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REVIEW ARTICLE

Presence of SARS-CoV-2 in abdominal tissues and biologic fluids during abdominal surgery: a systematic review

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Abstract

Background Viral transmission to healthcare providers during surgical procedures was a major concern at the outset of the COVID-19 pandemic. The presence of the severe acute respiratory disease syndrome coronavirus (SARS-CoV-2), the virus responsible for COVID-19, in the abdominal cavity as well as in other abdominal tissues which surgeons are exposed has been investigated in several studies. The aim of the present systematic review was to analyze if the virus can be identify in the abdominal cavity.

Methods We performed a systematic review to identify relevant studies regarding the presence of SARS-CoV-2 in abdominal tissues or fluids. Number of patients included as well as patient's characteristics, type of procedures, samples and number of positive samples were analyzed.

Results A total of 36 studies were included (18 case series and 18 case reports). There were 357 samples for detection of SARS-CoV-2, obtained from 295 individuals. A total of 21 samples tested positive for SARS-CoV-2 (5.9%). Positive samples were more frequently encountered in patients with severe COVID-19 (37.5% vs 3.8%, $p < 0.001$). No health-care provider related infections were reported.

Conclusion Although a rare occurrence, SARS-CoV-2 can be found in the abdominal tissues and fluids. It seems that the presence of the virus in the abdominal tissues or fluids is more likely in patients with severe disease. Protective measures should be employed in the operating room to protect the staff when operating patients with COVID-19.

Keywords SARS-CoV-2 · COVID-19 · Surgery · Safety · Review

The coronavirus disease 2019 (COVID-19) pandemic had an unprecedented impact in the world [1]. Numerous changes were implemented across the healthcare system to mitigate the risk of viral spread to healthcare workers while providing care to those who were infected. Surgical care was deeply affected as it was not exempt to the evolving adjustments produced by the pandemic, including the early deployment of surgeons to non-surgical responsibilities where much help was needed [2–4]. In addition, millions of elective surgeries were canceled to both safeguard the needed resources for the incoming influx of infected patients, as well to protect the healthcare providers from a potential infection. [2]

Based on extrapolated data from other viruses, there was a fear that surgeons could be exposed to infective levels of virus while performing surgery [5, 6]. Some societies published recommendations cautioning against the use of laparoscopy in COVID-positive patients as this was considered to be a potential aerosolizing procedure [5, 6]. The hypothesis was that if the virus were present in the abdominal tissues, it could be aerosolized and travel along with the insufflation gas or surgical plume during laparoscopic port insertion and removal, port venting, during instrument exchanges or specimen extraction, and hence transmitted to the operating room staff. However, as previously mentioned, for a potential transmission, the virus would need to

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be present in the abdominal cavity. As such, several groups investigated the presence of the COVID-19 virus in the abdominal cavity, as well as in other abdominal tissues to which surgeons are exposed. [7–29]

Nevertheless, the results were conflicting, in addition to being based just on case reports and case series [7–43]. Early during the pandemic, a systematic review attempted to clarify the issue by pooling the available data [44]. However, they could not support the hypothesis that the COVID-19 virus could be aerosolized in the operating room, and the majority of publications analyzed for inclusion were case reports. Since then, more studies have been published in this matter. As the world recovers from the COVID-19 pandemic we must be prepare for the ongoing emergence of new variants and future pandemics. Thus, the objective of the present study was to study the presence of the COVID-19 virus in the abdominal tissues and fluids.

