ORIGINAL ARTICLE

Acute abdomen in patients with SARS-CoV-2 infection or co-infection

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Abstract

Purpose Patients with an acute abdomen require emergency surgery. SARS-CoV-2 infection can affect multiple organ systems, including the digestive tract. Little is known about the consequences of COVID-19 infection in emergency surgical patients.
Methods Perioperative data for COVID-19 patients undergoing emergency surgery from March 1, 2020, to May 23, 2020 were collected prospectively (NCT04323644).
Results During this period, 215 patients underwent surgery, including 127 patients in an emergency setting, of whom 13 (10.2%) had COVID-19. Two scenarios were identified: (a) patients who were admitted to a hospital for an acute surgical condition with a concomitant diagnosis of COVID-19, and (b) patients with severe COVID-19 developing acute abdominal pathologies during their hospital stay. When compared with those in group B, patients in group A globally recovered better, with a lower mortality rate (14.3% vs. 33.3%), lower ARDS rate (28.5% vs. 50.0%), less rates of preoperative invasive ventilation (14.3% vs. 50.0%) and postoperative invasive ventilation (28.5% vs. 100.0%), and a shorter duration of invasive ventilation. No causality between SARS-CoV-2 infection and gastrointestinal affliction was found.
Conclusion Our observations underline that mild co-infection with COVID-19 did not result in more complications for emergency abdominal surgery. Howe, an acute abdomen during severe COVID-19 infection was part of an unfavorable prognosis.

Keywords COVID-19 · Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) · Acute abdomen · Laparoscopy · Abdominal surgery

Introduction

Most of the elective interventions were descheduled as of March 12, 2020. Due to the magnitude of the COVID-19 pandemic in the North-Eastern Grand Est region of France, only emergency surgery was maintained in our department from March 24 to April 24, 2020. Patients with an acute abdomen require emergency abdominal surgery, including with a concomitant COVID-19 infection [1, 2]. The consequences of the COVID-19 infection in patients undergoing emergency surgery are still poorly known [2]. In severely affected COVID-19 patients, the incidence of gastrointestinal complications is high (73.8%), including the occurrence of gastrointestinal ischemia (3.8%) [3]. The factors accountable for this digestive involvement are not clearly defined. Pathophysiological hypotheses include pharmacological side effects, microvascular thrombotic events, and viral enteroneuropathy [3]. Common gastrointestinal symptoms include nausea, vomiting, abdominal pain, and diarrhea [4]. Based on surgical treatment of an acute abdomen as indicated irrespective of a concomitant SARS-CoV-2 infection, the aim of this consecutive prospective series was to assess the underlying pathology and postoperative clinical course of COVID-19-infected emergency surgical patients. Our hypotheses were that SARS-CoV-2–co-infected patients with an acute abdomen at admission had a more favorable outcome than patients presenting an acute abdomen during hospitalization for severe COVID-19 disease, and that an acute abdomen during COVID-19 disease might merely coincide with SARS-CoV-2 infection.

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Patients and methods

From March 1, 2020, to May 23, 2020, emergency surgical patients with a confirmed SARS-CoV-2 infection were included in the present study. These COVID-19 patients with an acute abdomen were consecutively included in a prospective database as part of the CovidSurg international multicentric cohort study (NCT04323644, French national approval by the Ethics Committee of the University Hospital of Rennes on March 20, 2020, No. 20.25). The diagnosis of COVID-19 was established using thoracic CT scan and/or reverse transcription polymerase chain reaction (RT-PCR) of SARS-CoV-2 RNA, performed according to the Institute Pasteur protocol and WHO technical guidelines [5].

The first COVID-19 patients underwent surgery 2 weeks before the lockdown period in France. The operating rooms were dedicated to COVID-19 patients. Surgeons and staff were equipped with protective surgical gowns, glasses, FFP2 respirators, and double gloves in accordance with the recommendations of surgical societies [6] and the European Centre for Disease Prevention and Control (ECDC) [7].

Primary endpoint was the mortality during hospital stay. Secondary outcomes were postoperative ARDS, respiratory support, and postsurgical complications according to the Clavien-Dindo classification.

