Radiology

ORIGINAL RESEARCH • PEDIATRIC IMAGING

Abdominal US in Pediatric Inflammatory Multisystem Syndrome Associated with SARS-CoV-2 (PIMS-TS)

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Conflicts of interest are listed at the end of this article.

See also the editorial by van Rijn and Pajkrt in this issue.

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Background: Children with pediatric inflammatory syndrome temporally associated with SARS-CoV-2 (PIMS-TS), also known as multisystem inflammatory syndrome in children, present with abdominal pain among other nonspecific symptoms. Although initial imaging features of PIMS-TS have been reported, the duration of sonographic features remains unknown.

Purpose: To describe the abdominal US features of PIMS-TS at initial presentation and follow-up.

Materials and Methods: A retrospective review of children and young adults presenting with clinical features suspicious for PIMS-TS between April 2020 and June 2021 was carried out. US features were documented and reviewed at initial presentation and follow-up. Descriptive statistics were used and interobserver variability was calculated.

Results: Of 140 children and young adults presenting with suspected PIMS-TS, 120 had confirmed PIMS-TS (median age, 9 years; interquartile range, 7–12 years; 65 male patients) and 102 underwent abdominal US at presentation. PIMS-TS was present as a single abnormality in 109 of the 120 patients (91%) and abdominal symptoms were present in 104 of the 109 (95%). US examinations were abnormal in 86 of 102 patients (84%), with ascites being the most common abnormality in 65 (64%; 95% CI: 54, 73). Bowel wall thickening was present at US in 14 of the 102 patients (14%; 95% CI: 7, 20) and mesenteric inflammation was present in 16 (16%; 95% CI: 9, 23); all of these patients presented with abdominal symptoms. Among the patients with bowel wall thickening, the distal and terminal ileum were most involved (eight of 14 patients, 57%). Abdominal symptoms decreased to seven of 56 patients (13%) in those followed up at 6 months. Thirty-eight patients underwent follow-up US, and the presence of bowel inflammation had decreased to three of 27 patients (11%; 95% CI: −1, 23) in those followed up for less than 2 months and 0 of 17 (0%) in those followed up for more than 2 months.

Conclusion: Of 102 patients with pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2 who underwent US at presentation, 14 (14%) had abdominal US findings of bowel inflammation and 16 (16%) had mesenteric edema. All US abnormalities resolved after 2 months.

Online supplemental material is available for this article.

Pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2 (PIMS-TS), also known as multisystem inflammatory syndrome in children, is characterized by systemic immune-mediated inflammation related to recent COVID-19 infection. The Royal College of Paediatrics and Child Health (RCPCH) has formulated a case definition and described presenting features (1) (Appendix E1 [online]), and the PIMS-TS National Consensus Management Study Group published a guideline in September 2020 to guide investigation and management of suspected cases (2).

Alongside a rash and fever seen in other pediatric inflammatory syndromes such as Kawasaki disease and toxic shock, children with PIMS-TS typically have gastrointestinal symptoms: Recent studies have found that 62% may present with abdominal pain and 71%–90% present with any abdominal symptom (pain, diarrhea, or vomiting) (3–5). A clinical dilemma exists in differentiating between acute appendicitis and PIMS-TS (6). There are cases reported of presentations typical for appendicitis, normal appendixes intraoperatively, and subsequent diagnoses of PIMS-TS and/or multisystem inflammatory syndrome in children (7–9). Abdominal US has therefore become an essential investigation in those with abdominal pain and is advocated by the consensus guideline (2).

There are limited reports to date regarding abdominal abnormalities as part of wider reviews of PIMS-TS (5,10–15), with the largest study including 19 patients (10). Bowel wall thickening, particularly terminal ileitis, and right iliac fossa inflammation with

Abbreviations

PIMS-TS = pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2, RCPCH = Royal College of Paediatrics and Child Health

Summary

Of 102 children and young adults with pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2 who underwent US at presentation, 14 (14%) had abdominal US findings of bowel inflammation; these findings were reduced to 11% by 2 months, resolving thereafter.

Key Results

- In a retrospective review of 140 children and young adults with suspected pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2 (PIMS-TS), abdominal symptoms were present in 104 of 109 (95%) with PIMS-TS as a single abnormality.
- Of 102 children and young adults who underwent abdominal US at presentation, ascites was present in 65 (64%), mesenteric inflammation in 16 (16%), and bowel wall thickening in 14 (14%).
- In 17 children with more than 2 months of follow-up, bowel involvement and other US abnormalities resolved in all 17 patients.

enlarged local mesenteric lymph nodes have been described (5,10–15). Sahn et al (13) described bowel obstruction secondary to inflammation in two patients, one requiring ileocolic resection. Other nonspecific findings include ascites, hepatosplenomegaly, echogenic and enlarged kidneys, and gallbladder fossa edema. In a case series of four children who underwent CT after the appendix could not be located with US, this successfully demonstrated no evidence of appendicitis while confirming the presence of PIMS-TS-like features in all cases (16).

