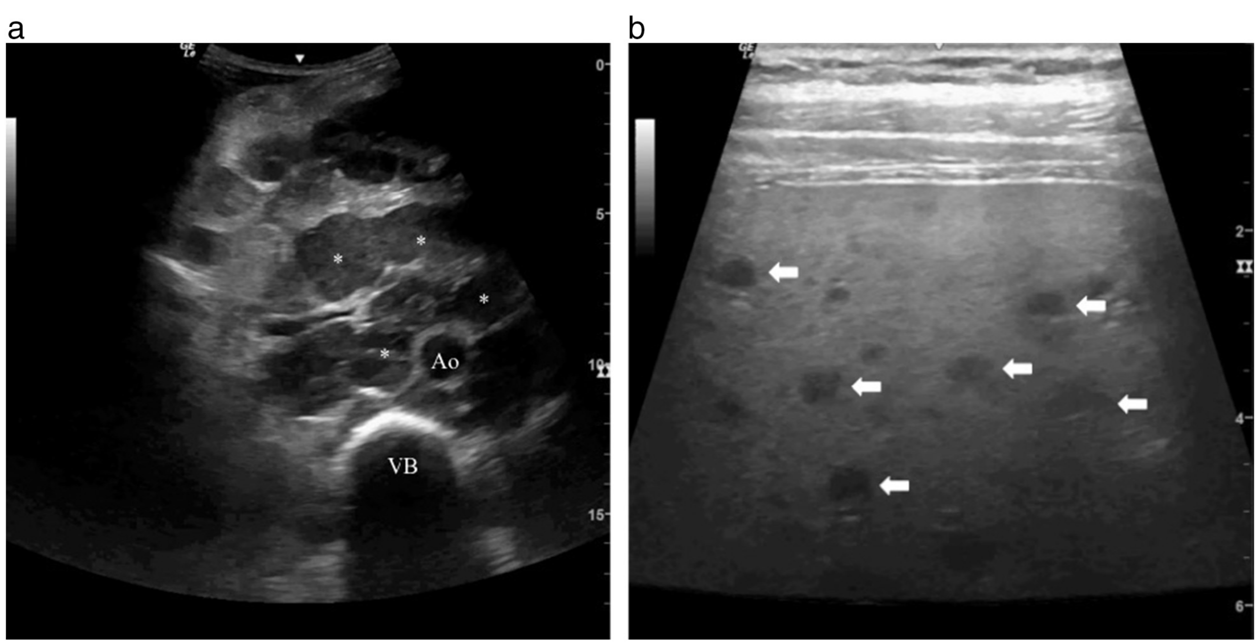

Figure 1. Ultrasonographic findings of EPTB by FASH examination. A, Periaortic lymphadenopathy (*) surrounding the aorta (Ao) and anterior to the vertebral body (VB); transverse view.B, Splenic microabscesses (white arrows) viewed with linear probe.

PNEUMONIA

Although TB is the single leading cause of infectious disease death in all age groups, pneumonia is the leading cause of death for those less than 5 years of age.[32,33] Approximately 2 children die each minute from pneumonia, and 99% of those deaths are in RLS.[34] In these settings, children can present with a febrile illness for a myriad of reasons. Delaying antibiotics in young children with pneumonia can be potentially life-threatening, especially those who are malnourished. To encourage more aggressive treatment for pneumonia, the World Health Organization (WHO) released guidelines that increased the sensitivity of diagnosis at the cost of lower specificity.[32,35] Because of the low specificity, the WHO guidelines do not differentiate well between pneumonia requiring antibiotics and other respiratory or systemic febrile illnesses.[32]

CXR has been the diagnostic imaging modality of choice. However, the availability of CXR at the initial point of contact for patients in RLS is limited, and even when available, it is not perfect in diagnosing pediatric pneumonia.

There are several benefits to using lung US in children including decreased radiation, decreased cost, and decreased length of stay.[35,36] Multiple studies have demonstrated that lung US has similar sensitivities and specificities when compared to CXR. Two recent meta-analyses compared lung US to CXR and found US to have an increased sensitivity and a similar specificity.[36,37] When compared to the current syndromic approach of the WHO guidelines, lung US was found to have both an increased sensitivity and specificity.[35] In another study in RLS, consolidation on lung US had a sensitivity of 88.5% and a specificity of 100% when compared to radiographically confirmed pneumonia, and any abnormality seen on lung US had a sensitivity of 92.2% and specificity of 95.2% when compared to radiologically confirmed pneumonia.[38]

Thoracic US differs from solid organ US in that image interpretation is based on the artifacts created by the interaction of US waves with either normal air-filled or consolidated lung (Figure 2). There are many nuances to thoracic US which are beyond the scope of this article but have been covered well in other publications.[39-41] Although there is some complexity to lung US, many studies have shown that it can be used by trainees and general practitioners, rather than US experts, to diagnose pneumonia.[35,36,38,42,43] In each case, training involved some classroom time combined with hands-on teaching by an expert and was accomplished in less than a day.

Lung US does have some limitations. Because imaging relies on the pleural interface, a consolidation that does not contact the pleura might be missed. Differentiating between consolidations and atelectasis can be challenging in acutely ill patients.[35,38,44] One option to help providers is artificial intelligence (AI) built into US software. Although still in its infancy, AI might someday be able to help differentiate normal and abnormal lung. Early studies leave room for optimism, with one Peruvian study reporting a sensitivity of 90.9% and a specificity of 100% using AI to identify pediatric pneumonia.[45]

There is still much work to be done to improve the care of pediatric pneumonia patients throughout the world. US is just one link in the diagnostic and therapeutic chain, but early studies, although small, are encouraging. A large multicenter study, the Pediatric Pneumonia Lung Ultrasound Study, is currently evaluating lung US for pneumonia diagnosis in RLS. Results from this study are to be published shortly and will provide more definitive answers on the application of US for pneumonia.

DIARRHEA AND DEHYDRATION

Fluid management in children with tropical infectious diseases is a significant challenge, confounded by high rates of chronic malnutrition. Diarrhea is the clearest example of the challenge of fluid management in tropical infections. Every year, acute diarrhea in children causes approximately 130 million outpatient and inpatient visits and 1.5 million deaths.[46,47] Children with large gastrointestinal fluid losses require rapid assessment and treatment, leading to questions about the optimal way for clinicians to assess dehydration severity. Most patients should be given oral rehydration solutions, but some will require more aggressive intravenous resuscitation and hospitalization, depending on severity.

