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Prioritizing rapid COVID-19 testing in emergency general surgery patients decreases burden of inpatient hospital admission

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ABSTRACT

Objectives The COVID-19 pandemic has changed delivery of emergency general surgery (EGS) and contributed to widespread bed shortages. At our institution, rapid testing is not routinely approved for EGS patients. We examined common EGS conditions (appendicitis and acute cholecystitis), hypothesizing that necessity of testing for COVID-19 significantly delayed operative intervention.

Methods We performed a prepost study to examine a 2-month timeframe, or historical control, prior to COVID-19 testing (January 1, 2020–March 1, 2020) as well as a 2-month timeframe during the COVID-19 era (January 1, 2021–March 1, 2021). We chose conditions that are frequently treated surgically as outpatient or observation status. We examined time for COVID-19 test to result, and associated time to operative intervention (operating room (OR)) and need for admission.

Results Median time to COVID-19 test results was 7.4 hours (IQR 5.8–13.1). For appendectomy, time to surgical consultation or case request did not differ between cohorts. Time to OR after case request was significantly longer (12.5 vs 1.9 hours, p<0.001) and patients more frequently required admission prior to operative intervention if receiving treatment in the COVID-19 timeframe. Similarly, for cholecystectomy there were no differences in time to surgical consultation or case request, but time to OR after case request was longer in the COVID-19 era (21.1 vs 9.0 hours, p<0.001).

Conclusion While COVID-19 positivity rates have declined, the purpose of this study was to reflect on one element of our hospital system's response to the COVID-19 pandemic. Based on our institutional experience, waiting for COVID-19 test results directly impacts time to surgery, as well as the need for admission for a historically outpatient procedure. In the future, if the healthcare system is asked to respond to another pandemic or similar situation, expediting time to OR to eliminate unnecessary time in the hospital and non-critical admissions should be paramount.

Level of evidence Level III, prognostic/epidemiological.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Little is known about the impact of COVID-19 on emergency general surgery (EGS), as such this study was designed to evaluate the impact of routine preoperative COVID-19 testing on time to surgery for patients undergoing frequently performed EGS procedures.

WHAT THIS STUDY ADDS

⇒ During the pandemic, COVID-19 testing delayed time to surgery for patients undergoing laparoscopic appendectomy and cholecystectomy.

⇒ Additionally, testing increased need for prehospital admission prior to operative intervention among patients presenting with acute appendicitis.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Waiting for preoperative COVID-19 test results directly impacted time to surgery, as well as the need for admission for a historically outpatient procedure.

⇒ In the future, if the healthcare system is asked to respond to another pandemic or similar situation, expediting time to surgery to eliminate unnecessary time in the hospital and non-critical admissions should be paramount.

BACKGROUND

The COVID-19 pandemic has impacted and disrupted the delivery of emergency general surgery (EGS), in part due to widespread bed shortages for both patients with COVID-19 and without COVID-19. Given the excess burden on hospital capacity during times of high SARS-CoV-2 positivity and the risk of multisystemic complications associated with operative care of infected patients, there have been changes in peri-operative surgical algorithms, including but not limited to case triage and SARS-CoV-2 testing, patient counseling, recommended surgical treatment, increasing threshold for emergency procedures, and hospital course.[1–3]

Throughout the pandemic, clinical guidelines were formulated to assist with the safe maintenance of essential surgeries, providing a loose framework for management. It was suggested that peri-operative SARS-CoV-2 testing requirements be in accordance with Centers for Disease Control and Prevention guidelines, however specific policies for testing were implemented at the facility level.[2] At our institution, a level 1 trauma center and tertiary referral center, a universal preoperative testing protocol was implemented. However, rapid testing is not routinely approved for EGS patients. Standard testing, which takes significantly longer to result than a rapid test, is recommended

per protocol; however, a documented result directly dictates ability to proceed to the operating room (OR). The implications of COVID-19 testing in EGS are unknown. In particular, it is unclear whether waiting for testing to result significantly delays time to operative intervention.

