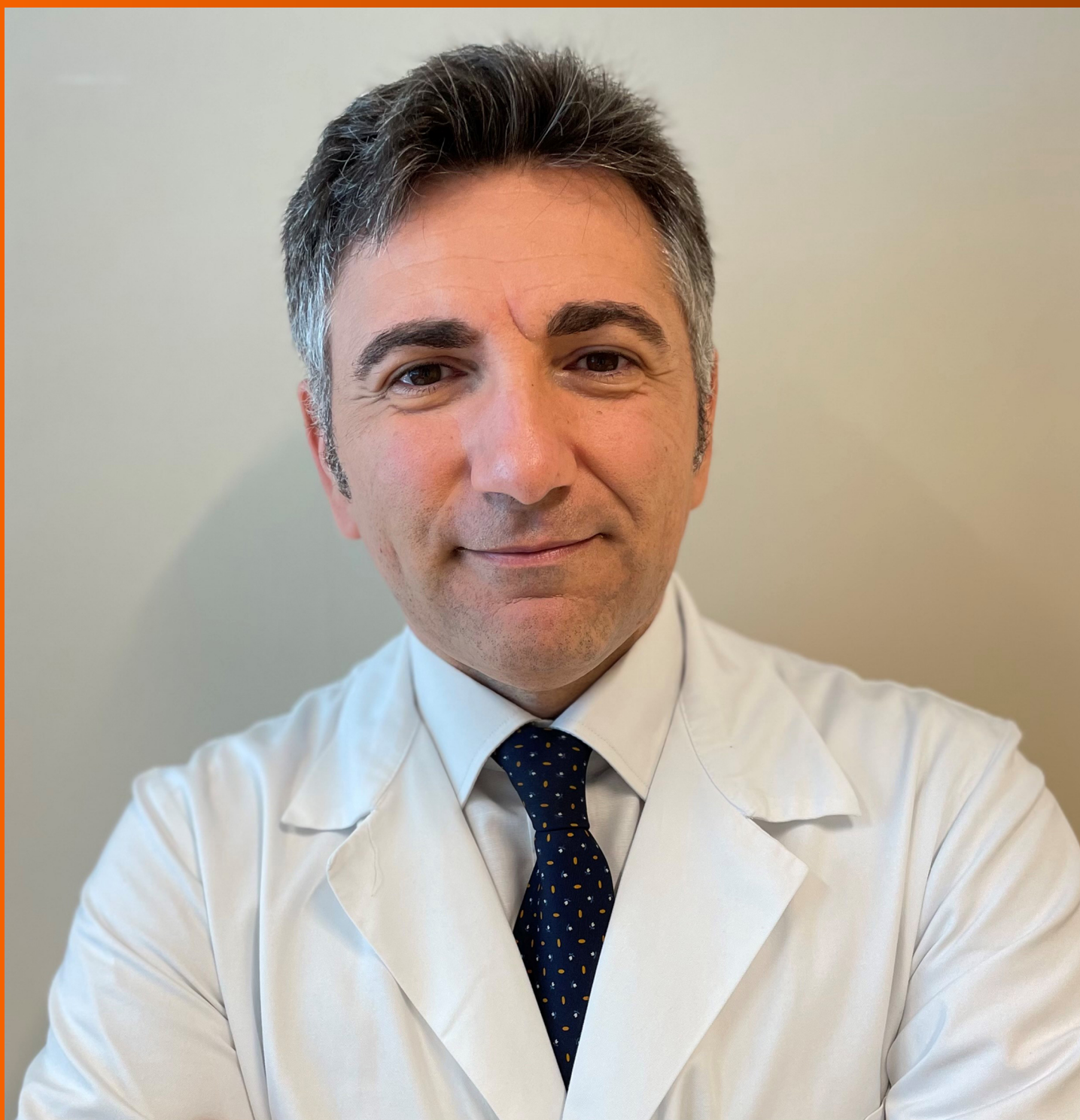


# World Journal of *Gastrointestinal Surgery*

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## Contents

Monthly Volume 13 Number 8 August 27, 2021

### REVIEW

- 734** Paradigm shift in gastrointestinal surgery – combating sarcopenia with prehabilitation: Multimodal review of clinical and scientific data  
*Koh FH, Chua JM, Tan JL, Foo FJ, Tan WJ, Sivarajah SS, Ho LML, Teh BT, Chew MH*

