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Original article

Abdominal imaging in ICU patients with viral pneumonia: Are findings in COVID-19 patients really different from those observed with non-SARS-CoV-2 viral pneumonia?



Edouard Reizine^{a,*}, Sebastien Mule^{a,b,c}, Nicolas De Prost^{d,e}, Nicolas Mongardon^{b,f,g}, Jean-François Deux^{a,b}, Hicham Kobeiter^{a,b}, Alain Luciani^{a,b,c}

^a Department of Radiology, APHP, Imagerie Medicale, CHU Henri Mondor, 51 avenue du Marechal de Lattre de Tassigny, Creteil, Val-de-Marne F-94010, France

^b Faculté de Médecine, Université Paris Est Creteil, Creteil, F-94010, France

^c INSERM Unit U 955, Equipe 18, Creteil, F-94010, France

^d Service de Médecine Intensive Réanimation, Hôpitaux Universitaires Henri Mondor, Assistance Publique-Hôpitaux de Paris (AP-HP), Créteil, France

^e Groupe de Recherche Clinique CARMAS, Université Paris Est-Créteil, Créteil, France

^f Service D'anesthésie-Réanimation Chirurgicale, DMU CARE, DHU A-TVb, Assistance Publique-Hôpitaux de Paris (AP-HP), Hôpitaux Universitaires Henri Mondor, Créteil F-94010, France

^g U955-IMRB, Equipe 03 "Pharmacologie et Technologies pour les Maladies Cardiovasculaires (PROTECT)", Inserm, Univ Paris Est Creteil (UPEC), Ecole Nationale Vétérinaire d'Alfort (EnVA), Maisons-Alfort F-94700, France

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ABSTRACT

Purpose: To evaluate and compare the prevalence and type of abdominal involvements identified on CT scans in COVID-19 critically ill patients to those observed in critically ill patients with non-SARS-CoV-2 viral pneumonia.

Methods: Monocentric IRB approved retrospective study comparing all abdominal CT scans performed for patients admitted in the ICU with COVID-19 and those performed in a historical cohort of ICU patients with non-SARS-CoV-2 viral pneumonia. For each patient, gallbladder abnormality, acute pancreatitis signs, acute adrenal infarction, renal infarcts, bowel wall thickening and CT scan signs of bowel ischemia were assessed. Results were then compared between critically ill COVID-19 and non-COVID-19 patients (Chi-2 or Fisher exact tests for categorical data and Student t-test or Mann-Whitney U test for continuous data as appropriate).

Results: Ninety-nine COVID-19 patients and 45 non-COVID-19 patients were included. No difference was found between the rate of abnormal findings comparing COVID-19 patients and patients with other viral pneumonia (63/99 [64%] vs 27/45 [61%], $p=0.94$). Acute pancreatitis signs were more commonly seen in COVID-19 patients but without statistically difference between groups (14/99 [14%] vs 3/45 [6.7%], $p=0.31$). Bowel wall thickening was slightly more commonly seen in patients with other viral pneumonia (18/99 [18%] vs 11/45 [24%], $p=0.52$), however ischemic features were observed in higher rate in the COVID-19 group, although without reaching statistically significant differences (7/99 [7.1%] vs 2/45 [4.4%], $p=0.75$).

Conclusion: The rate and severity of abdominal involvement demonstrated by CT in ICU patients hospitalized for COVID-19 although high were not different to that observed in patients with other severe viral pneumoniae

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Abbreviations: CT, computed tomography; COVID-19, Coronavirus disease 2019; ECMO, extracorporeal membrane oxygenation; ICU, intensive care unit; RT-PCR, reverse transcription-polymerase chain reaction; SARS-CoV-2, severe acute respiratory syndrome Coronavirus 2

* Corresponding author.

E-mail address: edouard.reizine@aphp.fr (E. Reizine).

Key points

Abdominal abnormal findings were found in 62% ICU patients with viral pneumonia.

