Abdominal Imaging Findings in Patients with COVID-19 Part 2: Solid Organs

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Abstract

Since severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) first appeared in China in December 2019, the globe has been dealing with an ever-increasing incidence of coronavirus disease 2019 (COVID-19). In addition to respiratory disorders, 40% of patients present with gastrointestinal (GI) involvement. Abdominal pain is the most common indication for computed tomography (CT) and ultrasonography. After GI tract involvement, solid visceral organ infarction is the most prevalent abdominal abnormality in COVID-19. This review aims to gather the available data in the literature about imaging features of solid abdominal organs in patients with COVID-19. Gallbladder wall thickening and distension, cholelithiasis, hyperdense biliary sludge, acalculous cholecystitis, periportal edema, heterogeneous liver enhancement, and liver hypodensity and infarction are among hepatobiliary imaging findings in CT, particularly in patients admitted to ICU. Pancreatic involvement can develop as a result of direct SARS-CoV2 invasion with signs of acute pancreatitis in abdominal CT, such as edema and inflammation of the pancreas. Infarction was the most prevalent renal and splenic involvement in patients with COVID-19 who underwent abdominal CT presenting with areas of parenchymal hypodensity.

In conclusion, although solid abdominal organs are rarely affected by COVID-19, clinicians must be familiar with the manifestations since they are associated with the disease severity and poor outcome.

Keywords: COVID-19, Abdominal, Imaging, Computed tomography, Ultrasonography

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Introduction

The world has been confronting the upsurge of coronavirus disease 2019 (COVID-19) since the first novel coronavirus infection (SARS-CoV-2) initially emerged in China in December 2019.[1] The most common symptoms reported in COVID-19 are related to respiratory system involvement, including fever, dry cough, fatigue, and dyspnea.[2] Angiotensin-converting enzyme 2 (ACE2) plays a significant role in mediating the inflammation of COVID-19, which can contribute to COVID-19 manifestations.[3] ACE2 receptors are found in various cells, including hepatocytes, cholangiocytes, podocytes, and enterocytes.[2,3]

Forty percent of infected patients have shown gastrointestinal (GI) manifestations, including loss of taste, nausea, vomiting, diarrhea, and

abdominal pain.[4] A significant number of patients have GI symptoms, and sometimes it is the only presentation of the disease without respiratory manifestations.[2]

The reverse-transcriptase polymerase-chain-reaction (RT-PCR) diagnostic test and chest computed tomography (CT) were reported to be highly sensitive in the early diagnostic stage of suspected COVID-19.[5] Cross-sectional abdominal imaging is not usually used in COVID-19.[6] Nevertheless, abdominal CT may be performed if specific symptoms exist, such as abdominal pain. Abdominal ultrasound is frequently ordered if evidence of abdominal pain or increased liver enzymes exists.[7] Other GI symptoms like diarrhea, nausea, vomiting, abdominal distention, and GI bleeding may demand an abdominal CT for further evaluation.[8] While COVID-19 testing is becoming widely available, cross-sectional abdominal imaging can be utilized more quickly in patients with a severe GI manifestation of COVID-19 to diagnose severe complications and start treatment as soon as possible.[9] Common indications for abdominal imaging in COVID-19 are presented in Table 1.

On abdominal CT, thickened bowel walls and fluid-filled colon were the most common findings in patients with COVID-19.[7] After GI tract abnormalities, solid visceral organ infarction and vascular thrombosis are the second most prevalent manifestations of SARS-CoV-2 infection.[10] Goldberg-Stein and colleagues reported that 18% of patients with abnormal abdominopelvic findings showed solid organ infarctions or vascular thromboses.[11] Solid-organ infarction, vascular thrombosis, and pancreatitis are not infrequent in patients with COVID-19, and they are related to the severity and poor prognosis of the disease.[10]

This study aims to review and describe imaging findings of solid abdominal viscera in patients with COVID-19.