### MINIREVIEWS

- 756** Borderline resectable for colorectal liver metastases: Present status and future perspective  
*Kitano Y, Hayashi H, Matsumoto T, Kinoshita S, Sato H, Shiraishi Y, Nakao Y, Kaida T, Imai K, Yamashita YI, Baba H*
- 764** Rectovaginal fistula after low anterior resection: Prevention and management  
*Lohsiriwat V, Jitmongkarn R*
- 772** Advances in endoscopic therapy using grasping-type scissors forceps (with video)  
*Akahoshi K, Komori K, Akahoshi K, Tamura S, Osada S, Shiratsuchi Y, Kubokawa M*
- 788** Surgical complications in COVID-19 patients in the setting of moderate to severe disease  
*Gulinac M, Novakov IP, Antovic S, Velikova T*
- 796** Treatment for hepatocellular carcinoma with tumor thrombosis in the hepatic vein or inferior vena cava: A comprehensive review  
*Zhang ZY, Zhang EL, Zhang BX, Chen XP, Zhang W*
- 806** Multidisciplinary management of acute mesenteric ischemia: Surgery and endovascular intervention  
*Sakamoto T, Kubota T, Funakoshi H, Lefor AK*
- 814** Associating liver partition and portal vein ligation for staged hepatectomy in the treatment of colorectal cancer liver metastases  
*Wen XD, Xiao L*
- 822** Persistent bowel dysfunction after surgery for Hirschsprung's disease: A neuropathological perspective  
*Verkuijl SJ, Friedmacher F, Harter PN, Rolle U, Broens PM*
- 834** Robotic transanal total mesorectal excision: Is the future now?  
*Sebastián-Tomás JC, Martínez-Pérez A, Martínez-López E, de'Angelis N, Gómez Ruiz M, García-Granero E*

### ORIGINAL ARTICLE

#### Retrospective Study

- 848** Reappraisal of surgical decision-making in patients with splenic sclerosing angiomatoid nodular transformation: Case series and literature review  
*Tseng H, Ho CM, Tien YW*

**Observational Study**

- 859** Impact of COVID-19 on presentation, management, and outcomes of acute care surgery for gallbladder disease and acute appendicitis

*Farber ON, Gomez GI, Titan AL, Fisher AT, Puntasecca CJ, Arana VT, Kempinsky A, Wise CE, Bessoff KE, Hawn MT, Korndorffer JR Jr, Forrester JD, Esquivel MM*

**META-ANALYSIS**

- 871** Genitourinary function and defecation after colorectal cancer surgery with low- and high-ligation of the inferior mesenteric artery: A meta-analysis

*Bai X, Zhang CD, Pei JP, Dai DQ*

**ABOUT COVER**

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The primary aim of *World Journal of Gastrointestinal Surgery* (WJGS, *World J Gastrointest Surg*) is to provide scholars and readers from various fields of gastrointestinal surgery with a platform to publish high-quality basic and clinical research articles and communicate their research findings online.

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## Observational Study

## Impact of COVID-19 on presentation, management, and outcomes of acute care surgery for gallbladder disease and acute appendicitis

Orly Nadell Farber, Giselle I Gomez, Ashley L Titan, Andrea T Fisher, Christopher J Puntasecca, Veronica Toro Arana, Arielle Kempinsky, Clare E Wise, Kovi E Bessoff, Mary T Hawn, James R Korndorffer Jr, Joseph D Forrester, Micaela M Esquivel

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Orly Nadell Farber, Giselle I Gomez, Ashley L Titan, Andrea T Fisher, Christopher J Puntasecca, Veronica Toro Arana, Arielle Kempinsky, Clare E Wise, Kovi E Bessoff, Mary T Hawn, James R Korndorffer Jr, Joseph D Forrester, Micaela M Esquivel, Department of Surgery, Stanford University School of Medicine, Palo Alto, CA 94305, United States

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## Abstract

## BACKGROUND

The ongoing coronavirus disease 2019 (COVID-19) pandemic has significantly disrupted both elective and acute medical care. Data from the early months suggest that acute care patient populations deferred presenting to the emergency department (ED), portending more severe disease at the time of presentation. Additionally, care for this patient population trended towards initial non-operative management.

## AIM

To examine the presentation, management, and outcomes of patients who developed gallbladder disease or appendicitis during the pandemic.

## METHODS

A retrospective chart review of patients diagnosed with acute cholecystitis, symptomatic cholelithiasis, or appendicitis in two EDs affiliated with a single tertiary academic medical center in Northern California between March and June, 2020 and in the same months of 2019. Patients were selected through a research repository using international classification of diseases (ICD)-9 and ICD-10 codes. Across both years, 313 patients were identified with either type of gallbladder disease, while 361 patients were identified with acute appendicitis. The primary outcome was overall incidence of disease. Secondary outcomes included presentation, management, complications, and 30-d re-presentation rates. Relationships between different variables were explored using Pearson's  $r$  correlation coefficient. Variables were compared using the Welch's  $t$ -Test, Chi-squared tests, and Fisher's exact test as appropriate.

**Informed consent statement:** This retrospective chart review study is exempt from requiring informed consent.

**Conflict-of-interest statement:** There are no conflicts of interest to report.

**Data sharing statement:** Technical appendix, statistical code, and dataset available from the corresponding author at [mesquive@stanford.edu](mailto:mesquive@stanford.edu). No additional data are available.