Assessing the degree of dehydration is challenging because no particular clinical signs, symptoms, or laboratory testing has adequate accuracy in detecting pediatric dehydration.[46] In addition, most children needing rehydration therapy are not assessed by a pediatrician.[48] Thus, there is a need for a tool that could help all clinicians decide on the optimal fluid strategy for children. US has been studied in the evaluation of dehydration severity. One measurement, the inferior vena cava (IVC)–aorta ratio, which compares the diameters of the IVC and aorta at the same anatomic level, was thought to be a good candidate for a simple POCUS protocol. Initial studies using a cutoff of 0.8 for the IVC-aorta ratio showed only

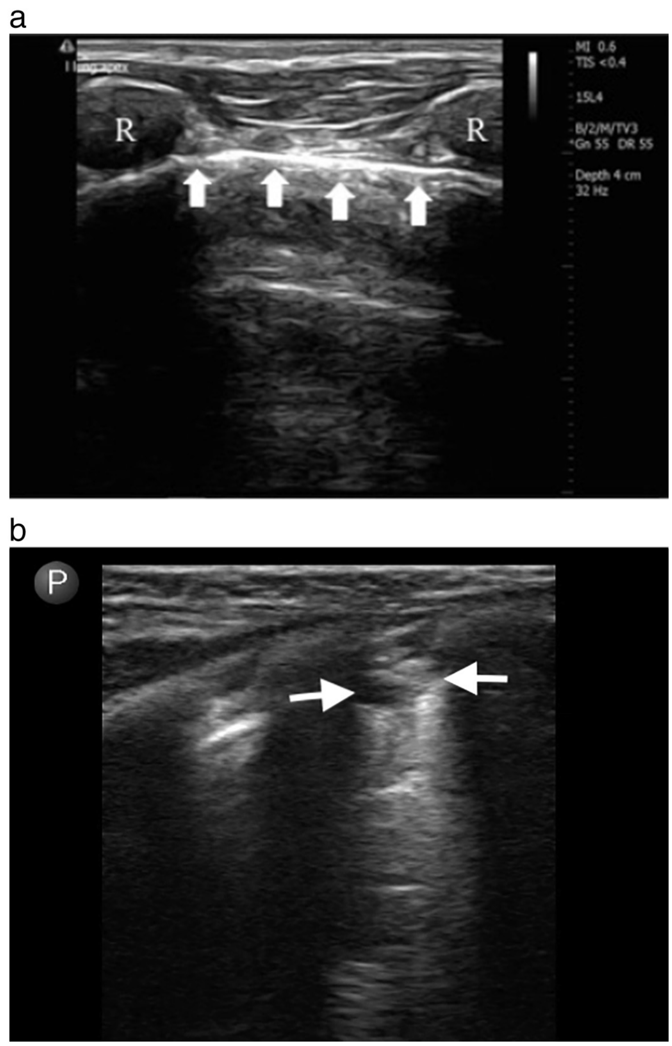

Figure 2. A, Thoracic US. Normally aerated lung and pleura (white arrows) seen with linear probe between two ribs (R) with linear probe.B, Consolidation with air bronchograms (white arrows) indicating pneumonia with linear probe.

mediocre test characteristics with sensitivities between 67 and 86% and specificities between 56 and 71%.[49,50] These studies were done in high-resource settings where chronic malnutrition and dehydration are less common. When looking at studies in RLS, the IVC-aorta ratio performed worse.[46,51,52] Methodology for each study and type of US probe used differed but results were similar. In a Bangladeshi prospective cohort study using nurse-obtained measurements, the aorta-IVC ratio was inaccurate when assessing for dehydration.[46] Another study in 3 Rwandan hospitals reported that the aorta-IVC ratio had a sensitivity of 93% but with a specificity of only 59% for severe dehydration.[51] One of the largest studies to date on children with diarrhea done in Bangladesh reported that the aorta-IVC ratio did not increase sensitivity or specificity when assessing dehydration.[48]

Given the challenge of acute diarrhea and dehydration, more studies of POCUS should be done. Fluid management and volume status assessment are an ongoing challenge in every area of medicine, and this population is no exception. Although a single cutoff value that could be easily assessed would be extremely useful, the current literature does not support this approach. The best evidence to date does not support using the aorta-IVC ratio to decide how best to resuscitate an acutely or chronically dehydrated child in RLS.

DENGUE

Dengue is an arthropod-born virus transmitted throughout the tropics by the *Aedes* mosquito and carries a high burden of disease in RLS.[53] Because many patients are not overtly symptomatic and the disease itself can vary from a mild illness to life-threatening shock, it is difficult to quantify its impact. A 2013 study estimated between 284 million and 528 million dengue infections occur each year; of these, approximately 96 million manifest clinically.[54] The 2017 global burden of disease study reported that dengue contributed 0.12% to the total global burden of disease based on disability-adjusted life-years.[55]

The primary burden of severe disease falls on children, who initially present with a mild viral illness but can decompensate quickly and dramatically. POCUS may potentially identify those most at risk. Although most children recover after the febrile phase, it is during defervescence that some may acutely worsen and develop severe dengue or dengue shock syndrome. The warning signs in each case involve plasma leakage.[56] Since plasma leakage is the primary driver of the pathophysiology behind worsening dengue infections, a tool to visualize extravascular fluid would be invaluable.[57] US can easily visualize free and extravascular fluid resulting in edema, so it can help identify those who need more aggressive support.

Several studies have evaluated US use to detect plasma leakage into tissues and body cavities in both adult and pediatric patients.[58-64] Although the sample sizes are small, themes helpful for the treating clinician emerge.

US use in dengue is primarily focused on identifying extravascular fluid. The traditional physical examination findings of free fluid such as ascites and pleural effusions can be easily detected by US and are markers of more severe illness.[57,58,60,62,65] Current studies highlight that gallbladder wall edema (Figure 3) is significantly correlated with severe dengue infection.[58,59,62] Several studies have also identified different patterns of gallbladder wall edema in patients with dengue.[62] In particular, the honeycomb pattern of wall thickening may be most predictive of severe infection.[62,63]

A focused abdominal and thoracic US to detect free fluid (ascites, pericardial effusion, and pleural effusion) involves the same techniques used in the FAST examination, obviating the need to learn a new examination. Although more technically advanced, gallbladder US is also frequently taught in POCUS curricula.[3,7] Gallbladder POCUS can help to identify patients with gallbladder wall thickening which is an early and relatively specific sign of plasma leakage in a patient with severe dengue.[63]

The majority of studies evaluating the use of US for dengue have involved hospitalized patients with known disease. No studies have evaluated US use by community clinicians to risk stratify children at an earlier stage of illness. US could be used in community clinics in patients with fever and suspected dengue. Testing for dengue by serology is difficult to implement in many practice environments. In general, clinicians are left with their history and physical examination to determine if a child is at risk for severe dengue. US could identify early signs of plasma leakage missed by examination and help determine which children should be monitored closely or hospitalized. Further studies are needed in this population to more clearly evaluate the efficacy of US at an early stage of illness.