Hepatobiliary system

The liver is the second most commonly involved organ in COVID-19 after the lungs resulting in hepatobiliary dysfunction in up to 19% of patients, particularly in severe cases.[17,18] According to previous studies, among patients with COVID-19, 29% had liver involvement.[19] Furthermore, the gallbladder and biliary systems were affected in 25% of individuals.[11] Mokhtari et al found that liver involvement in patients with COVID-19 occurred secondary to direct infection of bile ducts, poor immune reactions, coagulation abnormalities, systemic inflammation, and hypoxic conditions.[20] Hepatobiliary involvement is exhibited by an increase in aspartate aminotransferase and alanine aminotransferase levels.[21]

CT findings in the hepatobiliary system include gallbladder thickening, gallbladder dilation, cholelithiasis, hyperdense sludge, acalculous cholecystitis, periportal edema, heterogeneous liver enhancement, and liver hypodensity and infarction, especially in patients admitted to the ICU[13,18,22-24] (Figure 1). In viral acute hepatic failure, widespread hypoattenuating areas can be visualized in unenhanced CT.[25] The liver-spleen ratio (L/S) on unenhanced CT has been applied to detect hepatic steatosis.[26] The liver/spleen attenuation ratio (LSR) calculated by CT is associated with the severity of the hepatic failure related to multiorgan dysfunction syndrome.[27] During

Table 1. Indications for abdominal cross-sectional imaging of patients with COVID-19 in previous studies

Studies	Indications					
Bhayana et al[12]	Abdominal pain	Sepsis				
Shiralkar et al[9]	Abdominal pain	Nausea	Vomiting	Diarrhea	Abdominal distension	GI bleeding
Goldberg-Stein et al[11]	Abdominal pain					
Horvat et al[13]	Abdominal pain	Diarrhea	Nausea or vomiting			
Tirumani et al[14]	Abdominal pain	Diarrhea	GI bleeding			
Barkmeier et al[15]	Abdominal pain	Fever	Abdominal infection			
Singh et al[10]	Abdominal pain	Nausea and/or vomiting	Diarrhea	Abdominal infection or sepsis	Abdominal bloating or distension	GI bleeding
Dane et al[16]	Abdominal pain	Diarrhea	Nausea			

GI: Gastrointestinal

the follow-up period of patients with COVID-19, LSR is correlated with the lung CT score; as the lung CT score increases, LSR tends to decrease.[26] Acute cholecystitis, including acalculous and ischemic types, was reported in COVID-19.[23,28,29] Liver hypodensity and pericholecystic fat stranding are the most frequent findings on abdominal tomograms of patients with COVID-19.[27] CT findings of the hepatobiliary system reported in recent studies are listed in Table 2.

The most common results of the right upper abdominal ultrasound include gallbladder distension and sludge and intra- and extrahepatic biliary ductal dilation[22,24] (Figure 2). Furthermore, abdominal ultrasonography is an appropriate modality to assess imaging features of acute pancreatitis, cholecystitis, and microvasculature of the liver and kidneys.[32,33] Bhayana et al[12] reported distended gallbladder with sludge and pericholecystic fluid on ultrasound examination of

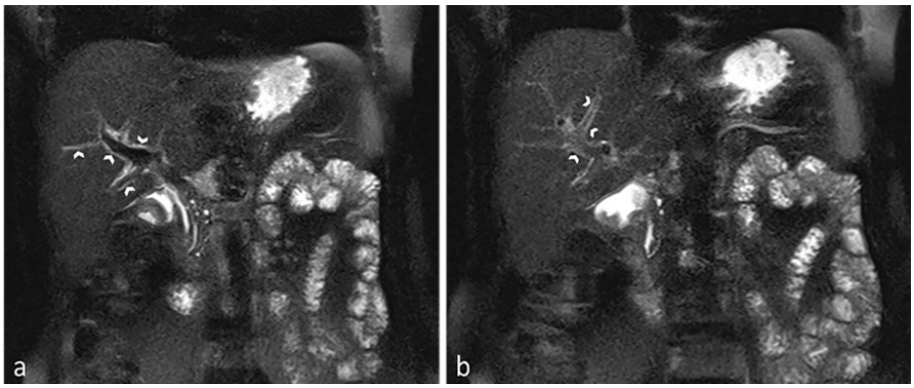

Figure 1. Cholangiopathy in a 59-year-old woman with a recent SARS-CoV-2 infection presenting with jaundice and elevated liver enzymes. Coronal T2 HASTE images (a, b) reveal diffuse periportal hyperintensity (white arrowheads) in favor of periportal edema. Intra and extrahepatic bile ducts show normal diameter.