We examined two common EGS conditions, appendicitis and acute cholecystitis, to observe the impact of COVID-19 testing. Given the novelty of the COVID-19 virus, there is little to no published literature evaluating the impact of testing on operative delays or its impact on resource utilization. We hypothesized that the necessity of testing for COVID-19, without offering rapid testing, will delay operative intervention significantly, contributing to the need for admission during a time of hospital bed shortage.

METHODS

The study was conducted at an urban, academic medical center. Patients included in the study underwent one of two common EGS operations: laparoscopic appendectomy for acute appendicitis or laparoscopic cholecystectomy for acute cholecystitis or other gallbladder pathology. These conditions were chosen because they can frequently be managed outpatient with direct transfer from the emergency room to the preoperative area followed by operative intervention and discharge from the postoperative care unit (PACU), avoiding any need for hospitalization. We excluded patients who underwent an initial course of non-operative management, defined as >8 hours prior to placement of the case request. Reasons for initial non-operative management included preoperative management of underlying pathology, patient preference, or comorbidities. Elective surgeries were excluded.

We included two study periods. The first timeframe served as a historic control, including patients who underwent surgery between January 1, 2020 and March 1, 2020, prior to the beginning of the COVID-19 pandemic in our region. The second group of patients underwent surgery between January 1, 2021 and March 1, 2021, which corresponded with a second wave of COVID-19 cases in our area (COVID-19 era). During the latter timeframe, hospital policy required universal testing for all patients undergoing surgery prior to bringing patients to the perioperative area, except in the case of a life-threatening emergency surgery such as trauma laparotomy or emergency exploratory laparotomy in an unstable patient. COVID-19 assays were either collected as rapid or standard per fluctuating testing algorithms at our institution during the COVID-19 era. Rapid testing was conducted by RT-PCR qualitative detection of SARS-CoV-2 RNA via either the Cepheid or Biofire platforms. Rapid testing was estimated to result with 2.5–3.5 hours. Standard testing, similarly, was conducted by qualitative assay by RT-PCR on ThermoFisher and Roche platforms, but often required >8 hours to result.

Testing algorithms with subsequent routing to the appropriate platform were determined by patient characteristics at the time of evaluation, including symptomatology, exposure, baseline health status, and anticipated disposition. Most surgical patients underwent routine or standard testing despite symptomatology, unless emergent surgery was indicated. When standard testing was used, COVID-19 assays were run in batches at prespecified times, often resulting in waves throughout the day. Rapid tests were used infrequently as they required increased personnel and equipment strain, in addition to assay reagent that was scarcely available at our institution.

Data were abstracted from the electronic medical record including patient demographics, time from presentation to the surgery consultation, time from presentation to placement of a case request, time from presentation to time of ordering COVID-19 test, time from presentation to COVID-19 testing result, time from presentation to patient arrival in the OR, and time to discharge after operative intervention. Data were also collected on whether patients were able to be taken directly to the perioperative area from the emergency department (ED), as well as whether patients were able to be discharged from PACU. For patients receiving treatment in the COVID-19 era, time from presentation to the emergency room to obtaining the result of preoperative COVID-19 testing was also documented.

Given the retrospective nature of this study, we acknowledge the impact of bias and confounding variables throughout each phase of care. In particular, we consider variability in treatment provided as a result of patient presentation, diagnostic workup, or involved physician, COVID-19-associated or other sources of delay with regard to diagnostic workup or consultation, patient preferences, and system-wide hospital delays contributing to observed data patterns.

Statistical analysis was done using the R Program for Statistical Computing.[4] Wilcoxon rank-sum tests (for continuous variables) and χ^2 tests (for proportions) were used for univariate analysis. P value <0.05 was considered significant.