Published data remain lacking specifically on follow-up imaging or outlook for those with abdominal sonographic findings at presentation. The expected duration of sonographic bowel inflammation is an important clinical question as it could contribute to counseling of patients and caregivers on the predicted timeline of symptoms. Knowing the expected duration also could guide clinicians and radiologists involved in the further management of patients with PIMS-TS as protracted bowel inflammation may require further investigation (eg, MR enterography or colonoscopy to rule out inflammatory bowel disease).

The purpose of this observational study was to describe the abdominal US features in our PIMS-TS cohort at initial presentation and follow-up.

Materials and Methods

This retrospective, observational study has been registered under our institution's service evaluation program (registration number: 3073). Formal research and ethics committee review, including written informed consent, has been waived as per National Health Service guidance.

Patients

In this single-center retrospective consecutive case series, we interrogated the electronic patient record (Epic 2020–2021, SlicerDicer) for all children and young adults (age, ≤18 years) with a clinical suspicion of PIMS-TS referred for abdominal US in a tertiary center during a 15-month study period (April 1, 2020, to June 24, 2021). The search results were compared with a separate database of suspected cases by our local gastroenterology clinicians. Any additional patients missed by the search were added. No exclusion criteria were applied. The number of patients presenting were compared with national U.K. cases of COVID-19.

Demographic patient data (age, sex, and ethnicity from the electronic patient record) and comorbidities were recorded. Because the electronic patient record search included all patients with possible PIMS-TS, the final diagnosis was recorded according to the patient's discharge summary and documented opinion of infectious disease specialists, who made the diagnosis based on RCPCH criteria (Appendix E1 [online]).

A subset of this study sample has been published in a recent article addressing clinical and biochemical outcomes in 46 patients with confirmed PIMS-TS (17). This was a clinical study reporting on a large number of variables, without an in-depth evaluation of imaging findings. By including all children and young adults with suspected rather than confirmed PIMS-TS, we address differential diagnoses including appendicitis.

Imaging Protocol

US examinations were performed with one of three different machines (Logiq S8, E9, or E10; GE Medical Systems) using both high-frequency linear probes (L2–9, ML6–15) and curvilinear, lower frequency probes (C2–9, C1–6) as per local institution protocol (Appendix E2 [online]). This included imaging the appendix to rule out appendicitis. Operators included 24 radiology residents (seven 2nd to 3rd year residents, including S.E.; 11 4th to 5th year residents, including R.M., F.C.W., and M.G.; and six fellows with >6 years of experience, including S.C.S.) and nine pediatric sonographers (each with >5 years of experience) supervised by eight pediatric radiology consultants (including O.J.A., K.M., M.P.H., P.D.H., A.D.C., M.J.E., and T.W.), each with more than 10 years of experience. Due to the consensus guideline and the nature of dealing with unknowns in a new entity (including long-term outcomes), all patients with suspected PIMS-TS were scanned at presentation at our institution.

Data Collection

The clinical notes were reviewed for the presence of abdominal pain, diarrhea, and vomiting at presentation. The following laboratory test results were recorded: nasopharyngeal SARS-CoV-2 reverse transcriptase polymerase chain reaction, SARS-CoV-2 immunoglobulin G antibody status, C-reactive protein level, and fecal calprotectin level (where tested).

Four radiology residents with 2–5 years of experience (R.M., F.C.W., M.G., S.G.) reviewed all the images and reports from the US examinations. The presence of 14 abdominal US findings

was recorded within a predefined data collection template. The abnormalities recorded were as follows: hepatomegaly (as defined by extension of the right lobe of the liver below the lower pole of the right kidney), periportal echogenicity, gallbladder fossa edema, gallbladder debris, echogenic kidneys, enlarged kidneys (18), splenomegaly (19), splenic infarct, bowel wall thickening equal to or greater than 3 mm (20), appendicitis, inflammatory mesenteric fat, enlarged mesenteric lymph nodes greater than 7 mm in short axis (21), ascites (any volume of free fluid), and bladder wall thickening. Where bowel wall thickening was documented, the specific location to the nearest major bowel part (eg, terminal ileum) was recorded, although there was no reference standard available to apply and the accuracy of this was therefore unknown. Whether a normal appendix was visualized was also noted. Where there was no mention of the presence of an abnormality in the report, the finding was marked as absent.

Patients with PIMS-TS were routinely clinically reviewed in a dedicated outpatient clinic 6 weeks (early follow-up) and 6 months (late follow-up) after discharge. Where patients had radiographic bowel involvement on their initial US scan, persisting abdominal symptoms, or a raised fecal calprotectin level, a repeat abdominal US examination was performed. Where available, follow-up abdominal US reports were reviewed for persisting sonographic features and the time since discharge was recorded. Follow-up studies were defined as early (>7 days but <2 months after discharge) or late (>2 months after discharge) (Fig 1).

