GASTROINTESTINAL

Lung base CT findings in COVID-19 adult patients presenting with acute abdominal complaints: case series from a major New York City health system

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Abstract

Objective To describe demographic, clinical, and lung base CT findings in COVID-19 patients presenting with abdominal complaints.

Methods In this retrospective study, 76 COVID-19 patients who underwent abdominal CT for abdominal complaints from March 1 to April 15, 2020, in a large urban multihospital Health System were included. Those with positive abdominal CT findings ($n = 14$) were then excluded, with 62 patients undergoing final analysis (30M/32F; median age 63 years, interquartile range (IQR) 52–75 years, range 30–90 years). Demographic and clinical data were extracted. CT lung base assessment was performed by a cardiothoracic radiologist. Data were compared between discharged and hospitalised patients using Wilcoxon or Fisher's exact tests.

Results The majority of the population was non-elderly (56.4%, < 65 years) and most (81%) had underlying health conditions. Nineteen percent were discharged and 81% were hospitalised. The most frequent abdominal symptoms were pain (83.9%) and nausea/vomiting/anorexia (46.8%). Lung base CT findings included ground-glass opacities (95.2%) in a multifocal (95.2%) and peripheral (66.1%) distribution. Elevated laboratory values (when available) included C-reactive protein (CRP) (97.3%), D-dimer (79.4%), and ferritin (68.8% of males and 81.8% of females). Older age ($p = 0.045$), hypertension ($p = 0.019$), and lower haemoglobin in women ($p = 0.042$) were more frequent in hospitalised patients. There was no difference in lung base CT findings between discharged and hospitalised patients ($p > 0.165$).

Conclusions COVID-19 patients can present with abdominal symptoms, especially in non-elderly patients with underlying health conditions. Lung base findings on abdominal CT are consistent with published reports. Radiologists should be aware of atypical presentations of COVID-19.

Key Points

• *COVID-19 infected patients can present with acute abdominal symptoms, especially in non-elderly patients with underlying health conditions, and may frequently require hospitalisation (81%).*

• *There was no difference in lung base CT findings between patients who were discharged and those who were hospitalised.*

• *Lung base CT findings included multifocal and peripheral ground-glass opacities, consistent with published reports.*

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Abbreviations

CT	Computed tomography
COVID-19	Coronavirus disease 2019
ED	Emergency department
GGO	Ground-glass opacity
HIPAA	Health Insurance Portability and Accountability Act
ICU	Intensive care unit
IQR	Interquartile range
RT-PCR	Reverse transcriptase polymerase chain reaction
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
WHO	World Health Organization

Introduction

Following its initial discovery in December 2019 in Wuhan, China, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was declared a global pandemic by the World Health Organization (WHO) on March 11, 2020 [1]. SARS-CoV-2, transmitted between symptomatic and asymptomatic humans through respiratory droplets and direct contact, can result in severe pneumonia, acute respiratory distress syndrome (ARDS), and multiorgan failure [2]. Coronavirus disease 2019 (COVID-19), the term for the clinical illness caused by SARS-CoV-2, has placed immense stress on the global healthcare apparatus and has resulted in profound economic disruption. As of 2 June 2020, there have been approximately 6 million confirmed cases and 371,000 deaths worldwide, with an estimated $2.7 trillion in global economic losses [3, 4]. Approximately 1.9 million of those cases and 107,000 of those deaths are within the USA, with 372,000 cases and 24,000 deaths within New York State [3]. Currently, there is no specific anti-viral therapy or vaccine available for COVID-19.

Although typically characterised by fever and respiratory symptoms, gastrointestinal (GI) and/or genitourinary (GU) complaints as an initial presentation of COVID-19 have recently been described, albeit to a lesser extent [5–10]. In a meta-analysis of 69 studies including 4302 COVID-19 patients in Asia, 17.6% of patients reported GI symptoms [11]. Viral RNA was detected in stool samples from 48.1% of these patients [11]. A multicentre study from China with 204 patients showed that 50.5% reported GI symptoms on presentation [12]. Interestingly, and as we have observed clinically within our major multihospital Health System in New York City (NYC), many COVID-19 patients present with abdominal symptoms either in isolation or in combination with respiratory complaints. These patients commonly undergo computed tomography (CT),

with incidental findings of peripheral ground-glass opacities (GGOs) and/or consolidative opacities noted at the lung bases, which have been described in the setting of COVID-19 [13–16].