Qualitative variables were expressed in absolute numbers and percentages. Quantitative variables were expressed as mean ± standard deviation. In order to compare SOFA (Sepsis-related Organ Failure Assessment [8]) scores at admission and right before surgery, Wilcoxon's matched-pairs signed-rank test was used. Sample sizes were too small for subgroup analyses.

Results

From March 1, 2020, to May 23, 2020, 215 patients underwent surgery, including 127 patients in an emergency setting, of whom 13 patients (10.2%) had COVID-19. They were 7 women and 6 men with a mean age of 64.4 ± 18.7 years (median: 70.0, range 28–82) (Table 1). All patients had a follow-up of 4 weeks or more (mean: 66 ± 21 days; median: 63 days; range: 26–100). Mean body mass index (BMI) was 26.3 ± 6.7 (median: 27.3, range 16.6–38.5) and the ASA score was 3.5 ± 0.7 (median: 4.0, range 2–4). Laparotomy was mainly performed (12 cases), and there is one laparoscopic appendectomy (Table 1). The mean SOFA scores were significantly higher on the day of surgery than on the day of admission (8.1 ± 5.3 vs. 5.6 ± 4.4, $p = 0.0156$; median: 10.0, range 0–15 vs. median: 4.0, range 0–13). In all patients undergoing CRP and D-dimer analysis, values were above the normal range (CRP: $N < 4$ mg/l; D-dimer: $N < 500$ μg/l; Table 1).

In all patients, chest CT scans were performed prior to surgery, showing varying degrees of infectious changes. The preoperative nasopharyngeal swab was SARS-CoV-2 positive in 9 patients, negative in 3 patients, and not performed in 1 patient. When the RT-PCR was negative, the CT scan showed COVID-19 lung involvement < 10%.

Two scenarios can be identified, namely patients hospitalized for an acute abdominal condition in whom a COVID-19 coinfection was detected (group A) and patients hospitalized for a severe COVID-19 infection with a digestive complication requiring emergency surgery (group B). When compared with group B, patients in group A globally recovered better, with a lower mortality rate (14.3% vs. 33.3%), lower ARDS rate (28.5% vs. 50.0%), less rates of preoperative invasive ventilation (14.3% vs. 50.0%) and postoperative invasive ventilation (28.5% vs. 100.0%), and a shorter duration of invasive ventilation (Table 1).

Patients presenting an acute abdomen at admission

In the first scenario, 7 patients required surgery within 24 h of hospital admission (A1 colonic perforation due to obstruction, A2/A3 incarcerated hernia, A4 appendicitis, A5/A7 pneumoperitoneum with peritonitis, A6 stab wound to the liver). In this group, 6 patients underwent a preoperative abdominal CT scan. In one patient, the diagnosis of an incarcerated hernia was purely clinical. Postoperatively, oxygen supplementation was required in 5 patients, and 2 patients needed invasive ventilation for 1 and 2 days for an acute respiratory distress syndrome (ARDS). The majority of patients in this group recovered uneventfully, and 6 patients were discharged home between postoperative day (POD) 3 and POD 12 (Table 2). Two patients had complications according to the Clavien-Dindo classification (A1: grade IIIb, sepsis and radiological drainage of an intraperitoneal abscess; A5: grade V, death from septic shock within the night of surgery). Mortality rate in group A was 1 out of 7 (14.3%).

Patients presenting an acute abdomen during hospitalization for COVID-19 infection

In the second scenario, 6 patients underwent surgery after 16.5 ± 9.1 days of hospitalization (median: 19.0, range 3–25). The pathologies were as follows: B1, perforated duodenal ulcer; B2/B3, small bowel ischemia; B4, ischemia of the sigmoid colon; B5/B6, retroperitoneal and intraperitoneal hematoma. Patients B2 and B3 required a two-stage surgical management: first a bowel resection with temporary abdominal closure, then re-exploration at POD 2 with abdominal wall closure and double-barrel ostomy. These 2 patients had a restoration of digestive continuity at POD 88 and POD 79 respectively, with uneventful outcomes. Five patients had a preoperative abdominal CT scan. In one patient, the diagnosis of sigmoid ischemia was purely endoscopic.