RESULTS

We identified 210 patients who underwent either appendectomy (n=101) or cholecystectomy (n=109) during the two respective time periods. During the COVID-19 era (n=100), the median time from presentation to ordering of COVID-19 testing was 2.8 hours (IQR 2.3–3.8 hours, range 0–25.6 hours). The median time from when the order for a COVID-19 test was placed to when it was collected was 0.3 hours (IQR 0.2–0.7, range 0–1.9 hours). Finally, the median time from collection to COVID-19 test result was 7.7 hours (IQR 5.7–11.5, range 1.1–22.2 hours). Within this cohort, n=2 patients tested positive for COVID-19 (2%). Rarely, patients went to the OR prior to final result of the COVID-19 test (n=3, 3%) or were expedited to the OR on the basis of a recent negative test within 3 days of presentation or at an outside emergency room prior to transfer for surgical intervention (n=5, 5%). Including patients who had testing prior to transfer, only 20 patients (20%) had a COVID-19 test ordered prior to surgical consultation but nearly all patients had a test ordered prior to placement of a surgical case request (n=92, 92%). Only three patients had rapid COVID-19 testing, both in the cholecystectomy cohort, and with times from collection to test result of between 1.1 and 1.4 hours in all three cases.

When evaluating cases of laparoscopic appendectomy, specifically, there were a total of 101 patients who underwent operative intervention, with a comparable case volume in the time period of historical controls (n=50) as in the COVID-19 era (n=51). Of these, at total of n=9 patients underwent an initial course of non-operative management with antibiotics either due to patient preference (n=5), unclear or delayed diagnosis (n=2) or anticoagulated status (n=2) and were excluded from further analysis. After exclusion, there were n=44 historical controls and n=48 patients from the COVID-19 era that remained for comparison (table 1). There was no difference between these cohorts with regard to patient age, sex, or insurance type. There was also no difference in the rate of perforated appendicitis (13% vs 11%, p=1.00) between historical controls and patients in the COVID-19 era.

Table 1 Comparison of patients undergoing immediate operative management with laparoscopic appendectomy for acute appendicitis in the COVID-19 era and among historical controls

	Historical controls (n=44)	COVID-19 era (n=48)	P value
Age (median (IQR))	29 (23, 43)	31 (25, 42)	0.69
Male sex (%)	20 (45.5)	29 (60.4)	0.22
Perforated (%)	5 (11.4)	6 (12.5)	1.00
Payor (%)			0.10
Private	15 (34.1)	25 (52.1)	
Medicaid	12 (27.3)	8 (16.7)	
Medicare	3 (6.8)	2 (4.2)	
Other public	6 (13.6)	1 (2.1)	
Self-pay	8 (18.2)	12 (25.0)	
Time to COVID-19 test result, hours (median (IQR))	–	7.4 (5.8, 13.1)	–
Time from presentation to EGS consult, hours (median (IQR))	2.3 (1.7, 3.0)	2.5 (1.0, 2.9)	0.83
Time from presentation to case request, hours (median (IQR))	3.9 (2.6, 4.8)	3.8 (2.9, 4.8)	0.97
Time from case request to OR, hours (median (IQR))	1.9 (1.4, 3.3)	12.5 (7.3, 16.2)	<0.001
Time from presentation to OR, hours (median (IQR))	6.2 (4.7, 7.5)	16.3 (11.5, 20.0)	<0.001
Time from OR to discharge (median (IQR))	5.6 (4.1, 15.0)	5.2 (3.6, 21.5)	0.79
Direct transfer from ED to OR without inpatient admission (%)	29 (65.9)	7 (14.6)	<0.001
PACU discharge (%)	28 (63.6)	28 (58.3)	0.76

ED, emergency department; EGS, emergency general surgery; OR, operating room; PACU, postoperative care unit.

When evaluating time to intervention, there was no difference between time to surgical consult (2.5 vs 2.3 hours, p=0.83) or time to surgical case request (3.8 vs 3.9 hours, p=0.97) between the COVID-19 era and the historical controls (table 1). However, time from placing surgical case request to the patient arriving in the OR was significantly delayed in the COVID-19 era (12.5 vs 1.9 hours, p<0.001) which was also reflected in longer time from patient arrival in the ED to patient arrival in the OR (16.3 vs 6.2 hours, p<0.001). The time from the start of operative intervention to discharge was similar (5.2 vs 5.6 hours, p=0.79). Finally, significantly fewer patients in the COVID-19 era were able to be transferred directly from the ED to the preoperative area (15% vs 66%, p<0.001), although a similar number of patients could be discharged from PACU (58% vs 64%, p=0.76).