Data is rapidly emerging given the novel nature of this devastating disease, with a paucity of published reports investigating abdominal presenting symptoms and subsequent CT imaging findings in COVID-19 patients. It remains to be determined how certain clinical and demographic factors including ethnic minority status, advanced age, or a lower income neighbourhood in NYC impact imaging findings or outcomes. To our knowledge, only a few small case series and case reports have been published on this topic to date [17–20].

The purpose of our study is to describe the demographic, clinical, biological, and lung base CT findings in COVID-19 patients presenting with acute abdominal complaints, either in isolation or in combination with respiratory complaints.

Materials and methods

Patients

This retrospective, Health Insurance Portability and Accountability Act (HIPAA)–compliant study was approved by our institutional review board with exemption for patient consent. The Department of Radiology imaging database was queried for abdominal or abdominopelvic CT examinations performed out of the emergency department (ED) throughout the hospitals in our Health System located within NYC (including 6 hospitals in Manhattan) between March 1, 2020, and April 15, 2020, using the search term 'viral pneumonia'. Inclusion criteria were the following: (1) patient age > 20 years; (2) acute abdominal symptoms (with or without respiratory complaints); (3) patients who underwent abdominal or abdominopelvic CT for evaluation of their symptoms; and (4) patients with confirmed positive COVID-19 reverse transcriptase polymerase chain reaction (RT-PCR) nasopharyngeal swab test obtained during the same ED visit. Exclusion criteria were the following: (1) lack of a positive COVID-19 RT-PCR test or (2) incomplete clinical information. The initial patient population consisted of 150 patients, with 74 cases excluded for various reasons (Fig. 1), resulting in a remaining population of 76 patients (37M/39F, median age 61.5 years, IQR 51–74 years, range 20–90 years).

Demographic and clinical data was recorded for each patient from the electronic medical records (EMR). Patients were stratified by age, sex, race, ethnicity, and NYC borough of residence. The following presenting symptoms were recorded: fever (oral temperature at ED presentation ≥ 37.0 °C), abdominal pain, nausea/vomiting/anorexia, diarrhoea, dysuria/haematuria/oliguria, cough, shortness of breath, chest
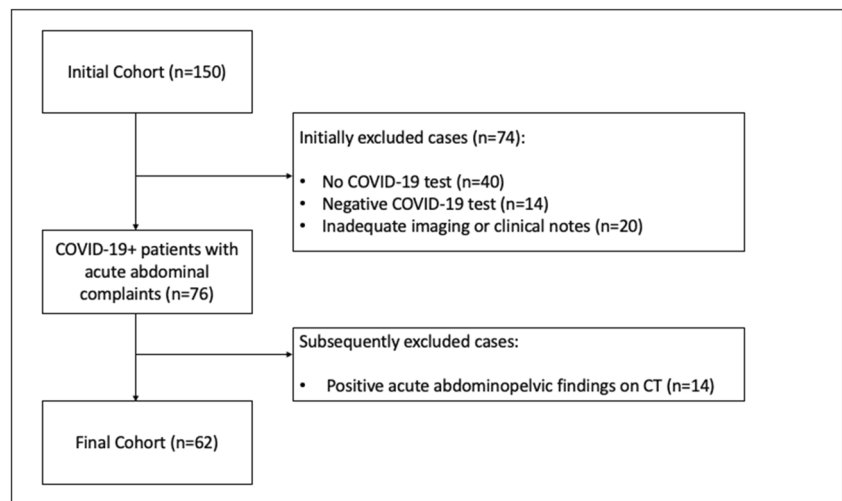
pain, symptoms commonly attributable to viral syndromes (including myalgia, malaise, fatigue, headache, rhinorrhoea, and sore throat), and other symptoms (including syncope, weakness, dizziness, and altered mental status). The following underlying medical conditions were recorded: obesity (defined as body mass index (BMI) ≥ 30 kg/m^2), hypertension, diabetes mellitus, cardiovascular disease (including coronary artery disease, cerebrovascular disease, peripheral vascular disease, and/or congestive heart failure), chronic renal disease, asthma/chronic obstructive pulmonary disease (COPD), and any cancer history or other reasons for immunosuppression. Blood laboratory values were recorded, including aspartate aminotransferase (AST), alanine aminotransferase (ALT), C-reactive protein (CRP), procalcitonin, D-dimer, ferritin, lipase, white blood cell (WBC) count, lymphocyte percentage, and haemoglobin (Hb).