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## RESULTS

Patients with gallbladder disease and appendicitis both had more severe presentations in 2020. With respect to gallbladder disease, more patients in the COVID-19 cohort presented with acute cholecystitis compared to the control cohort [50% (80) *vs* 35% (53);  $P = 0.01$ ]. Patients also presented with more severe cholecystitis in 2020 as indicated by higher mean Tokyo Criteria Scores [mean (SD) 1.39 (0.56) *vs* 1.16 (0.44);  $P = 0.02$ ]. With respect to appendicitis, more patients were diagnosed with a perforated appendix at presentation in 2020 [20% (36) *vs* 16% (29);  $P = 0.02$ ] and a greater percentage were classified as emergent cases using the emergency severity index [63% (112) *vs* 13% (23);  $P < 0.001$ ]. While a greater percentage of patients were admitted to the hospital for gallbladder disease in 2020 [65% (104) *vs* 50% (76);  $P = 0.02$ ], no significant differences were observed in hospital admissions for patients with appendicitis. No significant differences were observed in length of hospital stay or operative rate for either group. However, for patients with appendicitis, 30-d re-presentation rates were significantly higher in 2020 [13% (23) *vs* 4% (8);  $P = 0.01$ ].

## CONCLUSION

During the COVID-19 pandemic, patients presented with more severe gallbladder disease and appendicitis. These findings suggest that the pandemic has affected patients with acute surgical conditions.

**Key Words:** COVID-19; Cholecystitis; Biliary colic; Appendicitis; Acute care surgery

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**Core Tip:** The coronavirus disease 2019 (COVID-19) pandemic has impacted patients with a wide range of diseases due to stay-at-home orders and concerns surrounding the safety and feasibility of accessing care. This study demonstrates that the pandemic resulted in more severe presentations of gallbladder disease and appendicitis, which may be related to delays prior to presentation. Additionally, the pandemic influenced the management of patients with acute surgical conditions, and affected outcomes for patients with acute appendicitis. These findings can inform policy and public messaging surrounding stay-at-home orders and access to care during future COVID-19 surges.

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## INTRODUCTION

Early-on, the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic [coronavirus disease 2019 (COVID-19)] necessitated widespread shifts throughout healthcare systems in an effort to preserve hospital resources, maintain capacity, and minimize infection risk[1,2]. Consequently, surgeons have faced unique changes in their clinical practice. Beginning in March of 2020, hospitals and surgical centers around the world began postponing elective interventions and minimizing operative management of emergency general surgery conditions[3-6]. At the same time, global reports suggest that public fear in conjunction with stay-at-home orders may have discouraged patients with acute conditions from presenting for care in a timely manner, resulting in increased morbidity[7-11]. As of June 2020, an estimated 41% of United States adults reported having delayed or avoided medical consultation, 12% of which was for urgent or emergent medical needs[12].

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Gallbladder disease and appendicitis are common surgical conditions diagnosed among patients presenting to the emergency department (ED). Approximately 600000 cholecystectomies[13] and 280000 appendectomies[14] are performed in the United States annually. Cholecystectomy is the standard of care for both symptomatic cholelithiasis[15] and acute cholecystitis[16]; however, timing of surgery (*e.g.*, elective *vs* urgent) is dependent on the patient's symptoms[15]. With persistent symptoms, the cost of delayed surgical intervention is significant as individuals with untreated cholelithiasis and cholecystitis are at risk of developing recurrent symptoms, severe pain, biliary tract obstruction, and pancreatitis[16,17]. Similarly, appendectomy is the standard of care for uncomplicated appendicitis; however, antibiotic management can be a successful treatment modality[18,19]. Untreated appendicitis can lead to recurrent disease or progress to perforation and peritonitis; therefore, excessive delays in treatment should be avoided[18].

Much remains to be determined about how COVID-19 has impacted the presentation, management, and outcomes of patients with emergency general surgery conditions. We sought to assess the effect of the pandemic on cholecystitis, cholelithiasis, and appendicitis in Santa Clara County, California in the months following the region's initial stay-at-home order.

## MATERIALS AND METHODS

### *Patient cohort and data collection*

This retrospective study was designed to examine patients who presented to our tertiary academic medical center and an affiliate ED utilizing the Stanford Research Repository Database, an IRB-approved resource for aggregating clinical data. This study was conducted after approval by the Stanford University Institutional Review Board, No. 56347.

Patients presenting between March-June, 2019 (control cohort) and March-June, 2020 (COVID-19 cohort) with acute cholecystitis, symptomatic cholelithiasis, or appendicitis were included. Patients were identified using international classification of diseases (ICD)-9 and ICD-10 codes. Patients with incidental findings of cholelithiasis, chronic biliary colic unrelated to the chief complaint at time of presentation, biliary tract malignancy and acute biliary pancreatitis were excluded from the gallbladder cohort. Patients with appendectomy unrelated to appendicitis or malignancy were excluded from the appendicitis cohort.

Records were reviewed by medical students (O.F, G.G, A.F, C.P, A.K, C.W), a surgical trainee (A.T), and an attending surgeon (M.E.) who performed standardized abstraction on eligible patients. Demographic and clinical data were retrospectively reviewed and recorded. Additionally, hospital admission, treatment modalities (operative *vs* non-operative management), time to intervention, length of hospital stay, surgical findings, complication rates, and 30-d re-presentation rates were recorded. Emergency severity index (ESI), which stratifies patients in the ED into five groups ranging from 1 (most urgent) to 5 (least urgent), and the Tokyo Guidelines severity grade of cholecystitis were calculated for each patient[20,21].