Table 1 Preoperative data

Patient	Gender	Age	BMI	SOFA score on admission	Preoperative nasopharyngeal swab	Pulmonary involvement on preoperative CT scan	Preoperative respiratory assistance	Preoperative COVID-19 symptoms	Preoperative ventilation (h)	ASA	Delay from hospital admission to intervention (in days)	D-dimer on admission	D-dimer OP day	CRP OP day	SOFA score OP day
A1	M	31	21.5	8	Positive	<10% unilateral	High-flow O₂	Dyspnea	1–23	3	1		1400	260.1	10
A2	F	81	27.3	5	Positive	10–25% bilateral	Low-flow O₂	Cough + dyspnea	1–23	3	1		8920	52.2	5
A3	M	70	29.4	2	Negative	<10% bilateral	Low-flow O₂	Nil	1–23	3	1		N/A	87.4	2
A4	F	71	29.4	1	Positive	10–25% bilateral	Low-flow O₂	Fever	1–23	3	1		N/A	46.7	1
A5	F	82	16.6	11	Negative	<10% bilateral	Invasive ventilation	Dyspnea + diarrhea	1–23	4	1		>20,000	467.4	15
A6	M	44	17.1	3	Negative	<10% bilateral	Low-flow O₂	Nil	1–23	3	1		N/A	7.2	3
A7	M	80	21.6	0	Positive	10–25% bilateral	No	Nil	0	4	1		N/A	35.8	0
B1	M	77	36.3	2	Positive	25–50% bilateral	Low-flow O₂	Dyspnea	168+	4	23	1820	3440	45.6	7
B2	F	28	21.8	3	N/A	<10% bilateral	High-flow O₂	Fever + dyspnea + diarrhea	72–167	2	3	N/A	3800	271.1	10
B3	M	56	38.5	11	Positive	25–50% bilateral	Invasive ventilation	Fever + ARDS + acute renal insufficiency	168+	4	9	2620	5500	N/A	13
B4	F	70	30.5	13	Positive	25% bilateral	Invasive ventilation	Fever + ARDS + acute renal insufficiency	168+	4	24	500	2200	258.6	12
B5	F	77	24.2	10	Positive	10–25% bilateral	Invasive ventilation	Fever + dyspnea + diarrhea	168+	4	15	3510	1640	85.9	13
B6	F	70	27.7	4	Positive	50–75% bilateral	Low-flow O₂	Fever + dyspnea + diarrhea	168+	4	25	1850	7230	124.2	14

Group A: one D-dimer value available on admission day = OP day

O_2 oxygen, *N/A* not available, *OP* operation

Table 2 Intraoperative and postoperative data

Patient	Indication for surgery	Procedure performed	Postoperative respiratory assistance	Postoperative COVID-19 symptoms	Postoperative ventilation (h)	Follow-up	Postoperative complication (Clavien-Dindo classification)
A1	Left colonic perforation caused by fecaloma	Left hemicolectomy	High-flow O_2	Fever + dyspnea	72–167	Discharge on POD 12	III b
A2	Incarcerated femoral hernia	Open hernia repair	Invasive ventilation	ARDS	24–48	Discharge on POD 9	0
A3	Incarcerated incisional hernia	Diagnostic laparoscopy, open hernioplasty	Low-flow O_2	Nil	1–23	Discharge on POD 4	0
A4	Acute appendicitis	Laparoscopic appendectomy	Low-flow O_2	Fever	1–23	Discharge on POD 4	0
A5	Covered sigmoid perforation/sigmoiditis	Open drainage of peritonitis	Invasive ventilation	Fever + ARDS	1–23	Death on POD 1	V
A6	Liver stab wound	Open drainage of hemoperitoneum, liver hemostasis	Low-flow O_2	Nil	24–48	Discharge on POD 3	0
A7	Perforated sigmoiditis	Open rectosigmoid resection (Hartmann)	Low-flow O_2	Nil	1–23	Discharge on POD 7	0
B1	Perforated duodenal ulcer	Open duodenal exclusion, omega gastro-enteric anastomosis	Invasive ventilation	ARDS	168 h+	Death on POD 11	V
B2	Venous mesenteric ischemia	Open small bowel resection	Invasive ventilation	Fever + dyspnea + diarrhea	72–167	Discharge on POD 17	IV a
B3	Mesenteric ischemia	Open small bowel resection, second look and double barrel ileostomy on POD2	Invasive ventilation	Fever + ARDS + acute renal insufficiency	168 h+	ICU	IV a
B4	Sigmoid ischemia	Open rectosigmoid resection	Invasive ventilation	Fever + acute renal insufficiency	168 h+	Death on POD 48	V
B5	Retroperitoneal hematoma	Open drainage of retroperitoneal hematoma	Invasive ventilation	Fever + ARDS	168 h+	Discharge on POD 40	0
B6	Internal hernia small bowel obstruction	Open drainage of hemoperitoneum, reduction of incarcerated small bowel in lumbar incision	Invasive ventilation	Fever + acute renal insufficiency	168 h+	ICU	IV a