In the cholecystectomy cohort, there were a total of n=109 patients, n=49 in the COVID-19 era and n=60 among historical controls. Of these, n=37 were excluded due to an initial course of non-operative management, mostly in the setting of choledocholithiasis (n=10) or gallstone pancreatitis (n=12) where patients underwent initial management with endoscopic retrograde cholangiopancreatography. A total of n=9 patients underwent further workup to determine a diagnosis where presentation was unclear. There were n=6 patients who were initially managed non-operatively due to severe sepsis (n=3),

Table 2 Comparison of patients undergoing immediate operative management with laparoscopic cholecystectomy for acute cholecystitis in the COVID-19 era and among historical controls

	Historical controls (n=39)	COVID-19 era (n=33)	P value
Age (median (IQR))	41 (31, 50)	38 (31, 51)	0.80
Male sex (%)	8 (20.5)	11 (33.3)	0.34
Converted (%)	1 (2.6)	2 (6.1)	0.88
Payor (%)			0.75
Private	14 (35.9)	12 (36.4)	
Medicaid	9 (23.1)	11 (33.3)	
Medicare	3 (7.7)	1 (3.0)	
Medicare/Private	1 (2.6)	1 (3.0)	
Other public	1 (2.6)	2 (6.1)	
Self-pay	11 (28.2)	6 (18.2)	
Time to COVID-19 test result, hours (median (IQR))	–	7.9 (6.2, 12.2)	–
Time from presentation to EGS consult, hours (median (IQR))	1.9 (1.5, 2.6)	1.7 (1.1, 2.0)	0.31
Time from presentation to case request, hours (median (IQR))	4.5 (3.1, 6.3)	4.3 (3.2, 5.4)	0.79
Time from case request to OR, hours (median (IQR))	9.0 (4.2, 19.6)	21.1 (15.3, 25.0)	<0.001
Time from presentation to OR, hours (median (IQR))	14.4 (8.3, 23.9)	25.0 (19.9, 29.3)	0.001
Time from OR to discharge (median (IQR))	8.2 (5.7, 26.4)	7.1 (4.9, 26.6)	0.46
Direct transfer from ED to OR without inpatient admission (%)	5 (12.8)	2 (6.1)	0.57
PACU discharge (%)	21 (53.8)	19 (57.6)	0.94

ED, emergency department; EGS, emergency general surgery; OR, operating room; PACU, postoperative care unit.

multiple comorbidities (n=2) or anticoagulated status (n=1). After exclusion, n=33 patients in the COVID-19 era and n=39 historical controls were included and underwent initial operative management with laparoscopic cholecystectomy (table 2). There were no significant differences in age, sex, or insurance status between cohorts. There was a similar rate of conversion to an open operation (6% vs 3%, p=0.88).

Among all included patients treated with cholecystectomy, we again found no significant differences in time to surgical consult (1.7 vs 1.9 hours, p=0.31) or time to case request (4.3 vs 4.5 hours, p=0.79) between the COVID-19 era cohort and historical controls. Predictably, the time from case request to proceeding to the OR was significantly longer in the COVID-19 era (21.1 vs 9.0 hours, p<0.001), again reflected in longer time from arrival to the ED to operative intervention (25.0 vs 14.4 hours, p=0.001). Time from start of operative intervention to discharge was similar between groups (7.1 vs 8.2 hours, p=0.46). There were no significant differences in the number of patients who were able to be transferred directly to the preoperative area from the ED (6% vs 13%, p=0.57) or who could be discharged from PACU (58% vs 54%, p=0.94).

