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THORACIC IMAGING

Imaging findings in acute pediatric coronavirus disease 2019 (COVID-19) pneumonia and multisystem inflammatory syndrome in children (MIS-C)

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Abstract
The two primary manifestations of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) in children are acute coronavirus disease 2019 (COVID-19) pneumonia and multisystem inflammatory syndrome (MIS-C). While most pediatric cases of acute COVID-19 disease are mild or asymptomatic, some children are at risk for developing severe pneumonia. In MIS-C, children present a few weeks after SARS-CoV-2 exposure with a febrile illness that can rapidly progress to shock and multiorgan dysfunction. In both diseases, the clinical and laboratory findings can be nonspecific and present a diagnostic challenge. Thoracic imaging is commonly obtained to assist with initial workup, assessment of disease progression, and guidance of therapy. This paper reviews the radiologic findings of acute COVID-19 pneumonia and MIS-C, highlights the key distinctions between the entities, and summarizes our understanding of the role of imaging in managing SARS-CoV-2-related illness in children.

Keywords Chest · Children · Computed tomography · Coronavirus disease 2019 · Lungs · Multisystem inflammatory syndrome in children · Radiography

Introduction

Coronavirus disease 2019 (COVID-19), the disease caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was initially reported in late 2019. It subsequently spread rapidly throughout the world in early 2020 and was officially declared a pandemic by the World Health Organization (WHO) on March 11, 2020 [1]. People at highest risk for serious complications and fatality from acute COVID-19 include older adults and those with underlying medical conditions including obesity, diabetes, hypertension, cardiovascular disease and chronic respiratory disease [2–5]. The vast majority of clinical and imaging data from the pandemic has been reported in adults because children are less susceptible to symptomatic infection with SARS-CoV-2 and account for only a small number of cases [6–8]. However, children might be a significant source of transmission [9]. The considerable variability of findings and outcomes reported in children with COVID-19 yields an unclear picture of the pandemic's effect on the pediatric population [10, 11].

Most acute COVID-19 infections in children are asymptomatic or only mildly symptomatic, consisting of fever, dry cough, fatigue, headache, sore throat, rhinorrhea and gastrointestinal symptoms [8, 10, 12–17]. A small subset of children develops severe pneumonia, with some cases leading to respiratory failure and shock, requiring intensive care and mechanical ventilation [12–16, 18]. While COVID-19 infection can present at any age, risk factors for severe disease in children include younger age, obesity, neurologic and metabolic conditions, congenital heart disease, malignancy, asthma, sickle cell disease and immunosuppression [8, 10, 12, 18, 19]. The prognosis of pediatric COVID-19 infection is generally good, with most children recovering in 1–2 weeks, although rare fatalities have been reported [10, 12, 13, 16, 20].

Multisystem inflammatory syndrome in children (MIS-C) is a syndrome associated with SARS-CoV-2 that is characterized by fever, inflammation and multiorgan dysfunction.

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It was first reported several months following the original peak of the COVID-19 pandemic, with the earliest known cases in Italy, the United Kingdom and the United States in April and May of 2020 [21–26]. The syndrome initially presented as an unexplained systemic illness originally considered to be similar to Kawasaki disease and toxic shock syndrome [21–26]. As more cases arose around the globe, MIS-C was subsequently recognized as a distinct entity by the Centers for Disease Control and Prevention (CDC) and the WHO [27, 28]. It has not been proved that SARS-CoV-2 causes MIS-C; however, strong evidence includes the temporal and geographic relationship to outbreaks of COVID-19 [29, 30]. Children usually present a few weeks after a history of COVID-19-like symptoms, and they test positive for SARS-CoV-2 immunoglobulin M (IgM) and immunoglobulin G (IgG) antibodies [7, 22, 29–33]. This association suggests that MIS-C is caused by post-infectious immune dysregulation that leads to an exaggerated inflammatory response, rather than an acute viral infection, although a possible direct viral effect has not been excluded [7, 32–34].

Diagnostic criteria for MIS-C include pediatric age group (<21 years by CDC definition, <19 years by WHO definition), fever, involvement of two or more organ systems (common findings include mucocutaneous rash, gastrointestinal symptoms, hypotension, shock, cardiac dysfunction, acute kidney injury and coagulopathy), elevated inflammatory markers (e.g., erythrocyte sedimentation rate, C-reactive protein), evidence of current or prior SARS-CoV-2 infection, and exclusion of other microbial infections or alternative diagnoses [27, 28]. Gastrointestinal symptoms (abdominal pain and diarrhea) and cardiovascular dysfunction (myocardial injury, depressed ejection fraction, hypotension) occur with high frequency, while respiratory symptoms are less common [21, 30]. In contrast to COVID-19 pneumonia, most children with MIS-C develop critical illness within a few days, requiring resuscitation, ionotropic support and intensive care admission, with occasional severe cases leading to mechanical ventilation or extracorporeal membrane oxygenation (ECMO) [30]. Unlike COVID-19 pneumonia, severe illness in MIS-C occurs in children who are otherwise healthy with no comorbidities [21, 30]. Despite the initial severity of the disease, short-term outcomes are positive and most children recover within a few days, although a few deaths have been reported [30, 35, 36].

In both acute COVID-19 and MIS-C, the presenting symptoms and laboratory markers are often nonspecific and the diagnosis can be delayed. Radiologic studies are often requested during initial workup, and these studies must be synthesized with the clinical presentation to recognize the diagnosis [10]. Although the imaging features of COVID-19 and MIS-C can overlap with those of other infectious and non-infectious diseases, it is important for the radiologist to recognize the characteristic findings that would support one of these diagnoses, especially when a critically ill child presents with suspected COVID-19 infection or known COVID-19 exposure [12, 14, 37, 38]. In this review, we describe the imaging findings of acute COVID-19 pneumonia in children and MIS-C, and highlight the features that distinguish the two conditions.