Image Analysis

Three pediatric radiology consultants (T.W., O.J.A., K.M.), with 7, 9, and 31 years of tertiary experience, respectively, independently reviewed all presentation and follow-up US scans. Readers were blinded to the clinical indication and final diagnosis but not to the original report. Agreement with the original radiology report regarding the presence or absence of 14 sonographic features was noted for each patient. Interobserver variability was calculated, and a consensus sought for disagreements.

Statistical Analysis

Descriptive statistics were used for the presence of clinical features (abdominal symptoms, raised C-reactive protein

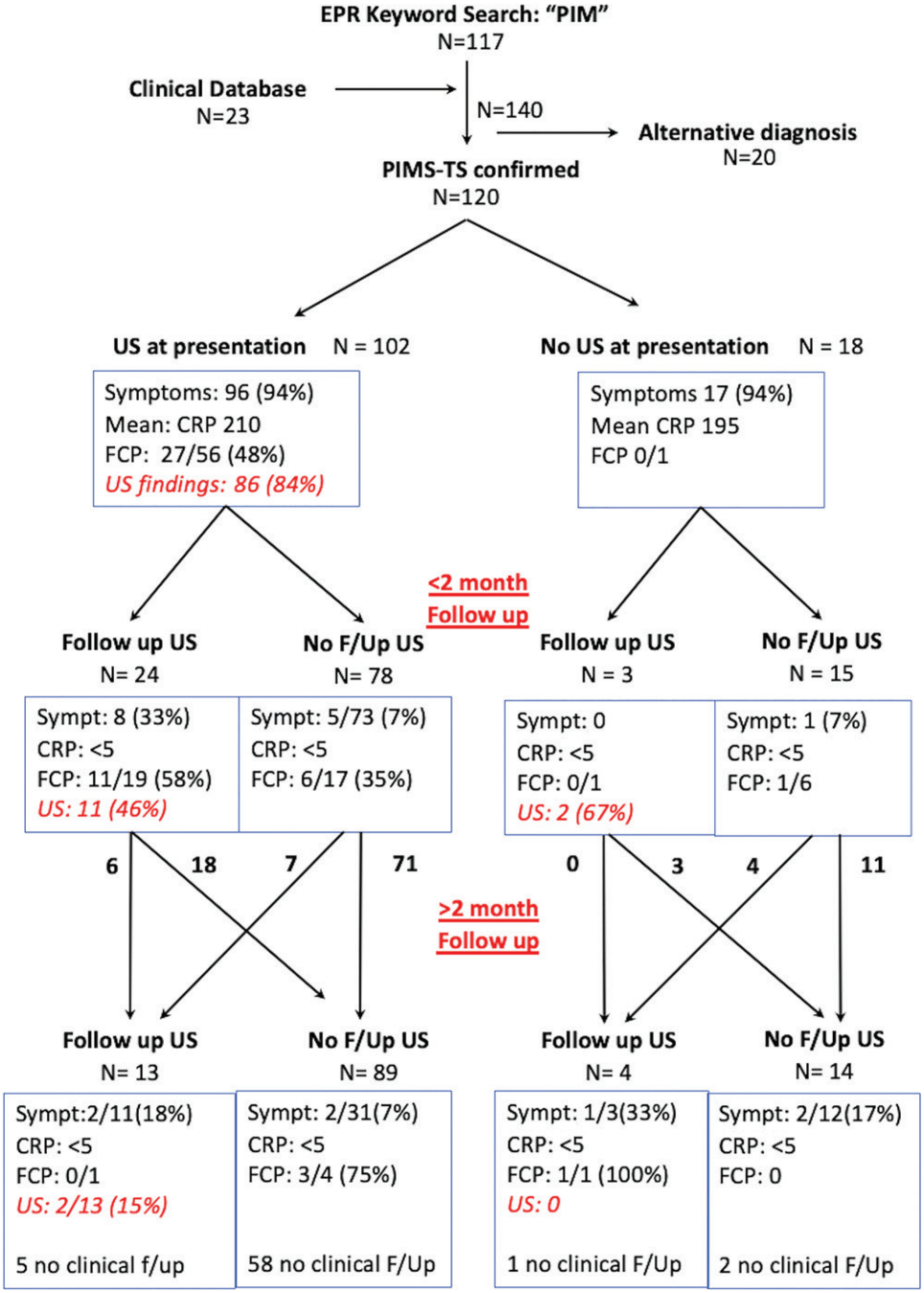

Figure 1: Flowchart shows study case definition with symptoms, biochemical markers, and US findings at presentation and early (<2 months) and late (>2 months) follow-up. CRP = C-reactive protein, EPR = electronic patient record, FCP = fecal calprotectin, F/Up = follow-up, PIMS-TS = pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2, Sympt = symptoms.

level, raised fecal calprotectin level) and 14 abdominal US findings at admission and follow-up. Interobserver variability was calculated (R.M., with 5 years of radiology experience) with 95% CIs.