The rate and type of abdominal involvement demonstrated by CT were similar in all types of severe viral pneumoniae.

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1. Background

Although Coronavirus disease 2019 (COVID-19) is mainly defined by its respiratory symptoms [1,2], it has been reported that the virus can also affect the digestive system [3]. Hence, a preliminary study reported significant findings in up to 57% of COVID-19 patients referred for abdominopelvic computed tomography (CT) [4], especially regarding digestive tract abnormalities [4]. In another study, up to one third of the patients who underwent a CT scan were reported to have bowel wall abnormalities and signs of bowel ischemia were seen in 20% of Intensive Care Unit (ICU) patients (2.7% of ICU patients) [5]. Although the precise mechanisms accounting for these involvements remain poorly understood, thromboembolic episodes could occur more frequently in COVID-19 patients [6]. A recent study showed that non-occlusive mesenteric ischemia was the most common pattern suggestive of microvascular involvement [7]. In addition other ischemic damages have been reported such as renal infarctions, which was commonly identified on abdominal CT [4] and similarly, a high incidence of acute adrenal infarction have been reported on initial chest CT in severe COVID-19 patients, which might be a sign of a poorer prognosis [8]. Besides vascular injuries, other abnormal abdominal findings have been reported such as a dilated sludge-filled gallbladder, notified in more than half of right upper quadrant ultrasound performed in patients with COVID-19 [5] or signs of acute pancreatitis [9]. To date, there is no evidence of prevalent CT scan signs of acute pancreatitis in patients with COVID-19, even if the pancreas is target organs of SARS-CoV-2 because ACE2 receptor is expressed in the pancreas acinar and islet cells [10].

Interestingly, abdominal imaging findings seem related to the intrinsic diseases severity as patients with moderate to severe COVID-19 pneumonia have a significantly higher rate of vascular complications in the abdomen and pelvis [9].

Nevertheless, those findings, notably bowel ischemia, are not uncommon in critically ill patients regardless of the etiology [11,12]. Interestingly, in a small autopsy series focusing on pulmonary embolism, alveolar capillary microthrombi were 9 fold more prevalent in patients with COVID-19 than in patients with influenza [13], suggesting that abdominal abnormalities, and especially those secondary to thromboembolism could occur more commonly in patients with COVID-19 than in patients with other viral pneumonia.

Our purpose was hence to evaluate and compare the prevalence and type of abdominal involvements identified on CT scans in COVID-19 critically ill patients to those observed in critically ill patients with non-SARS-CoV-2 viral pneumonia.

2. Materials and methods

This retrospective study was approved by the local institution review board and informed consent was waived.

2.1. Population

All patients hospitalized in ICU for or with a viral pneumonia between October 2009 and February 2021 were extracted from an institutional ICU database. Patients without RT-PCR to confirm the viral pneumonia or patients for whom the viral pneumonia was not the cause of ICU hospitalization were excluded. All patients who underwent an enhanced abdomen and pelvic CT were finally included. Demographic data including age, sex, main comorbidity such as Hypertension, Chronic kidney disease, Diabetes, Obesity (BMI>30kg/m²), Cancer, Solid organ transplantation or immune-suppressive medications and Cirrhosis, was collected for each patient according to the clinical chart of ICU hospitalization. Details of ICU hospitalization including acute respiratory failure, bacterial pulmonary coinfection and liver function tests at admission, numbers of days in ICU and deaths during the ICU hospitalization were noted.

The ICU hospitalization day on which the abdominal CT was performed and details of the CT protocols were reported. For patients who underwent several CT during the hospitalization, only one CT per patient was analyzed.

Two groups of patients were compared: the COVID-19 group for patients admitted in the ICU with COVID-19 confirmed by reverse transcription-polymerase chain reaction (RT-PCR), and the Non-COVID-19 group for ICU patients with non-SARS-CoV-2 viral pneumonia.