Imaging findings in acute coronavirus 2019

In pediatric acute COVID-19 infection, imaging is usually reserved for children who have risk factors for developing severe disease, or who are clinically deteriorating. According to current recommendations from the American College of Radiology (ACR), imaging should not routinely be performed for screening or first-line diagnostic testing [39, 40]. In children with a complicated disease course requiring imaging to guide therapy, chest radiograph and chest CT are the mainstay modalities being used [41]. Of note, a handful of papers have also reported chest US findings of children with severe COVID-19 infection; however, only a small number of cases have been described, and this technique has not been widely adopted [42].

Classically, chest radiograph is the primary diagnostic imaging tool used to assess for pneumonia in a child presenting with fever and cough. However, there is a paucity of reliable data regarding chest radiograph findings in children with COVID-19 pneumonia because of its low prevalence [39]. There is also high variability in the incidence of abnormal exams and patterns of opacities described in the literature, which further limits our understanding of the radiographic findings [12, 43–54]. This could reflect institutional differences in frequency of image utilization, differences in severity of illness among various pediatric study populations (disease severity is not ubiquitously well-documented), and radiologist intra- and interobserver variability (a known challenge in interpretation of pediatric chest radiographs) [50, 55, 56].

A wide variety of findings have been reported on chest radiographs in pediatric COVID-19; however, the most common abnormalities include consolidation, ground-glass opacity and peribronchial thickening [43–54]. The opacities can be unilateral or bilateral, focal (singular) or non-focal (multiple, patchy, diffuse), and peripheral or central [43–53] (Figs. 1, 2 and 3). Some studies note a predilection for the lung bases, with equal distribution in the right and left lung [12, 39, 43, 47, 56]. These findings are overall nonspecific, and there is overlap of the classic patterns of viral infection (symmetrical perihilar opacity and peribronchial thickening) and bacterial infection (focal or multifocal dense consolidation) [48, 57]. Of note, pleural effusions and lymphadenopathy are uncommon in pediatric COVID-19 pneumonia [43, 44, 47].

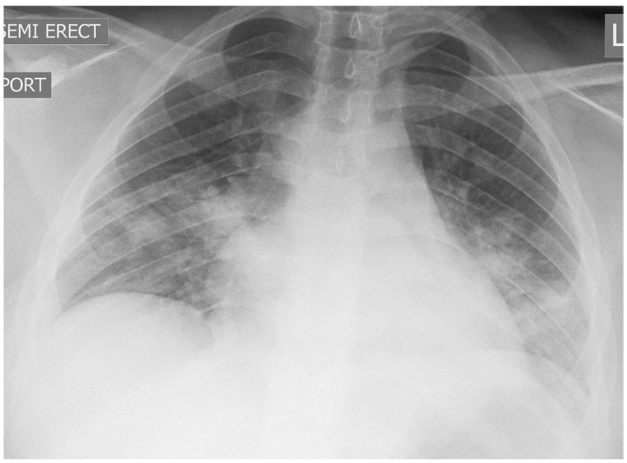

Fig. 1 Ground-glass opacities on radiography in acute coronavirus disease 2019 (COVID-19) pneumonia. A 12-year-old obese boy presented with fever, cough and hypoxia. Anteroposterior chest radiograph demonstrates ill-defined ground-glass opacities in both the mid and lower lung fields, with superimposed patchy perihilar consolidation

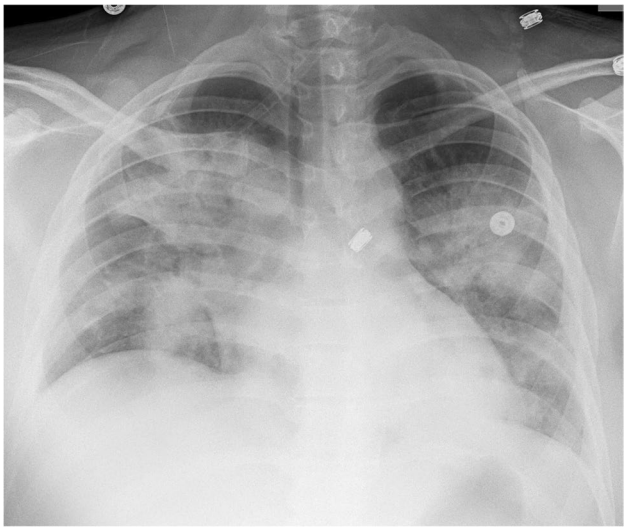

Fig. 2 Radiography of consolidation in acute coronavirus disease 2019 (COVID-19) pneumonia in a 20-year-old man. He presented with fever, cough and dyspnea. Anteroposterior chest radiograph demonstrates multiple confluent regions of consolidation throughout both lungs

The number of studies in the literature describing chest CT in acute COVID-19 pneumonia is significantly greater than for chest radiography. Unfortunately, because of the low incidence of disease in children, these studies focus on small populations, and as with chest radiography there is considerable variability in reported chest CT patterns. Therefore, the role of chest CT in pediatric COVID-19 has not been fully established. Just as with most other