DISCUSSION

The COVID-19 pandemic created significant strain on the healthcare system, changing delivery of care across all disciplines during a time of widespread bed shortages. In the surgical population, the pandemic disrupted the delivery of EGS, with care paradigms shifting towards routine perioperative testing, delaying elective procedures when able particularly for patients testing positive for COVID-19, and protecting healthcare workers.[1]

The CovidSurg Collaborative, among other leaders in the surgical field, has been critical in guiding early and current recommendations for surgical care during the COVID-19 pandemic, publishing consistent data from various prospective, multicenter trials on the increased risk of 30-day mortality, venous thromboembolism, and pulmonary-related complications associated with perioperative SARS-CoV-2 infection.[1 5] Given preliminary data to this effect, there has been a clear indication for preoperative COVID-19 testing since early phases of the pandemic. The CovidSurg network has also been critical in establishing recommendations for delaying elective cases and for optimal duration of planned surgery delay after COVID-19 infection, which has helped mitigate the growing demand for backlogged surgical cases.[6]

Testing protocols are created at the facility level and there is limited literature available on the feasibility, reliability, and use of various testing methods prior to emergency surgery cases. In general, the recommendation has been for universal preoperative testing, although protocols that allow for preoperative isolation without preoperative testing for elective surgery populations have also been implemented.[7–11] Due to the urgent nature of EGS, however, preoperative isolation is not feasible, and universal testing is likely still necessary particularly when community incidence of COVID-19 is high. There is less data on whether rapid testing should be used in the preoperative setting. In a World Society for Emergency Surgery position paper, RT-PCR testing, often resulting in 4–6 hours, was recommended over rapid antibody testing given concern for poor sensitivity of the IgM/IgG testing alone in acute patients in the ED.[12 13]

The impact of testing, particularly with regard to its role in creating delays in emergency surgical treatment, has not been clearly studied in the literature. One small study in Korea investigated patients undergoing laparoscopic appendectomy, finding a similar delay between patient presentation and operative intervention (17.6 vs 9 hours, p<0.001) and that patients in the COVID-19 era appeared to have increased severity of inflammation but similar outcomes to prepandemic patients.[7] Our study more clearly demonstrates that this delay is attributable to time spent waiting for results of preoperative testing.

At our hospital, during the COVID-19 era, COVID-19 tests were typically ordered based on determination of surgical need at time of surgical consultation. By our data, COVID-19 tests were typically completed by the request of the surgical team at the time of surgical consultation but prior to complete surgical evaluation, typically 30 min to 1 hour before case request. A COVID-19 test was only ordered prior to surgical consultation in n=2 (20%) patients studied. Given this, unnecessary testing was controlled and results were more expeditious given testing was obtained early in the evaluation period, prior to case request. Our institution does not routinely offer rapid COVID-19 testing to EGS patients, and requiring standard testing preoperatively has contributed to significant delays in getting patients to the OR. Rapid testing was not used given limited assay reagent availability and prioritization of resource conservation. During the study period, standard RT-PCR tests took a median 7.7 hours to result, creating significant delays in time from patient presentation to providing laparoscopic appendectomy (16.3 vs 6.2 hours, p<0.001) and laparoscopic cholecystectomy (25.0 vs 14.4 hours, p=0.001). Time to surgical consult and case request were similar between groups for both studied operations. Importantly, significantly fewer patients undergoing laparoscopic appendectomy during the COVID-19 era were transferred directly from the ED to the OR, which equates to more preoperative admissions for a traditionally outpatient procedure, which has critical significance during a time of vast bed shortages. Among patients undergoing laparoscopic cholecystectomy during the COVID-19 era, there was not a significant difference in rate of admission preoperatively. All patients, regardless of presurgical course, had similar times from operative intervention to discharge.

During the COVID-19 era, our hospital, like others, experienced significant workforce shortages, including limitations in preoperative and postoperative care unit staff, reductions in the number of running operating rooms, and reduced numbers of in-house and on-call operating and anesthesia teams. These shortages did contribute to delays in various phases of care, however associated delays would be very difficult to quantify. Despite this, however, we believe the majority of observed delay in proceeding to the OR was secondary to waiting for standard COVID-19 tests to result. In the COVID-19 era, median time from test result to OR in the appendectomy cohort was 3.2 hours (1.6, 4.7). This is a small portion of the total time from presentation to the OR (16.3 hours (11.5, 20.0)) in the COVID-19 era. Additionally, the time from getting test result to OR is minimally longer than the general time from case request to OR in the pre-COVID-19 era (1.9 hours (1.4, 3.3)), which indicates that the OR was generally able to mobilize quickly after tests resulted, eliminating the excess contribution of additional sources of delay. For cholecystectomy, the time from test result to OR was longer (14.3 hours (8.1, 19.1)) and a greater proportion of the total time from admission to OR (25.0 hours (19.9, 29.3)). However, the difference between time from case request to OR in the pre-COVID-19 era was also longer at approximately 9.0 hours (4.2, 19.6), suggesting something inherent to laparoscopic cholecystectomy that delays OR mobilization.