2.2. CT analysis

All patients underwent a 64-section contrast-enhanced CT scanner (Discovery HD 750; GE Healthcare for patients before 2016 and Revolution CT; GE Healthcare for patients after 2016). The number of patients undergoing unenhanced, arterial phase and portal-phase acquisitions performed were assessed. A volume of 2 mL/kg body weight of nonionic contrast material (iomeprol, 350 mg iodine/mL; Iomeron® 350, Bracco Imaging, Milano, Italy or Iobitridol, 350mg iodine /mL, Xenetix®, Guerbet, Aulnay France) was injected into an antecubital vein at a flow rate of 5 mL/sec followed by 50 mL of saline solution at the same flow rate. Acquisition parameters were as follows: tube voltage, 120 kVp; section collimation, 64 × 1.25 mm; helical pitch, 1.375; reconstructed image thickness 1.25mm.

All CT scans were reviewed by 2 radiologists specialized in abdominal imaging (with respective 5 and 15 years of experience) in consensus who were both blinded to the final diagnosis. For each patient the following features were assessed: presence of free air, free fluid or fluid collection, gallbladder abnormality defined as distension associated to wall edema, acute pancreatitis signs, acute adrenal hemorrhage, renal infarcts, spleen infarcts, bowel wall thickening, bowel distension and CT scan signs of bowel ischemia including lack of bowel wall enhancement, intramural pneumatosis, mesenteric or portal venous gas, and mesenteric arterial or venous thrombosis [14].

Relevant imaging findings were defined as abnormalities found on CT including exclusively acute pancreatitis signs, acute adrenal hemorrhage, renal infarcts, spleen infarcts, bowel wall thickening and CT scan signs of bowel ischemia.

For each patient, the lung involvement was quantitatively estimated using a 0 to 5 score as previously reported [15]; 0, no involvement; 1, <5% involvement; 2, 25% involvement; 3, 26–49% involvement; 4, 50–75% involvement; 5, > 75% involvement [15].

2.3. Statistical analysis

For statistical analysis, categorical variables are presented as numbers and percentages, and continuous variables as means (standard deviations) or medians (ranges), depending on the distribution of values. A Kolmogorov-Smirnov test was used to assess the normality of distributions. Comparison of categorical variables was performed using Chi-2 or Fisher exact tests. Continuous data were compared using the Student t-test or Mann-Whitney U test, as appropriate. No matching was performed between the two populations. Finally, a logistic regression was used to identify statistically significant predictors of relevant imaging findings between the lung involvement, the COVID-19 infection, the clinical state of the patients in ICU and the outcome.

3. Results

3.1. Population

Four hundred and forty-four patients with COVID-19 confirmed by RT-PCR and 283 patients with non-SARS-CoV-2 viral pneumonia were eligible to this study. A total of 99 COVID-19 patients (99/411

Table 1
Comparison of demographics data and biological data of ICU patients with COVID-19 or with other viral pneumonia.

	Other viral pneumonia, N = 45	COVID-19, N = 99	p-value
Male	23 (51%)	79 (80%)	<0.01
Age (y), median (IQR)	65 (54, 76)	61 (54, 70)	
Hypertension	18 (40%)	59 (60%)	0.22
Chronic kidney disease	7 (16%)	6 (6.1%)	0.05
Diabetes	12 (27%)	44 (44%)	0.11
Obesity (BMI>30kg/m2)	6 (13%)	35 (35%)	0.07
BMI, median (IQR)	23.0 (21.1, 29.4)	28.0 (25.0, 33.2)	0.01
Cancer	12 (27%)	5 (5.1%)	<0.01
Solid organ transplantation or immune-suppressive medications	12 (27%)	6 (6.1%)	<0.01
Cirrhosis	7 (16%)	2 (2.0%)	<0.01
Recent surgery	3 (6.7%)	1 (1.0%)	<0.01
History of thromboembolic event	7 (16%)	5 (5.1%)	0.05

Unless otherwise indicated, values present number of patients with percentage in parentheses

[24%]) and 45 non-COVID-19 patients (45/283 [16%]) underwent an abdominal CT scan during the study period and were included.