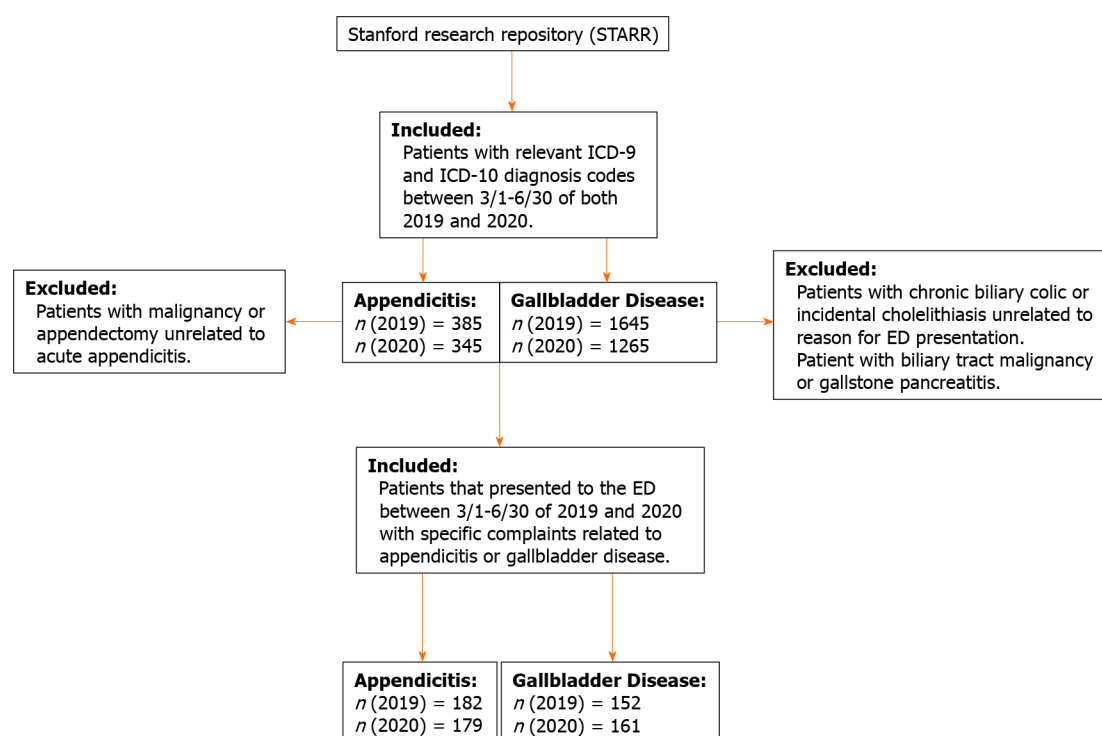
### *Data analysis*

Relationships between different variables were explored using Pearson's *r* correlation coefficient. Data were presented as number (%), mean (SD), or median (IQR). Variables were compared using the Welch's *t*-test, Chi-squared tests, and Fisher's exact test as appropriate. Statistical analysis was performed using R version 1.3.1056 and STATA version 15. Statistical significance was defined as  $P < 0.05$ .

## RESULTS

### *Study population characteristics*

Seven hundred and nine patients were identified overall. Three-hundred and thirteen patients with gallbladder disease (Figure 1) were identified. Of those, 161 patients presented in 2020 [median age (IQR) 49 (35-61) years; 93 (58%) female; 58 (36%) white] while 152 patients presented in 2019 [median (IQR) 46 (33-65) years; 97 (65%) female; 58 (38%) white]. Three-hundred and sixty nine patients with acute appendicitis were identified (Figure 1), with 179 presenting in 2020 [median age (IQR) 32 (15-49); 82 (46%) female; 79 (44%) white] and 182 in 2019 [median age (SD) 25 (14-47); 77 (42%) female;



**Figure 1 Cohort selection.** ED: Emergency departments; ICD: International classification of diseases.

96 (53%) white]. There were no significant differences between the COVID-19 and control cohorts in either disease group with respect to age, gender, race, body mass index, interpreter needs, or Charlson Comorbidity Index (Table 1).

Two patients in the gallbladder group (1%) and zero in the appendicitis group were confirmed positive for SARS-CoV-2 in 2020. One patient with symptomatic cholelithiasis was discharged directly from the ED with a COVID-positive test resulting after the time of discharge. The second patient was admitted to the hospital for magnetic resonance cholangiopancreatography to evaluate for possible choledocholithiasis, which was negative. The patient was found to be COVID positive on admission and was transferred to the COVID isolation unit before being discharged home to self-isolate.

### Presentation

**Cholecystitis and cholelithiasis:** The share of patients with acute cholecystitis was greater during the COVID-19 pandemic compared to the year prior (50% *vs* 35%;  $P = 0.01$ ), with the remaining patients presenting with biliary colic (50% *vs* 65%;  $P = 0.01$ ). Although not statistically significant, the duration of symptoms prior to presentation was longer in the COVID-19 cohort than in the control group [mean (SD) 4.2 d (12.7) *vs* 2.9 d (5.8);  $P = 0.212$ ]. Mean Tokyo Criteria Guidelines grade was higher in the COVID-19 cohort with acute cholecystitis compared to the control group [mean (SD) 1.39 (0.562) *vs* 1.17 (0.437);  $P = 0.02$ ] (Table 2). Overall severity of presentation was similar between cohorts. Seven percent of patients in 2020 and 5% in 2019 were classified as emergent presentations by an ESI score of 2 ( $P = 0.60$ , Table 3).