Results

Patient Characteristics

One hundred forty children and young adults presented to our tertiary center with suspected PIMS-TS between April 2020 and June 2021 (Fig 1), with a small peak in April 2020 and a larger peak in January 2021, reflecting COVID-19 case surges in the United Kingdom (Fig 2) and likely increasing awareness. Of the 140 children and young adults, 120 had confirmed PIMS-TS (median age, 9 years; interquartile range, 7–12 years; 65 male patients) and 102 underwent abdominal US at presentation. Demographic data are summarized in Table 1.

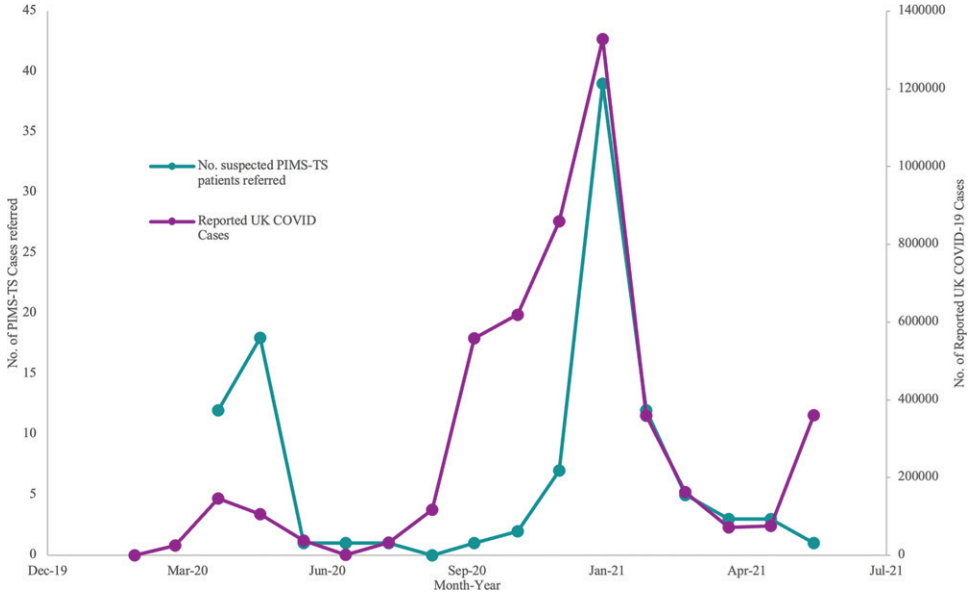

Figure 2: Graph compares monthly number of patients with suspected pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2 (PIMS-TS) referred to our tertiary hospital with the reported cases of COVID-19 in the United Kingdom. COVID-19 case data are from a publicly available database at *https://coronavirus.data.gov.uk*.

PIMS-TS at Diagnosis

PIMS-TS was confirmed in 109 of the 140 patients (78%), with an additional 11 (8%) diagnosed with dual pathologic conditions. Four patients had PIMS-TS–Kawasaki disease overlap and single cases of urosepsis, macrophage activation syndrome, aspiration pneumonia, hemophagocytic lymphohistiocytosis, sickle cell crisis, idiopathic intracranial hypertension, and a first presentation of diabetic ketoacidosis. Two patients underwent appendectomy at another hospital before being referred and diagnosed with PIMS-TS. Alternative diagnoses were made in 20 of the 140 patients (14%), including five with Kawasaki disease, six with respiratory COVID-19, and one each with infective endocarditis, appendicitis, meningoencephalitis, staphylococcal septic shock syndrome, gastrointestinal toxin-mediated sepsis, myocarditis, ileocolitis of uncertain origin, systemic juvenile inflammatory arthritis, and an unconfirmed diagnosis of systemic vasculitis (Table 1). No patients had a history of inflammatory bowel disease. SARS-CoV-2 immunoglobulin G antibodies were detected in 113 of 120 patients (94%), and 25 of 120 patients (21%) were positive for SARS-CoV-2 at reverse transcriptase polymerase chain reaction testing at presentation.

Presenting Abdominal Symptoms and Blood Markers

One hundred four of 109 patients (95%; 95% CI: 91, 99) with PIMS-TS as a single pathologic condition had abdominal symptoms. Ninety of 109 patients (83%) had abdominal pain, 65 (60%) had diarrhea, and 68 (62%) had vomiting. As per RCPCH definitions (1), all patients presented with a prolonged fever. The mean C-reactive protein level was 214 mg/L, and the fecal calprotectin level was raised in 25 of the 54 patients tested (46%).

Abdominal US at Presentation

Of the 120 patients with PIMS-TS (including dual pathologic conditions), 102 (85%) underwent abdominal US at presentation upon admission to intensive care (Figs 3–5, E1–E4 [online]). US findings were abnormal in 86 of the 102 patients (84%; 95% CI: 77, 91) and normal in 16 (16%; 95% CI: 9, 23). The most common abnormality was ascites in 65 of 102 patients (64%; 95% CI: 54, 73).