For non-SARS-CoV-2 viral pneumonia, the causal virus was Influenza A for 22 patients, Influenza B for 7 patients, Parainfluenza for 4 patients, Herpes Virus for 3 patients, Metapneumovirus for 3 patients, Rhinovirus for 3 patients, Human Respiratory Syncytial Virus for 2 patients, and Coronavirus HCoV for 1 patient.

Results of demographic and biological data are provided in **Table 1**.

Comparing the demographic data, COVID-19 patients were more frequently male (79/99 [99%] vs 23/45 [51%], p<0.01) and obese (35/99 [35%] vs 6/45 [13%], p<0.01) with a significantly higher body mass index (28.0 [25.0, 33.2] vs 23.0 [21.1, 29.4], p <0.01). On the other hand, underlying cancer (5/99 [5.1%] vs 12/45 [27%], p<0.01), transplantation and immune-suppressive medications (6/99 [6.1%] vs 12/45 [27%], p<0.01) were more frequent in non-COVID-19 patients.

The median number of days in ICU was similar in both groups (15 [6, 28] vs 12 [7, 26], p=0.76) Regarding results of liver function tests, COVID-19 patients demonstrated a slightly increased rate of cytolysis (57/99 [59%] vs 23/45 [53%], p=0.64) without significant differences, while the rate of cholestasis was similar in both groups (30/99 [31%] vs 12/45 [28%], p=0.84, respectively). Regarding the outcome of those patients, more patients died with COVID-19 than with other pneumonia without reaching a significant difference (47/99 [47%] vs 15/45 [33%], p=0.16). Details of ICU hospitalization are provided in **Table 2**.

Table 2
Comparison of ICU hospitalization data of ICU patients with COVID-19 or with other viral pneumonia.

	Other viral pneumonia, N = 45	COVID-19, N = 99	p-value
Acute respiratory failure at admission	29 (64%)	87 (88%)	<0.01
Number of days in ICU	12 (7, 26)	15 (6, 28)	0.76
Bacterial pulmonary coinfection at admission	15 (36%)	6 (6.3%)	<0.01
Cytolysis	23 (53%)	57 (59%)	0.64
Cholestasis	12 (28%)	30 (31%)	0.84
Death during ICU hospitalization	15 (33%)	47 (47%)	0.16
ICU hospitalization day which the CT was performed	6 (1, 11)	11 (2, 20)	0.03
Patient intubated	26 (58%)	74 (75%)	0.06
Patient with ECMO	1 (2.2%)	16 (16%)	0.03

Values present number of patients with percentage in parentheses

In COVID-19 patients, the abdominal CT scans were performed after a longer delay in ICU than with other pneumonia (mean 11 days [2, 20] vs 6 days [1, 11] respectively, p=0.03) while more patients were intubated or under an extracorporeal membrane oxygenation (ECMO) (74/99 [75%] vs 26/45 [58%] p=0.06 and 16/99 [16%] vs 1/45 [2.2%] p=0.03 respectively).

The lung involvement was more severe for COVID-19 patients with a significantly higher prevalence of 50%–75% involvement and above 75% involvement (28/99 [28%] vs 3/45 [6.7%] respectively and 20/99 [20%] vs 2/45 [2.2] respectively, p<0.01).

3.2. Abdominal imaging findings

The main clinical settings in which the CT were performed were sepsis (49/144, [34%]), shock (16/144, [11%]), bleeding (18/144, [13%]), abdominal pain (11/144, [9%]) and bowel ischemia for 9 patients (9/144, [6%]).

Results of abdominal imaging findings are provided in **Table 3** while main abdominal imaging findings are summarized in **Fig. 1**.