Image acquisition

Abdominal CT examinations were performed at several EDs across our Health System using clinically available platforms, including GE Medical Systems Revolution ($n = 12$), GE Medical Systems Lightspeed VCT ($n = 20$), Siemens Somatom ($n = 16$), and Toshiba Aquilion ($n = 14$) scanners. The CT examinations were performed on the abdomen or the abdomen and pelvis, with ($n = 39$) or without ($n = 23$) Isovue-370 intravenous contrast (iopamidol 76%, Bracco Diagnostics), in the supine or prone position depending on initial patient complaint. CT scanning parameters were as follows: matrix size of 512×512, kVp values ranging from 80 to 140 mSv, slice thickness reconstructed at 3 mm, and pixel spacing (in-plane resolution) range of 0.596–0.977 mm in the axial plane. Coronal and sagittal reconstructions were generated automatically by the scanners. Lung base images were reconstructed using a lung kernel with reconstructed slice thickness of 3 mm.

Image analysis

The abdominal CT examinations were reviewed by two board-certified fellowship-trained abdominal radiologists (M.K. and S.L.) in consensus with 2 and 10 years of experience, respectively, using PACS (Centricity 3.0, General Electric Medical Systems), to confirm the absence/presence of findings in the abdomen that could explain the clinical symptoms. The lung base findings were then independently reviewed by a board-certified fellowship-trained cardiothoracic radiologist (M.C.) with 5 years of experience, who was aware of the presence of COVID-19 diagnosis but blinded to clinical symptoms. The lung bases were qualitatively assessed for the presence or absence of the following findings: ground-glass opacities (GGOs), consolidation, lesions with a rounded morphology, septal thickening, 'crazy paving' pattern, peripheral distribution, lung base multifocal involvement, bilateral involvement, and pleural effusion. Two patients underwent chest CT at the same time as their abdominal CT. In both cases, the chest portion of the study was not evaluated, and only the lung base findings on the abdominal scan were included in our analysis for consistency.

Study endpoints

The following patient outcomes were recorded: (1) discharge from the ED (mild disease); (2) hospitalisation, including admission to an intensive care unit (ICU); and (3) death. For patients who were admitted, the duration of hospitalisation or the time from admission to death was recorded. A final review of the patient's EMR was undertaken on April 24, 2020.

Statistical analysis

Demographic, clinical, biological, and imaging data were summarised using descriptive statistics. The Wilcoxon test was used for continuous variables. Fisher's exact test was used for categorical variables. Data were compared between groups of patients who were either discharged from the ED or hospitalised (including patients who died). A p value ≤ 0.05 represented an acceptable level of statistical significance in our study. All statistical tests were conducted using R statistical software (version 3.6.3).

Results

Patients

Of the initially included patients ($n = 76$), those found to have a positive CT finding within the abdomen or pelvis ($n = 14$) were excluded from analysis. The final study population comprised 62 patients (30M/32F; median age 63 years, interquartile range (IQR) 52–75 years, range 30–90 years). The fourteen patients who were excluded due to the presence of positive findings within the abdomen or pelvis at CT had GI diagnoses (oesophagitis ($n = 1$), perforated duodenal ulcer ($n = 1$), small bowel enteritis ($n = 1$), small bowel obstruction ($n = 1$), large bowel obstruction ($n = 1$), colitis ($n = 2$), perianal abscess ($n = 1$), biliary distention ($n = 1$), cholelithiasis ($n = 1$), or acute pancreatitis ($n = 1$)) or GU diagnoses (nephrolithiasis and/or hydronephrosis ($n = 5$), pyelonephritis ($n = 1$), or post-cystectomy fluid collection ($n = 1$)). Four patients had both GI and GU diagnoses.