O_2 oxygen, *ARDS* acute respiratory distress syndrome, *POD* postoperative day, *ICU* intensive care unit

Three patients had preoperative invasive ventilation for more than 7 days, and all 6 patients required postoperative invasive ventilation for ARDS. In this group, there was only one patient (B5) with no postoperative complication: renal failure caused by bilateral ureteral compression resolved with the evacuation of the retroperitoneal hematoma. Complications were more frequent and more severe, including 4 septic shocks and 3 renal failures (4× grade IVa, 2× grade V). Mortality rate in group B was 2 out of 6 (33.3%). Patient B6 required 7 procedures, due to an abdominal compartment syndrome and the occurrence of biliary peritonitis, with temporary parietal closures. In this group, only two patients (B2 and B5) were discharged (Table 2).

Discussion

Coronaviruses commonly cause respiratory and/or enteric infections [9, 10]. The hallmark symptoms of COVID-19 are those of acute lower respiratory diseases. However, the involvement of the digestive system is increasingly studied. In a systematic review with meta-analysis of more than 6000 patients, the grouped prevalence of digestive symptoms and digestive co-morbidities was 15% and 4% respectively. Higher rates of gastrointestinal symptoms were found in severe COVID-19 infections, and their exclusive presentation (about 10% of patients) resulted in delayed diagnosis [11]. The new onset of gastrointestinal symptoms was predictive of a severe disease course [11]. Consistent with the higher sensitivity of chest CT scan as compared with RT-PCR [12], CT scan revealed COVID-19 disease in patients with negative RT-PCR.

In group A, some pathologies were unlikely to be related to the SARS-CoV-2 co-infection (colonic obstruction and perforation due to a fecaloma, incarcerated hernia without cough or dyspnea, liver stab wound), and some were potentially related (incarcerated hernia during cough and dyspnea, perforated sigmoiditis, and ulcerating gangrenous perforated appendicitis). COVID-19 infection may mimic an appendicular syndrome [13]. In patient A4, the CT scan of the abdomen and chest confirmed the diagnosis of acute appendicitis concurrent with COVID-19, and histopathological analysis confirmed an appendicular perforation.

Visceral infarction should be considered in COVID-19 patients with severe abdominal pain [14]. As clinical examination of intubated and sedated patients can be misleading, CT scans of chest and abdomen were performed in case of a clinical degradation of unknown etiology [15]. In group B, 3 patients presented this clinical form, each time leading to a bowel resection.

Small bowel ischemia patients B2 (portal vein and mesenteric vein thrombosis leading to diagnosis of essential thrombocythemia and venous small bowel ischemia) and B3 (inflammatory small bowel necrosis) were presented

elsewhere in detail [15]. Although COVID-19 can entail hypercoagulability, we cannot say for sure that the hypercoagulability and intramural micro-thrombi were caused or aggravated by SARS-CoV-2 infection [15]. Sigmoid ischemia patient B4 had mucosal necrosis and discharge, with intense peridiverticular lymphoplasmacytic infiltration and permeable vasculature, uncertainly a complication of COVID-19 disease.

Peritoneal fluid sampling in a proportion of these patients did not reveal any SARS-CoV-2 virus [16]. Virological analysis of resected specimens was requested, but not performed due to logistical reasons. Overall, no causality between SARS-CoV-2 infection and gastrointestinal affliction was found.