Methods

Study design

A systematic literature search to identify relevant studies regarding the presence of severe acute respiratory disease syndrome coronavirus (SARS-CoV-2), the virus responsible for COVID-19, in abdominal tissues or fluids. The query was performed using the following databases: PubMed, Web of Science, EMBASE and Cochrane Central Library. It was restricted to articles in English and Spanish languages and was not time limited. References from previous reviews, as well as references from relevant primary studies were manually searched to identify any additional studies. The search was completed on March 1st, 2023. The systematic review was conducted in conformity with the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines and was registered in the prospective international register of systematic reviews (PROSPERO: CRD42023408176). [45]

Search strategy

Medical subject heading (MeSH) terms to search was broad to encompass articles related to the identification of SARS-CoV-2 RNA in samples of abdominal tissues or fluids in patients with SARS-CoV-2 infection. Therefore, the terms were as follow: "*SARS-COV-2*", "abdominal tissue*", "abdominal fluid*", "peritoneal fluid*", "biologic* fluid*", "swab test", "bile", "biliary", and "surgery". All identified abstracts were assessed for inclusion or exclusion by 2 independent evaluators (G.R-V. and G.P-B). There was no disagreement between evaluators that required the participation of a third investigator. Studies meeting the inclusion criteria were retrieved and the full texts reviewed.

Study selection

Observational studies (retrospective or prospective cohorts, case series, and case reports) that included patients with SARS-CoV-2 infection who underwent any abdominal procedure and in which samples of abdominal tissues or fluids were taken for qualitative detection of SARS-CoV-2 RNA were included in this systematic review.

Data extraction

Information extracted from eligible studies included basic study data (last name of the first author, country, design, sample size), demographic data (gender, age), SARS-CoV-2 infection status and symptoms (diagnostic test status, respiratory symptoms, radiologic signs of pneumonia, severity, length of disease), abdominal procedure parameters (type of procedure – surgery, paracentesis, dialysis, endoscopic procedures), and sample analysis (type, performed test for detection of SARS-CoV-2, positive status and timing with the surgery). Severe COVID-19 infection was defined as the patient requiring invasive respiratory support, intensive care unit admission or death [46]. Data were extracted and verified by three independent investigators (G.R-V, G.P-B, and M.A.Z.).

Analysis

Data within individual studies was extracted to fields within an Excel (Microsoft, Redmond, WA, USA) database. Data manipulation and analysis was performed using SAS v9.4 (SAS, Cary, NC, USA). The positivity between patients with severe and non-severe disease was analyzed with Chi-square, and statistical significance was defined as $p < 0.05$.

Results

Search results and study characteristics

A total of 335 studies (G.P-B. and G.R-V.) were identified from the previously described search strategy. After duplicates were removed, the titles and full abstracts of 259 studies were evaluated, from which only 45 were assessed for eligibility. The full text of these 45 articles were reviewed, and 36 were identified for inclusion (Fig. 1). From the included studies, 18 were case series (Table 1), and 18 were case reports (Table 2).