Demographic and clinical findings

Demographic and clinical characteristics of the study population are summarised in Table 1. Most patients lived in Manhattan (45%, $n = 28/62$) and a majority (81%, $n = 50/62$) had at least one underlying medical condition. The median time interval between scanning and confirmed COVID-19 diagnosis via RT-PCR was 0.5 days (IQR 0–1).

Patients were stratified by demographic, clinical, biological, and lung base CT findings according to patient outcomes. In our study sample, 19% ($n = 12/62$) of patients were discharged from the ED without hospital admission, while 81% ($n = 50/62$) were hospitalised. Of the hospitalised patients, 10% ($n = 6/62$) died while the remaining 71% ($n = 44/62$) were discharged. The 6 patients who died had a median age of 69 years (range 58–83 years); 1 died of cardiopulmonary arrest with COVID-19 pneumonia and diabetes listed as contributing factors despite attempted resuscitation, 4 died of COVID-19 respiratory failure in the setting of a do not resuscitate/do not intubate (DNR/DNI) order, and 1 died of

COVID-19 respiratory failure and acute renal failure in the setting of a DNR/DNI order. No patients were ventilated or admitted to the ICU. Of those hospitalised, the median duration of hospitalisation (until discharge or death) was 5.0 days (IQR 3.0–9.0 days). The hospitalised patients were older than those discharged from the ED (median age 63.0 years (IQR 55.8–77.8 years) vs. 54.5 years (IQR 46.0–65.0 years), $p = 0.045$, respectively). The hospitalised patients were managed clinically at the discretion of the medical teams, and none received subsequent abdominal imaging throughout their hospital stay. There was no difference in sex or BMI (all p values > 0.844) between the 2 groups. Hypertension was more frequent in hospitalised patients ($p = 0.019$), whereas cough ($p = 0.044$) and shortness of breath ($p = 0.038$) were more frequent in those discharged from the ED. Otherwise, there was no significant difference in the frequency of presenting symptoms (all p values > 0.116) or underlying health conditions (all p values > 0.085) (Table 1).

Blood laboratory results

The median and interquartile ranges of selected blood laboratory values (when available) are summarised in Table 2. Although a majority (57.4%, $n = 31/54$) of patients demonstrated a mildly elevated AST, the most frequent abnormalities were acute markers of inflammation. Median haemoglobin was lower for female patients hospitalised compared with those discharged from the ED (median Hb 11.8 g/DL (IQR 10.9–13.4) vs. 13.6 g/DL (IQR 12.9–14.1), $p = 0.042$). There was no difference in other blood laboratory values between the 2 patient groups (all p values > 0.087). With regard to elevated D-dimer, no patients demonstrated acute thrombotic events at the time of imaging.

Imaging results

A summary of the lung base CT findings in the whole patient population and stratified by outcome is described in Table 3. All patients demonstrated at least one lung base finding on abdominal CT. An overwhelming majority of patients demonstrated GGOs (95.2%), with findings described in a multifocal (95.2%) and bilateral (93.6%) pattern (Figs. 2 and 3). Only 1 patient (1.6%) demonstrated pleural effusion. There was no significant difference in the frequency of imaging findings at the lung bases between the discharged and hospitalised groups ($p > 0.165$).

Discussion

In this study, we described demographic, clinical, biological, and lung base CT findings in a population of COVID-19 patients who presented to our Health System with acute

Table 1 Demographic and clinical characteristics of patients with COVID-19 in relation to outcomes (discharged vs hospitalised). Values are given as numerical value with percentages (percent relative to total number in the respective patient group) unless otherwise stated