The implications of such a delay in providing surgical intervention are multifold. In our study group, patients were

hospitalized longer, which creates significant burden on an already overwhelmed healthcare system. Moreover, patients requiring admission prior to laparoscopic appendectomy due to delays in testing then required a hospital bed, using unnecessary resources and nursing care. While not directly evaluated in this study, prolonged duration in the hospital contributes to higher healthcare costs for the patient and hospital while increasing possible patient exposure to unnecessary treatments and infectious pathogens. Moreover, it could be implied that delay to OR would increase patient morbidity and risk of clinical deterioration for certain pathologies, although increased rates of appendiceal perforation, for example, were not observed in study cohort. It would also be reasonable to assume that additional in-hospital time while awaiting surgery contributes to a variety of hardships for patients and their families, which would likely be reflected as negative experiences on patient-reported outcome measures.

We did not find significant differences in patient outcomes associated with this testing-related delay. The aim of this paper, however, is not to suggest that testing delays negatively influenced outcomes at the patient level. Rather, we intended to reflect on one element of our hospital system's response to the COVID-19 pandemic (presurgical testing). We hope that analysis of our system's response to the pandemic will guide future responses to a pandemic or other source of healthcare system strain.

Importantly, patients in our study were in the hospital longer (an overage of 10 hours longer preoperatively for all patients). Delays and unnecessary admissions ultimately result in resource overutilization and increased costs to the patient and hospital. Moreover, prolonged ED holding and inpatient admission decreases the number of beds available to other patients who require acute assessment and inpatient care.

Based on American Hospital Association data, the average expense of inpatient admission per day in Colorado was US$3273 in 2021.[14] Particularly among patients in the cholecystectomy cohort, COVID-19 testing increased time from ED presentation to OR from 14.4 hours to 25 hours. As such, it is likely that patients undergoing COVID-19 testing prior to laparoscopic cholecystectomy were billed for an additional in-hospital day. Rapid testing would have expedited the time from presentation to operative intervention, thus decreasing in-hospital time and its associated burden. While rapid testing would have increased the need for more personnel and resources, it is certainly important to consider that the additional expense incurred from rapid testing may prove to be less costly than the overall expense that resulted from delayed operative intervention.

The utility and need for perioperative testing in the context of vaccination is also unknown and evolving. Whether testing an asymptomatic patient who has received all recommended doses of the COVID-19 vaccination causes more harm than benefit requires inquiry.

There are a number of limitations in the study, most notably, the ever-evolving COVID-19 climate, particularly with regard to ebbs and flows in viral positivity, changing viral variants, and to dissemination of vaccination. This study is retrospective with a small sample size, creating a conflict with confounding effects and limiting generalizability. In this study, we did not evaluate healthcare costs, or long-term patient outcomes that may be associated with preoperative delay, which will be important in future prospective trials.

While COVID-19 positivity rates have declined, the purpose of this study was to reflect on one element of our hospital system's response to the COVID-19 pandemic. We still have a lot to learn about our response to the pandemic, particularly using a system-level approach. Important questions include: how could we have decreased time in the hospital for patients? how could we have prevented unnecessary admissions? where would resources have been more effectively used? and how could we have saved money without sacrificing outcomes? We hope that analysis of our system's response will guide future responses to healthcare crises. Based on our institutional experience, waiting for COVID-19 test results directly impacts time to surgery, as well as the need for admission for a historically outpatient procedure. In the future, if the healthcare system is asked to respond to another pandemic or similar situation, expediting time to OR to eliminate unnecessary time in the hospital and non-critical admissions should be paramount.

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Competing interests None declared.

Patient consent for publication Not applicable.

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