**Appendicitis:** More patients presenting during the COVID-19 pandemic had severe cases of appendicitis as indicated by lower (*i.e.* more severe) ESI [mean (SD) 2.37 (0.49) *vs* 2.87 (0.33);  $P < 0.001$ ]. There was no significant difference in the Alvarado scores between the two cohorts (mean (SD) 6.50 (1.89) in 2020 *vs* 6.53 (1.82) in 2019;  $P = 0.63$ , Table 4).

### Management

**Cholecystitis and cholelithiasis:** During COVID-19, more patients with gallbladder disease were admitted to the hospital from the ED than in the year prior (65% *vs* 50%;  $P = 0.02$ ) (Table 2). Although not statistically significant, the operative rate was overall higher in the COVID-19 cohort (52% in 2020 *vs* 40% in 2019;  $P = 0.06$ ). However, split by disease group, a greater proportion of patients with symptomatic cholelithiasis underwent surgery (27% in 2020 *vs* 16% in 2019) while a smaller share of patients with

**Table 1** Demographic characteristics of patients, stratified by cohort and time period

	Appendicitis					Gallbladder disease				
	March–June 2019		March–June 2020		P value	March–June 2019		March–June 2020		P value
	n	(%)	n	(%)		n	(%)	n	(%)	
Demographics	182	50	179	50		152	49	161	51	
Age, median (IQR)	24.9	13.8–47.2	32.2	15.1–48.9	0.33	46.7	32.6–65.3	48.8	35.4–61.4	0.99
Gender, n (%)					0.57					0.33
Female	77	42	82	46		97	64	93	58	
Male	105	58	97	54		55	36	68	42	
Race, n (%)					0.35					0.98
White	96	53	79	44		58	32	58	32	
Black or African American	1	1	3	2		7	4	8	4	
Asian	35	19	40	22		29	16	31	17	
Other	50	27	57	32		58	32	64	36	
Interpreter needed, n (%)	25	14	24	13	> 0.99	23	13	28	16	0.68
Spanish	21	84	18	75	0.50	20	87	24	86	0.78
BMI, median (IQR)	24.2	20.2–29.8	23.1	19.9–27.5	0.13	28.8	25.8–32.5	29.5	24.5–33.9	0.73
Charlson Comorbidity score					0.35					0.22
None: CCI score 0, n (%)	136	75	133	74		80	53	69	43	
Mild: CCI score 1–2, n (%)	31	17	24	13		33	22	46	29	
Moderate: CCI score 3–4, n (%)	12	7	14	8		21	14	26	16	
Severe: CCI ≥ 5, n (%)	3	2	8	4		14	9	19	12	

CCI: Comprehensive complication index; BMI: Body mass index.

acute cholecystitis were operated on in 2020 (76% in 2020 *vs* 87% in 2019). Of those managed surgically, laparoscopic cholecystectomy rates were comparable (90% in both years), with conversion to open cholecystectomy in 1% and 3% of cases, respectively ( $P = 0.8$ ) (Table 2). Eight percent of patients in 2020 and 7% in 2019 underwent percutaneous cholecystostomy. There was no significant difference in time from presentation to operative intervention [median (IQR) 19 (13–28) h in 2020 *vs* 18 (11–28) h in 2019, Table 3].

**Appendicitis:** Hospital admission rates (97% *vs* 96%;  $P = 0.68$ ) and operative rates (87% *vs* 82%;  $P = 0.47$ ) did not differ between 2020 and 2019 (Table 4). There was a positive correlation between surgical intervention and diagnosis of ruptured appendix ( $P < 0.05$ ) (Supplementary Tables 1–3). In those managed surgically, laparoscopic appendectomy rates were similar (96% in 2020 *vs* 97% in 2019), and only 1% of cases in either cohort required conversion to open appendectomy. Additionally, there was a trend toward increased intraoperative drain placement in 2020 (7% *vs* 4%;  $P = 0.07$ ). There was no significant difference in the time from ED presentation to operation between the two cohorts [median (IQR) 11 (6–17) h in 2020 *vs* 11 (6–17) h in 2019;  $P = 0.38$ ] (Table 4).

