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Impact of COVID-19 on volume of elective and nonelective ventral hernia repair

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\textbf{Abstract}

Background: The significant decrease in elective surgery during the COVID-19 pandemic prompted fears that there would be an increase in emergency or urgent operations for certain disease states. The impact of COVID-19 on ventral hernia repair is unknown. This study aimed to compare volumes of elective and nonelective ventral hernia repairs performed pre–COVID-19 with those performed during the COVID-19 pandemic.

Methods: An analysis of a prospective database from 8 hospitals capturing patient admissions with the International Classification of Diseases, Tenth Revision Procedure Coding System for ventral hernia repair from January 2017 through June 2021 were included. During, COVID-19 was defined as on or after March 2020.

Results: Comparing 3,558 ventral hernia repairs pre–COVID-19 with 1,228 during COVID-19, there was a significant decrease in the mean number of elective ventral hernia repairs per month during COVID-19 (pre–COVID-19: 61 ± 5 vs during COVID-19: 39 ± 11; $P < .001$), and this persisted after excluding the initial 3-month COVID-19 surge (61 ± 5 vs 42 ± 9; $P < .001$). There were fewer nonelective cases during the initial 3-month COVID-19 surge (32 ± 9 vs 24 ± 4; $P = .031$), but, excluding the initial surge, there was no difference in nonelective volume (32 ± 9 vs 33 ± 8; $P = .560$). During COVID-19, patients had lower rates of congestive heart failure (elective: 9.0% vs 6.6%; $P = .0047$; nonelective: 17.7% vs 11.6%; $P < .001$) and chronic obstructive pulmonary disease (elective: 13.7% vs 10.2%; $P = .017$; nonelective: 17.9% vs 12.0%; $P < .001$) and underwent fewer component separations (10.2% vs 6.4%; $P < .001$). Intensive care unit admissions decreased for elective ventral hernia repairs (7.7% vs 5.0%; $P = .016$). Length of stay, cost, and readmission were similar between groups.

Conclusion: Elective ventral hernia repair volume decreased during COVID-19 whereas nonelective ventral hernia repairs transiently decreased before returning to baseline. During COVID-19, patients appeared to be lower risk and less complex. The possible impact of the more complex patients delaying surgery is yet to be seen.

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Introduction

When the United States declared a national state of emergency due to the COVID-19 pandemic on March 13, 2020, there were an estimated 41 deaths from COVID-19 out of 1,666 confirmed cases across the nation.\textsuperscript{1} In only 77 days, the death toll surpassed 100,000, with >1.7 million confirmed cases.\textsuperscript{2,3} An extraordinary demand for health care resources during this period was met with unprecedented changes in surgical practice. Guidelines released by the American College of Surgeons,\textsuperscript{4} Centers for Medicare & Medicaid Services,\textsuperscript{5} and other national societies calling for a postponement of nonessential services led to an almost 50% decrease in surgical procedures during the initial COVID-19 surge, from March to May 2020.\textsuperscript{6} The decision to resume nonemergency procedures after this period was left up to individual states and health care systems based on local epidemiology and resources.\textsuperscript{7,8} Most surgical specialties,
including general surgery, subsequently returned to prepandemic volume.\textsuperscript{6}

Ventral hernia repair (VHR) is one of the most common procedures performed by general surgeons\textsuperscript{9} and, historically, a majority of these have been performed as elective procedures. It is well established that morbidity and mortality are significantly increased for nonelective VHR\textsuperscript{10,11}; therefore, the timing of elective VHR must be considered carefully to avoid development of an acute hernia–related complication. Current evidence supports a delay of elective surgery to allow for the optimization of modifiable risk factors, such as tobacco use, obesity, and glycemic control.\textsuperscript{12} A nonoperative strategy of “watchful waiting” has also been described for select patients, particularly those with minimal symptoms, but risk of subsequent emergency VHR ranges from 4 to 24% in 2 to 5 years.\textsuperscript{13,14} There is an ongoing effort to define which ventral hernia patients can safely delay or avoid surgery; yet, many patients who would have otherwise undergone VHR were instead managed nonoperatively due to the COVID-19 pandemic. With limited evidence to describe outcomes for nonoperative management of ventral hernias, the consequences from pandemic-related changes in operative patient selection remain unclear.

In this study, a retrospective analysis was performed using a multicenter database to compare the volume of elective and nonelective VHR during the COVID-19 pandemic with a prepandemic control group. The secondary objective was to analyze short-term outcomes, such as length of stay, cost, and readmission. This was the largest study to date to primarily analyze ventral hernia repairs during COVID-19. The authors hypothesized that there would be no change in the rate of nonelective VHR and equivalent short-term outcomes during COVID-19, despite a decrease in elective operations.