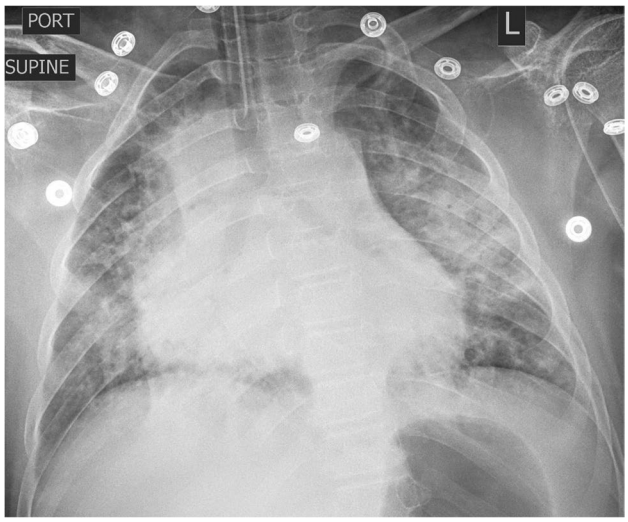

Fig. 3 Dense consolidation on radiography in acute coronavirus disease 2019 (COVID-19) pneumonia in a 14-year-old boy. The boy had a history of seizure disorder. He presented with fever and respiratory distress. Anteroposterior chest radiograph demonstrates diffuse ground-glass opacification of the lungs, with bilateral perihilar and retrocardiac dense consolidation

pulmonary processes, it is likely that in COVID-19 pneumonia, chest CT is more sensitive in detecting abnormalities that might not be visible on chest radiograph [46]. However, these findings can be subtle and nonspecific, and their presence does not necessarily affect patient management [20, 46]. In adults, typical findings include bilateral multifocal peripheral ground-glass opacities, with or without consolidation, which can be rounded and can demonstrate "crazy paving" (ground-glass opacity with intralobular lines) [58]. "Halo sign" (central dense consolidation with surrounding ground-glass opacity) and "reverse halo sign," also known as "atoll sign" (central ground-glass opacity with surrounding dense consolidation), have also been reported [58–62]. The primary findings of ground-glass opacity and consolidation are also seen in children, but studies comparing pediatric and adult CT have shown that the opacities in children are less severe with regard to number, size and extent [63–66].

The most common CT abnormalities described in pediatric COVID-19 pneumonia are multiple ground-glass opacities, with or without consolidation, which can be subpleural/peripheral or central in location [45–48, 51, 54, 56, 63–72] (Figs. 4 and 5). A "halo sign" has also been reported, and this seems to be more common in children than in adults [54, 64, 65, 68, 69, 72] (Fig. 6). Interstitial-type opacities and small airway-type findings, such as bronchial wall thickening, septal thickening and tree-in-bud nodules, have been described as highly frequent in some studies, but uncommon in other studies [45, 51, 54, 64, 66–68]. As with chest radiography, pleural effusions are not usually seen, and

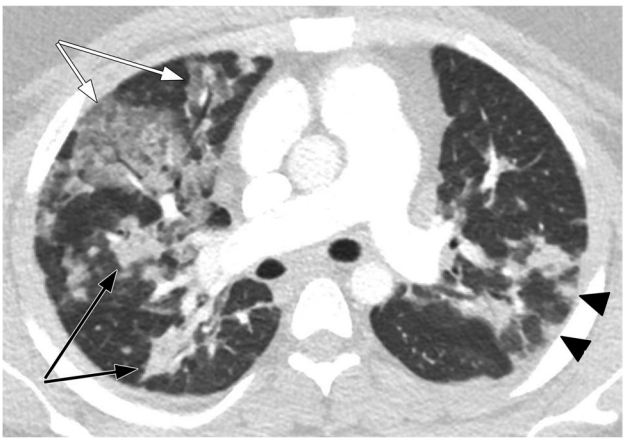

Fig. 4 CT findings in acute coronavirus disease 2019 (COVID-19) pneumonia. A 19-year-old obese man presented with fever, cough and hypoxia. Axial chest CT image in lung window demonstrates ground-glass opacities (*white arrows*), consolidative opacities (*black arrows*) and subpleural nodular opacities (*arrowheads*)

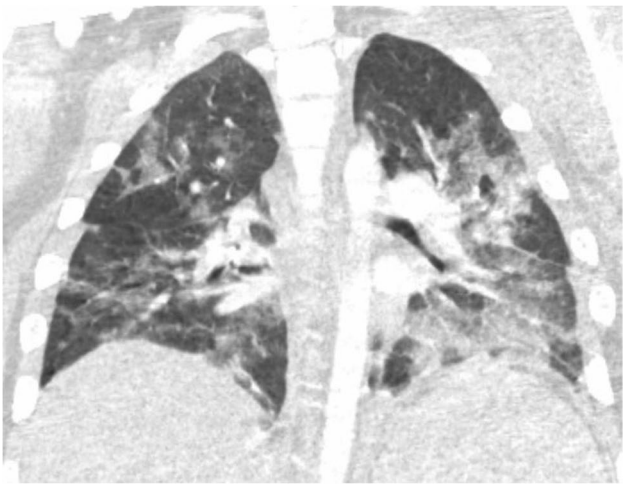

Fig. 5 CT findings in a 13-year-old boy with acute coronavirus disease 2019 (COVID-19) pneumonia who presented with fever, dyspnea and chest pain. Coronal chest CT image in lung window demonstrates multiple peripheral and central ground-glass opacities throughout both lungs