Characteristic	All patients ($n = 62$)	Discharged from ED ($n = 12$)	Hospitalised ($n = 50$)	p
Age (year)	62.5 (52.3–75.0)[#]	54.5 (46.0–65.0)[#]	63.0 (55.8–77.8)[#]	*0.045*
21–49 years	12 (19.4%)	4 (33%)	8 (16%)	
50–64 years	23 (37.1%)	5 (42%)	18 (36%)	
≥ 65 years	27 (43.5%)	3 (25%)	24 (48%)	
Sex				0.844
Female	32 (51.6%)	7 (58%)	25 (50%)	
Male	30 (48.4%)	5 (42%)	25 (50%)	
Body mass index (BMI) (kg/m^2)	27 (24–31)[#]	28 (25–28.5)[#]	27 (24–31)[#]	0.879
Race				0.697
White	29 (46.8%)	5 (42%)	24 (48%)	
African American	19 (30.7%)	4 (33%)	15 (30%)	
Asian	2 (3.2%)	1 (8%)	1 (2%)	
Other/unknown	12 (19.3%)	2 (17%)	10 (20%)	
Ethnicity				0.912
Hispanic	20 (32.3%)	3 (25%)	17 (34%)	
Non-Hispanic	30 (48.4%)	7 (58%)	23 (46%)	
Other/unknown	12 (19.3%)	2 (17%)	10 (20%)	
Borough of residence				0.872
Manhattan	28 (45.2%)	6 (50%)	22 (44%)	
Brooklyn	11 (17.7%)	1 (8%)	10 (20%)	
Queens	16 (25.8%)	4 (33%)	12 (24%)	
Bronx	6 (9.7%)	1 (8%)	5 (10%)	
Staten Island	0 (0.0%)	0 (0%)	0 (0%)	
Outside NYC	1 (1.6%)	0 (0%)	1 (2%)	
Presenting symptom				
Fever[$]	29 (46.8%)	6 (50%)	23 (46%)	1
Abdominal pain	52 (83.9%)	11 (92%)	41 (82%)	0.670
Nausea/vomiting/anorexia	29 (46.8%)	3 (24%)	26 (52%)	0.116
Diarrheal	16 (25.8%)	3 (24%)	13 (26%)	1
Dysuria/haematuria/oliguria	7 (11.3%)	3 (24%)	4 (8%)	0.125
Cough	12 (19.4%)	5 (42%)	7 (14%)	*0.044*
Shortness of breath	8 (12.9%)	4 (33%)	4 (8%)	*0.038*
Chest pain	4 (6.5%)	1 (8%)	3 (6%)	1
General viral syndromic symptoms*	14 (22.6%)	4 (33%)	10 (20%)	0.266
Other^	8 (12.9%)	2 (17%)	6 (12%)	0.64
Underlying health conditions	50 (81%)			
Obesity[%]	19 (30.7%)	1 (8%)	18 (36%)	0.085
Hypertension	36 (58.1%)	3 (24%)	33 (66%)	*0.019*
Diabetes mellitus	19 (30.7%)	2 (17%)	17 (34%)	0.313
Cardiovascular disease	11 (17.7%)	1 (8%)	10 (20%)	0.674
Chronic renal disease	11 (17.7%)	0 (0%)	11 (22%)	0.102
Asthma/COPD	13 (21.0%)	2 (17%)	11 (22%)	1
Cancer history	10 (16.1%)	0 (0%)	10 (20%)	0.186
Immunosuppression	3 (4.8%)	0 (0%)	3 (6%)	1

Continuous variables (age and BMI) were assessed using Wilcoxon, while categorical variables (sex, race, ethnicity, borough of residence, presenting symptoms, and underlying health conditions) were tested using Fisher's exact test. Significant p values are italicised

[#] Value given as median (interquartile range)

[$] Defined as oral temperature on presentation to the ED ≥ 37.0 °C

*Includes myalgia, malaise, fatigue, headache, rhinorrhoea, sore throat

^Includes syncope, weakness, dizziness, altered mental status

[%] Defined as BMI ≥ 30 kg/m^2

abdominal complaints, either in isolation or in combination with respiratory complaints. Nineteen percent of the patients were discharged from the ED without hospital admission and 81% were hospitalised. Of those hospitalised, the median duration of hospitalisation (until discharge or death) was 5 days. Less than 10% of our patient population died, all of whom were admitted to the hospital, but not to the ICU. The higher median age observed in patients that died is consistent

Table 2 Blood laboratory values in patients with COVID-19 in relation to outcomes (discharged vs hospitalised). Data between each patient group were compared using the Wilcoxon test. Values are given as median with interquartile range in parentheses unless otherwise stated. Reference ranges are given below each laboratory value name in brackets