Methods

A multicenter retrospective cohort study was performed using an institutional database, which collects data from 8 hospitals in North Carolina. These hospitals service the metropolitan population of Charlotte and its adjacent suburban communities, and the database includes a tertiary care, high-volume hernia center. The database captures information from all inpatient admissions, procedures, and readmissions at each facility based on hospital billing data. Admissions were designated as either elective or urgent/emergency as adjudicated by the medical coder who generated the billing information after reviewing the history and operative information. No identifying information of individuals or covered health care institutions was provided according to standards set by the US Health Insurance Portability and Accountability Act. This study was approved by the Atrium Health Institutional Review Board and the requirement of informed consent was waived. Strengthening the Reporting of Observational Studies in Epidemiology guidelines for reporting cohort studies were followed.

Data were collected from admissions between January 1, 2017 and June 30, 2021. The earlier date was selected because it marks the transition from the International Classification of Disease, Ninth Revision Procedure Coding System (PCS) to the International Classification of Disease, Tenth Revision (ICD-10) PCS codes. Two time periods were distinguished for comparison: pre—COVID-19 (PC) represents a 38-month period from January 2017 to February 2020, and during COVID-19 (DC) reflects 16 months between March 2020 and June 2021. The “initial COVID-19 surge” is defined as a 3-month period from March through May 2020. During the initial surge, our institution formally suspended all nonessential elective surgeries. Elective procedures resumed by June 2020 using a tiered approach that prioritized low-risk patients, as distinguished by American Society of Anesthesiologists classification, body mass index (BMI), comorbidities, anticipated length of stay, and expected procedure length.\textsuperscript{15}

Patients were included if they underwent VHR as indicated by ICD-10 PCS code for either open (0WQF0ZZ, 0WUF07Z, 0WUF0JZ, or 0WUF0KZ), laparoscopic (0WUF47Z, 0WUF4JZ, 0WUF4KZ, or 0WUF4Z2), or robotic-assisted (8E0W4CZ) VHR. Concurrent component separations were also identified using ICD-10 PCS codes (0KNK0ZZ, 0KNK4ZZ, 0KNKXZZ, 0KNL0ZZ, 0KNL4ZZ, or 0KNLXZZ). Patients <18 years of age were excluded.

The primary outcome was frequency of procedure. The secondary outcomes included intensive care unit (ICU) admission, in-patient mortality, hospital cost, length of stay, and 30-day readmission. Patients were stratified based on elective status and compared between time periods. Subgroup analysis comparing the tertiary care center with nontertiary care centers was also performed.

Statistical analysis

Statistical analysis was performed using R, version 4.1.1 (R Foundation for Statistical Computing, Vienna, Austria), and SAS, version 9.4 (SAS Institute, Inc, Cary, NC). Statistical significance was determined a priori at a 2-sided \( \alpha \)-level of 0.05. Descriptive statistics were used to analyze patient characteristics. The continuous variables were analyzed by calculating mean and standard deviation (SD) or median and inter-quartile range (IQRs) and were compared using Student’s \( t \) or Wilcoxon rank sum tests, respectively. Fischer exact test or the Pearson \( \chi^2 \) statistic of independence was used when appropriate for categorical data.

Results

Excluding 88 pediatric patients, there were 4,786 patients who met inclusion criteria. Stratified by time, there were 3,558 (74.3%) VHR patients PC (2,321 elective and 1,237 nonelective) versus 1,228 (25.7%) DC (695 elective and 533 nonelective).

Baseline patient and operative characteristics

Demographic and patient characteristics for elective and nonelective VHR patients in each period are shown in Table 1. When comparing all patients PC with DC, there was no difference in age (55.8 ± 16.8 vs 54.8 ± 18.8 years; \( P < .091 \)), sex (female: 56.7% vs 57.3%; \( P = .788 \)), race (white: 71.5% vs 70.4%; black: 23.3% vs 24.9%; \( P = .219 \)), or Hispanic ethnicity (4.8% vs 5.7%; \( P = .133 \)). There was no difference in mean BMI (31.6 ± 8.5 vs 31.8 ± 9.3 kg/m\(^2\); \( P = .427 \)), history of tobacco use (5.3% vs 5.2%; \( P = .952 \)), or rate of chronic kidney disease (16.6% vs 14.9%; \( P = .161 \)). There was a lower rate of diabetes in the DC group (30.3% vs 26.9%; \( P = .022 \)), although this was not a statistically significant decrease when stratified by elective status (Table 1). The DC patients had a lower rate of congestive heart failure (12.0% vs 8.8%; \( P = .002 \)) and chronic obstructive pulmonary disease (15.2% vs 11.0%; \( P < .001 \)) and had fewer concurrent component separations (10.2% vs 6.4%; \( P < .001 \)).