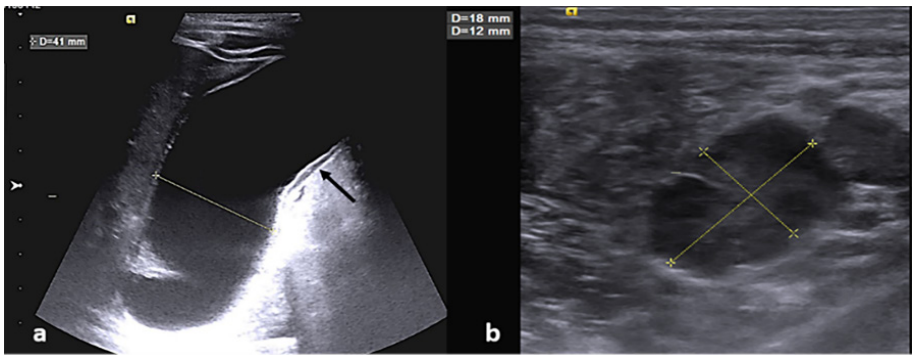

Figure 2. Multisystem inflammatory syndrome in children in a 4-year-old boy with abdominal pain and low-grade fever 4 weeks after infection with SARS-CoV-2. Abdominal ultrasound images reveal gallbladder distension (a), mild wall thickening (black arrow in a), and multiple mesenteric reactive lymphadenopathies (b).

Table 2. CT findings of patients with COVID-19 with hepatobiliary system involvement in previous studies

Studies	Abdominal imaging features of hepatobiliary system involvement		
Bhayana et al[12]	GB wall thickening,	Heterogeneous liver	
Cirillo et al[23]	Active contrast extravasation around and inside a perforated acalculous cholecystitis		
Boraschi et al[18]	Intrahepatic biliary dilatation	Cholelithiasis	Liver hypodensity
Palacios et al[30]	Distension and mild wall thickening of the gallbladder	Distended gallbladder without gallstones or sludge secondary to acute acalculous cholecystitis	Pericholecystic fluid collections
Fang et al[31]	Reduced hepatic CT attenuation value and liver-to-spleen attenuation ratio		

GB: Gallbladder.

patients with signs of acute cholecystitis. Right upper quadrant ultrasonography shows signs of gallbladder distension and sludge in up to 54% of admitted patients with COVID-19.[12] Moreover, in some COVID-19 cases, hepatomegaly has been reported with hyperechogenicity of hepatic parenchyma in ultrasound.[34] Ultrasound findings in hepatic steatosis include increased echogenicity of the liver parenchyma, which might mask periportal echogenicity seen in acute viral hepatitis.[12] An overview of the ultrasound findings of the patients with hepatobiliary involvement in prior studies is shown in Table 3.

Radzina et al found that multiparametric ultrasonography may be more sensitive than CT and Magnetic resonance imaging in assessing liver damage at the cellular level in patients with COVID-19 before progressing into liver cirrhosis.[37]

Pancreas

Given the fact that ACE2 receptors are vastly expressed in pancreatic islet cells, COVID-19 can induce islet cell damage presenting with acute diabetes.[38] The pancreatic involvement can occur through the direct invasion by SARS-CoV2, a systemic response to pneumonia, or a destructive immune reaction due to viral stimulation.[19] According to Wang and colleagues, the pancreas was affected in 17% of patients with COVID-19 pneumonia.[19]

In reported cases of SARS-CoV-2 infection, abdominal CT revealed features of acute pancreatitis, including edema and inflammation of the pancreas with surrounding fluid collections and fat stranding[30,39] (Figure 3). Pancreatic necrosis is suspected when parenchymal hypodensity is appreciated on contrast-enhanced tomograms.[40]

Despite the low sensitivity of ultrasound in the diagnosis of acute pancreatitis, it may show enlargement and hypoechogenicity of the pancreas and blurred margins.[24] Hadi et al reported a case of acute pancreatitis in a COVID-19 patient with diffuse enlargement of the pancreas in the absence of focal lesions or gallstones in the ultrasound.[33] A summary of pancreatic imaging findings is presented in Table 4.