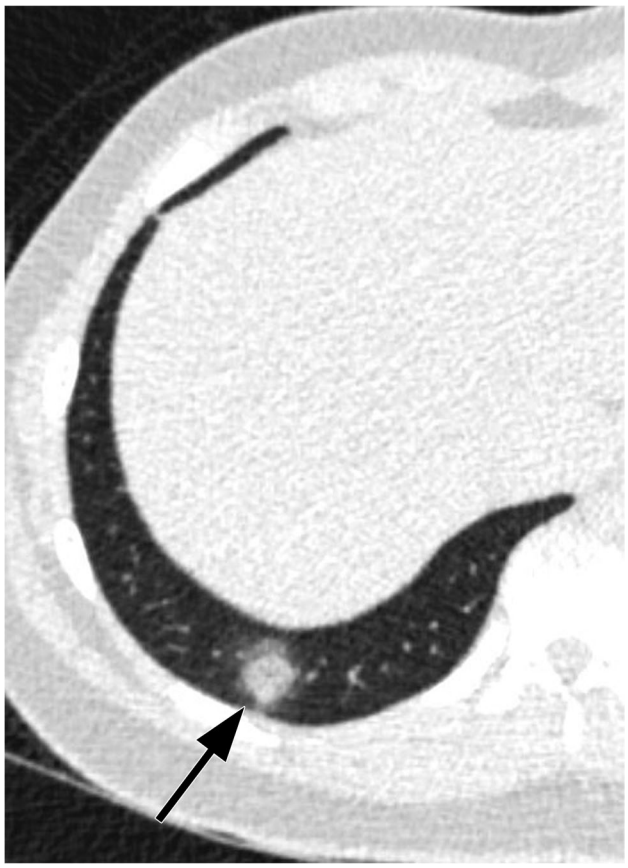

Fig. 6 Halo sign in a 15-year-old asymptomatic boy with osteosarcoma. He underwent surveillance imaging and was subsequently found to have coronavirus disease 2019 (COVID-19) infection by reverse transcriptase polymerase chain reaction (RT-PCR). Axial chest CT image in lung window shows a right lower lobe subpleural nodule with surrounding ground-glass opacity, or halo sign *(arrow)*. The finding resolved on a follow-up scan

when present are typically small in size [45, 51, 56, 67]. An increased risk for pulmonary embolism in COVID-19-infected adults has been well described, but thus far it appears to be uncommon in children [45, 68, 73, 74].

Because of the uncertainty of test availability and reliability during the early peak of the pandemic in adults, it was thought that imaging might be a useful tool in primary diagnosis of acute COVID-19. However, despite the presence of a positive RT-PCR test, imaging in children is often normal [20, 75]. When abnormalities are present, there is great diversity and nonspecificity of findings [20, 56, 68, 69, 76, 77]. Moreover, the majority of pediatric studies available in the literature do not adjust for the clinical severity of disease, nor do they take into account possible coexisting infections [20, 56, 76]. These issues limit the meaningfulness of radiographic interpretations in pediatric COVID-19 disease. In a few studies, some data support a link between the severity of pulmonary opacities on imaging and indicators of clinical severity, such as degree of respiratory distress, need for hospital admission and intensive care stay, presence of underlying conditions, and patient fatalities [45, 47, 50, 51, 53, 71, 72]. Thus, while imaging might not play a primary diagnostic role in acute pediatric COVID-19, it remains an integral part of patient care, mainly to assess disease progression or anticipate a change in management, especially in children with critical illness and chronic comorbidities [20, 41, 43, 45, 48].

Imaging findings in multisystem inflammatory syndrome in children

Imaging is not required for diagnosis of MIS-C because the criteria are based on clinical symptoms, laboratory values, history of SARS-CoV-2 infection and exclusion of other conditions [27, 28]. However, radiologic studies are frequently obtained in children with MIS-C because of their rapid clinical deterioration, and imaging abnormalities are important to recognize because they are associated with fulminant illness including shock [29]. Chest radiographs are often obtained in children with MIS-C who are undergoing cardiac workup or being admitted to the intensive care unit. Additionally, because of the high prevalence of gastrointestinal symptoms in this syndrome, abdominal imaging including plain radiograph, US or CT is often obtained, even before the diagnosis of MIS-C is recognized. As the following sections demonstrate, a variety of organ systems can manifest with imaging abnormalities in MIS-C, which reflects the systemic inflammatory response that characterizes this disease.

Intrathoracic imaging findings

Pulmonary

Primary pulmonary involvement is not a leading feature of MIS-C, and therefore at initial presentation, chest imaging might be normal [30, 43]. Within the first few days as the illness evolves, the most common radiographic findings are bilateral symmetrical hazy airspace opacities with perihilar or basilar/lower lobe predominance, as well as increased interstitial markings and peribronchial cuffing/thickening, bilateral small pleural effusions and enlargement of the cardiac silhouette [14, 37, 38, 43, 78–80] (Figs. 7 and 8). The underlying etiology of these findings is unclear; however, the appearance is reminiscent of interstitial pulmonary edema or acute respiratory distress syndrome (ARDS), indicating that it could originate from a cardiogenic process, systemic inflammatory process, or aggressive fluid resuscitation and third spacing [14, 37, 76, 80]. Of note, chest radiographs in MIS-C can be abnormal even in children without respiratory symptoms, suggesting that the findings reflect cardiac dysfunction or fluid overload rather than pulmonary inflammation [38, 78–80].

Chest CT is rarely needed in children with MIS-C, although it is sometimes obtained as part of a sepsis workup pathway or if there is clinical concern for pulmonary embolism [37, 38]. Compared to acute COVID-19 pneumonia, there is a paucity of descriptions of MIS-C on CT in the literature; however, existing reports generally mimic the chest radiograph findings. The most common abnormalities include bibasilar consolidation, ground-glass opacities, interstitial opacities including septal thickening and bronchial wall thickening, bilateral small pleural effusions, mild hilar lymphadenopathy, and cardiomegaly [38, 78, 81] (Figs. 9 and 10). Pulmonary nodules have been reported in a few instances and are of uncertain significance [38, 78].

Cardiac

Cardiac imaging is indicated in MIS-C to document baseline systolic function during the initial phase of illness, and for serial follow-up [82]. On echocardiography, children typically demonstrate myocardial dysfunction with depressed ejection fraction [35, 36, 83–86]. Pericardial effusion and mitral regurgitation have also been described [35, 36, 38, 83–87]. Coronary artery ectasia or aneurysm has been reported in some case series on echocardiogram and cardiac CT angiography, but this is not a universal finding [38, 78, 86–89].

Cardiac MRI is also suggested for characterizing myocardial disease in children with MIS-C with significant left ventricular dysfunction (ejection fraction <50%) [82]. Limited data are available; however, most studies report a myocarditis-type picture, demonstrated as diffuse myocardial edema or a non-ischemic gadolinium enhancement pattern, without evidence of necrosis or fibrosis [78, 85, 90–92]. Fortunately, both the clinical and imaging findings of heart failure in MIS-C appear to be transient, with quick recovery of systolic function and normalization of myocardial signal on MRI [88, 91, 93].