### Outcomes

**Cholecystitis and cholelithiasis:** Most patients with gallbladder disease who underwent surgery had a pathologic diagnosis of acute cholecystitis, including acute cholecystitis with gallbladder mucocele, acute gangrenous cholecystitis, and acute hemorrhagic cholecystitis (52% in 2020 *vs* 62% in 2019, Table 2). Of those with a preoperative diagnosis of acute cholecystitis, fewer patients underwent surgery in 2020 (76% *vs* 85%;  $P = 0.12$ ). The number of patients with gangrenous cholecystitis did not differ between years (17% *vs* 10%;  $P = 0.30$ ). Median hospital length of stay for surgically-managed patients was similar between groups [median (IQR) 2 (1–3) in 2020



**Table 2 Gallbladder disease presentation, management, and operative findings**

	Gallbladder disease				P value
	March–June 2019		March–June 2020		
	152		161		
Diagnosis, <i>n</i> (%)					0.01
Symptomatic cholelithiasis	99	65%	81	50%	
Acute cholecystitis	53	35%	80	50%	
Tokyo criteria, mean (STD)	1.17	0.437	1.39	0.562	0.02
Symptom duration prior to ED (d), mean (STD)	2.9	5.8	4.2	12.7	0.21
ED length of stay (h), median (IQR)	5	(3.5–7)	5	(4–7)	0.55
Disposition from ED					0.02
Discharged, <i>n</i> (%)	52	34%	41	25%	
Discharged with urgent follow up, <i>n</i> (%)	17	11%	15	9%	
Admitted, <i>n</i> (%)	76	50%	104	65%	
Other, <i>n</i> (%)	7	5%	1	1%	
Time from presentation to OR (h), median (IQR)	18	(11–28.2)	19	(13–27.5)	0.42
Pre-op ERCP required, <i>n</i> (%)	22	14%	18	11%	0.40
Antibiotics during admission, <i>n</i> (%)	61	80%	98	94%	0.10
Underwent surgical procedure, <i>n</i> (%)	61	40%	83	52%	0.06
Symptomatic cholelithiasis	16	16%	22	27%	0.098
Acute cholecystitis	45	87%	61	76%	0.12
Operations performed, <i>n</i> (%)					0.75
Laparoscopic cholecystectomy	55	90%	75	90%	
Laparoscopic converted to open cholecystectomy	2	3%	1	1%	
Percutaneous cholecystostomy	4	7%	7	8%	
Post-op diagnosis, <i>n</i> (%)					0.23
Acute cholecystitis only	38	62%	43	52%	
Acute cholecystitis with gallbladder mucocele (Hydrops)	1	2%	2	3%	
Acute gangrenous cholecystitis	6	10%	14	17%	
Acute hemorrhagic cholecystitis	1	2%	0	0%	
Symptomatic cholelithiasis	6	10%	11	13%	
Chronic cholecystitis	1	2%	8	10%	
Other	7	12%	6	7%	
Choledocholithiasis present, <i>n</i> (%)–Biliary colic subgroup	24	16%	28	17%	0.92
Drains left in place post op, <i>n</i> (%)	8	13%	15	18%	0.39
Patients with additional procedures, <i>n</i> (%)	8	13%	7	8%	0.40
Drain placement	1	6%	0	0%	
PICC line	0	0%	1	7%	
Lysis of adhesions	0	0%	2	13%	
Intra-op cholangiogram	1	6%	1	7%	

ED: Emergency departments; ERCP: Endoscopic retrograde cholangiopancreatography; OR: Odds ratios; PICC: Peripherally inserted central catheters.

vs 3 (2-4) in 2019; *P* = 0.30]. Additionally, rate of discharge on antibiotics (14% in 2020

**Table 3 Gallbladder disease postoperative course and complications**

	Gallbladder disease				
	March–June 2019		March–June 2020		P value
	152		161		
Length of stay for surgically managed patients (d), median (IQR)	3	(2–4)	2	(1–3)	0.3
Discharged on antibiotics, <i>n</i> (%)	21	14%	29	18%	0.39
Inpatient complications, <i>n</i> (%)	10	16%	11	13%	0.62
Sepsis	0	0%	4	5%	
Transaminitis	1	2%	1	1%	
Death	0	0%	1	1%	> 0.99
Representation within 30 d, <i>n</i> (%)	16	11%	20	12%	0.71
Postoperative intra-abdominal abscess	0	0%	1	1%	
Cholecystitis	3	2%	4	2%	
Cholelithiasis/Choledocholithiasis	1	1%	5	3%	

*vs* 18% in 2019;  $P = 0.4$ ) and the rate of 30-d re-presentations to the hospital (12% in 2020 *vs* 11% in 2019;  $P = 0.71$ ) did not differ across the years (Table 3). There was one death during admission among the COVID-19 cohort and none in the control group ( $P > 0.99$ ).

**Appendicitis:** More patients in the COVID-19 cohort were diagnosed with perforated appendicitis at presentation compared to the year prior (20% *vs* 16%;  $P = 0.02$ ). However, there was no significant difference in postoperative diagnosis of ruptured appendicitis between the cohorts ( $P = 0.68$ ). The rate of ruptured appendicitis was higher in both cohorts when diagnosed postoperatively compared to diagnosis at the time of presentation (23% *vs* 20% in 2020;  $P < 0.01$  and 23% *vs* 16% in 2019;  $P < 0.01$ ). Of those admitted, the length of hospital stay did not differ between cohorts [median (IQR) 2 (2–3) *vs* 2 (2–3);  $P > 0.99$ ] (Table 5).

Patients in the COVID-19 cohort were more likely to be discharged on antibiotics (29% *vs* 19%;  $P = 0.04$ ). Antibiotic prescription upon discharge was positively correlated with the duration of symptoms prior to ED presentation ( $P < 0.05$ ) (Supplementary Table 2). Additionally, the 30-d representation rate was significantly higher in 2020 than in 2019 (13% *vs* 4%;  $P = 0.01$ ). There was no significant difference between the two cohorts with regards to complication rate or the rate of additional procedures (Tables 4 and 5).