MALARIA

Malaria and dengue are the 2 vector-borne diseases with the most significant impact on children. Although malaria afflicts both adults and children, children bear the brunt of the associated morbidity and mortality. The WHO estimated that

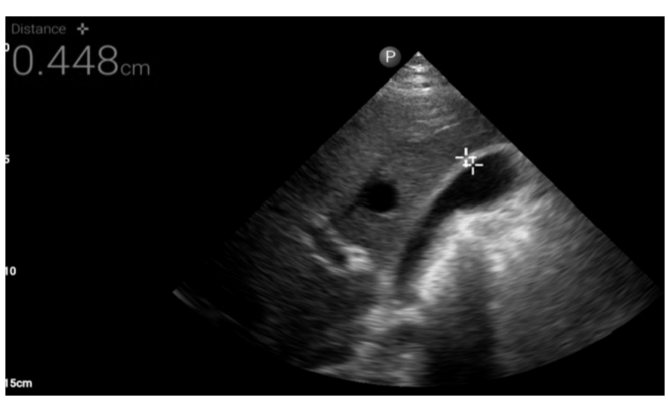

Figure 3. Ultrasonographic findings suggestive of severe dengue infection. Gall bladder wall thickening measured to 4.48 mm by calipers on US. A normal gall bladder wall measures <3 mm.

there were 219 million cases and 435 000 deaths from malaria in 2017, with children younger than 5 years accounting for 61% of deaths.[66]

Malaria often presents as a nonspecific fever and is difficult to distinguish in its early stages from other febrile illnesses. Adult patients who live in hyperendemic areas may present with only fever and general malaise. In young children or adults not previously infected, the disease can result in life-threatening organ damage. Many other diseases in malaria-endemic regions can produce similar symptoms of fever, headache, rash, confusion, seizure, renal failure, and shock.[67,68] Advanced testing is often not available in regions where the malaria burden is highest. Rapid diagnostic tests can be helpful, but the presence of parasites does not directly translate into severity of disease. In areas of high transmission, asymptomatic parasitemia can be as high as 70%.[69,70] An imaging modality allowing clinicians to accurately risk stratify patients with suspected or proven malaria would be extremely helpful.

Plasmodium falciparum is responsible for the majority of the mortality associated with malaria.[66] *P falciparum* causes end-organ dysfunction as a result of the malaria parasite sequestering in end organs such as the brain, liver, lungs, kidneys, and spleen. US protocols evaluating each of these organs in other diseases processes already exist and have been applied to pediatric malaria patients to try and identify unique findings.

A recent literature review analyzed the application of US by organ system.[71] The authors concluded that although there are several ultrasonographic abnormalities seen in malaria, particularly liver and spleen size, there is no clear correlation between these findings and severity of infection. There may be a role for transcranial Doppler based on some limited and conflicting studies.[72-74] The only finding that showed some promise was the evaluation of optic nerve sheath diameter (ONSD) in children with proven cerebral malaria.[75] In this study, an enlarged ONSD was a marker for more severe disease. A recent study in Benin reported similar results.[76]

Based on current literature, US has limited utility in malaria patients. In areas highly endemic for malaria, the clinician might use US to search for other sources of fever but should not expect findings that would be diagnostic of malaria. There may be utility in evaluating patients in whom there is a strong suspicion for cerebral malaria by performing ONSD measurement. Performing ONSD measurement has been used in other POCUS protocols, and there is some suggestion that it may help in RLS with patients with increased intracranial pressure (author [DK] personal communication; currently unpublished data). Performing ONSD is somewhat more complex than basic examination but is still well within the range of the average clinician.

SCHISTOSOMIASIS

Unlike dengue and malaria, where acute infections are life threatening, schistosomiasis is a parasitic infection where the burden of disease accumulates with increased exposure and duration of infection. Schistosomiasis affects an estimated 250 million people worldwide and can cause significant morbidity including anemia, wasting, and stunting.[77,78] Infections acquired early in life can have significant consequences for development

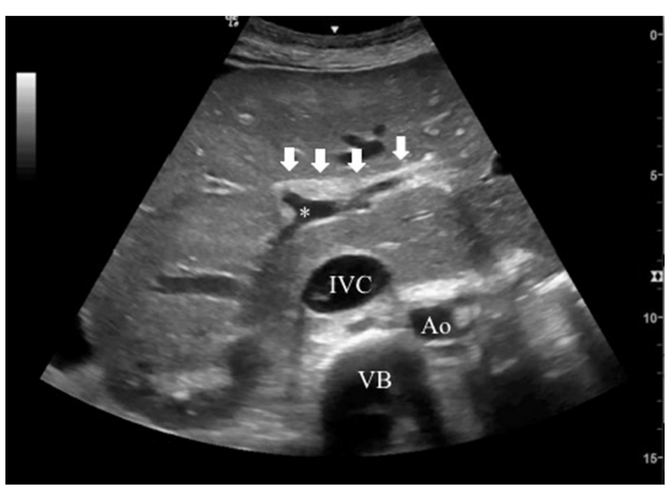

Figure 4. Periportal fibrosis (white arrows) surrounding the portal vein (*) in a patient infected with intestinal schistosomiasis. IVC, aorta (Ao), and vertebral body (VB) are labeled for orientation.

and can be life threatening by early adulthood. Delays in antiparasitic therapy early in the infection can result in unfavorable clinical outcomes.[78]

The immune response to the eggs rather than the adult worm drives morbidity. US is particularly well suited to identify the immune response in infected patients. Adult worms can live in the bladder venous plexus (*Schistosoma hematobium*) or mesenteric venules (*S mansoni*, *S japonicum*, *S intercalatum*) and cause disease. Eggs can become trapped either in the bladder wall or in portal or pulmonary capillary beds, resulting in chronic inflammation and fibrosis. These fibrotic changes are readily visualized on US, and the WHO has published standardized US protocols and scoring systems for both intestinal and urogenital schistosomiasis.[77] In the case of intestinal schistosomiasis, the WHO protocol evaluates periportal fibrosis (Figure 4) and portal hypertension, whereas the urogenital protocol evaluates bladder wall thickening and resulting hydronephrosis. Both scoring systems are based primarily on US findings and can grade the severity of disease.[79] US can also evaluate the response to treatment with praziquantel. Patients with lower severity of infection as graded by US can have improvement or resolution of mild periportal fibrosis and urinary lesions after treatment.[79,80] For patients with higher disease severity, treatment is less likely to result in improvement. Thus, US could be helpful in screening high-risk pediatric populations to identify disease early and target treatment to prevent irreversible complications such as esophageal varices or squamous cell carcinoma of the bladder. (Figure 5.)