Ventral hernia repair volume

Volume of elective and nonelective VHR cases over time are displayed in Figure 1, and a comparison of case volume between time periods is shown in Figure 2. Compared with the PC control group, there was a significant decrease in the mean number of elective VHR cases per month DC (61 ± 5 vs 39 ± 11; \( P < .001 \)). Comparing PC elective case volume per month with the initial 3-
month COVID-19 surge from March through May 2020, there were significantly fewer elective cases (61±5 vs 23±16; P < .001). Notably, there were only 4 elective cases in April 2020. Excluding the initial COVID-19 surge, there remained fewer elective VHRs DC (61±5 vs 42±9; P < .001).

The average number of nonelective VHRs was similar between time periods (32±9 vs 30±9; P = .483). Comparing PC volume with the initial 3-month surge, there were fewer nonelective cases (32±9 vs 24±4; P = .031). Excluding the initial 3-month COVID-19 surge, there was again no difference in volume of nonelective cases (32±9 vs 33±8; P = .560).

### Postoperative outcomes

Postoperative outcomes are reported in Table II. There was no significant difference in length of stay between time periods, although there was a trend toward decreased length of stay for elective patients (median days [IQR]: 4 [2–5] vs 3 [2–5]; P = .060). Furthermore, there was no difference in the rate of patients discharged the same day of surgery for either elective (11.3% vs 12.4%; P = .740) or nonelective (8.2% vs 6.4%; P = .206) VHRs. The elective cohort also had fewer admissions to the ICU DC (7.7% vs 5.0%; P = .016). There was no difference in hospital cost, inpatient mortality,
or rate of 30-day readmission when comparing PC with DC for either elective or nonelective groups.

**Subgroup analysis: tertiary versus nontertiary care centers**

Comparisons of tertiary care (1 hospital) versus nontertiary care (7 hospitals) center patients, stratified by elective status and time, are shown in Tables III and IV. During COVID-19, the mean monthly elective case volume decreased by 28.6% at the tertiary care center (42 ± 4 vs 30 ± 7; P < .001) and 68.9% at nontertiary care centers (45 ± 6 vs 14 ± 11; P < .001). There were no differences in nonelective case volume DC at the tertiary center (16 ± 6 vs 16 ± 8; P = .598) or at nontertiary care centers (14 ± 9 vs 17 ± 14; P = .232). The median patient BMI was lower at the tertiary care center across all groups. Laparoscopy was more frequent at nontertiary care centers, whereas component separation was performed more commonly at the tertiary care center. The length of stay and rate of ICU admission were higher at the tertiary care center across all cohorts. There was no difference between rates of in-hospital mortality. Elective patients were less likely to be readmitted after discharge from the tertiary care center both PC and DC.

When comparing outcomes at the tertiary care center between time periods, there was a decrease in rate of ICU admission for elective VHRs DC (9.5% vs 6.5%; P < .001). At nontertiary care centers, readmission after nonelective VHR was increased DC (30.7% vs 40.8%; P = .003). Other postoperative outcomes between time periods were similar.

**Discussion**

The COVID-19 pandemic prompted a national effort to redistribute hospital resources by postponing hundreds of thousands of surgical procedures across all surgical specialties.1 The VHR is one of the most common procedures performed by general surgeons, and there is concern that a prolonged delay in elective surgery may result in an acute hernia–related complication, therefore mandating nonelective repair. In this retrospective, multicenter cohort study comparing patients who underwent VHR in the 38 months PC with 16 months DC, elective case volume decreased 62% during the initial 3-month COVID-19 surge, and there were 31% fewer elective VHRs in the months after this. Nonelective VHR volume decreased by 25% during the initial COVID-19 surge and then returned to PC levels.

