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Original Research Article

## A retrospective single-institution review of the impact of COVID-19 on severity of biliary disease

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## ABSTRACT

**Background:** The COVID-19 pandemic possessed far-reaching health implications beyond the public health impact that have yet to be fully elucidated. We hypothesized that the COVID-19 pandemic led to an increase in biliary disease complexity and incidence of emergency cholecystectomy.

**Methods:** We reviewed our institutional experience with cholecystectomy from February 2019–February 2021, n = 912. Pre COVID-19 pandemic patients were compared to patients after the onset of the pandemic. Baseline characteristics were compared between groups. A Cochran-Armitage test for trend assessed the temporal impact of COVID-19 on emergency presentation and gallbladder disease complexity.

**Results:** We identified 442 patients pre-pandemic and 470 patients during the pandemic. No significant differences were noted in demographics. COVID-19 significantly impacted emergency presentation (43.2% vs. 56.8%, p = <0.01), cholecystitis (53.2% vs 61.8%; p = <0.01), and gangrenous cholecystitis (2.8% vs 6.1%; p = <0.01). Both groups had similar clinical outcomes.

**Conclusions:** The COVID-19 pandemic affected an increased incidence of emergency presentation and complexity of gallbladder disease but did not significantly impact clinical outcomes. These findings may have broader implications for other diseases possibly affected by COVID-19.

## 1. Introduction

Since the onset of the COVID-19 pandemic in March of 2020, worldwide efforts to combat the pandemic have resulted in far-reaching healthcare implications beyond the immediate public health impact of the virus. In the United States, healthcare systems prioritized care and modified protocols to mitigate COVID-19 transmission and resource burden.<sup>1,2</sup> Hospital systems reallocated health resources to accommodate COVID-19 patient care, resulting in the postponement and/or cancellation of operations. Some institutions, like ours, implemented a triage system to triage surgical priority based on recommendations from the American College of Surgeons.<sup>3</sup> Because of resource scarcity, non-emergency operations were the most likely to be cancelled in favor of higher priority procedures.<sup>4</sup> In addition, many clinic appointments were postponed and patients delayed their access of medical care to avoid COVID-19 exposure in hospital systems and emergency departments.<sup>5</sup>

Due to this COVID-19 burden, professional organizations suggested alternative treatments to biliary disease should be implemented to minimize the resource allocation to non-emergency operations. Percutaneous cholecystostomy was advocated in this setting as a temporizing measure for high-risk patients or for bridging to future operations.<sup>6–8</sup> Thus, the pandemic not only impacted patient access to care but also affected how patients with biliary disease were managed. Early studies to characterize the presentation, severity, and outcomes in the surgical management of biliary disease during the pandemic have shown conflicting results.<sup>9–11</sup> While Valles et al. demonstrated decreased cholecystitis admissions without increased disease severity during the pandemic,<sup>9</sup> another study by Murphy et al. identified increases in acute calculous cholecystitis presentation.<sup>10</sup>

With these potential changes in surgical management, a better understanding of the downstream effects of the pandemic on benign biliary disease and clinical outcomes is needed.<sup>10</sup> We hypothesized that COVID-19 impacted the severity of benign biliary disease and, as a

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result, led to an increased incidence of emergency cholecystectomy and complexity. We reviewed our institutional experience at a high-volume quaternary care center to determine the impact of the COVID-19 pandemic on outcomes for patients with biliary disease.

## 2. Methods

The Institutional Review Board at the University of Alabama at Birmingham reviewed the study protocol and met criteria for exemption.

### 2.1. Patient population

A retrospective chart review was conducted to include all patients who underwent cholecystectomy at our institution from February 2019 to February 2021, a time period one year immediately prior to the start of the pandemic and one year after the start. Billing data was used to identify all patients who underwent an operation with current procedural terminology (CPT) codes 47600, 47605, 47562, and 47563 (n = 1195). Those undergoing cholecystectomy concurrently with transplant, malignancy-oriented, or obstetrical surgery were excluded to develop our final cohort (n = 912). We used the month of March 2020 as the inflection point and surrogate date for beginning of the pandemic for our region of the country and compared outcomes for patients before and after this date. Data collected included patient demographics and outcome variables: age, sex, race, body mass index, ASA class, type of insurance, the setting in which the operation took place (emergency vs. non-emergency), the need for percutaneous cholecystostomy tube at any time before the patient's index operation; and postoperative complications including 30-day readmissions, return to the operating room, or need for postoperative ERCP. Any deviations from a normal postoperative course were deemed complications. We reviewed all operative notes to determine the need for subtotal cholecystectomy, operative time, and need for conversion to open. Finally, all pathology reports were reviewed to determine final pathology and this pathologic diagnosis was used as the final clinical diagnosis.