The WHO protocols are widely used and accepted.[81,82] They were not initially designed for practicing clinicians and can be more detailed and time consuming than a standard POCUS examination.[1,8] Several simplifications and adaptations to the WHO protocols have been proposed to allow for POCUS application by nonspecialists.[1,2,81] Initial investigations into these modifications suggest that even novice clinicians and first-year medical students can obtain adequate images with high sensitivity and specificity after short training courses.[83,84]

Little data exist on US use specifically for pediatric schistosomiasis. However, many studies evaluating the WHO protocols were performed in a

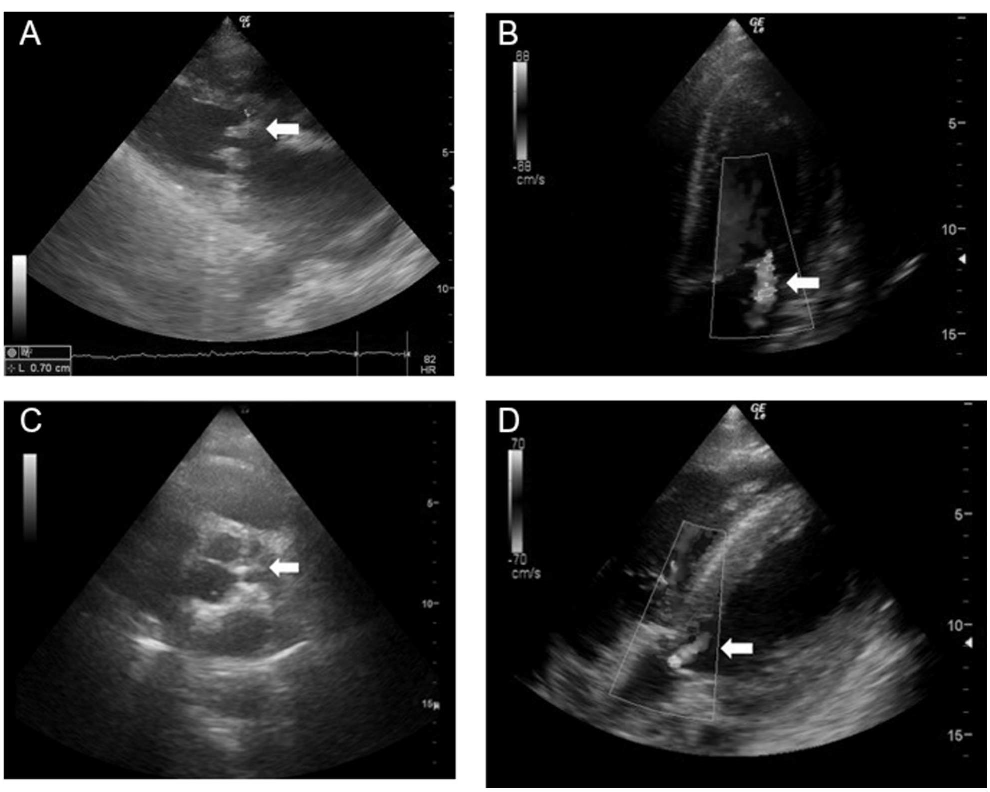

Figure 5. A, Echocardiographic signs of RHD (Nunes).[90] Parasternal long-axis view demonstrating thickening (3 mm measured by calipers) of the anterior mitral valve leaflet (white arrow). B, Apical 4-chamber view demonstrating mitral regurgitation jet 2 cm (white arrow) by color Doppler. C, Parasternal short-axis view demonstrating aortic valve thickening and irregularity (white arrow). D, Apical 5-chamber view demonstrating aortic regurgitation jet (white arrow) by color Doppler.

mixed population of children and adults. For both screening protocols and current research, the WHO criteria are applied regardless of age. Current research is investigating the validity of a more user-friendly POCUS protocol for schistosomiasis that might allow clinicians to readily identify patients with early or mild lesions amenable to treatment and those with advanced lesions requiring specialty follow-up.

RHEUMATIC HEART DISEASE

POCUS of the heart and pericardium is extremely useful in children in RLS for the evaluation of pericardial effusion; cardiomyopathies; and, in certain areas of the world, endomyocardial fibrosis. Its greatest value, however, may be in the assessment of rheumatic heart disease (RHD) in areas of medium to high prevalence for RHD. The World Heart Federation (WHF) estimates that 33 million people worldwide are affected with RHD, with 320 000 deaths annually, many in adolescents or young adults.[85] The prevalence of RHD in children varies dramatically with geography, with the prevalence in westernized countries low, less than 5 per 100 000 people. In Africa, the Middle East, and Central and South Asia, a substantial percentage of school-aged and adolescent children show echocardiographic signs of disease, with a prevalence of 4-10 per 1000 persons. The prevalence is even greater than 10 per 1000 in several Pacific locations.[86] Some of these children are asymptomatic without a history of acute rheumatic fever, and some do not have cardiac murmurs, making screening by auscultation alone ineffective.[87]

Echocardiography remains the tool of choice for the detection of early and moderate to severe RHD.[85] Handheld US machines and traditional standard portable machines are much superior to auscultation, with handheld machines having good sensitivity and specificity compared to standard echo.[87-89] The WHF has published criteria for the diagnosis of RHD in children and for the classification of RHD into 3 distinct categories: normal, borderline, and definite.[89] These diagnostic criteria are widely accepted.[89,90] The WHF defined these categories using 2-dimensional echo, color Doppler, and continuous wave criteria.[90] By defining RHD using continuous wave and color Doppler, only higher-end machines, which are often unavailable in RLS, could be used to classify RHD in children.

Recently, it has been suggested that the WHF echo criteria be simplified to only 5 criteria using just 2D echo (Table 3 and Figure 5).[91,96] This makes the diagnosis and classification of RHD less complicated. These images can be obtained on most machines and by clinicians with limited echo training and experience.[91,92] By assigning a score to each of the positive criteria, children can be stratified into low, intermediate, and high risk for adverse outcome (Table 4).