Regarding the CT protocol, the rates of unenhanced (73/99 [74%] vs 39/45 [87%], p=0.13), arterial phase (52/99 [53%] vs 20/45 [44%], p=0.47) and portal phase acquisitions (89/99 [90%] vs 40/45 [89%], p>0.99) were similar in both groups.

Fifty-four patients did not show any abnormal findings on CT (54/144 [38%]). Of the 90 patients with abnormal CT (90/144 [62%]), the most common findings were gallbladder abnormalities in 31 patients (31/90 [34%]) and bowel wall thickening in 29 patients (29/90 [32%]). Signs of bowel ischemia were noted in 9 patients (9/90 [10%]), including 1 patient with simultaneous splenic and renal infarcts and two patients with renal infarcts alone. Seventeen patients showed acute pancreatitis signs (17/90 [19%]), including 5 patients with simultaneous bowel wall thickening, and two patients with additional renal infarcts.

No difference was found between the rate of abnormal findings when comparing COVID-19 patients and patients with other viral pneumonia (63/99 [64%] vs 27/45 [61%], p=0.94) as well as the rate of

Table 3
Comparison of abdominal imaging findings of ICU patients with COVID-19 or with other viral pneumonia.

	Other viral pneumonia, N = 45	COVID-19, N = 99	p-value
Pre contrast	39 (87%)	73 (74%)	0.13
Arterial Phase	20 (44%)	52 (53%)	0.47
Portal venous phase	40 (89%)	89 (90%)	>0.99
Lung involvement			<0.01
less than 5%	25 (56%)	16 (16%)	
5%–25% involvement	11 (24%)	25 (25%)	
26%–49% involvement	5 (11%)	10 (10%)	
50%–75% involvement	3 (6.7%)	28 (28%)	
More than 75% involvement	1 (2.2%)	20 (20%)	
Abnormal abdominal findings	27 (61%)	63 (64%)	0.94
'Relevant abdominal findings'	18 (40%)	42 (42%)	0.93
Intra-abdominal free fluid	2 (4.4%)	4 (4.0%)	>0.99
Intra-abdominal free air	22 (49%)	35 (35%)	0.18
Intra-abdominal fluid collection	0 (0%)	1 (1.0%)	>0.99
Periportal edema	8 (18%)	4 (4.0%)	<0.01
Gallbladder abnormality	10 (22%)	21 (21%)	>0.99
Acute pancreatitis	3 (6.7%)	14 (14%)	0.31
Spleen infarcts	4 (8.9%)	2 (2.0%)	0.08
Adrenal hemorrhage	7 (16%)	13 (13%)	0.90
Renal infarcts	2 (4.4%)	6 (6.1%)	>0.99
Bowel wall thickening	11 (24%)	18 (18%)	0.52
Small bowel involvement	6 (13%)	5 (5.1%)	0.10
Large bowel involvement	9 (20%)	14 (14%)	0.52
Bowel distension	4 (9.5%)	13 (13%)	0.75
Bowel ischemia	2 (4.4%)	7 (7.1%)	0.72