Bowel and mesenteric abnormalities included hyperechoic inflammatory mesenteric fat in 16 of 102 patients (16%; 95% CI: 9, 23), mesenteric lymphadenopathy in 14 (14%; 95% CI: 7, 20), and bowel wall thickening in 14 (14%; 95% CI: 7, 20), with specifically terminal or distal ileal thickening in eight of the 14 (57%) (Fig 6). In the 14 patients with bowel wall thickening, seven (50%) also had mesenteric abnormalities and all presented with at least one abdominal symptom. The appendix was visualized in 21 of the 102 patients (21%), and there were no cases of appendicitis in the patients with PIMS-TS.

Nonspecific features of systemic inflammation (third-spacing of fluid, acute kidney injury, and cholestasis) included periportal echogenicity in 21 of 102 patients (21%; 95% CI: 12, 28), gallbladder fossa edema in 18 (18%; 95% CI: 10, 25), gallbladder debris in 15 (15%; 95% CI: 8, 22), enlarged kidneys in 17 (17%; 95% CI: 9, 24), echogenic kidneys in 10 (10%; 95% CI: 4, 16), splenomegaly in 11 (11%; 95% CI: 5, 17), and hepatomegaly in nine (9%; 95% CI: 3, 14). There were no patients with bladder wall thickening or splenic infarct. One 18-year-old patient

Table 1: Baseline Demographic Data, Clinical Presentation, and US Findings according to Final Diagnosis

Parameter	Confirmed PIMS-TS (*n* = 120)			Alternative Diagnosis (*n* = 20)		
	PIMS-TS (*n* = 109)	PIMS-TS Plus Kawasaki Disease (*n* = 4)	PIMS-TS Plus Other (non-Kawasaki Disease) (*n* = 7)	Kawasaki Disease (*n* = 5)	COVID-19 Pneumonia (*n* = 6)	Other (*n* = 9)
Mean age (y)*	10 (1–18)	3 (2–5)	10 (9–15)	1 (0–3)	12 (4–17)	11 (4–17)
No. of male patients	65 (59.6)	3 (75)	3 (43)	2 (40)	5 (83)	6 (67)
Ethnicity						
African-Caribbean	28 (26)	0	2 (29)	1 (20)	0	2 (22)
South Asian	26 (24)	0	1 (14)	2 (40)	2 (33)	1 (11)
White European (including British)	22 (20)	2 (50)	1 (14)	1 (20)	3 (50)	4 (45)
Other†	9 (8)	0	0	0	1 (17)	0
Multiethnic	7 (6)	0	1 (14)	0	0	0
Not available	17 (16)	2 (50)	2 (29)	1 (20)	0	2 (22)
Medical comorbidities	6 (5)	0	2 (29)	1 (20)	3 (50)	2 (22)
Abdominal symptoms						
Abdominal pain	91 (83)	2 (50)	5 (71)	2 (40)	3 (50)	3 (33)
Diarrhea	65 (60)	2 (50)	1 (14)	3 (60)	1 (17)	2 (22)
Vomiting	68 (62)	3 (75)	4 (57)	2 (40)	1 (17)	4 (44)
Any	104 (95)	3 (75)	6 (86)	3 (60)	3 (50)	5 (55)
Laboratory markers						
Mean CRP level (mg/L)	214	141	141	201	175	179
Raised fecal calprotecin level (μg/g)/no. tested	25/54	2/2	0/1	1/2	0/3	1/1
SARS-CoV-2 RT-PCR positive	23 (21)	0	2 (29)	1 (20)	6 (100)	0
SARS-CoV-2 IgG positive	103 (94)	4 (100)	6 (86)	2 (40)	5 (83)	1 (11)
No. of patients who underwent US at presentation	93	3	6	5	6	9
Abdominal US findings						
Ascites	60 (65)	3 (100)	2 (33)	4 (80)	1 (17)	2 (22)
Bowel wall thickening	14 (15)	0	0	1 (20)	0	1 (11)
Mesenteric inflammation (including enlarged mesenteric LNs)	22 (23)	1 (33)	0	1 (20)	1 (17)	1 (11)
Other nonspecific abnormalities	55 (59)	3 (100)	3 (50)	3 (60)	1 (17)	6 (66)

Note.—Except where indicated, data are numbers of patients, with percentages in parentheses. Six patients with PIMS-TS (5%) had medical comorbidities, including sickle cell disease (*n* = 2), cardiac septal defects (*n* = 2), neonatal hydrocephalus (*n* = 1), type 1 diabetes mellitus (*n* = 1), and asthma (*n* = 1). CRP = C-reactive protein, IgG = immunoglobulin G, LN = lymph node, PIMS-TS = pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2, RT-PCR = reverse transcriptase polymerase chain reaction.