TABLE 3. Scoring system for risk stratification for progression of RHD in children (Nunes).[90]

Variable	Points
Mitral valve	
Anterior leaflet thickening 3 mm	3
Excessive leaf tip motion	3
Regurgitation jet 2 cm	6
Aortic valve	
Irregular or focal thickening	4
Any regurgitation	5
Total	

Any clinician delivering care in RLS, especially areas with a high prevalence of RHD in children, can expect to be confronted with children in various stages of RHD. The simplified criteria for the diagnosis and stratification of RHD in children make it possible for those with limited experience and limited resources to accurately diagnose and risk stratify children with (and without) RHD and refer those at high risk for progression for intervention or to an appropriate higher level of care.[93,94]

TROPICAL PYOMYOSITIS

US evaluation of soft tissue abnormalities in RLS overlaps significantly with scanning in resource-rich settings. The evaluation of lymph nodes, soft tissue masses, foreign bodies, abscesses, and cellulitis is essentially the same. One soft tissue abnormality

TABLE 4. Progression-free survival at 1, 2, and 3 years by score (Nunes).

Points	Survival Rates	1 y	2 y	3 y
0-6	Low risk	100%	100%	93%
6-10	Intermediate risk	98%	93%	70%
>10	High risk	90%	60%	47%

that is rarely seen in temperate climates, but common in tropical settings, is tropical pyomyositis (TP). TP is found primarily in immunocompetent children and is responsible for up to 4% of pediatric hospital admissions in tropical countries, but the diagnosis is frequently elusive and made at the time of hospital admission only 25% of the time.[95,96] TP is a soft tissue abscess most often surrounding or encasing the large muscles of the lower extremity and pelvic girdle, especially the quadriceps and iliopsoas muscles, but can also involve muscles of the upper extremity and limb girdle.[97,98] Its pathophysiology is poorly understood, but it does not arise from contiguous infections of skin, bone, or other soft tissues.[97,99]

The most common presentation is fever and painful limping or refusal to use the affected limb without a history of substantial injury.[99,100] Although there is usually fever, temperature may be normal, and the abscess site may not be red, warm to touch, or fluctuant.[100,101] TP may present similarly to a variety of musculoskeletal and soft tissue pathologies. A 3-phase evolution of TP has been described in the literature.[96,98] The first is the invasive phase with painful swelling of the area and fever with or without erythema. The area will be described as "wooden" on palpation. Result of US evaluation of the area in the first phase is usually normal. In the second phase, at 2-3 weeks, an abscess forms surrounding the muscle with severe systemic signs and symptoms. Classic signs of an abscess, including erythema and fluctuance, may still be lacking. However, US evaluation will demonstrate an abscess, and aspiration by US guidance will yield pus, frequently in enormous quantities in the hundreds of milliliters. In the third phase, if the abscess remains unrecognized or untreated, the child develops signs of disseminated infection, bacteremia, and sepsis.

Results of plain x-rays of the area in TP are normal and only help to rule out bony abnormalities. US is the primary method of imaging for TP because of its availability, portability, and low cost in RLS.[98,101-104] TP has also been successfully demonstrated using handheld US devices.[105,106] MRI is the imaging method of choice when TP is considered likely and the result of the US examination is normal; however, MRI is frequently not available in RLS or may be too expensive for poor families.[99,102,107] US is also useful in directing aspiration of the abscess in TP[14] and in evaluating if the abscess has been fully drained.[108] The US findings of TP are those of a large, deep abscess, best seen with a high-frequency linear transducer. As with all abscesses, there will be no Doppler color flow.

SUMMARY

POCUS is increasingly used to improve patient care in adult and pediatric patients in various settings around the world. It has a lack of radiation, is portable, and has relatively low cost, making it an ideal diagnostic modality for children in RLS. For clinicians with prior POCUS training, some applications and findings with which they are already familiar can be directly applied to patient care in RLS, as in the diagnosis of pneumonia. Other protocols take well-known examination and apply them to new contexts, such as the FASH examination for EPTB, the search for extravascular fluid in severe dengue, TP, and screening for RHD. For clinicians working in RLS, relatively simple POCUS applications may be a valuable adjunct to diagnosis or risk stratification and may be worth the investment in equipment and training. Further research is needed in many areas to clarify to role of POCUS and its diagnostic accuracy in the hands of bedside clinicians, such as in schistosomiasis, and US may not be as helpful as hoped in some disease processes and settings, such as in dehydration and malaria. The authors believe that with appropriate knowledge of the clinical context and specific disease processes and adequate training in the modality itself, POCUS can be used to improve the care of children around the world.

DISCLOSURE

The authors have no conflicts of interest to disclose and were not supported by any grants.

REFERENCES

1. Belard S, Tamarozzi F, Bustinduy AL, et al. Point-of-care ultrasound assessment of tropical infectious diseases—a review of applications and perspectives. Trop Med Hyg 2016;94:8-21.
2. Brunetti E, Heller T, Richter J, et al. Application of ultrasonography in the diagnosis of infectious diseases in resource-limited settings. Curr Infect Dis Rep 2016;18:6.
3. Henwood PC, Mackenzie DC, Liteplo AS, et al. Point-of-care ultrasound use, accuracy, and impact on clinical decision making in Rwanda hospitals. J Ultrasound Med 2017;36: 1189-94.
4. Shah S, Noble VE, Umulisa I, et al. Development of an ultrasound training curriculum in a limited resource international setting: successes and challenges of ultrasound training in rural Rwanda. Int J Emerg Med 2008;1:193-6.
5. Sippel S, Muruganandan K, Levine A, Shah S. Review article: use of ultrasound in the developing world. Int J Emerg Med 2011;4:72.
6. Stanley A, Wajanga BM, Jaka H, et al. The impact of systematic point-of-care ultrasound on management of

patients in a resource-limited setting. Trop Med Hyg 2017; 96:488-92.