Vascular

It is well established that adults with COVID-19 are vulnerable to vascular complications including multiorgan thromboembolic disease, and based on this assumption, some expert multidisciplinary groups have recommended thromboprophylaxis in children with COVID-19 or MIS-C [94–96]. However, there is a lack of consensus on this topic, including whether imaging should be obtained in pursuit of deep venous thrombosis and pulmonary embolism. The greater pro-inflammatory cytokine response and higher plasma D-dimer levels seen in MIS-C suggest that these children are more vulnerable to thromboembolic phenomenon compared to those with acute COVID-19 [74, 97]. It appears from some reports that the incidence of deep venous thrombosis and pulmonary embolism in pediatric SARS-CoV-2-related illnesses is higher than baseline; however, at some institutions, no cases of pulmonary embolism have been documented [21, 37, 38, 74, 98–100]. In MIS-C, the known cases of pulmonary embolism have been small and segmental in location, but few papers include information on embolism size or location [37, 93]. There is data to suggest that the existing cases of pediatric SARS-CoV-2-associated thromboembolism are linked to underlying risk factors, such as indwelling central lines, malignancy and ECMO [74, 94, 96, 98, 99].

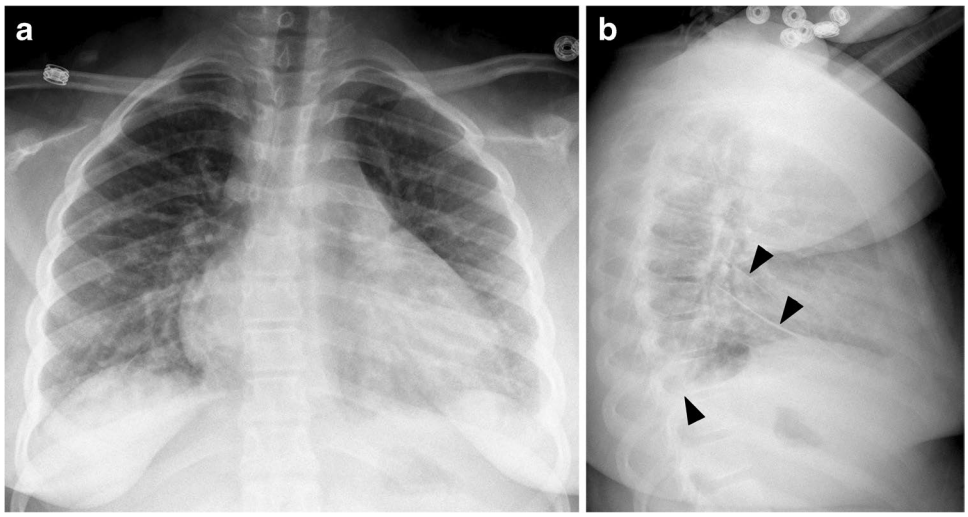

Fig. 7 Multisystem inflammatory syndrome in children (MIS-C) in an 11-year-old girl who presented with fever, abdominal pain and headache. **a, b** Posteroanterior (**a**) and lateral (**b**) chest radiographs demonstrate a mildly enlarged cardiac silhouette and interstitial edema with basilar-predominant hazy interstitial markings. There are small pleural effusions with blunting of the costophrenic angles and fluid tracking into the fissures (*arrowheads*)

Extrathoracic imaging findings

Abdominal

Gastrointestinal symptoms are among the most common presenting findings of MIS-C, often mimicking acute appendicitis, and leading to imaging of the abdomen before the diagnosis of MIS-C is considered [38, 88, 101–103]. On US and CT, children with MIS-C frequently demonstrate nonspecific inflammatory changes in the right lower quadrant, including lymphadenopathy, mesenteric edema (hyperechogenicity, thickening, stranding) and bowel wall thickening especially at the terminal ileum and cecum [37, 38, 78–80, 103–105] (Figs. 11, 12 and 13). Some researchers have suggested that the localized right lower quadrant findings in a mesenteric adenitis pattern is due to the abundant lymphoid tissue in the terminal ileum (Peyer patches), which is vulnerable to vasculitis and necrotizing lymphadenitis caused by the systemic hyperinflammatory illness [38, 78, 102, 105]. The appendix can appear radiologically normal or abnormal, and imaging cannot always clearly distinguish between MIS-C and acute appendicitis [38, 79, 101, 104, 106–108]. Therefore, these findings must be considered in light of multiorgan involvement and laboratory data that would support a diagnosis of MIS-C.

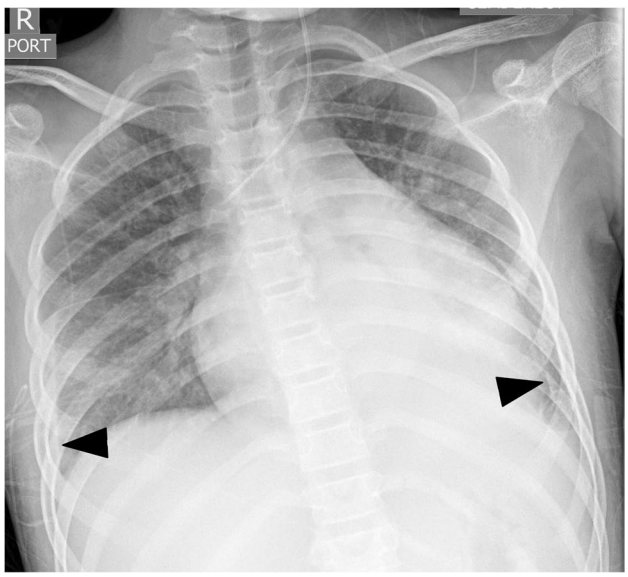

Fig. 8 Multisystem inflammatory syndrome in children (MIS-C) in a 9-year-old girl who presented with fever and abdominal pain. Anteroposterior chest radiograph shows a mildly enlarged cardiac silhouette, interstitial edema with increased interstitial markings and hazy pulmonary opacity, worst at the bases, and bilateral small pleural effusions (*arrowheads*)