Laboratory value	All patients (n = 62)	Patients with abnormal lab values (%)	Discharged from ED (n = 12)	Hospitalised (n = 50)	p
Aspartate aminotransferase (AST) [1–35 U/L]	39.0 (25.0–62.3)	31/54 (57.4%)	37.0 (25.5–53.3)	41.5 (25.0–70.0)	0.385
Alanine transaminase (ALT) [1–45 U/L]	25.0 (19.0–44.0)	13/57 (22.8%)	25.0 (18.5–45.5)	25.5 (19.0–42.3)	0.911
C-reactive protein (CRP) [0–5.0 mg/L]	67.8 (35.9–99.3)	36/37 (97.3%)	56.4 (28.9–77.6)	68.8 (36.3–107.0)	0.522
Procalcitonin [0–0.49 ng/mL]	0.1 (0.1–0.4)	8/39 (20.5%)	0.3 (0.2–0.4)	0.1 (0.1–0.3)	0.632
D-dimer [0–0.5 μg/mL]	1.0 (0.7–1.7)	27/31 (79.4%)	7.0 (0.4–1.0)	1.1 (0.7–2.3)	0.323
Ferritin (males)[#] [30–400 ng/mL]	740.5 (387.8–1994.3)	11/16 (68.8%)	NA	740.5 (387.8–1994.3)	NA
Ferritin (females) [15–150 ng/mL]	391.5 (248.0–626.3)	18/22 (81.8%)	346.0 (322.5–269.5)	422.5 (225.3–656.3)	0.689
Lipase [8–78 U/L]	29.5 (16.8–71.3)	12/52 (23.1%)	31.0 (22.3–44.8)	29.5 (16.3–75.8)	0.972
White blood cell count (WBC) [4.5–11.0 K/μL]	6.7 (5.6–8.9)	15/62 (24.2%)*	6.0 (5.0–6.7)	7.1 (5.6–9.4)	0.090
Lymphocyte % [15–50]	16.6 (11.1–23.3)	27/62 (43.5%)^	21.6 (15.9–24.3)	15.2 (10.6–22.9)	0.087
Haemoglobin (Hb) (males) [13.9–16.3 g/D]	14.3 (12.7–15.7)	12/29 (41.4%)[&]	15.4 (15.0–15.7)	14.2 (12.4–15.6)	0.201
Haemoglobin (Hb) (females) [11.7–15.0 g/DL]	12.4 (11.1–13.7)	11/32 (34.3%)[&]	13.6 (12.9–14.1)	11.8 (10.9–13.4)	*0.042*

No patients were admitted to the ICU. Not all laboratory tests were available in all patients. *NA* not applicable. Significant *p* values are italicised

*Includes patients with WBC < 4.5 K/μL and > 11.0 K/μL

^Includes only patients with lymphocyte % < 15

[&] Includes only patients with Hb < 13.9 g/D (males) and 11.7 g/D (females)

[#] Results available only for hospitalised patients

with anecdotal evidence and with one of the earliest and largest published clinical reports on COVID-19 from Wuhan, China [5]. Interestingly, our 0% ICU admission rate is in line with very recent reports—including one from a neighbouring academic institution in NYC consisting of 278 patients—supporting an emerging concept that patients presenting with GI complaints may have milder disease severity with lower ICU admission and mortality rates [7, 8]. However, these findings contrast with a study of 204 Chinese patients with GI symptoms that demonstrated a 7.8% ICU admission rate [12]. Our mortality rate is in line with other reported mortality rates for COVID-19, which vary between 1.4 and 28% depending on the series [5, 9, 21, 22].

Most patients (81%, n = 50/62) in our study had underlying medical conditions, which likely mirrors the US public health situation. The only risk factor associated with need for hospitalisation was hypertension, contrasting with a recent Chinese report that suggested diabetes be considered a poor prognostic risk factor in COVID-19 [23]. A recent report of 107 patients suggested that lymphopenia is an indicator of disease severity in COVID-19 patients [24]. The most frequent laboratory abnormalities in our study were acute markers of inflammation (including CRP, D-dimer, and ferritin); however, the only significant difference in laboratory values was for hospitalised women having a lower haemoglobin compared with those discharged from the ED.