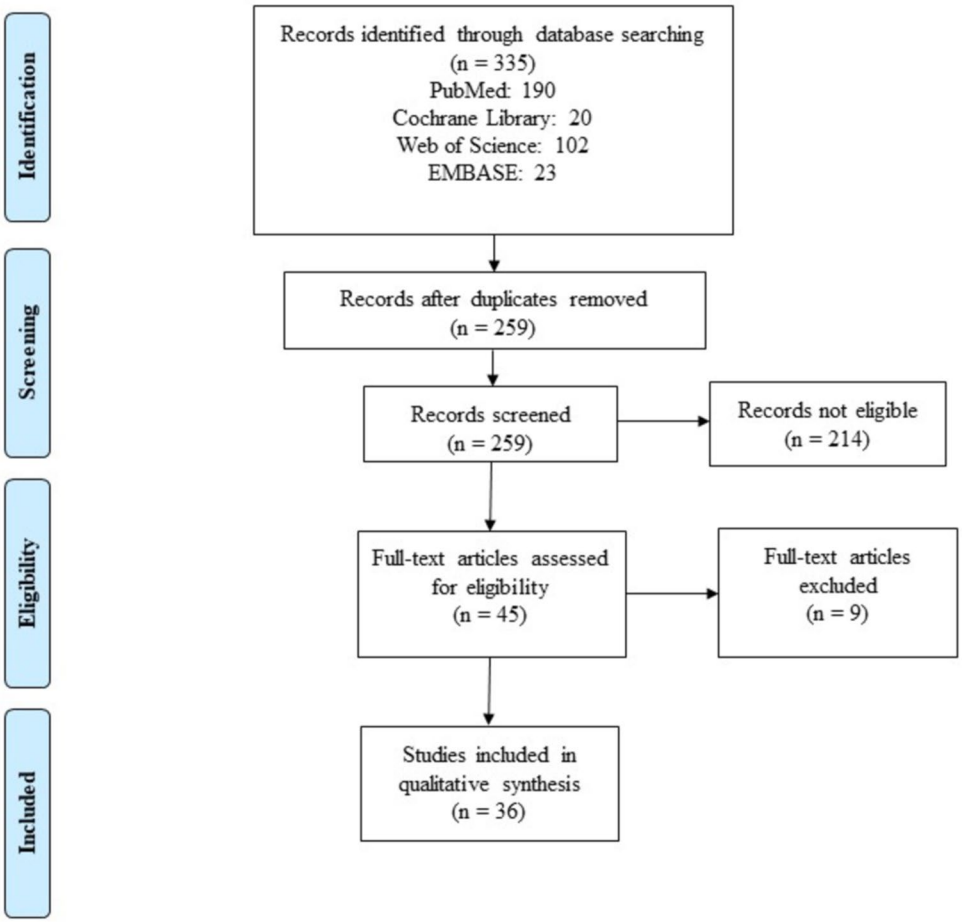

Fig. 1 PRISMA flowchart

Descriptive analysis

A total of 295 patients were included, of whom 76% were female ($n = 224$). Age range was between 12 and 95 years. At least 141 (47.8%) patients were positive for SARS-CoV-2 at the moment of sample collection, in whom respiratory symptoms were registered in 109 (36.9%), and radiologic findings were described in 46 (15.6%). Severe COVID-19 infection, as previously defined was registered in 32 patients (10.8%).

Abdominal sample characteristics

Reverse transcriptase-polymerase chain reaction (RT-PCR) was the test used in all of the cases. Collection time of the abdominal sample from the presence of symptoms ranged between 0 and 63 days. Samples for detection of SARS-CoV-2 were obtained from direct swab of the peritoneum or peritoneal fluid during surgery or paracentesis in 259 individuals, from peritoneal dialysis in 43, from smoke during surgery in 25, from bile or other gastrointestinal fluid in 13, and 17 from other tissues (including omentum, subcutaneous tissue, and hollow organs). Out of 357 total samples, 21 were reported to be positive (5.9%).

From all positive samples, 12 were in patients with severe COVID-19 infection (57.1%). Patients with severe COVID-19 infection were more likely to have positive samples compared to patients without severe infection (37.5% vs 3.8%, $p < 0.001$). Description of SARS-CoV-2 positive samples from abdominal sources is shown in Table 3 There were no healthcare provider infections reported across the included studies.

Discussion

As the world emerges from the COVID-19 pandemic there is opportunity to re-examine and collate the data collected during the pandemic to draw more concrete conclusions and prepare for potential future pandemics. As we are likely to experience new variants and future pandemics, surgeons need to be prepared and understand the potential risks for viral exposure and infection in the operating room. A key component to comprehend the potential for COVID-19 transmission during abdominal operations is to delimit the