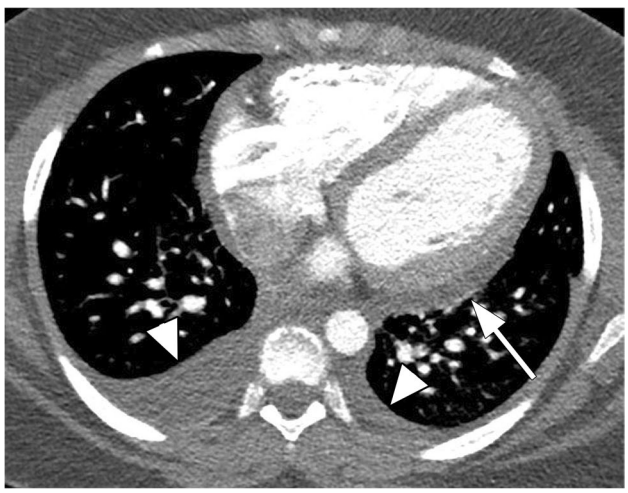

Fig. 9 Chest CT findings in a 10-year-old girl with multisystem inflammatory syndrome in children (MIS-C) who presented with fever and chest and abdominal pain. Axial contrast-enhanced chest CT image in soft-tissue window demonstrates cardiomegaly, small pericardial effusion (*arrow*) and bilateral small pleural effusions (*arrowheads*)

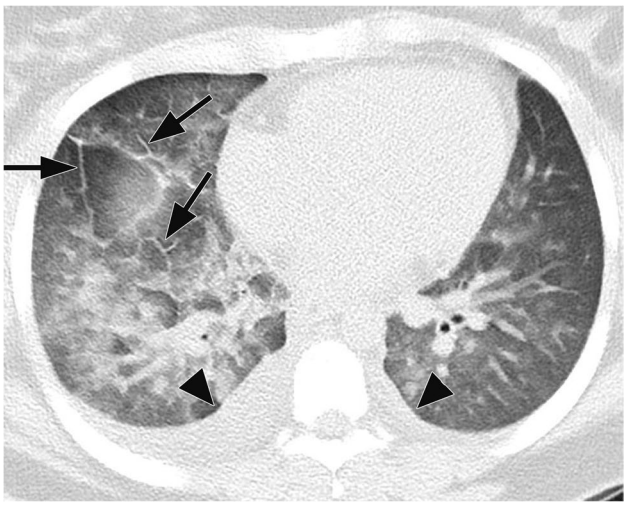

Fig. 10 Chest CT findings in an 18-year-old woman with multisystem inflammatory syndrome in children (MIS-C) who presented with fever and hypoxia. Axial chest CT in lung window demonstrates pulmonary edema with ground-glass opacities, interlobular septal thickening (*arrows*) and small pleural effusions (*arrowheads*)

Other common abdominal imaging findings of MIS-C include small-volume simple ascites, gallbladder wall thickening and pericholecystic fluid, gallbladder sludge and urinary bladder wall thickening [37, 79, 104] (Figs. 12 and 14). Hepatosplenomegaly, periportal edema, hyperechogenic kidneys, and splenic hypoechoic lesions or infarcts have also been reported [37, 38, 79, 104].

Neurologic

Brain imaging in MIS-C is usually normal, but recently there have been increasing reports of MRI signal abnormalities, specifically involving the splenium of the corpus callosum, on T2-weighted sequences, fluid-attenuated inversion recovery (FLAIR) sequences and diffusion-weighted imaging [14, 78, 79, 109–113]. Splenial lesions have also been reported in children with

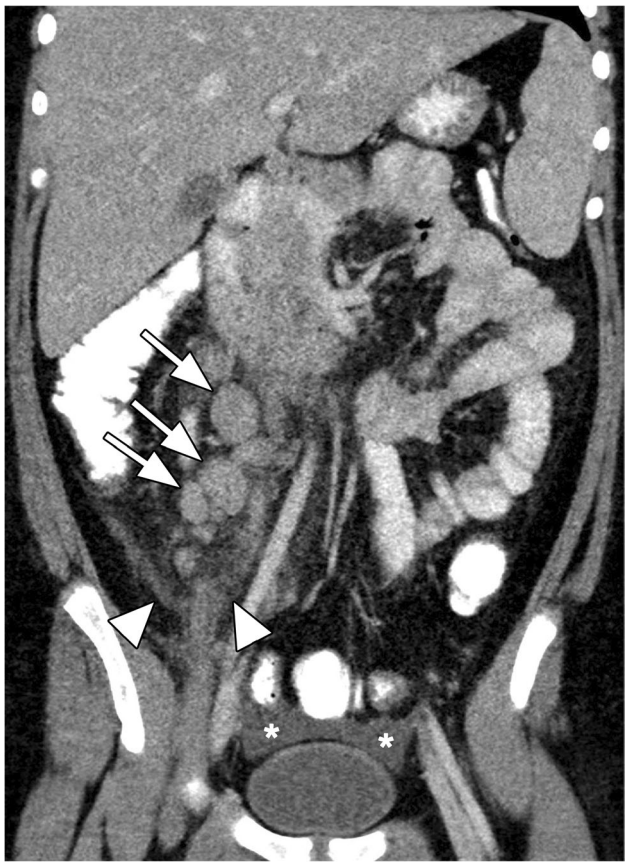

Fig. 12 Abdominal CT findings in a 13-year-old boy with multisystem inflammatory syndrome in children (MIS-C) who presented with fever, abdominal pain and tachycardia. Coronal contrast-enhanced abdominal CT image demonstrates multiple enlarged right lower quadrant lymph nodes (*arrows*) and stranding of the surrounding mesenteric fat (*arrowheads*). A small amount of pelvic ascites is also present (*)