In the present series, all patients with an acute abdomen underwent surgical treatment according to the current evidence and standard of care, and no experimental medical treatment was performed due to concomitant or underlying COVID-19 disease. COVID-19 infection even during the incubation period may complicate the postoperative period with disease exacerbation and progression, and with a higher postoperative mortality [17]. In contrast, our 5/7 patients requiring surgery on hospital admission, with a concomitant diagnosis of COVID-19, had a rapidly favorable outcome. Radiologic drainage of an intraperitoneal abscess after colonic resection for obstruction was not related to mild COVID-19 infection treated with preoperative and postoperative oxygen supplementation. For mildly infected or asymptomatic patients, postoperative recovery did not appear to be affected [18].

The only patient who died on the day of the intervention in the immediate procedure group was an 82-year-old female with a high SOFA score [3] and D-dimer > 20,000 μg/l ($N < 500$), which were considered to be early poor prognostic factors [19].

During this period, protocols recommended by scientific societies [6, 7] were followed and no personnel was infected with COVID-19. In the high-surge period (March 24, 2020–April 24, 2020), our hospital ensured not only ward and ICU care of COVID patients, but special efforts were made in order to perform surgery safely, with strict hygienic measures and separation of COVID and non-COVID areas, as recommended by Flemming et al. [20]. Aside from operating emergency patients (and very few urgent cancer patients) at the University Hospital, our team operated select cancer patients in dedicated COVID-free private hospitals nearby.

Conclusion

Contrary to the poor prognosis of gastrointestinal involvement with severe COVID-19 infection, clinical information and pathology findings could not associate any acute abdomen with SARS-CoV-2 infection in the present case series. Mild co-infection with COVID-19 did not appear to cause more complications for emergency abdominal surgery. However, an

acute abdomen during severe COVID-19 infection was part of an unfavorable prognosis.

References

1. COVIDSurg Collaborative (2020) Global guidance for surgical care during the COVID-19 pandemic. Br J Surg doi:https://doi.org/10.1002/bjs.11646, 107, 1097, 1103

2. Gao Y, Xi H, Chen L (2020) Emergency surgery in suspected COVID-19 patients with acute abdomen: case series and perspectives. Ann Surg 272:e38–e39. https://doi.org/10.1097/SLA.0000000000003961

3. Kaafarani HMA, Moheb ME, Hwabejire JO, Naar L, Christensen MA, Breen K, Gaitanidis A, Alser O, Mashbari H, Bankhead-Kendall B, Mokhtari A, Maurer L, Kapoen C, Langeveld K, El Hechi MW, Lee J, Mendoza AE, Saillant NN, Parks J, Fawley J, King DR, Fagenholz PJ, Velmahos GC (2020) Gastrointestinal complications in critically ill patients with COVID-19. Ann Surg 272:e61–e62. https://doi.org/10.1097/SLA.0000000000004004

4. Patel KP, Patel PA, Vunnam RR, Hewlett AT, Jain R, Jing R, Vunnam SR (2020) Gastrointestinal, hepatobiliary, and pancreatic manifestations of COVID-19. J Clin Virol 128:104386. https://doi.org/10.1016/j.jcv.2020.104386

5. World Health Organization Molecular assays to diagnose COVID-19: summary table of available protocols. https://www.who.int/docs/default-source/coronaviruse/whoinhouseassays.pdf?sfvrsn=de3a76aa_2&download=true. Accessed 24.1.2020

6. Francis N, Dort J, Cho E, Feldman L, Keller D, Lim R, Mikami D, Phillips E, Spaniolas K, Tsuda S, Wasco K, Arulampalam T, Sheraz M, Morales S, Pietrabissa A, Asbun H, Pryor A (2020) SAGES and EAES recommendations for minimally invasive surgery during COVID-19 pandemic. Surg Endosc 34(6):2327–2331. https://doi.org/10.1007/s00464-020-07565-w

7. European Centre for Disease Prevention and Control Infection prevention and control and preparedness for COVID-19 in healthcare settings. https://www.ecdc.europa.eu/sites/default/files/documents/Infection-prevention-control-for-the-care-of-patients-with-2019-nCoV-healthcare-settings_update-31-March-2020.pdf. Accessed 31.03.2020