Table 1 Case series included in the review

Author	Country	Sample size	Age	Gender (F:M)	COVID-19 status at procedure	Respiratory symptoms	Radiologic pneumonia	Severe	Procedure	Time from COVID-19 positive to specimen collection	Sample collected	Positive test ratio (#Positive/Total Sample)
AlAradi et al. [30]	Manama, Bahrain	5	22–55	0:5	5/5 positive	0/5 symptomatic	0/5	0/5	4 open appendectomy, 1 hernia repair	24–36 h	Peritoneal swab	0/5
Bogani et al. [31]	Milan, Italy	17	26–77	17:0	0/17 positive	0/17 symptomatic	Not reported	0/17	17 laparoscopic gynecological procedures	Simultaneous	Surgical smoke, endotracheal	1/17 surgical smoke
Candellier et al. [16]	Brussels, Belgium	3	53–68	1:2	3/3 positive	3/3 symptomatic	3/3	0/3	None	1–3 days	Peritoneal dialysate	0/3
El Shamy et al. [17]	New York, United States	10	60 ± 9	Not reported	10/10 positive	10/10 symptomatic	Not reported	10/10	None	Not reported	Peritoneal dialysate	0/10
Fabbri et al. [32]	Italy	8	44–92	5:3	8/8 positive	6/8 symptomatic	Not reported	0/8	3 chest tube placement, 2 sigmoid resection, 1 exploratory laparotomy, 1 laparoscopic cholecystectomy, 1 open cholecystectomy	Not reported	Peritoneal fluid, bile, pleural fluid	0/13 peritoneal fluid 0/5 pleural fluid 0/2 bile
Gaba et al. [18]	Uttar Pradesh, India	8	23–75	0:8	8/8 positive	8/8 symptomatic	Not reported	0/8	5 soft tissue cases, 2 perforated viscus, 1 small bowel obstruction	< 3 days	Wound, peritoneal fluid, hollow organ	0/2 peritoneal 0/7 wound 0/1 hollow organ
Jakimiuk et al. [33]	Warsaw, Poland	65	18–44	65:0	34/65 positive	34/65 symptomatic	6/65	0/65	65 cesarean section	< 13 days	Peritoneal fluid	0/65
Jones et al. [34]	Manchester, United Kingdom	102	20–83	102:0	1/102 positive	Not reported	Not reported	0/102	72 cesarean section, 19 cancer surgery, 11 other	48 h	Peritoneal cavity, vaginal	0/102 abdominal 0/98 vaginal

Table 1 (continued)

Author	Country	Sample size	Age	Gender (F:M)	COVID-19 status at procedure	Respiratory symptoms	Radiologic pneumonia	Severe	Procedure	Time from COVID-19 positive to specimen collection	Sample collected	Positive test ratio (#Positive/Total Sample)
Pani et al. [35]	Padova, Italy	2	12	1:1	2/2 positive	0/2 symptomatic	0/1	0/2	1 laparoscopic appendectomy 1 open appendectomy	Not reported	Purulent peritoneal fluid	2/2
Romero-Velez et al. [36]	New York, United States	6	23–80	3:3	6/6 positive	1/6 symptomatic	1/5	1/6	3 laparoscopic cholecystectomy, 2 exploratory laparotomy, 1 laparoscopic appendectomy	1–6 days	Peritoneal cavity, peritoneal fluid, surgical smoke	0/8 peritoneal fluid 0/8 surgical smoke 0/4 peritoneal cavity
Safari et al. [19]	Tehran, Iran	4	30–75	1:3	4/4 positive	1/4 symptomatic	4/4	2/4	2 exploratory laparotomy, 1 laparoscopic cholecystectomy, 1 open appendectomy	Not reported	Peritoneal fluid, omentum, abdominal fat, hollow organ, bile, rectal	0/4 peritoneal fluid 0/4 omentum 0/4 abdominal fat 1/4 hollow organ 0/1 bile
Scutari et al. [10]	Rome, Italy	2	74–80	0:2	2/2 positive	2/2 symptomatic	2/2	2/2	2 cholecystostomy	46–63 days	Bile	2/2 bile
Seeliger et al. [13]	Strasbourg, France	5	44–71	3:2	4/5 positive	4/5 symptomatic	5/5	3/5	1 small bowel resection, 1 laparoscopic appendectomy, 1 sigmoid resection, 2 drainage of hemoperitoneum	Not reported	Peritoneal fluid × 2	0/8
Suarez et al. [37]	Mexico City, Mexico	4	35–64	2:2	3/4 positive	4/4 symptomatic	0/2	0/4	None	< 7 days	Peritoneal dialysate	3/4