7. Stolz LA, Muruganandan KM, Bisanzo MC, et al. Point-of-care ultrasound education for non-physician clinicians in a resource-limited emergency department. Trop Med Int Health 2015;20:1067-72.
8. Kaminstein D, Heller T, Tamarozzi F. Sound around the 686 world: ultrasound for tropical diseases. Infect Dis Clin North Am 2019;33:169-95.
9. Bortcosh W, Shaahinfar A, Sojar S, Klig JE. New directions in point-of-care ultrasound at the crossroads of paediatric emergency and critical care. Curr Opin Pediatr 2018;30: 350-8.
10. Gold DL, Marin JR, Haritos D, et al. Pediatric emergency medicine physicians' use of point-of-care ultrasound and barriers to implementation: a regional pilot study. AEM Edu Train 2017;1:325-33.
11. Good R, Orsborn J, Stidham T. Point-of-care ultrasound education for pediatric residents in the pediatric intensive care unit. MedEdPortal 2018;1410683 Available at: https://www.mededportal.org/publication/10683/. Accessed 5-5-2019.
12. Le Coz J, Orlandini S, Titomanlio L, Rinaldi VE. Point of care ultrasonography in the pediatric emergency department. Ital J Pediatr 2018;44:87.
13. World Health Organization. Global tuberculosis report 2018. Available at: https://www.who.int/tb/publications/global_report/en/. Accessed 5-5-2019.
14. Newton SM, Brent AJ, Anderson S, et al. Paediatric tuberculosis. Lancet Infect Dis 2008;8:498-510.
15. Seddon JA, Shingadia D. Epidemiology and disease burden of tuberculosis in children: a global perspective. Infect Drug Resis 2014;7:153-65.
16. Belard S, Heller T, Orie V, et al. Sonographic findings of abdominal tuberculosis in children with pulmonary tuberculosis. Pediatr Infect Dis J 2017;36:1224-6.
17. Heuvelings CC, Belard S, Andronikou S, et al. Chest ultrasound findings in children with suspected pulmonary tuberculosis. Pediatr Pulmonol 2019;54:463-70.
18. Sodhi KS, Bhalla AS, Mahomed N, Laya BF. Imaging of thoracic tuberculosis in children: current and future directions. Pediatr Radiol 2017;47:1260-8.
19. Scheepers S, Andronikou S, Mapukata A, Donald P. Abdominal lymphadenopathy in children with tuberculosis presenting with respiratory symptoms. Ultrasound 2011;19: 134-9.
20. Belard S, Heuvelings CC, Banderker E, et al. Utility of point-of-care ultrasound in children with pulmonary tuberculosis. Pediatr Infect Dis J 2018;37:637-42.
21. Heller T, Wallrauch C, Goblirsch S, Brunetti E. Focused assessment with sonography for HIV-associated tuberculosis (FASH): a short protocol and a pictorial review. Crit Ultrasound J 2012;4:21.
22. Heller T, Wallrauch C, Lessells RJ, et al. Short course for focused assessment with sonography for human immunodeficiency virus/tuberculosis: preliminary results in a rural setting in South Africa with high prevalence of human immunodeficiency virus and tuberculosis. Trop Med Hyg 2010;82:512-5.
23. Agostinis P, Copetti R, Lapini L, et al. Chest ultrasound findings in pulmonary tuberculosis. Trop Doct 2017;47:320-8.
24. Heuvelings CC, Belard S, Janssen S, et al. Chest ultrasonography in patients with HIV: a case series and review of the literature. Infection 2016;44:1-10.
25. Hunter L, Belard S, Janssen S, et al. Miliary tuberculosis: sonographic pattern in chest ultrasound. Infection 2016;44: 243-6.
26. Di Gennaro F, Pisani L, Veronese N, et al. Potential diagnostic properties of chest ultrasound in thoracic tuberculosis—a systematic review. Int J Environ Res Pub Health 2018;15, https://doi.org/10.3390/ijerph15102235.
27. Marais BJ, Gie RP, Schaaf HS, et al. A proposed radiological classification of childhood intra-thoracic tuberculosis. Pediatr Radiol 2004;34:886-94.
28. Bosch-Marcet J, Serres-Creixams X, Zuasnabar-Cotro A, et al. Comparison of ultrasound with plain radiography and CT for the detection of mediastinal lymphadenopathy in children with tuberculosis. Pediatr Radiol 2004;34:895-900.
29. Moseme T, Andronikou S. Through the eye of the suprasternal notch: point-of-care sonography for tuberculous mediastinal lymphadenopathy in children. Pediatr Radiol 2014;44:681-4.
30. Bosch-Marcet J, Serres-Creixams X, Borras-Perez V, et al. Value of sonography for follow-up of mediastinal lymphadenopathy in children with tuberculosis. J Clin Ultrasound 2007;35:118-24.
31. Pool KL, Heuvelings CC, Belard S, et al. Technical aspects of mediastinal ultrasound for pediatric pulmonary tuberculosis. Pediatr Radiol 2017;47:1839-48.
32. World Health Organization. Pneumonia: the fact sheet. Available at: https://www.who.int/en/news-room/fact-sheets/detail/pneumonia. Accessed 5-5-2019.
33. Rambaud-Althaus C, Althaus F, Genton B, D'Acremont V. Clinical features for diagnosis of pneumonia in children younger than 5 years: a systematic review and meta-analysis. Lancet Infect Dis 2015;15:439-50.
34. Watkins K, Wright S, Le Nestour A, et al. Fighting for breath: a call to action on childhood pneumonia. Save the Children. Available at: https://resourcecentre.savethechildren.net/node/12479/pdf/fighting_for_breath_-_africa_cover.pdf. Accessed 5-5-2019.
35. Chavez MA, Naithani N, Gilman RH, et al. Agreement between the World Health Organization algorithm and lung consolidation identified using point-of-care ultrasound for the diagnosis of childhood pneumonia by general practitioners. Lung 2015;193:531-8.
36. Pereda MA, Chavez MA, Hooper-Miele CC, et al. Lung ultrasound for the diagnosis of pneumonia in children: a meta-analysis. Pediatrics 2015;135:714-22.
37. Balk DS, Lee C, Schafer J, et al. Lung ultrasound compared to chest X-ray for diagnosis of pediatric pneumonia: a meta-analysis. Pediatr Pulmonol 2018;53:1130-9.
38. Ellington LE, Gilman RH, Chavez MA, et al. Lung ultrasound as a diagnostic tool for radiographically-confirmed pneumonia in low resource settings. Respir Med 2017;128:57-64.
39. Lichtenstein D, Meziere G, Biderman P, et al. The comet-tail artifact. An ultrasound sign of alveolar-interstitial syndrome. Respir Crit Care Med 1997;156:1640-6.
40. Lichtenstein DA. BLUE-protocol and FALLS-protocol: two applications of lung ultrasound in the critically ill. Chest 2015;147:1659-70.
41. Lichtenstein DA, Meziere GA. Relevance of lung ultrasound in the diagnosis of acute respiratory failure: the BLUE protocol. Chest 2008;134:117-25.
42. Amatya Y, Rupp J, Russell FM, et al. Diagnostic use of lung ultrasound compared to chest radiograph for suspected pneumonia in a resource-limited setting. Int J Emerg Med 2018;11:8.