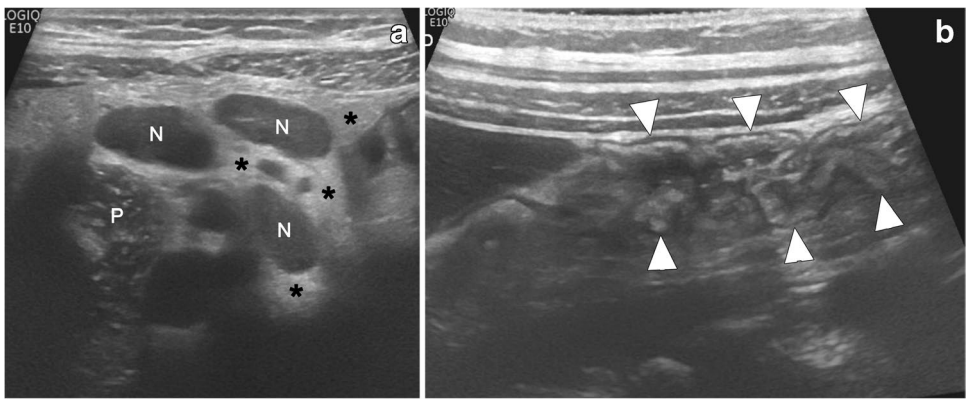

Fig. 11 Abdominal US findings in a 9-year-old girl with multisystem inflammatory syndrome in children (MIS-C) who presented with fever and abdominal pain. **a** Transverse US image of the right lower quadrant shows multiple enlarged lymph nodes (*N*), with thickening and increased echogenicity of the surrounding mesenteric fat (*). *P* psoas muscle. **b** Sagittal US image of the right lower quadrant shows thick-walled bowel (*arrowheads*)

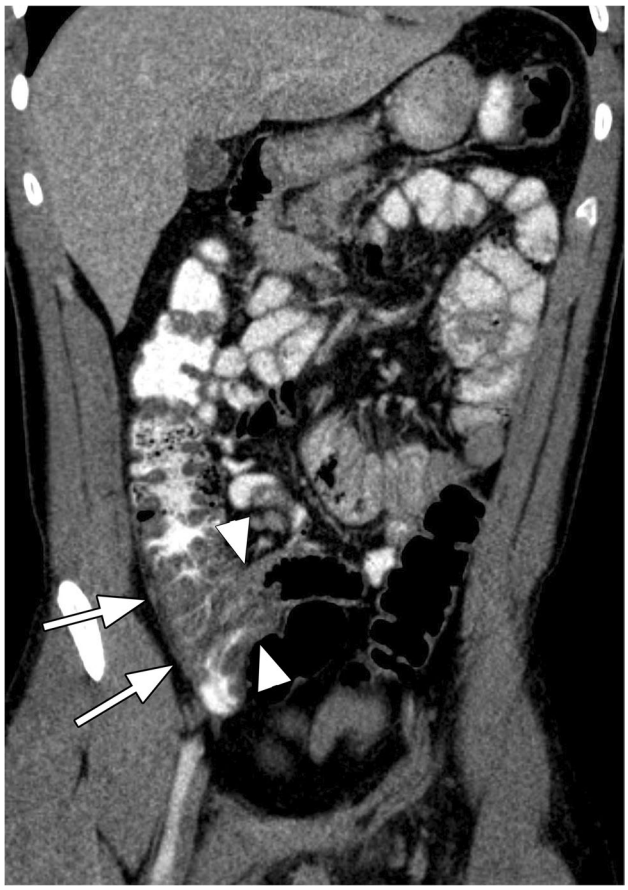

Fig. 13 Mural thickening in a 16-year-old boy with multisystem inflammatory syndrome in children (MIS-C) who presented with right lower quadrant abdominal pain. Coronal contrast-enhanced abdominal CT image demonstrates mural thickening of the terminal ileum (*arrowheads*), cecum and ascending colon (*arrows*)

COVID-19 infection who present with only neurologic symptoms and no respiratory symptoms [114]. Other neuroimaging findings reported in MIS-C include cerebral infarcts, encephalomyelitis or acute disseminated encephalomyelitis (ADEM)-like lesions, leptomeningeal enhancement, venous sinus thrombosis, papilledema and Guillain–Barré syndrome-like findings [14, 38, 78–80, 90, 112, 113].

Miscellaneous

Neck pain has been reported in more than one-quarter of children with MIS-C, along with other otolaryngologic symptoms such as neck swelling, dysphagia, trismus, stridor and drooling [115–117]. Cervical imaging with US or contrast-enhanced CT might be requested to assess for signs of inflammation. The most common abnormalities are retropharyngeal edema and cervical lymphadenopathy [14, 22, 80, 81, 115, 118] (Fig. 15).

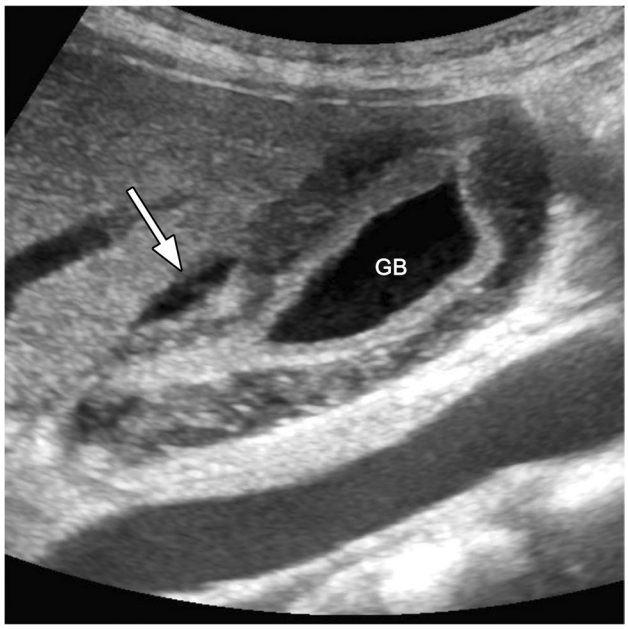

Fig. 14 US findings in a 6-year-old boy with multisystem inflammatory syndrome in children (MIS-C) who presented with fever and abdominal pain. Sagittal US image of the right upper quadrant shows edematous thickening of the gallbladder (*GB*) wall and a small amount of pericholecystic fluid (*arrow*)