* Numbers in parentheses are ranges.

† Other ethnicity = other Asian (*n* = 6), other Black (*n* = 1), Filipino (*n* = 1), South American (*n* = 1), Vietnamese (*n* = 1).

had unsuspected and extensive thrombosis of the inferior vena cava and iliac, splenic, and portal veins. The patient was treated with anticoagulants and the thrombosis resolved within 3 months without any apparent complications.

Follow-up Clinical and Sonographic Features

All patients with PIMS-TS were invited for clinical review at 6 weeks and 6 months after discharge. One hundred fifteen of the 120 patients (96%) had been reviewed at 6 weeks and 56 (47%) had been reviewed at 6 months at the time of writing. Thirty-one of the 120 patients (26%) underwent follow-up US 8–269 days after their initial imaging examination, and an additional seven underwent follow-up US without undergoing imaging at presentation, for a total of 38 of 120 patients (32%).

At 6-week clinical follow-up, abdominal symptoms (eight of 27 patients, 30%) and a raised fecal calprotectin level (11 of 20 patients tested, 55%) were more common in patients who had an early follow-up US scan (<2 months after discharge) compared with those who did not (six of 88 patients [7%] and seven of 23 patients [30%] respectively). Five of 11 patients (45%) with raised fecal calprotectin level had bowel inflammation on presentation US scans. There was a reduction in sonographic abnormalities at less than 2 months, with 13 of 27 patients (48%; 95% CI: 29, 67) having persistent abnormalities and three (11%; 95%

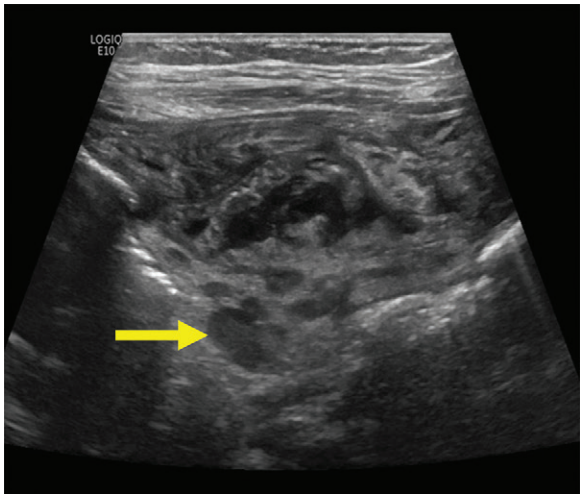

Figure 3: Noncontrast US scan (transverse plane) of the right iliac fossa in a 7-month-old boy with pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2. Image shows extensive inflammatory change with abnormal lymph nodes in the right iliac fossa (arrow).

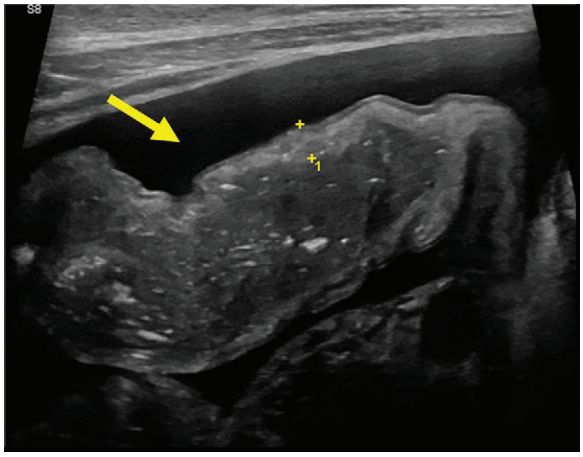

Figure 4: Noncontrast US scan (transverse plane) of the right iliac fossa in a 10-year-old boy with pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2. Image shows distal ileal thickening (measured between "+" markers and labeled "1") and ascites (arrow).

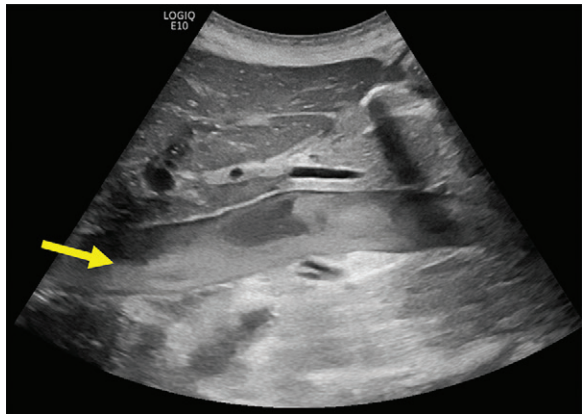

Figure 5: Noncontrast US scan (longitudinal plane) in an 18-year-old man with pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2. Image shows an extensive thrombus in the inferior vena cava (arrow).