Few studies have primarily investigated VHRs DC, and results are conflicting. A single center in New York City reported a significant decrease in the number of emergency VHRs from 11 cases prepandemic to 2 during the initial COVID-19 peak.16 In contrast, the rates of emergency VHR were increased in a multicenter study from Sweden17 as well as in single-center studies from Turkey18 and the United Kingdom19. Differences in these reported volumes may be related to variations in regional epidemiology. Using COVID-19 case estimates published by the World Health Organization on June 27, 2020,20 and population estimates from the US Census Bureau,21 the ratio of confirmed COVID-19 cases to total national population was ~0.72% in the United States, 0.62% in Sweden, 0.24% in Turkey, 0.53% in Spain, and 0.46% in the United Kingdom. In addition, health care resources vary between nations and centers, which further complicates direct comparison. The database used in this study does not distinguish between urgent and emergency operations, and it is possible that these would reveal different trends if analyzed separately. This was the largest study to primarily analyze VHR DC and notably had a longer control period than the aforementioned studies, mitigating bias from normal variations in volume. The transient decrease in nonelective VHR cases found in this study was congruent with a broader pattern of decreased volume of emergency general surgery DC seen in the United States.22–24 Reports from other countries are conflicting, with fewer emergency procedures performed in Italy,26,27 England, and Wales28 but a
higher volume at several centers in Spain. This suggests that changes in VHR volume are a result of a larger phenomenon, which has had a widespread impact on acute care surgery. Even as restrictions on elective surgeries were lifted after the initial COVID-19 surge, there remained fewer elective VHRs. This trend is supported by a recent study by Mattingly et al.6 which included analysis of 132,006 abdominal hernia repairs in a sample of >13 million surgical procedures performed in the US. Their study compared procedure volume DC with volume in 2019. Abdominal hernia repair had an incidence rate ratio 0.23 (95% CI, 0.08–0.39; P

| Table II |
| --- |
| Postoperative outcomes |
| Elective ventral hernia repairs at tertiary versus nontertiary care centers |
| **Table III** |
| Ventral hernia repairs pre—COVID-19 |
| Tertiary center, n = 1,594 | Nontertiary center, n = 727 | P value |
| Age (y) | 56.5 ± 14.3 | 57.9 ± 14.3 | .055 |
| BMI (kg/m²) | 30.1 | 31.8 | < .001 |
| Median (IQR) | 26.4–34.3 | 26.7–38.4 | |
| Comorbidities | | | |
| Diabetes | 432 (27.1) | 243 (33.4) | .002 |
| Chronic heart failure | 110 (6.9) | 99 (13.6) | < .001 |
| Chronic obstructive pulmonary disease | 193 (12.1) | 125 (17.2) | < .001 |
| Chronic kidney disease | 212 (13.8) | 116 (16.9) | .095 |
| Laparoscopic | 234 (14.7) | 257 (35.4) | < .001 |
| Robotic-assist | 107 (6.7) | 37 (5.1) | .139 |
| Component separation | 323 (20.3) | 14 (1.9) | < .001 |
| Length of stay (d) | 4 (3–6) | 3 (1–5) | < .001 |
| Discharged same day | 87 (5.5) | 190 (26.1) | < .001 |
| In-hospital mortality | 9 (0.6) | 3 (0.4) | .636 |
| 30-day readmission | 220 (13.8) | 128 (17.6) | .017 |

| Nonelective ventral hernia repairs at tertiary versus nontertiary care centers |
| **Table IV** |
| Elective ventral hernia repairs during COVID-19 |
| Tertiary center, n = 727 | Nontertiary center, n = 1,594 | P value |
| Age (y) | 56.5 ± 14.3 | 57.9 ± 14.3 | .055 |
| BMI (kg/m²) | 30.1 | 31.8 | < .001 |
| Median (IQR) | 26.4–34.3 | 26.7–38.4 | |
| Comorbidities | | | |
| Diabetes | 432 (27.1) | 243 (33.4) | .002 |
| Chronic heart failure | 110 (6.9) | 99 (13.6) | < .001 |
| Chronic obstructive pulmonary disease | 193 (12.1) | 125 (17.2) | < .001 |
| Chronic kidney disease | 212 (13.8) | 116 (16.9) | .095 |
| Laparoscopic | 234 (14.7) | 257 (35.4) | < .001 |
| Robotic-assist | 107 (6.7) | 37 (5.1) | .139 |
| Component separation | 323 (20.3) | 14 (1.9) | < .001 |
| Length of stay (d) | 4 (3–6) | 3 (1–5) | < .001 |
| Discharged same day | 87 (5.5) | 190 (26.1) | < .001 |
| In-hospital mortality | 9 (0.6) | 3 (0.4) | .636 |
| 30-day readmission | 220 (13.8) | 128 (17.6) | .017 |

Numbers represent mean ± SD or frequency (%) unless otherwise specified.

**y,** Years; BMI, body mass index; ICU, intensive care unit; IQR, interquartile range; DC, pre—COVID-19.
erations. Mattingly et al found that general surgical procedures, as a whole, had returned to baseline volume after the initial COVID-19 surge, whereas abdominal wall hernias, specifically, have not yet rebounded to prepandemic levels.