43. Jones BP, Tay ET, Elikashvili I, et al. Feasibility and safety of substituting lung ultrasonography for chest radiography when diagnosing pneumonia in children: a randomized controlled trial. Chest 2016;150:131-8.
44. Trovato FM, Catalano D, Trovato GM. Thoracic ultrasound: an adjunctive and valuable imaging tool in emergency, resource-limited settings and for a sustainable monitoring of patients. World J Radiol 2016;8:775-84.
45. Correa M, Zimic M, Barrientos F, et al. Automatic classification of pediatric pneumonia based on lung ultrasound pattern recognition. PLoS One 2018;13e0206410.
46. Modi P, Glavis-Bloom J, Nasrin S, et al. Accuracy of inferior vena cava ultrasound for predicting dehydration in children with acute diarrhea in resource-limited settings. PLoS One 2016;11e0146859.
47. World Health Organization. Diarrhoeal disease. Available at: https://www.who.int/en/news-room/fact-sheets/detail/diarrhoeal-disease. Accessed 5-5-2019.
48. Koeller E, Robertson SE, Garbern SC, et al. Ultrasound adds no benefit to clinical exam for predicting dehydration in children with acute diarrhea in a resource-limited setting. J Ultrasound Med 2019;38:685-93.
49. Chen L, Hsiao A, Langhan M, et al. Use of bedside ultrasound to assess degree of dehydration in children with gastroenteritis. Acad Emerg Med 2010;17:1042-7.
50. Jauregui J, Nelson D, Choo E, et al. The BUDDY (bedside ultrasound to detect dehydration in youth) study. Crit Ultrasound J 2014;6:15.
51. Levine AC, Shah SP, Umulisa I, et al. Ultrasound assessment of severe dehydration in children with diarrhea and vomiting. Acad Emerg Med 2010;17:1035-41.
52. Mazza G, Romo CM, Torres M, et al. Assessment of clinical dehydration using point of care ultrasound for pediatric patients in rural Panama. World J Emerg Med 2019;10:46-50.
53. Guzman MG, Harris E. Dengue. Lancet 2015;385:453-65.
54. Bhatt S, Gething PW, Brady OJ, et al. The global distribution and burden of dengue. Nature 2013;496:504-7.
55. GBD 2017 DALYs and HALE Collaborators. Global, regional, and national disability-adjusted life-years (DALYs) for 359 diseases and injuries and healthy life expectancy (HALE) for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 2018;392(10159):1859–1922.
56. World Health Organization. Dengue: guidelines for diagnosis, treatment, prevention, and control: new edition. Geneva: World Health Organization; 2009. Available at: https://apps.who.int/iris/handle/10665/44188. Accessed 5-8-2019.
57. Balasubramanian S, Janakiraman L, Kumar SS, et al. A reappraisal of the criteria to diagnose plasma leakage in dengue hemorrhagic fever. Indian Pediatr 2006;43:334-9.
58. Bharath Kumar Reddy KR, Laksmana RR, Veerappa BG, Shivananda N. Ultrasonography as a tool in predicting the severity of dengue fever in children—a useful aid in a developing country. Pediatr Radiol 2013;43:971-7.
59. Ferreira BDC, Correia D. Ultrasound assessment of hepatobiliary and splenic changes in patients with dengue and warning signs during the acute and recovery phases. J Ultrasound Med 2018; Dec 14, https://doi.org/10.1002/jum.14890.
60. Joob B, Wiwanitkit V. Ultrasound and screening tool for dengue fever. Pol J Radiol 2018;83:e587.
61. Khurram M, Qayyum W, Umar M, et al. Ultrasonographic pattern of plasma leak in dengue haemorrhagic fever. J Pakistan Med Assoc 2016;66:260-4.
62. Parmar JP, Mohan C, Vora M. Patterns of gall bladder wall thickening in dengue fever: a mirror of the severity of disease. Ultrasound Int Open 2017;3:E76-81.
63. Pothapregada S, Kullu P, Kamalakannan B, Thulasingam M. Is ultrasound a useful tool to predict severe dengue infection? Indian J Pediatr 2016;83:500-4.
64. Venkata Sai PM, Dev B, Krishnan R. Role of ultrasound in dengue fever. Br J Radiol 2005;78:416-8.
65. Santhosh VR, Patil PG, Srinath MG, et al. Sonography in the diagnosis and assessment of dengue Fever. J Clin Imaging Sci 2014;4:14.
66. World Health Organization. World malaria report. Available at: https://www.who.int/malaria/publications/world_malaria_report/en/. Accessed 5-8-2019.
67. D'Acremont V, Kilowoko M, Kyungu E, et al. Beyond malaria—causes of fever in outpatient Tanzanian children. N Engl J Med 2014;370:809-17.
68. Kallander K, Nsungwa-Sabiiti J, Peterson S. Symptom overlap for malaria and pneumonia - policy implications for home management strategies. Acta Trop 2004;90:211-4.
69. Mwangi TW, Ross A, Snow RW, Marsh K. Case definitions of clinical malaria under different transmission conditions in Kilifi District, Kenya. J Infect Dis 2005;191:1932-9.
70. Smith T, Charlwood JD, Kihonda J, et al. Absence of seasonal variation in malaria parasitaemia in an area of intense seasonal transmission. Acta Trop 1993;54:55-72.
71. Malerba P, Kaminstein D, Brunetti E, Manciulli T. Is there a role for bedside ultrasound in malaria? A survey of the literature. J Ultrasound 2019; Mar 9, doi: https://doi.org/10.1007/s40477-019-00371-8.
72. Newton CR, Marsh K, Peshu N, Kirkham FJ. Perturbations of cerebral hemodynamics in Kenyans with cerebral malaria. Pediatr Neurol 1996;15:41-9.
73. Murphy S, Cserti-Gazdewich C, Dhabangi A, et al. Ultrasound findings in plasmodium falciparum malaria: a pilot study. Pediatr Crit Care Med 2011;12:e58-63.
74. O'Brien NF, Mutatshi Taty T, Moore-Clingenpeel M, et al. Transcranial doppler ultrasonography provides insights into neurovascular changes in children with cerebral malaria. J Pediatr 2018;203:116-24 e113.
75. Beare NA, Glover SJ, Lewallen S, et al. Prevalence of raised intracranial pressure in cerebral malaria detected by optic nerve sheath ultrasound. Trop Med Hyg 2012;87:985-8.
76. Savi de Tové K. Savi de Tové-Sissinto Y, Adedemy DJ, et al. Sonographic measurement of optic nerve sheath diameter: a prognostic tool for childhood cerebral malaria? Open J Radiol 2019;9:69-81.
77. World Health Organization. Schistosomiasis. Available at: http://www.who.int/schistosomiasis/epidemiology/en/. Accessed 5-8-2019.
78. Bustinduy AL, Parraga IM, Thomas CL, et al. Impact of polyparasitic infections on anemia and undernutrition among Kenyan children living in a Schistosoma haematobium-endemic area. Trop Med Hyg 2013;88:433-40.
79. Berhe N, Myrvang B, Gundersen SG. Reversibility of schistosomal periportal thickening/fibrosis after praziquantel therapy: a twenty-six month follow-up study in Ethiopia. Trop Med Hyg 2008;78:228-34.
80. Bocanegra C, Pintar Z, Mendioroz J, et al. Ultrasound evolution of pediatric urinary schistosomiasis after treatment with praziquantel in a highly endemic area. Trop Med Hyg 2018;99:1011-7.