### 2.2. Hospital policy

Our institutional policy for addressing emergency and non-emergency operations was in flux throughout the study period and reflects the challenges for many institutions during this unprecedented period. At the beginning of the pandemic, all non-emergency operations were halted for a period of one month. Following this, non-emergency operations were then resumed based on protocols established by the American College of Surgeons.<sup>12</sup> Emergency medical care was not changed during the pandemic with the exception of avoiding operations in patients with COVID positivity.

### 2.3. Variables and statistical analysis

Pre-pandemic patients were compared to pandemic patients using standard statistical comparisons. Both preoperative variables and outcome variables were compared for the two groups. T-tests were employed for continuous variables and chi square tests for categorical variables (in select cases with small sample size, Fisher's exact test was performed). The primary outcome of interest was emergency presentation and severity of disease based on pathology (acute cholecystitis or gangrenous cholecystitis). A Cochran-Armitage test for trend was used to determine the temporal impact of COVID-19 on emergency presentation and complexity of gallbladder disease. A subset analysis was also performed only in those patients who underwent emergency cholecystectomy, which we defined as cholecystectomy performed by acute care surgery. All analyses were performed using SAS 9.4 (Cary, IN).

## 3. Results

**Table 1** illustrates baseline characteristics for patient groups. A total of 912 patients, 470 (51.5%) pre-COVID 19 and 442 (48.5%) during the COVID-19 pandemic were identified. There was no difference between the two groups with regards to sex, age, or BMI. Racial differences were noted between the groups; both Black (31.9%–27.6%,  $p < 0.01$ ) and Hispanic (7.45%–3.17%,  $p < 0.01$ ) patient populations had decreases in presentation post-pandemic. In addition, there was a decrease in presentation for patients using commercial insurance (58.1% vs 45.5%;  $p < 0.01$ ) and self-pay (12.1% vs 5.4%;  $p < 0.01$ ). Both charity care (1.1% vs 5.4%;  $p > 0.01$ ) and Medicare (13.8% vs 28.3%;  $p < 0.01$ ) patients experienced increases in the need for cholecystectomy. There was surgical specialty consistency across both populations with minimally invasive surgery (MIS) surgeons having the highest volumes (61.3%) followed by acute care surgery (35.8%). Laparoscopic surgery was most used overall (75.1%) with no change over time.

Overall, a shift in disease severity occurred over time during the pandemic. **Table 2** presents clinical diagnostic data. There was an increase in emergency presentation of disease during the pandemic (28.5% vs 39.8%;  $p = 0.0003$ ). Pathologic diagnosis of cholelithiasis (38.1% vs 30.3%,  $p = 0.0019$ ) and biliary dyskinesia (3.4% vs 0.7%,  $p = 0.0019$ ) decreased in incidence, while chronic cholecystitis (23.0% vs 32.1%;  $p = 0.0019$ ) and gangrenous cholecystitis (2.8% vs 5.9%;  $p = 0.0019$ ) increased over the same time period. While statistically significant, acute cholecystitis incidence was similar between the two group (29.6% vs 29.0%,  $p = 0.002$ ). In addition, an increased need for subtotal cholecystectomy over time was noted (2.98% vs 5.43%), but it was not statistically significant ( $p = 0.06$ ).

**Table 3** includes outcome measures for the two groups. Clinical outcomes between groups did not change regarding rates of conversion to open surgical procedure (1.9% vs. 2.0%,  $p = 0.89$ ), post-operative ERCP (2.3% vs 3.4%,  $p = 0.33$ ), rates of 30-day re-admission (3.8% vs 2.7%,  $p = 0.34$ ), or complication rates (2.8% vs 3.9%,  $p = 0.36$ ). In addition, no differences were found between group operative times, lengths of stay, incidence of percutaneous cholecystectomy, or surgical approach. In a Cochran Armitage test for trend, there was a significant increase over time in severity of gallbladder disease and the need for emergency cholecystectomy, but not for percutaneous cholecystostomy.

Finally, a subset analysis only for those patients who underwent emergency cholecystectomy did not reveal any difference in care outcomes between pre-pandemic and pandemic populations (**Table 4**).