Table 1 (continued)

Author	Country	Sample size	Age	Gender (F:M)	COVID-19 status at procedure	Respiratory symptoms	Radiologic pneumonia	Severe	Procedure	Time from COVID-19 positive to specimen collection	Sample collected	Positive test ratio (#Positive/Total Sample)
Tartaglia et al. [38]	Pisa, Italy	13	18–95	6:7	13/13 positive	9/13 symptomatic	11/13	5/13	5 colonic resections, 2 appendectomy, 1 small bowel resection, 1 loop ileostomy, 1 enterotomy, 1 lysis of adhesions, 1 packing open abdomen, 1 hernia repair	2 (IQR 0–57)	Peritoneal cavity	2/15
Vimalachandran et al. [39]	Birmingham, United Kingdom	10	32–72	4:6	9/10 positive	Not reported	1/10	0/10	4 colonic resection, 2 cesarean section, 1 salpingectomy, 1 appendectomy, 1 hepatectomy, 1 lysis of adhesions	Not reported	Peritoneal cavity, vaginal, hollow organ	0/21 peritoneum 0/1 vaginal 0/1 hollow organ
Wang et al. [40]	New York, United States	11	34–69	8:3	11/11 positive	11/11 symptomatic	Not reported	0/11	None	1–42 days	Peritoneal dialysate	0/24
Balaphas et al. [20]	Geneva, Switzerland	2	84–83	1:1	2/2 positive	2/2 symptomatic	1/2	1/2	Laparoscopic cholecystectomy	Positive after surgery 5 days	Gallbladder	1/2

F: female; *M*: male; *COVID-19*c: coronavirus disease 19

Table 2 Case reports included in the review

Author	Country	Age	Gender	COVID-19 status at procedure and symptoms	Respiratory symptoms	Radiologic pneumonia	Severe	Procedure	Time from COVID-19 diagnosis to specimen collection	Sample collected	Test
Agnes et al. [11]	Rome, Italy	72	Male	Positive/Naso-pharyngeal swab	symptomatic	Yes	Yes	Laparotomy due to perforated duodenal ulcer	2 Samples: 9 days and 15th day	Peritoneal fluid/ Gastrointestinal fluid	Negative
Ahmad et al. [21]	London, United Kingdom	28	Male	Negative/3 Throat and nasopharyngeal swabs	symptomatic	No	Yes	Open appendectomy	N/A	Appendix	Positive
Barberis et al. [8]	Genova, Italy	71	Female	Positive/Oro-pharyngeal swab	symptomatic	Yes	Yes	Open subtotal colectomy	N/A	Abdominal fluid	Positive
Coccolini et al. [12]	Pisa, Italy	78	Male	Positive/naso-pharyngeal swab	symptomatic	Yes	No	Laparotomy due to small bowel obstruction	Simultaneous	Peritoneal fluid	Positive
Culver et al. [22]	Marseille, France	71	Male	Positive/naso-pharyngeal swab, bronchial aspirate	symptomatic	Yes	Yes	Paracentesis	Simultaneous	Ascites	Positive
D'Introno et al. [41]	Brindisi, Italy	50	Male	Positive/naso-pharyngeal swab	asymptomatic	Yes	No	Laparoscopic cholecystectomy	Simultaneous	Bile	Negative
Han et al. [15]	Hangzhou, China	59	Male	N/A	symptomatic	Yes	Yes	Endoscopic retrograde cholangiopancreatography	23 days	Bile	Positive
Hong et al. [42]	Zhuhai, China	69	Male	Positive/oro-pharyngeal swab (Negative at the moment of the surgery)	Not reported	NA	No	Cholecystectomy + CBD exploration and T-tube placement	> 30 days	Bile and abdomen drainage fluid	Negative
Hui-Na Ngaserin et al. [23]	Singapore	21	Male	Positive naso-pharyngeal swab	asymptomatic	No	No	Lap appendectomy	Not mentioned	Peritoneal fluid	Negative
Kabir et al. [24]	Singapore	NA	Male	Positive naso-pharyngeal swab	symptomatic	NA	No	Laparoscopic—converted subtotal cholecystectomy	12	Bile and peritoneal fluid	Negative
Liao et al. [25]	Wuhan, China	NA	Female	Positive/IgG assay	symptomatic	Yes	No	Endoscopic retrograde cholangiopancreatography	2 months	Bile	Positive
Mattone et al. [26]	Catania, Italy	66	Male	Positive naso-pharyngeal swab	symptomatic	Yes	Yes	Percutaneous trans hepatic biliary drainage	49 days	Bile	Negative
Mofti et al. [43]	Dammam, Saudi Arabia	52	Male	Positive	symptomatic	NA	Yes	Diagnostic laparoscopy + lysis of adhesions	> 7 days	Peritoneal fluid	Positive