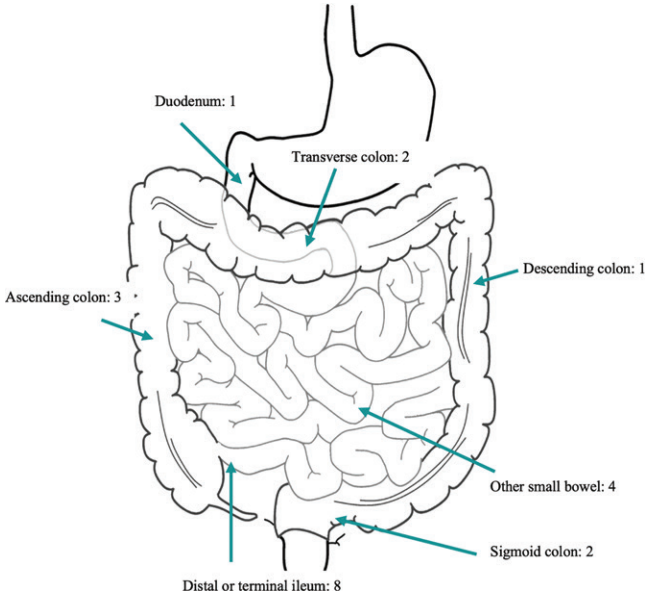

Figure 6: Diagram shows sites of bowel inflammation detected on presentation US scans in 14 patients with pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2. Nine patients had single-site involvement and five patients had more than one site involved. Numbers are instances of bowel inflammation at various sites in the 14 patients.

CI: −1, 23) bowel inflammation, reduced from 84% and 14% at presentation, respectively. The incidence of mesenteric inflammation at less than 2-month US follow-up was seven of 27 (26%; 95% CI: 9, 42), increased from 16% at presentation.

Nonspecific features of systemic inflammation also reduced by 2-month follow-up, as follows: ascites in four of 27 patients (15%, from 64%), enlarged kidneys in three (11%, from 17%), splenomegaly in two (7%, from 11%), hepatomegaly in two (7%, from 9%), periportal echogenicity in one (4%, from 21%), and gallbladder debris in one (4%, from 15%). All instances of persistent gallbladder fossa edema and echogenic kidneys resolved.

Of those who were scanned both at presentation and less than 2-month follow-up (24 of 27 patients, 89%), 20 (83%) had an abnormality at presentation, which reduced to 11 of 20 (55%) within 2 months.

At 6-month clinical follow-up, abdominal symptoms decreased further to seven of 56 patients (13%) with follow-up, and there were no instances of bowel or mesenteric inflammation in the 17 patients who underwent US more than 2 months after discharge. Aside from single instances of persistent splenomegaly in a patient with hemophagocytic lymphohistiocytosis and a small volume of ascites reported as "within physiological limits," all nonspecific features of systemic inflammation normalized at US at more than 2 months of follow-up.

Interobserver Variability

US review of 2422 indexes (14 observations × 173 US studies) by three consultants yielded a mean interobserver reproducibility of 99.3% between each of the readers and 99.6%

between the readers and the original report (Table 2). There was disagreement on one patient regarding bowel wall thickening and mesenteric inflammation where a consensus view was reached. There were 17 of 2422 minor disagreements regarding mesenteric inflammation (five patients), mesenteric lymph nodes (four patients). hepatomegaly and periportal echogenicity (four patients), and gallbladder edema or debris or other (four patients).

Discussion

Abdominal symptoms are prevalent in patients with pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2 (PIMS-TS), and US is advocated by the Royal College of Paediatrics and Child Health guidance (1) in those with abdominal pain. However, the current literature reporting sonographic abnormalities is limited

Table 2: Interobserver Agreement between Three Radiology Consultants and the Original Report from 14 Findings in 173 US Studies (2422 Indexes)

Reader	Radiologist 1	Radiologist 2	Radiologist 3
Original report	2415 (99.7) [99.4, 99.9]	2419 (99.9) [99.8, 99.9]	2407 (99.4) [99.1, 99.6]
Radiologist 2	2414 (99.7) [99.4, 99.9]	…	…
Radiologist 3	2400 (99.1) [98.7, 99.4]	2404 (99.2) [99.8, 99.5]	…

Note.—Data are numbers of indexes, with percentages in parentheses and 95% CIs in brackets.