## DISCUSSION

In our study, both patients with gallbladder disease and appendicitis presented with more severe cases during the COVID-19 pandemic.

For the gallbladder cohort, more patients were diagnosed with acute cholecystitis and fewer with symptomatic cholelithiasis during the pandemic, although overall rates of gallbladder disease were unchanged between the years. These findings deviate from a recent study that did, in fact, demonstrate an increased incidence of acute calculous cholecystitis during the pandemic, which the authors attributed primarily to greater consumption of fatty foods[22]. Our finding of proportionally fewer cases of symptomatic cholelithiasis suggests that patients may not have visited the ED for less severe or intermittent symptoms. Furthermore, since untreated biliary colic can progress to cholecystitis[22], this may have also accounted for the relative rise in acute cholecystitis cases in 2020.

Patients diagnosed with cholecystitis during the pandemic had more severe disease as evidenced by higher mean Tokyo Criteria scores. Although the difference in symptom duration prior to presentation did not reach statistical significance, it is plausible that delays in presentation partially accounted for the observed severity rise, as symptom duration  $\geq 72$  h increases the severity score from Tokyo Criteria grade I to grade II [23].

**Table 4** Appendicitis presentation, management, and operative findings

	Appendicitis				<i>P</i> value
	March–June 2019		March–June 2020		
	182		179		
Alvarado score, mean (SD)	6.53	1.82	6.50	1.89	0.63
Ruptured appendix, <i>n</i> (%) at diagnosis	29	16%	36	20%	0.02
Ruptured appendix, <i>n</i> (%) post op	43	23%	41	23%	0.68
Symptom duration prior to ED (d), mean (SD)	2.72	7.23	2.19	3.12	0.36
ED severity score, mean (SD)	2.87	0.33	2.37	0.49	< 0.0001
Resuscitation, <i>n</i> (%)	0	0%	0	0%	
Emergent, <i>n</i> (%)	23	13%	112	63%	
Non-emergent, <i>n</i> (%)	159	87%	67	37%	
ED length of stay (h), median (IQR)	5.00	3.5–6.6	6.00	4–7	0.51
Disposition from ED					0.57
Discharged, <i>n</i> (%)	3	2%	3	2%	
Discharged with urgent follow up, <i>n</i> (%)	0	0%	1	1%	
Admitted, <i>n</i> (%)	174	96%	173	97%	
Underwent surgical procedure, <i>n</i> (%)	150	82%	156	87%	0.47
Laparoscopic appendectomy	145	97%	149	96%	
Laparoscopic converted to open appendectomy	2	1%	1	1%	
Right hemicolectomy	2	1%	0	0%	
Percutaneous abscess drain (IR)	1	1%	6	4%	
Post-op diagnosis, <i>n</i> (%)					
Ruptured appendix	43	29%	41	26%	0.68
Appendix not ruptured	106	71%	116	74%	
Time from presentation to OR (h), median (IQR)	11.2	6–17	11.0	6–17	0.38
Drains left in place post op, <i>n</i> (%)	6	4%	11	7%	0.07
Patients with additional procedures, <i>n</i> (%)	17	11%	11	7%	0.27
Draining of abscess	7	41%	2	18%	
Bowel resection	2	12%	0	0%	
Drain placement	3	18%	1	9%	
PICC line	1	6%	2	18%	
NGT placement	0	0%	2	18%	

ED: Emergency departments; OR: Odds ratios; PICC: Peripherally inserted central catheters; IR: Immunoreactive; NGT: Nasogastric tube.

With more patients presenting with acute cholecystitis and of a higher grade, it follows that a greater proportion of patients with gallbladder disease were admitted to the hospital in 2020—even when system-wide efforts aimed to reduce non-COVID-related hospitalizations. Our finding again deviates from a previous report that found that, in New York City, hospitalizations for biliary disease decreased during the peak months of the pandemic period[24]. Interestingly, this same study notes that after the peak, overall non-COVID-related hospitalization rates rose slightly.

Similar to the gallbladder disease cohort, although rates of presentations for appendicitis remained stable during the pandemic, a greater proportion of patients presented with more severe appendicitis cases in 2020 as demonstrated by higher ED severity scores, higher drain placement rates, and higher antibiotic rates at discharge. Furthermore, more patients in the COVID-19 appendicitis cohort were diagnosed with

**Table 5 Appendicitis postoperative course and complications**

	Appendicitis				
	March–June 2019		March–June 2020		<i>P</i> value
	182		179		
Length of stay (d), median (IQR)	2.00	2–3	2.00	2–3	> 0.99
Discharged on antibiotics, <i>n</i> (%)	35	19%	52	29%	0.04
Patients with Inpatient complications, <i>n</i> (%)	5	3%	10	6%	0.32
Sepsis	0	0%	2	18%	
Post op ileus	3	27%	2	18%	
Abscess	3	27%	0	0%	
Representation within 30 d, <i>n</i> (%)	8	4%	23	13%	< 0.01

perforated appendicitis at presentation. If appendicitis is untreated, the risk of rupture has been shown to rise over the first 36 h after symptom onset[25]. Although, like in gallbladder disease, the increase in duration of appendicitis symptoms during the pandemic did not reach statistical significance in our study, the higher rate of perforation could support a delay in appendicitis care.