Table 3 Lung base findings on abdominal CT in 62 patients with COVID-19 in relation to outcomes (discharged vs hospitalised). Data between each patient group were compared using Fisher's exact test. Values are given as numerical value with percentages (percent relative to total number in the respective patient group)

Finding	All patients (n = 62)	Discharged from ED (n = 12)	Hospitalised (n = 50)	p
Ground-glass opacities	59 (95.2%)	12 (60%)	47 (94%)	1
Multifocal involvement	59 (95.2%)	11 (92%)	48 (96%)	0.482
Bilateral involvement	58 (93.6%)	10 (83%)	48 (96%)	0.165
Peripheral distribution	41 (66.1%)	10 (83%)	31 (62%)	0.195
Consolidation	29 (46.8%)	4 (33%)	25 (50%)	0.350
Rounded morphology	28 (45.2%)	6 (50%)	22 (44%)	0.755
'Crazy paving' attenuation	4 (6.5%)	0 (0%)	4 (8%)	0.578
Septal thickening	1 (1.6%)	0 (0%)	1 (2%)	1
Pleural effusion	1 (1.6%)	0 (0%)	1 (2%)	1

Fig. 2 A 58-year-old male presenting with abdominal pain for 7 days, who was subsequently discovered to be COVID-19-positive. (**a**) Axial and (**b**) coronal CT at the level of the lung bases show multifocal bilateral ground-glass opacities with a rounded morphology (arrows); many of which are peripheral in distribution. This patient was hospitalised and ultimately died 10 days later from respiratory failure related to COVID-19
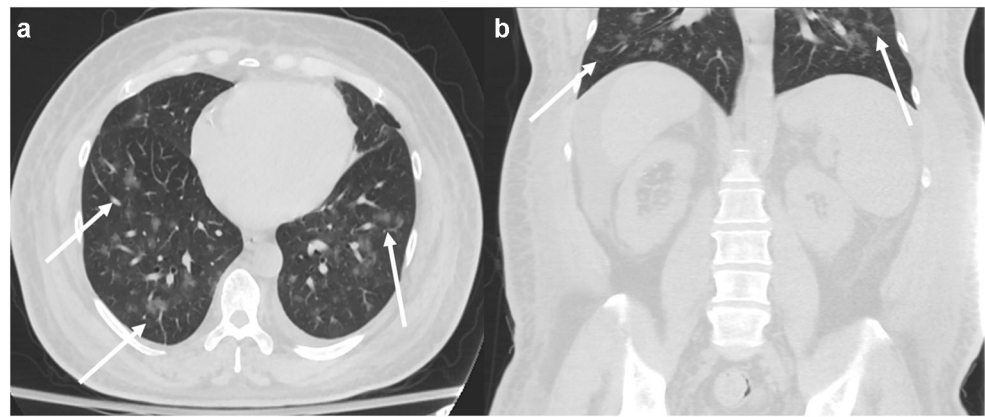

These discrepancies in our results compared with prior studies are likely due to our small sample size and differences in the study population.

Our lung base CT findings are consistent with numerous published reports on nonspecific imaging features that are typical for COVID-19, including ground-glass opacities and consolidation, often with a rounded morphology with a bilateral, peripheral, and/or multifocal distribution, while lymphadenopathy and pleural effusions are characteristically absent [13, 25–28]. As our study suggests, the lower lobe predominance of these findings requires abdominal radiologists to keep COVID-19 diagnosis in mind even when patients present solely with abdominal complaints, and to suggest it as a differential diagnosis where appropriate. Interestingly, no differences were found between the frequencies of lung base CT findings between the two patient groups.

Understanding the exact mechanism of SARS-CoV-2 resulting in abdominal symptoms remains both interesting and challenging. Potential explanations include direct viral infection of the GI or GU systems, co-infection with another pathogen, or referred pain from infection at the lung bases [29]. Similar to the 2003 coronavirus SARS-CoV but with a much higher affinity, SARS-CoV-2 infection in humans depends on the ability of the virus to bind with the angiotensin-converting enzyme 2 (ACE2) receptor [30, 31]. ACE2 is expressed in the human lung, upper oesophagus, ileum, colon, renal proximal tubules, and urinary bladder, providing a conceivable explanation for viral involvement at these sites [32, 33]. Viral infection of enterocytes is likely to cause an alteration of intestinal permeability, leading to a spectrum of GI symptoms including abdominal pain, nausea/vomiting, and diarrhoea [34]. According to Roman et al, there is no clear description of autonomous nervous system involvement with COVID-19 at this point [35].