Spleen

The most common splenic abnormality visualized in CT of patients with COVID-19 was infarction, causing left-sided abdominal pain if symptomatic.[44] COVID-19 infection induces a hypercoagulable state, predisposing patients to thromboembolic obstruction of the splenic artery or its branches with subsequent splenic infarction.[45,46] On coronal and axial CT angiography images, parenchymal splenic hypodensities associated with arterial thrombosis are apparent.[46] Also, CT venography has revealed wedge-shaped hypoattenuating spaces in the spleen compatible with infarction.[47] Rare manifestations of splenic involvement have been described on abdominal CT of patients with COVID-19 as splenomegaly and spontaneous splenic rupture leading to intraperitoneal bleeding.[48] A summary of splenic imaging findings is presented in Table 5.

Table 3. Ultrasound findings of hepatobiliary involvement in patients with COVID-19 reported in previous studies

Studies	Publication type	Sex	Age (y)	Symptoms	Abdominal ultrasonography features		
Hadi et al[33]	Case report	Female	47 y	Fever, headache, neck pain, anorexia, sore throat, and dyspnea	Diffusely enlarged pancreas without focal lesions or gallstones		
Bhayana et al[12]	Retrospective cross-sectional study				Gallbladder sludge	Gallbladder wall thickening	Pericholecystic fluid
Boraschi et al[18]	Review	Female	46 y	Right upper quadrant pain	Gallbladder distension with biliary sludge in the infundibular region.		
Samies et al[35]	Case reports	Female	16 y	Nausea and epigastric abdominal pain	Mild hepatomegaly	A single gallstone	Prominent pancreatic head, tail, and duct
Caro-Dominguez et al[36]	Case series	Female	13 y	Fever, dyspnea, and abdominal pain	Gallbladder wall edema	Ileal wall thickening	Free fluid in the pelvis

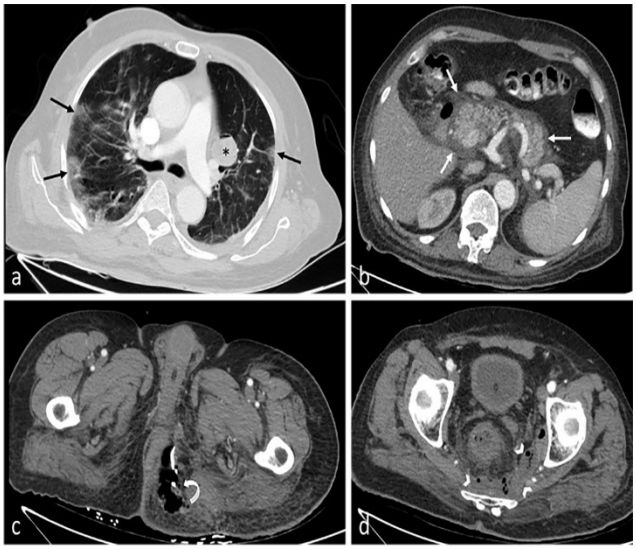

Figure 3. Acute pancreatitis and Fournier's gangrene in a 63-year-old man with COVID-19 pneumonia. Axial chest CT (a) shows multifocal subpleural patchy areas of ground glass opacity (black arrows). Also, a thin-walled cavitary lesion is seen (black asterisk). Axial contrast-enhanced CT (b) reveals an enlarged pancreas with surrounding fat stranding and inflammatory changes (white arrows) in keeping with acute pancreatitis. Axial CT images (c, d) demonstrate left perineal soft tissue gas (curved arrow) associated with abscess formation in the presacral region (arrowheads) secondary to Fournier's gangrene.