**Table 1**

Data of demographic trends for both patient populations.

		Pre-Covid (%) (N = 442)	COVID (%) (N = 470)	p-value
<b>Gender</b>	Female	69.4	68.6	0.57
	Male	30.6	31.2	
	Other	0	1	
<b>Race</b>	White	58.1	66.3	0.008
	Black	31.2	27.6	
	Hispanic	7.5	3.2	
	Other	2.6	2.9	
<b>ASA</b>	1	2.3	2.3	0.67
	2	40.9	37.5	
	3	54.7	57.3	
	4	2.1	3	
<b>Insurance Status</b>	Charity	1.1	5.4	<0.0001
	Commercial	58.1	45.5	
	Medicaid	14.9	15.4	
	Medicare	13.8	28.3	
	Self-Pay	12.1	5.4	
<b>Age (Mean, SD)</b>		48.0, 16.1	48.6, 16.6	0.57
<b>BMI (Mean, SD)</b>		32.9, 9.4	32.7, 8.8	0.66

**Table 2**

Table of all diagnoses for both patient populations. Pathologic diagnoses collected via final pathology reports. p = 0.0019. \* denotes Gallbladder. \*\* Denotes Porcelain Gallbladder.

	Pre-COVID (%) N = 442	COVID (%) N = 470	p-value
<b>Acute and Chronic Cholecystitis</b>	247 (55.9%)	270 (57.4%)	0.0019
<b>Symptomatic Cholelithiasis</b>	183 (41.4%)	135 (28.7%)	
<b>Gangrenous Cholecystitis</b>	13 (2.8%)	26 (5.9%)	
<b>Biliary Dyskinesia</b>	16 (3.4%)	3 (0.7%)	
<b>Adenomyomatosis/GB* polyp</b>	10 (0.2%)	5 (0.01%)	
<b>Gallbladder Perforation</b>	0 (0%)	2 (0.4%)	
<b>Other**</b>	1 (0.2)	1 (0.2)	

**Table 3**

Clinical outcomes between patient populations. Outcomes measured as means denoted with \*.

		PRE-COVID (%) N = 442	COVID (%) N = 470	p-value
<b>Presentation</b>	<b>Non-emergency</b>	336 (71.5)	266 (60.2)	0.0003
	<b>Emergency</b>	134 (28.5)	176 (39.8)	
<b>Use of Percutaneous Cholecystostomy Tube</b>	<b>No</b>	461 (98.1)	429 (97.1)	0.31
	<b>Yes</b>	13 (1.9)	9 (2.9)	
<b>Surgical Approach</b>	<b>Laparoscopic</b>	357 (76)	328 (74.2)	0.77
	<b>Open</b>	4 (0.9)	3 (0.7)	
	<b>Robotic</b>	109 (23.2)	111 (25.1)	
<b>Subtotal</b>	<b>No</b>	456 (97)	418 (94.6)	0.06
<b>Cholecystectomy</b>	<b>Yes</b>	14 (3)	24 (5.4)	0.25
	<b>Fenestrated</b>	8 (57.1)	18 (75)	
	<b>Reconstituting</b>	6 (42.9)	6 (25)	
<b>Conversion to Open</b>	<b>No</b>	461 (98.1)	433 (98)	0.9
	<b>Yes</b>	9 (1.9)	9 (2)	
<b>30 Day Re-Admission</b>	<b>No</b>	452 (96.2)	430 (97.3)	0.35
	<b>Yes</b>	18 (3.8)	12 (2.7)	
<b>Complications</b>	<b>No</b>	457 (97.2)	425 (96.2)	0.36
	<b>Yes</b>	13 (2.8)	17 (3.9)	
<b>Length of Stay* (days)</b>		1.7 ± 3.1	1.9 ± 3.3	0.47
<b>OR Times* (minutes)</b>	<b>Open</b>	231.9 ± 137.3		0.20
	<b>Laparoscopic</b>	96.2 ± 45.1		
	<b>Robotic</b>	85.7 ± 47.6		

#### 4. Discussion

We report the findings of the largest U.S.-based, quaternary medical center to investigate clinical trends and outcomes in benign biliary disease before and during the COVID-19 pandemic. Emergency presentation of biliary disease and biliary disease severity increased during this period. Despite these increases, no statistically significant change in short-term outcomes were identified for these patients. Finally, we noted trends in patient demographic distribution and medical insurance coverage likely related to the influence of the pandemic.