8. Vincent JL, Moreno R, Takala J, Willatts S, De Mendonca A, Bruining H, Reinhart CK, Suter PM, Thijs LG (1996) The SOFA (Sepsis-related Organ Failure Assessment) score to describe organ dysfunction/failure. On behalf of the Working Group on Sepsis-Related Problems of the European Society of Intensive Care Medicine. Intensive Care Med 22 (7):707–710. doi:https://doi.org/10.1007/BF01709751

9. Sirinarumitr T, Paul PS, Kluge JP, Halbur PG (1996) In situ hybridization technique for the detection of swine enteric and respiratory coronaviruses, transmissible gastroenteritis virus (TGEV) and porcine respiratory coronavirus (PRCV), in formalin-fixed paraffin-embedded tissues. J Virol Methods 56(2):149–160. https://doi.org/10.1016/0166-0934(95)01901-4

10. Perlman S, Netland J (2009) Coronaviruses post-SARS: update on replication and pathogenesis. Nat Rev Microbiol 7(6):439–450. https://doi.org/10.1038/nrmicro2147

11. Mao R, Qiu Y, He JS, Tan JY, Li XH, Liang J, Shen J, Zhu LR, Chen Y, Iacucci M, Ng SC, Ghosh S, Chen MH (2020) Manifestations and prognosis of gastrointestinal and liver involvement in patients with COVID-19: a systematic review and meta-analysis. Lancet Gastroenterol Hepatol 5:667–678. https://doi.org/10.1016/S2468-1253(20)30126-6

12. Ai T, Yang Z, Hou H, Zhan C, Chen C, Lv W, Tao Q, Sun Z, Xia L (2020) Correlation of chest CT and RT-PCR testing in coronavirus disease 2019 (COVID-19) in China: a report of 1014 cases. Radiology:200642. https://doi.org/10.1148/radiol.2020200642

13. Pautrat K, Chergui N (2020) SARS-CoV-2 infection may result in appendicular syndrome: chest CT scan before appendectomy. J Visc Surg 157:S63–S64. https://doi.org/10.1016/j.jviscsurg.2020.04.007

14. Besutti G, Bonacini R, Iotti V, Marini G, Riva N, Dolci G, Maiorana M, Spaggiari L, Monelli F, Ligabue G, Guaraldi G, Rossi PG, Pattacini P, Massari M (2020) Abdominal visceral infarction in 3 patients with COVID-19. Emerg Infect Dis 26(8):1926–1928. https://doi.org/10.3201/eid2608.201161

15. Ignat M, Philouze G, Aussenac-Belle L, Faucher V, Collange O, Mutter D, Pessaux P (2020) Small bowel ischemia and SARS-CoV-2 infection: an underdiagnosed distinct clinical entity. Surgery 168:14–16

16. Seeliger B, Philouze G, Benotmane I, Mutter D, Pessaux P (2020) Is the SARS-CoV-2 virus present intraperitoneally in patients with COVID infection undergoing emergency operations? Surgery 168(2):220–221. https://doi.org/10.1016/j.surg.2020.05.033

17. Lei S, Jiang F, Su W, Chen C, Chen J, Mei W, Zhan LY, Jia Y, Zhang L, Liu D, Xia ZY, Xia Z (2020) Clinical characteristics and outcomes of patients undergoing surgeries during the incubation period of COVID-19 infection. EClinicalMedicine:100331. https://doi.org/10.1016/j.eclinm.2020.100331

18. Cai M, Wang G, Zhang L, Gao J, Xia Z, Zhang P, Wang Z, Cai K, Wang G, Tao K (2020) Performing abdominal surgery during the COVID-19 epidemic in Wuhan, China: a single-centred, retrospective, observational study. Br J Surg 107(7):e183–e185. https://doi.org/10.1002/bjs.11643

19. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, Xiang J, Wang Y, Song B, Gu X, Guan L, Wei Y, Li H, Wu X, Xu J, Tu S, Zhang Y, Chen H, Cao B (2020) Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. Lancet 395(10229):1054–1062. https://doi.org/10.1016/S0140-6736(20)30566-3

20. Flemming S, Hankir M, Ernestus RI, Seyfried F, Germer CT, Meybohm P, Wurmb T, Vogel U, Wiegering A (2020) Surgery in times of COVID-19-recommendations for hospital and patient management. Langenbeck's Arch Surg 405(3):359–364. https://doi.org/10.1007/s00423-020-01888-x