81. Akpata R, Neumayr A, Holtfreter MC, et al. The WHO ultrasonography protocol for assessing morbidity due to Schistosoma haematobium. Acceptance and evolution over 14 years. Systematic review. Parasitol Res 2015;114:1279-89.
82. el Scheich T, Holtfreter MC, Ekamp H, et al. The WHO ultrasonography protocol for assessing hepatic morbidity due to Schistosoma mansoni. Acceptance and evolution over 12 years. Parasitol Res 2014;113:3915-25.
83. Barsky M, Kushner L, Ansbro M, et al. A feasibility study to determine if minimally trained medical students can identify markers of chronic parasitic infection using bedside ultrasound in rural Tanzania. World J Emerg Med 2015;6:293-8.
84. Bonnard P, Boutouaba S, Diakhate I, et al. Learning curve of vesico-urinary ultrasonography in Schistosoma haematobium infection with WHO practical guide: a "simple to learn" examination. Trop Med Hyg 2011;85:1071-4.
85. World Heart Federation. Rheumatic heart disease. Available at: https://www.world-heart-federation.org/programmes/rheumatic-heart-disease. Accessed 5-1-2019.
86. Seckeler MD, Hoke TR. The worldwide epidemiology of acute rheumatic fever and rheumatic heart disease. Clin Epidemiol 2011;3:67-84.
87. Godown J, Lu JC, Beaton A, et al. Handheld echocardiography versus auscultation for detection of rheumatic heart disease. Pediatrics 2015;135:e939-44.
88. Lu JC, Sable C, Ensing GJ, et al. Simplified rheumatic heart disease screening criteria for handheld echocardiography. J Am Soc Echocardio 2015;28:463-9.
89. Remenyi B, Wilson N, Steer A, et al. World Heart Federation criteria for echocardiographic diagnosis of rheumatic heart disease—an evidence-based guideline. Nat Rev Cardiol 2012;9:297-309.
90. Nunes MCP, Sable C, Nascimento BR, et al. Simplified echocardiography screening criteria for diagnosing and predicting progression of latent rheumatic heart disease. Circ Cardiovasc Imag 2019;12e007928.
91. Longenecker CT. Echo screening for rheumatic heart disease. Circ Cardiovasc Imag 2019;12e008818.
92. Mirabel M, Bacquelin R, Tafflet M, et al. Screening for rheumatic heart disease: evaluation of a focused cardiac ultrasound approach. Circ Cardiovasc Imag 2015;8, https://doi.org/10.1161/CIRCIMAGING.114.002324.
93. Beaton A, Aliku T, Dewyer A, et al. Latent rheumatic heart disease: identifying the children at highest risk of unfavorable outcome. Circulation 2017;136:2233-44.
94. Nishimura RA, Otto CM, Bonow RO, et al. 2017 AHA/ACC focused update of the 2014 AHA/ACC guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Circulation 2017;135(25):e1159-95.
95. Gubbay AJ, Isaacs D. Pyomyositis in children. Pediatr Infect Dis J 2000;19:1009-12.
96. Chauhan S, Jain S, Varma S, Chauhan SS. Tropical pyomyositis (myositis tropicans): current perspective. Postgrad Med J 2004;80:267-70.
97. Verma S, Singhi SC, Marwaha RK, et al. Tropical pyomyositis in children: 10 years experience of a tertiary care hospital in northern India. J Trop Pediatr 2013;59:243-5.
98. Verma S. Pyomyositis in children. Curr Infect Dis Rep 2016; 18:12.
99. Ovadia D, Ezra E, Ben-Sira L, et al. Primary pyomyositis in children: a retrospective analysis of 11 cases. J Pediatr Orthoped 2007;16:153-9.
100. Pannaraj PS, Hulten KG, Gonzalez BE, et al. Infective pyomyositis and myositis in children in the era of community-acquired, methicillin-resistant Staphylococcus aureus infection. Clin Infect Dis 2006;43:953-60.
101. Chiu NC, Hsieh MC, Chi H, Huang FY. Clinical characteristics of pyomyositis in children: 20-year experience in a medical center in Taiwan. J Microbiol Immunol Infect 2009; 42:494-9.
102. Manikandan V, Mehrotra S, Anand S, Maurya V. Tropical pyomyositis: revisited. Indian J Surg 2017;79:33-7.
103. Farrell G, Berona K, Kang T. Point-of-care ultrasound in pyomyositis: a case series. Am J Emerg Med 2018;36:881-4.
104. Chattopadhyay B, Mukhopadhyay M, Chatterjee A, et al. Tropical pyomyositis. North Am J Med Sci 2013;5:600-3.
105. Levitt DL, Byer R, Miller AF. Point-of-care ultrasound to diagnose pyomyositis in a child. Pediatr Emerg Care 2019; 35:69-71.
106. Park E, Chilstrom M. Diagnosis of pyomyositis in a pediatric patient with point-of-care ultrasound. West J Emerg Med 2016;17:464-5.
107. Hernandez RJ, Strouse PJ, Craig CL, Farley FA. Focal pyomyositis of the perisciatic muscles in children. Am J Roentgenol 2002;179:1267-71.
108. Palacio EP, Rizzi NG, Reinas GS, et al. Open drainage versus percutaneous drainage in the treatment of tropical myositis. Revista Brasileira Ortoped 2010;45:260-8.