Prior studies have documented both increased and decreased incidences of acute cholecystitis during the pandemic. Farber et al. first explored the impact of COVID-19 on gallbladder disease in a study of 313 patients at two institutions in Northern California and found an increase in the incidence of acute cholecystitis, as we did. Similar to our study, no difference in outcomes was observed in this cohort.<sup>12</sup> In a single institution study by Fouad et al.,<sup>13</sup> the authors reviewed the incidence and management of acute cholecystitis at Cairo University

**Table 4**

Clinical outcomes for emergency patient populations.

		PRE-COVID (%) N = 134	COVID (%) N = 176	p-value
<b>Use of Percutaneous Cholecystostomy Tube</b>	<b>No</b>	132 (98.5)	171 (97.2)	0.43
	<b>Yes</b>	2 (1.5)	5 (2.8)	
<b>Surgical Approach</b>	<b>Laparoscopic</b>	125 (93.3)	157 (89.2)	0.43
	<b>Open</b>	2 (1.5)	3 (1.7)	
	<b>Robotic</b>	7 (5.2)	16 (9.1)	
<b>Subtotal</b>	<b>No</b>	126 (94.0)	158 (89.8)	0.18
	<b>Yes</b>	8 (6.0)	18 (10.2)	
<b>Cholecystectomy</b>	<b>Fenestrated</b>	4 (50.0)	12 (66.7)	0.42
	<b>Reconstituting</b>	4 (50.0)	6 (33.3)	
	<b>No</b>	130 (97.0)	168 (95.5)	
<b>Conversion to Open</b>	<b>No</b>	130 (97.0)	168 (95.5)	0.48
	<b>Yes</b>	4 (3.0)	8 (4.5)	
<b>30 Day Re-Admission</b>	<b>No</b>	126 (94.0)	170 (96.6)	0.28
	<b>Yes</b>	8 (6.0)	6 (3.4)	
<b>Complications</b>	<b>No</b>	127 (94.8)	162 (92.1)	0.34
	<b>Yes</b>	7 (5.2)	14 (7.9)	

teaching hospital and found that compared with their 458 pre-pandemic patients, the 311 patients presenting during the pandemic experienced more severe acute cholecystitis as well as a 7.8% increase in the incidence of gangrenous cholecystitis.<sup>13</sup> In a five week study of emergency abdominal imaging, Murphy et al. noted a 63% increase in acute calculous cholecystitis when comparing pre- and intra-pandemic periods in 2019.<sup>10</sup> In contrast, Cano-Valderrama et al. also identified a 9.7% decrease in acute cholecystitis diagnosis across 401 acute care surgery patients in their multicenter retrospective study.<sup>5</sup> Valles et al. performed difference-in-difference analysis of 157 patients from Jan 1 to May 31, 2020 and found a 48.7% decrease in acute cholecystitis admissions compared to pre-pandemic.<sup>9</sup> These studies exhibit significant variation in incidence in part due to their differing sample sizes, geographic locations and access to care, use of multi-center sources, and timeframes of analysis. Our larger sample size helps to clarify these findings by identifying an increase in the emergency presentation and severity of biliary disease but no change in outcomes. This suggests that for large, university based safety-net populations, while the pandemic and future pandemics may lead to increased complexity of disease, this does not translate into worsened patient outcomes.

The reasons behind our observed increase in gallbladder disease severity are likely multifactorial and may be attributable to either patient delay in presenting to the emergency department or structural changes to healthcare delivery over the course of the pandemic. Cano-Valderrama et al. found that patients waited longer from symptom onset to arrival in the emergency department for acute care surgical diseases during the pandemic.<sup>5</sup> In this study, the authors identified that acute care surgical patients waited an average of 26.4 additional hours from symptom onset to arrival at the emergency department during the pandemic, suggesting that patients were delaying seeking medical attention, presumably due to the potential risk of COVID-19 exposure. Postponement and decreases in non-emergency surgery during the pandemic may have further lengthened this timeframe. A guideline by the Royal College of Surgeons suggested consideration of non-operative management of acute cholecystitis in the setting of the pandemic period.<sup>14</sup> This approach is problematic as it has been shown that non-surgical management of acute cholecystitis leads to high rates of relapse and failure of initial treatment.<sup>15</sup> Manzia et al. similarly identified that non-emergency surgical treatment of benign biliary disease decreased during the pandemic, resulting in larger populations of untreated patients ultimately at risk for high morbidity.<sup>16</sup> Our institutional experience represents the real-world reality of the uncertainty of the pandemic and reflects how many institutions approached the pandemic; first with a conservative halt to operations, then with the adoption of evidence-based strategies for resumption of non-emergency procedures.