Table 2 (continued)

Author	Country	Age	Gender	COVID-19 status at procedure and symptoms	Respiratory symptoms	Radiologic pneumonia	Severe	Procedure	Time from COVID-19 diagnosis to specimen collection	Sample collected	Test
Passarelli et al. [9]	Sao Paulo, Brazil	75	Male	Positive naso-pharyngeal swab	symptomatic	Yes	Yes	Paracentesis	2 days	Ascites	Positive
Romero-Velez et al. [7]	New York, United States	23	Male	Positive naso-pharyngeal swap	asymptomatic	No	No	Laparoscopic Appendectomy	Simultaneous	Peritoneal fluid	Negative
Sadioglu et al. [27]	Ankara, Turkey	62	Female	Positive naso-pharyngeal and oropharyngeal swab	symptomatic	Yes	No	Peritoneal dialysis	Same day	Peritoneal dialysis effusion	Negative
Vischini et al. [28]	Rome, Italy	53	Female	Positive naso-pharyngeal swab	symptomatic	Yes	No	Peritoneal dialysis	30	Peritoneal dialysate	Positive
Ying et al.[29]	Zhejiang, China	68	Female	Positive naso-pharyngeal swap	symptomatic	Yes	No	Percutaneous trans hepatic biliary drainage	13	Bile	Negative

COVID-19: coronavirus disease 19; *N/A*: not available; *Ig*: immunoglobulin

presence of the virus in the abdominal cavity. As there are conflicting results coming from case reports and small case series, the purpose of this study was to assess all the available data. We found that although a rare occurrence, SARS-CoV-2 can be isolated from abdominal tissues and fluids. While this study includes a small number of asymptomatic patients, it is noted that positive intra-peritoneal samples were noted among patients without disease symptoms.

Our study has some strengths and fills in a gap in the literature which are worth noting. First, more studies have been published since the previous systematic review in this topic was published, which allows to expand on the prior conclusions [44]. In addition, compared to the recently published guidelines by the Society of American Gastrointestinal and Endoscopic Surgeons (SAGES) for the use of laparoscopy in the era of COVID-19, our search strategy included the presence of SARS-CoV-2 in different specimens rather than just surgical plume. [5]

Our results support the recommendation by SAGES in which protective measures should be employed when operating on patients with COVID-19 for all cases regardless of the approach [5]. Nevertheless, it should be pointed out that even though SARS-CoV-2 has been found in the abdominal cavity by RT-PCR, the potential of these particles to infect has never been demonstrated [47]. In fact, none of the studies included in our review reported health care associated infections to the operating room staff. It is important to highlight that the type and extent of personal protective equipment or other isolation measures employed in the included studies are not known. Infections among healthcare workers may also be difficult to attribute to a specific exposure, as any worker in that environment presumably could have multiple potential opportunities for viral exposure throughout their routine course of work. Thus, a definitive statement regarding transmissibility of the detected viral loads is not possible and future studies should focus on the potential infectivity of viral particles found in the abdominal cavity.