Given this, a study of 204 patients with acute respiratory illnesses with confirmed nasopharyngeal swabbing for viral pathogens, including human coronavirus, found that GI symptoms could not be explained by the presence of viral respiratory pathogens in stool samples [29]. Abdominal symptoms have been described in other closely related coronavirus infections,
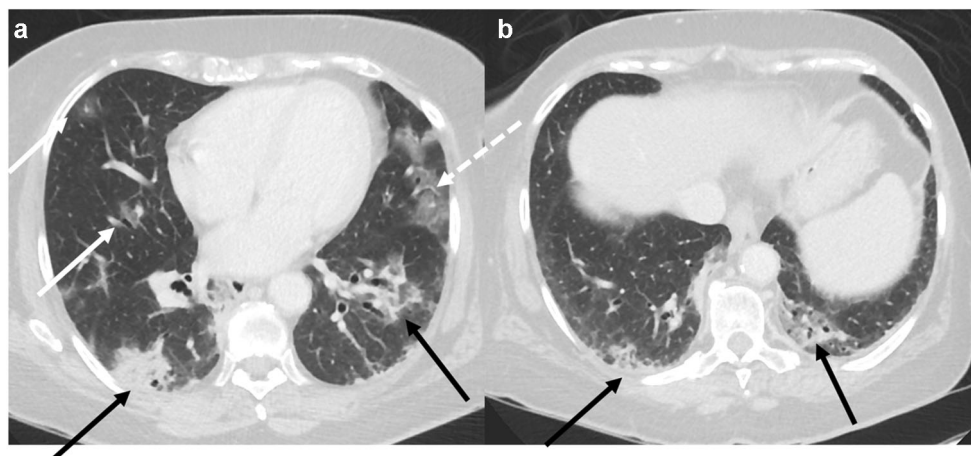
Fig. 3 A 63-year-old female with abdominal pain, nausea, and diarrhoea for 7 days, who was subsequently discovered to be COVID-19-positive. Axial CT of the lung bases at two different levels (**a**, **b**) shows predominantly peripheral, multifocal, and bilateral ground-glass (white arrows) and consolidative (black arrows) opacities with a region of 'crazy paving' attenuation (dashed arrow), a less commonly seen imaging finding in COVID-19. This patient was discharged home after being hospitalised for 8 days

with GI symptoms and diarrhoea reported with high frequency (23–70%) in severe acute respiratory syndrome (SARS) and in > 33% of patients with Middle Eastern respiratory syndrome (MERS) [36–38]. A recent preliminary, non-peer-reviewed study also suggested that ACE2 is also expressed in cholangiocytes, perhaps providing a mechanism for liver dysfunction and elevated serum liver enzymes [39]. Of note, there was mild elevation in serum AST in our study. The renal and urinary bladder expression of ACE2 may explain the urinary symptoms in our study sample. Further work is warranted to elucidate the mechanism of action in this regard.

Our study has several limitations. First, our data was obtained retrospectively from available data within the EMR, which may limit the generalisability of our results. Much of the clinical and radiologic literature published to date has been from Asia; more robust studies from the USA, a region with marked demographic and clinicopathologic differences (including higher rates of obesity and diabetes, for example), need to be performed in order to see how our results compare. We had incomplete race/ethnicity information, which has limited our ability to assess any meaningful associations related to these parameters. Additionally, future studies from the USA should incorporate longer follow-up periods and larger patient populations, including assessment for viral particles in stool and urine, an important clinical component missing in our analysis.

In conclusion, we report demographic, clinical, biological, and lung base CT findings in a group of patients presenting to our Health System with acute abdominal complaints who were found to have COVID-19. It is essential that the abdominal radiologist be aware that patients presenting with a wide variety of abdominal complaints may have COVID-19 infection in the absence of other findings in the abdomen or pelvis. Further work in a larger patient population is needed to evaluate these findings in relation to disease severity and outcome, especially given the urgency and widespread nature of COVID-19 infection.

Compliance with ethical standards

Guarantor   The scientific guarantor of this publication is Bachir Taouli, MD.

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Methodology
- Retrospective
- Observational
- Performed at one health system comprised of 6 hospitals

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