Values present number of patients with percentage in parentheses

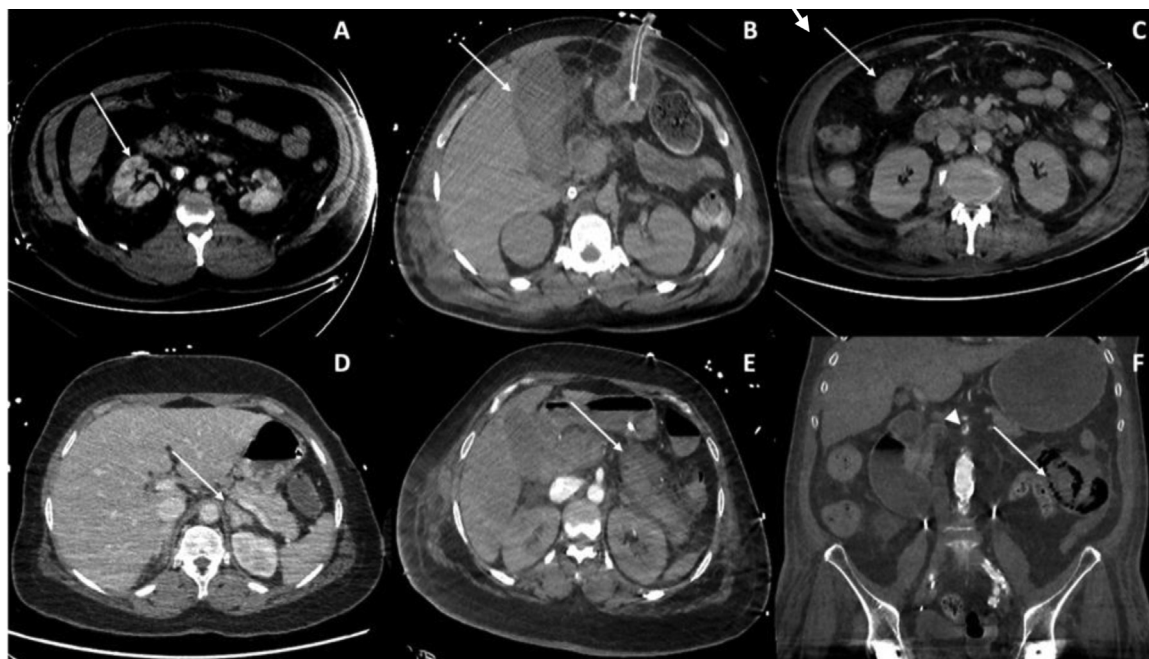


Fig. 1. Pictorial of different abdominal findings in ICU patients with COVID-19 patients

Cortical renal wedge-shaped parenchymal defects related to renal infarcts (A). Wall thickening and distension of the gallbladder (B) Wall thickening of a large bowel loop (C). Enlargement of the left adrenal gland with peripheral fat stranding related to adrenal hemorrhage (D). Peri-pancreatic fluid with mild heterogeneous enhancement of the pancreatic head in keeping with acute pancreatitis (E). CT scan demonstrating intramural pneumatosis in a patient with bowel ischemia (F) related to a nonocclusive thrombus in the superior mesenteric artery (arrowhead).

relevant imaging findings (42/99 [42%] vs 18/45 [40%], $p=0.93$). The same proportion of patients in both groups demonstrated gallbladder abnormalities (21/99 [21%] vs 10/45 [22%], $p>0.99$), adrenal hemorrhage (13/99 [13%] vs 7/45 [16%], $p=0.90$) and renal infarcts (6/99 [6.1%] vs 2/45 [4.4%], $p>0.99$). Acute pancreatitis signs were more commonly seen in COVID-19 patients but without reaching statistically significant difference between groups (14/99 [14%] vs 3/45 [6.7%] respectively, $p=0.31$). On the 17 patients with acute pancreatitis, only 2 had biliary stones based on US evaluation, both in the COVID-19 patients. On the opposite, spleen infarcts were more commonly seen in patients with other viral pneumonia (2/99 [2.0%] vs 4/45 [8.9%], $p=0.08$). Regarding bowel wall abnormalities, bowel thickening was slightly more commonly seen in patients with other viral pneumonia (18/99 [18%] vs 11/45 [24%], $p=0.52$), however ischemia features were observed in higher rate in the COVID-19 group, although not yielding statistically significant differences (7/99 [7.1%] vs 2/45 [4.4%], $p=0.75$).

No significant predictive factor of relevant imaging findings was found whether regarding the type of viral pneumonia involvement ($p=0.76$), the importance of lung involvement ($p=0.32$), intubation ($p=0.39$), ECMO ($p=0.07$), date of CT request during ICU stay (0.14) and death ($p=0.11$).