Patient perception plays a significant role in health care use as 41% of US adults reported delaying or avoiding medical care due to COVID-19, including 12% who neglected care for an urgent/emergency condition. Further studies are needed to elucidate the relationship between patient perceptions of risk and timing of VHR. Appropriate patient counseling regarding the benefit of an elective VHR is important to avoid the development of an acute hernia complication requiring nonelective surgery.

Secondary outcomes analyzed in this study suggested that patients operated on DC were lower risk than the prepandemic cohort. This is supported by a lower rate of comorbidities, such as congestive heart failure and chronic obstructive pulmonary disease. For elective patients, there was an intentional effort to prioritize low-risk patients to reduce prolonged hospital admissions and avoid potential COVID-19 exposure for high-risk patients. These efforts appeared to have been effective given the reduced rate of ICU admission and a trend toward reduced length of stay for elective VHR patients DC. Nonelective patients also had reduced rates of comorbidities, which likely reflects the role of patient attitudes, because those at high risk for COVID-19-related complications may be more likely to avoid seeking care. Interestingly, the rate of patients discharged the same day of surgery remained similar between time periods despite the general efforts to reduce hospital admissions. This trend was seen at both tertiary and nontertiary care facilities, although the rate of same-day discharge was lower at the tertiary care center, consistent with the higher complexity of patients at this center. Note that at our institutions, a suspension of outpatient procedures was also implemented transiently, along with the suspension of elective inpatient procedures, during the initial surge of COVID-19.

Reduced rates of component separation performed DC also suggest decreased hernia complexity. Component separation is more commonly performed for large hernias. Overall, it seems as though the large, complex hernias in patients with comorbidities were postponed DC. This study, however, does not account for patterns of preoperative abdominal wall botulinum toxin injection, which potentially influenced rates of component separation over time.

Although the rates of nonelective VHR did not increase during the pandemic, further research is needed to support a watchful waiting strategy. Prior studies of watchful waiting reported results with 2 to 5 years of postoperative follow-up3,4,5 compared with the 16-month interval DC in this study. We must remain vigilant that there is an increase in nonelective surgeries for these patients in the future. In addition, this study did not document the clinical course for hernias managed nonoperatively. Patients whose surgery was deferred owing to COVID-19 may have experienced morbidity aside from nonelective repair, such as emergency department visits or admissions with nonoperative intervention. Ventral hernia size increases with time,16 and larger hernias are associated with increased morbidity17; therefore, any delay in operative intervention must be considered carefully.

Compared with the tertiary center, nontertiary centers experienced a more profound decrease in elective case volume. There was no significant difference in rates of nonelective VHR between time periods in this subgroup analysis. This suggests that patterns of elective and nonelective VHR DC are generalizable across centers with different resources and referral patterns. Notably, there was an increase in readmission after nonelective VHR at nontertiary care centers, although the etiology of this is unclear. Further studies should further analyze outcomes of nonelective VHR at nontertiary care centers to better understand the quality of care over time.

This study was not without limitations. The study sample represented patients from a metropolitan/suburban community but did not include every hospital in this region. It is possible that smaller community hospitals experienced variations in VHR volume different from what was observed in our study. By including multiple centers, however, this study more accurately captured the trends in a community compared with results from a single center. Ultimately, COVID-19 has had an unequal distribution across the United States, and regional health care responses may also vary. The tiered response plan implemented by our institution may differ from other institutions. Furthermore, the retrospective nature of the data collection makes it impossible to determine how factors, such as patient perception, had an impact on surgical decision making. Results may not be generalizable to other populations because it is difficult to quantify the impact of variations in epidemiology, resources, policy, and individual beliefs about risk. Future studies should aim to characterize the factors that have the most impact on variations in VHR case volume DC, and long-term follow-up for the population in this study is needed to ensure there is not a delayed surge in nonelective operations related to a decrease in elective operations.

In conclusion, the volume of elective VHR decreased DC and did not rebound to prepandemic levels. The number of nonelective VHRs transiently decreased during the initial COVID-19 surge and then returned to baseline levels. Patients operated on DC appeared to be lower risk and less complex as evidenced by fewer comorbidities and component separations, as dictated by operative guidelines. Elective patients were less likely to require ICU care and had a trend toward decreased length of stay, whereas outcomes such as cost and readmission rate were similar between time periods. Further studies will truly define the consequences of delaying complex hernia repair in the high-risk group of individuals.

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Conflict of interest/Disclosure

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