Table 4. CT findings of patients with COVID-19 with pancreatic abnormalities in previous studies

Studies	Abdominal imaging features of pancreas				
Boraschi et al[18]	Fluid collections at the pancreatic head				
Samies et al[35]	Mild stranding around the head of the pancreas				
Funt et al[41]	Enlargement of the pancreas	Edema around the pancreas	Fluid around the left kidney		
Palacios et al[30]	Decreased attenuation in the body of the pancreas with the absence of parenchymal enhancement in keeping with necrosis	Peripancreatic fluid and increased attenuation	Heterogeneity of fat around the head and body of the pancreas	The increased signal intensity in the body and tail of the pancreas suggestive of hemorrhage and necrosis	
Kataria et al[42]	Diffuse expansion of pancreas with unclear margin and surrounding fluid				
Akarsu et al[43]	Pancreatic edema	Dilatation of the pancreatic duct	Inflammatory changes in peripancreatic fat	Peripancreatic fluid collections	Diffuse pancreatic enlargement
Arbati et al[40]	Severe inflammation and heterogeneous density of the pancreas				

Kidney

According to Pei et al, the most prevalent renal abnormalities in the setting of COVID-19 were proteinuria and hematuria, with acute kidney injury (AKI) happening less often.[50] Renal infarct might occur because of hypercoagulation.[6] The possible mechanisms of AKI in COVID-19 might be related to a variety of factors, including cytokine release syndrome, hypoxia, endotoxin produced by superimposed infections during ICU admission, and rhabdomyolysis.[51] Different studies have established that AKI considerably increased the mortality rate in admitted patients with COVID-19.[20] Renal parenchymal hypodensity and perirenal fat stranding on non-enhancement CT in patients with COVID-19 represent severe renal impairment.[52] Like the spleen, the most common renal finding in abdominal tomograms was infarction.[12] In such conditions, the affected kidney presents with patchy, sharply demarcated heterogeneous areas with hypoenhancement.[6] A summary of renal imaging findings is shown in Table 6.

Table 5. CT findings of patients with COVID-19 and splenic involvement reported in previous studies

Studies	Abdominal imaging features of spleen	
Boraschi et al[18]	Wedge-shaped hypoattenuating region at the spleen, typical of infarction	
Castro et al[46]	Low-density regions all over the spleen suggestive of splenic infarctions in CT angiography	
Abdelmohsen et al[47]	Several wedge-shaped regions of low attenuation in the spleen suggestive of multifocal splenic infarcts in CT venography	Hypodense spleen indicative of the splenic infarct in CT angiography
Knefati et al[48]	Active contrast extravasation and subcapsular hematoma	
Vadvala et al[49]	Splenomegaly	Infarction of the spleen

Table 6. CT findings of patients with COVID-19 and renal involvement in previous studies

Studies	Abdominal imaging features of kidney	
Boraschi et al[18]	Ischemic region and thickening of the left anterior pararenal fascia	Wedge-shaped parenchymal defects involving the cortex and medulla of the kidney with expansion to the capsular surface
Palacios et al[30]	wedge-shaped parenchymal infarcts involving the upper and lateral segments of the left kidney	
Vadvala et al[49]	Segmental renal infarcts	Swollen hypoenhancing kidneys
Goldberg-Stein et al[11]	Filling defect in the left renal artery suggestive of an arterial thrombus	Wedge-shaped hypoenhancing areas in the left kidney consistent with infarctions
Basara Akin et al[6]	Significant perinephric stranding	Sharply demarcated heterogeneous area with non/hypo enhancement

Conclusion

In patients with COVID-19, abdominal solid organ manifestations are not common, but they are catastrophic and related to the disease's clinical severity and poor prognosis. Given the poor prognosis for certain pathologic conditions such as solid organ infarction, vascular thrombosis, and pancreatitis, clinicians should consider abdominal imaging to detect critical abnormalities when suspicious symptoms and signs are present. Abdominal CT and ultrasonography can help clinicians effectively identify organ involvement quickly. Additionally, to diagnose COVID-19 infection promptly, radiologists should be aware and attentive to specific and common imaging manifestations of abdominal pathologies in COVID-19.

Conflicts of Interest

The authors declare no conflict of interest related to this work.

Ethical Approval

Not applicable.

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