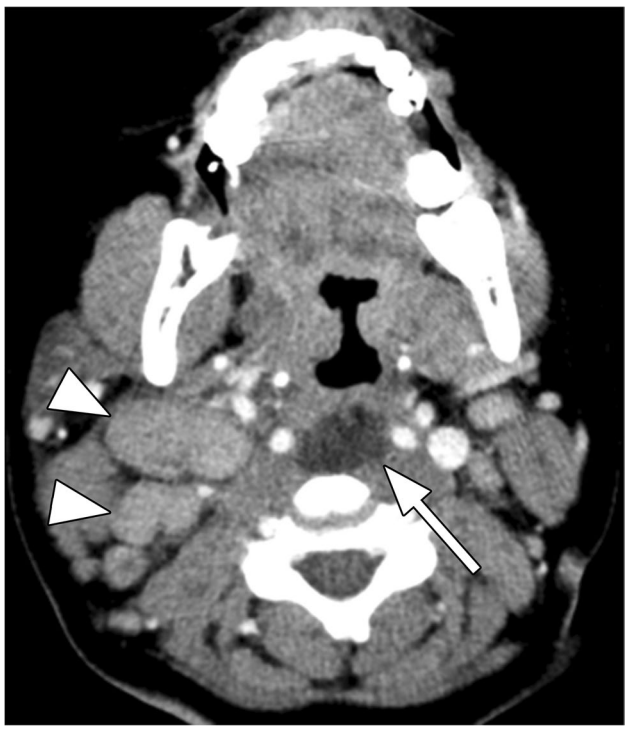

Fig. 15 Neck findings in a 7-year-old girl with multisystem inflammatory syndrome in children (MIS-C) who presented with fever, neck swelling, rash and conjunctivitis. Axial contrast-enhanced neck CT image demonstrates retropharyngeal edema (*arrow*) and cervical lymphadenopathy (*arrowheads*)

Table 1 Comparison of severe acute coronavirus disease 2019 (COVID-19) infection in children and multisystem inflammatory syndrome in children (MIS-C) associated with COVID-19

	Severe COVID-19	MIS-C
Etiology	Acute SARS-CoV-2 infection	Post-SARS-CoV-2 infection hyperinflammatory process
Patient population	Older age (>12 years) Comorbidities	Younger age (<12 years) Previously healthy
Time course	Acute infection (positive RT-PCR test)	2–6 weeks after infection or exposure (high antibody titers)
Clinical features	Presents with fever, cough and respiratory distress Primarily pulmonary disease caused by pneumonia and/or ARDS	Presents with fever and abdominal pain, rapidly progresses to heart failure, shock Multiorgan disease, including: cardiac, gastrointestinal, neurologic, mucocutaneous, respiratory (secondary to heart failure), renal, hematologic Greater elevation of inflammatory markers (CRP, D-dimer, etc.)
Pulmonary imaging findings	Pattern of opacity: - Unilateral or bilateral - Focal/non-diffuse - Peripheral/subpleural - GGO ± consolidation - Nodules, halo sign No pleural effusion Normal heart size	Pattern of opacity: - Bilateral and symmetrical - Non-focal/diffuse - Lower lung fields - GGO, interstitial opacities - No nodules Bilateral pleural effusions Cardiomegaly
Extrapulmonary imaging findings	Rare	Cardiac: myocardial dysfunction, low ejection fraction on echocardiogram, myocarditis on cardiac MRI, pericardial effusion, mitral regurgitation, coronary artery ectasia/aneurysm Gastrointestinal: RLQ inflammation (lymphadenopathy, mesenteric edema, thickened terminal ileum and cecum), ascites, thickened gallbladder wall, hepatosplenomegaly, hyperechogenic kidneys, splenic lesions/infarcts Neurologic: splenial lesions, cerebral infarct, encephalomyelitis, Guillain-Barré syndrome Miscellaneous: retropharyngeal edema, cervical lymphadenopathy

ARDS acute respiratory distress syndrome, *CRP* C-reactive protein, *GGO* ground-glass opacity, *MRI* magnetic resonance imaging, *RLQ* right lower quadrant, *RT-PCR* reverse transcriptase polymerase chain reaction, *SARS-CoV-2* severe acute respiratory syndrome coronavirus 2

Conclusion

While the vast majority of children with COVID-19 disease experience minimal to no symptoms, in rare cases a pediatric patient presents with severe illness after known SARS-CoV-2 exposure, and the differential diagnosis includes both severe COVID-19 pneumonia and MIS-C. Either of these conditions can present with fever and respiratory distress progressing to shock. Therefore, it is important for pediatricians and radiologists to understand the differences in their clinical and radiologic profiles so they can make a prompt diagnosis. The key distinctions between these entities are summarized in Table 1 [14, 22, 34, 43, 93, 119, 120]. With regard to thoracic imaging, children with MIS-C demonstrate a diffuse pattern of hazy pulmonary opacity with interstitial edema and small pleural effusions secondary to heart failure, whereas children with acute COVID-19 infection demonstrate heterogeneous patterns of ground glass, consolidation and nodules. Imaging findings of intrabdominal inflammation are also distinct and highly prevalent in MIS-C. Recognition of these various features allows for early diagnosis and appropriately targeted management of SARS-CoV-2-associated critical illness in children.

Declarations

Conflicts of interest None

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