Our study adds to these findings by illustrating that operative management at our institution shifted away from more benign diagnoses of cholelithiasis and biliary dyskinesia with higher incidences of severe disease such as chronic cholecystitis and gangrenous cholecystitis. In addition, our longer time period encompassing a full year both before and within the pandemic allowed for a more thorough assessment of the impact of the first major phase of the pandemic on emergency biliary disease trends.

Multiple prior studies found increased morbidity during the pandemic compared to previous populations.<sup>13</sup> Despite the increased severity of disease and emergency presentation, in our study patient clinical outcomes did not change during the pandemic. It is possible that our larger cohort coupled with local population differences, practice patterns as high-volume surgeons in acute care surgery, and access to care impacted our improved outcomes. In addition, differences in healthcare equity globally during the pandemic may have impacted resource access at these other centers. Ultimately, our findings of similar clinical outcomes during the pandemic across a large patient sample size may inform high volume surgical centers, both nationally and globally, in surgical decision making.

Finally, our study findings are reflective of a socioeconomic impact of the pandemic on patient presentation with emergency biliary disease. Burström et al. presented multiple socioeconomic factors impacting healthcare quality during the pandemic.<sup>17</sup> Socioeconomic status, employment and lack of finances to afford healthcare, and health literacy all contribute to morbidity and decreased healthcare quality for disadvantaged populations. In their systematic review, Sommer et al. found that lower socioeconomic status increased the likelihood for multiple comorbidities and subsequent increased mortality risks due to the pandemic.<sup>17,18</sup> Our finding that there was an increase in uninsured patients presenting for care during the pandemic supports these previous results. Further, the increase in unemployment during the pandemic could have contributed to loss of employment-associated insurance and decreased funds to afford medical insurance. A report from the Henry J Kaiser Family Foundation, a non-profit organization focusing on major health-care issues facing the US, indicated that loss of employer-sponsored insurance because of COVID-19 will have a major impact on the health-care coverage rates of the approximately 31 million Americans who filed for unemployment between March 1st and May 2nd, 2020.<sup>19,20</sup> Sercy et al. studied health insurance coverage trends in trauma patients across six level 1 trauma centers pre-pandemic and during the pandemic. They found a 6% increase in uninsured patients from January 1, 2018 to June 30, 2020.<sup>21</sup>

Our study has limitations. Acknowledging our institution's category of major regional tertiary center is an important facet and barrier to external validation of our data. While bed constraints and operative availability struggled, our institution had consistent access to resources to allow for continued high quality global care of patients. In comparison, smaller hospital systems that have less resource access, resulting in lower threshold for accommodation, may have experienced different incidence rates and surgical outcomes during this period. As such, our findings may not appropriately apply to all hospital settings. Identifying COVID status in the population proved a challenge. Consistent quality testing was difficult at the onset of the pandemic, so assessing actual COVID-19 infectious status was not attained, but this study's primary purpose was to investigate trends in biliary disease, not COVID-19 biliary pathophysiology. Further, the use of alternative non-surgical treatment due to COVID-19 health burden was not investigated in our study. Prior treatment history of benign biliary disease at outside facilities was not recorded, so it was not known if patients potentially received care prior to presentation.

Finally, while our study assessed primarily the incidence of biliary disease between these two time periods, we are limited by chart review and could not investigate many associated sequelae of disease.<sup>5</sup> Financial burdens accrued due to multiple ED visits for biliary disease, missed occupational time, or delaying care resulting in more intensive

management could all impact overall health during the pandemic. Lastly, the database recorded multiple surgeons operating on biliary disease during this timeframe, which may add to the heterogeneity of our diagnostic findings.

## 5. Conclusion

Our findings have mixed implications for the management of biliary disease in the case of future pandemic surges. We identified an increase in emergency presentation and complexity of biliary disease during the pandemic with a shift in demographic presentation but no change or increase in adverse outcomes. This supports the imperative to continue non-emergency cholecystectomy to mitigate worsening gallbladder disease, but also refutes the suggestion that delaying cholecystectomy for a later date leads to worse outcomes. Ultimately, our findings inform surgical practice for future pandemics, and large institutions may make future practice decisions for benign biliary disease based on practice referral patterns and resource availability, without concern for a significant impact on surgical patient care.

## Declaration of competing interest

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