Our findings are consistent with a robust body of literature evidencing increased incidence of complicated appendicitis (*e.g.*, perforation, peri-appendicular abscess, and gangrenous appendicitis) during the COVID-19 pandemic[26–28]. Prior work has found higher rates of perforated appendixes in children during the pandemic, as well as longer mean duration of symptoms in those children with perforations[27]. In patients of all ages, one study noted a delay between onset of symptoms and presentation for care in both the elderly and groups at high-risk for COVID-19[28].

With regards to management, non-operative management of appendicitis increased during COVID-19, with no lower failure rates than reported in meta-analyses published prior to the pandemic[29]. In our study however, the only component of management that differed between the two appendicitis cohorts was an increase in antibiotic administration upon discharge. While outcomes also were largely consistent between the years, more patients diagnosed with appendicitis in 2020 re-presented to the ED within 30 d of discharge, suggesting that they experienced a greater number and/or greater severity of complications after their initial presentation.

Understanding such changes in presentation, management, and outcomes of various disease processes during the COVID-19 pandemic is essential for preparing for any future surges or other public health crises. Multiple studies have previously reported delays in medical care attributable to COVID-19, resulting in higher morbidity and mortality[30–33]. Stay-at-home orders and social distancing guidelines, fear of contracting coronavirus, and concerns regarding overburdening the healthcare system are just some of the factors that may have influenced patients' delayed presentation for care and resulting clinical status[34,35]. Our finding, that patients with gallbladder disease and appendicitis also presented with disease of greater severity, adds to the body of literature raising concerns around the need to limit healthcare utilization during the pandemic, while also ensuring that patients do not avoid care at the cost of developing more advanced disease.

### Limitations

Although Santa Clara County experienced the first stay-at-home order in the United States due to the COVID-19 pandemic, the academic center where this study was completed did not have a surge in coronavirus infections during the study period. Case load in the area remained relatively well-controlled, reaching 4600 total cases between the beginning of the pandemic and the end of our study period (Santa Clara County population: 1.928 million)[36]. Although elective procedures were suspended for several months, those presenting with urgent/emergent abdominal complaints were still able to access care. This study is perhaps a more sensitive measure of how fear changed patient behavior during the pandemic rather than of changes in actual healthcare capacity. Outcomes of acute care surgical procedures may be different in an area harder-hit by the pandemic and more affected by provider and healthcare capacity limitations.

## CONCLUSION

We found that patients during the COVID-19 pandemic were more likely to present with more advanced gallbladder and appendicitis pathology compared to the same time period in 2019. Management of these acute surgical conditions differed during the pandemic in that, for gallbladder disease, a greater proportion of patients were admitted to the hospital, while for appendicitis, more patients received antibiotics at the time of discharge. Measures of patient outcomes did not meaningfully differ for gallbladder disease, but 30-d re-presentations were increased for patients with acute appendicitis.

It appears that the pandemic has affected patient decision-making, provider management approaches, as well as outcomes of acute care surgical conditions. As the response to the pandemic evolves on a local and national level, future research should continue to evaluate the effect of both patient behavior and guidelines for surgeons on outcomes for acute care surgical conditions. Projects such as the ongoing CholeCOVID study, which is auditing the impact of COVID-19 on patients with cholecystitis, may help guide management of this disease during future surges.

Additionally, attention is needed to strike a balance between discouraging excess healthcare utilization while also encouraging patients to seek care when necessary so as to avoid increased morbidity and mortality, and their accompanying costs to the health care system. Our study, among others, can help inform public messaging around healthcare utilization as the pandemic continues or future crises arise.

## ARTICLE HIGHLIGHTS

### **Research background**

Data from the early months of the coronavirus disease 2019 (COVID-19) pandemic suggest that acute care patient populations deferred presenting to the emergency department (ED), portending more severe disease at the time of presentation. Additionally, care for this patient population trended towards initial non-operative management.

### **Research motivation**

The ongoing COVID-19 pandemic has significantly disrupted both elective and acute medical care. Understanding the pandemic's impact on acute care surgery patients can help inform responses to future COVID-19 surges or other public health crises.

### **Research objectives**

The aim of this study was to examine the presentation, management, and outcomes of patients who developed gallbladder disease or appendicitis during the pandemic.

### **Research methods**

A retrospective chart review of patients diagnosed with acute cholecystitis, symptomatic cholelithiasis, or appendicitis in two EDs affiliated with a single tertiary academic medical center in Northern California between March and June, 2020 and in the same months of 2019.

### **Research results**

Patients with gallbladder disease and appendicitis both had more severe presentations during the pandemic in 2020 as compared to the year prior.

### **Research conclusions**

The pandemic has affected patients with acute surgical conditions.

### **Research perspectives**

These findings can inform policy and public messaging surrounding stay-at-home orders and access to care during future COVID-19 surges.

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