4. Discussion

The purpose of our study was to evaluate and compare the prevalence and type of abdominal involvements identified on CT scans in COVID-19 critically ill patients to those observed in critically ill patients with non-SARS-CoV-2 viral pneumonia.

The results of our study first confirm that abdominal findings are common in patients with viral pneumonia hospitalized in ICU. For patients with COVID-19, the rate of patients demonstrating abdominal abnormalities on CT scans remains in line with previous reports [4,16], apart from the lower rate of adrenal hemorrhage when compared to a previous study [8]. A significant number of studies indeed already reported abdominal symptoms related to SARS-CoV-2 and the utility of imaging and especially of CT [17] in detecting bowel

ischemia in severe COVID 19 patients [18]. In addition, pancreatitis has also been associated to SARS-CoV-2 infections, which could be related to the presence of the ACE2 receptor on the pancreatic islet cells [17].

For other viral pneumonia such as Influenza, studies reporting abnormal imaging findings are scarce even if example of abdominal presentation of Influenza virus infection have been reported [19]. However uncertainty remains regarding the prevalence and significance of gastro-intestinal symptoms in patients with Influenza [20]. Moreover, some studies also reported cases of acute pancreatitis in the context of Influenza infection [21].

Interestingly, the prevalence and type of abdominal involvement in our study, as demonstrated on CT, was not significantly different in COVID-19 patients when compared to viral pneumoniae of other causes. In addition, the signs of bowel ischemia which could be related to thrombosis complications associated with SARS-CoV-2 [22], were more frequently seen within the COVID-19 group, but failed to reach a statistical difference with that observed in the non-COVID-19 patients. This also applies to pancreatic involvement, which has been reported after SARS-CoV-2 infection [23,24], but which was also observed in non-COVID-19 patients.

The clinical data at admission, and the rate of patients with acute respiratory failure in both groups support a more critical illness in the COVID-19 group which is in line with a previous study comparing COVID-19 and Influenza [25].

Besides its retrospective design, this study suffers from limitations. The main limitation is the small number of patients analyzed. This is partly due to the limited number of patients with COVID-19 who underwent an abdominal and pelvic CT. However, a total of 727 patients were screened in our database to define the study population. Moreover, even if abnormal findings on CT are not uncommon, significant findings such as bowel ischemia were less frequently encountered. Second, because the study looked retrospectively at patient files over a study period extending from 2009 to 2021, the CT technique of the abdominal CT scan was not identical. Hence, arterial phase acquisitions were not systematically performed. However, the rate of unenhanced, arterial phase and portal phase acquisitions was similar in

both groups. In addition, the combination of unenhanced and portal venous phase acquisitions is known to be highly specific when looking for bowel ischemia [26]. Then, imaging analysis was done in consensus and not independently. Finally, as our study was monocentric and included patients throughout the different periods of the COVID-19 pandemic, the results might not be generalizable to other countries and cannot be associated to specific SARS-CoV2 variants.

Further studies merging a larger number of patients are mandatory to determine whether this yields more systematic abdominal CT evaluation in patients with severe viral pneumonia.

5. Conclusion

The rate and severity of abdominal involvement demonstrated by CT in patients hospitalized in ICU for COVID-19 although high were not different to that observed in patients with other severe viral pneumoniae.

Ethics approval and consent to participate

This retrospective study was approved by the local IRB and informed consent was waived.

Consent for publication

Not applicable.

Availability of data and materials

Not applicable.

Declaration of Competing Interest

None.

CRedit authorship contribution statement

Edouard Reizine: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Writing – original draft. **Sebastien Mule:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Software, Supervision, Writing – original draft. **Nicolas De Prost:** Formal analysis, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – review & editing. **Nicolas Mongardon:** Formal analysis, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – review & editing. **Jean-François Deux:** Validation, Visualization, Writing – review & editing. **Hicham Kobeiter:** Validation, Visualization, Writing – review & editing. **Alain Luciani:** Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Writing – review & editing.

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