Furthermore, the source of SARS-CoV-2 found in the peritoneum has also been investigated. Some reports have considered positive samples to be due to contamination by feces, bile or blood, which are well known to convey viral particles [36, 38, 44, 48–50]. Although some of the included cases in our review could be explained by contamination, the virus was also found in the dialysate effluent of peritoneal dialysis which likely is not prone to this contamination. This suggests that peritoneal viral translocation could occur in the absence of inflammation, but also be potentiated in the setting of inflammation [49]. Another important consideration in this regard is the correlation we found between severe COVID-19 disease and positive samples. Fabbri et al. have previously suggested the possibility that severe disease would translate to higher viral load and hence the increased possibility of translocation

Table 3 Description of positive abdominal samples

Case	Type of sample	SARS-CoV-2 status at procedure	Severe SARS-CoV-2 infection	Time from diagnosis to specimen collection
1	Smoke during surgery	Negative	No	Simultaneous
2	Purulent peritoneal fluid	Positive	No	Not reported
3	Purulent peritoneal fluid	Positive	No	Not reported
4	Bile	Positive	Yes	46 days
5	Bile	Positive	Yes	63 days
6	Peritoneal dialysis	Positive	No	< 7 days
7	Peritoneal dialysis	Positive	No	< 7 days
8	Peritoneal dialysis	Positive	No	< 7 days
9	Peritoneal fluid	Positive	Yes	Not reported
10	Peritoneal fluid	Positive	Yes	Not reported
11	Gallbladder	Positive	Yes	Simultaneous
12	Cecal appendix	Negative	Yes	Not reported
13	Peritoneal fluid	Positive	Yes	Not reported
14	Peritoneal fluid	Positive	No	Simultaneous
15	Ascites	Positive	Yes	Simultaneous
16	Bile	Not reported	Yes	23 days
17	Bile	Positive	No	2 months
18	Peritoneal fluid	Positive	Yes	7 days
19	Ascites	Positive	Yes	2 days
20	Peritoneal dialysis	Positive	No	30 days
21	Duodenal wall	Positive	Yes	7 days

to the abdominal cavity [32]. Regardless of the mechanism responsible for the presence of the virus in the abdominal cavity, the data suggest that surgeons could be exposed to viral particles when operating.

There are important limitations of the current study. First and most important, although we have evaluated multiple studies, the data comes from case series and case reports which are prone to selection bias. Also, there was significant heterogeneity of RT-PCR used, including varying promoter sequences and pooling or non-pooling techniques, the sampling site, and timing between COVID-19 diagnosis and specimen collection. In addition, these studies were completed during varying phases of the pandemic and likely include multiple SARS-COV2 variants and subvariants and whether a specific subvariant is more likely to be found in intra-abdominal tissues is not known. All of these factors in addition to the fact that RT-PCR may not have been validated for viral RNA detection from samples obtained from the abdominal cavity has been previously acknowledged by Fabbri et al. [49] Specifically, there may be a high false positive rate of RT-PCR, and nucleic acid amplification tests such as RT-PCR may remain positive for weeks to months after infection. Moreover, some tests designed and approved for screening and others for confirmatory diagnostic testing, which necessarily have different performance characteristics and expected positivity rates.

This study supports the assertion that SARS-CoV-2 can be identified from abdominal tissues and fluids that would be normally encountered during surgery. It seems that the presence of the virus in the abdominal tissues and fluids is more likely in patients with severe disease. Protective measures are needed in the operating room to protect the staff when operating patients with COVID-19.

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Declarations

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