Table 3: Summary of the Current Literature on Abdominal Imaging Findings in Pediatric Inflammatory Multisystem Syndrome Temporally Associated with SARS-CoV-2

		Abdominal Imaging Findings*				
Reference	No. of Patients	Ascites	Renal, Liver, Spleen, Gallbladder Abnormalities	Bowel Inflammation	Mesenteric Inflammation	Other
Hameed et al (10)	19	10 (53)	Periportal echogenicity: 3 (16); pericholecystic/ gallbladder fossa edema: 3 (16); gallbladder sludge: 3 (16); hepatosplenomegaly: 2 (11); hypoechoic splenic lesions: 2 (11); echogenic kidneys: 1 (5)	Bowel wall thickening: 4 (21)	Right iliac fossa inflammation: 9 (47), including echogenic and expanded mesenteric fat: 7 (37); mesenteric lymphadenopathy: 9 (47)	Normal appendix: 3 of 4 children in whom appendicitis was suspected
Caro-Dominguez et al (11)	17 (US); 6 (CT); 2 (MRI)	10/20 (50)	Hepatomegaly: 5/20 (25); gallbladder wall edema 3/20 (15); gallbladder sludge: 2/20 (10); periportal edema: 2/20 (10); splenomegaly: 2/20 (10)	Bowel wall thickening: 8/20 (40); terminal ileitis: 7/8 (88)	Right iliac fossa lymphadenopathy: 4/20 (20)	Hemorrhagic cystitis: 1/20 (5)
Blumfield et al (12)	16	6 (38)	Hepatomegaly: 6 (38); echogenic kidneys: 5 (31); gallbladder fossa edema: 3 (19); splenomegaly: 1 (6)	Bowel wall thickening: 3 (19)	Mesenteric lymphadenopathy: 2 (13)	Urinary bladder wall thickening: 1 (6)
Sahn et al (13)	14 (US); 7 (CT)	NA	Not reported	Terminal ileitis: 2 (18) at US and 6 (85) at CT	Mesenteric fat stranding and right lower quadrant lymphadenopathy at CT: 5 (71)	Not reported
Fenlon et al (14)	13	7 (54)	Gallbladder wall thickening: 3 (23)	Bowel wall thickening: 3 (23)	Abdominal lymphadenopathy: 2 (15)	Not reported
Biko et al (15)	2	Not reported	Not reported	Ileocolitis: 1	Not reported	Pancreatitis: 1
Ahmed et al (5)	14 of 39 studies	27	Not reported	16	Mesenteric lymphadenopathy: 15	Pancreatitis: 1

* Data are numbers of patients, with percentages in parentheses.

and studies investigating US findings at follow-up remain lacking. In our cohort of 102 patients with PIMS-TS who underwent abdominal US at presentation, the incidence of bowel wall thickening was 14% and mesenteric inflammation was 16% at presentation, both reduced to 0% at more than 2 months. Ascites was the most common abnormality at presentation, seen in 64%, reduced to 15% by 2 months and resolved thereafter. All other nonspecific features of systemic inflammation also resolved at follow-up US performed at more than 2 months after discharge. The incidence of abdominal symptoms decreased over time, from 83% at presentation to 30% at 6-week clinical follow-up and to 13% at 6-month follow-up.

Bowel wall thickening was present in 14% of patients, which is similar to the 21% previously reported by Hameed et al (10). Of note, 102 of the 120 patients (85%) in our study underwent abdominal US versus 19 of 35 (54%) in the study by Hameed et al (10), who only scanned those with abdominal symptoms. At our tertiary center, we routinely aim to scan all patients with suspected PIMS-TS at presentation. Abdominal US features in PIMS-TS to date are summarized in Table 3.

Our data conform to findings of early studies (17,22,23) that PIMS-TS is a short-term, albeit sometimes severe illness with clinical resolution in less than 6 months. Children and their parents therefore can be reassured that bowel inflammation rarely persists. If the child has persistent abdominal pain after discharge, then he or she should be reassessed.

For any child, imaging the appendix for presumed appendicitis before undergoing surgery is considered optimal practice for most and even more essential during the COVID-19 pandemic. Sepsis was a possible differential diagnosis for all our patients, and the diagnosis of PIMS-TS was made on clinical grounds based on RCPCH criteria (1), which involves the exclusion of microbial causes. Inflammatory bowel disease was unlikely in the differential diagnosis as our cohort presented with prolonged fever and required tertiary level intensive care support. However, inflammatory bowel disease could be considered a differential diagnosis for less severe cases. In our cohort, the persistence of symptoms or a raised fecal calprotectin level triggered a US examination for bowel inflammation and would lead to clinical review by a pediatric gastroenterologist.

Our study had limitations. First, we recognize selection bias in reporting features of children and young adults sufficiently unwell to require intensive tertiary-level care. It remains unknown whether milder cases of PIMS-TS have bowel inflammation, but these may be of limited clinical significance given our study findings. A second limitation inherent was interoperator variability. We used a standardized protocol and senior review to help address variability. Finally, out study lacked a control group.

In conclusion, 102 children and young adults in our cohort with confirmed pediatric inflammatory multisystem syndrome temporally associated with SARS-CoV-2 underwent abdominal US at presentation. Of those 102 patients, ascites was present in 64%, mesenteric inflammation in 16%, and bowel wall thickening in 14%. None of the patients had persistent clinical or imaging abnormalities after 2 months. Longer term multisystemic imaging studies will help us better understand the implications of this disease.

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