ARTICLE IN PRESS

The American Journal of Surgery xxx (xxxx) xxx

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.elsevier.com/locate/amjsurg

Original Research Article

Emergencies do not shut down during a pandemic: COVID pandemic impact on Acute Care Surgery volume and mortality at a level I trauma center☆

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ARTICLE INFO

Southwestern Surgical Congress Podium Presentation: April 2022, Wigwam, AZ

Keywords:
Acute care surgery
COVID
Mortality
Pandemic
Trauma
Emergency general surgery

ABSTRACT

Background: The aim of this study was to evaluate the impact of the COVID-19 pandemic on volume and outcomes of Acute Care Surgery patients, and we hypothesized that inpatient mortality would increase due to COVID+ and resource constraints.

Methods: An American College of Surgeons verified Level I Trauma Center's trauma and operative emergency general surgery (EGS) registries were queried for all patients from Jan. 2019 to Dec. 2020. April 1st, 2020, was the demarcation date for pre- and during COVID pandemic. Primary outcome was inpatient mortality.

Results: There were 14,460 trauma and 3091 EGS patients, and month-over-month volumes of both remained similar ($p > 0.05$). Blunt trauma decreased by 7.4% and penetrating increased by 31%, with a concomitant 25% increase in initial operative management ($p < 0.001$). Despite this, trauma (3.7%) and EGS (2.9–3.0%) mortality rates remained stable which was confirmed on multivariate analysis; $p > 0.05$. COVID + mortality was 8.8% and 3.7% in trauma and EGS patients, respectively.

Conclusion: Acute Care Surgeons provided high quality care to trauma and EGS patients during the pandemic without allowing excess mortality despite many hardships and resource constraints.

1. Introduction

The SARS-CoV-2 pandemic and its associated clinical syndrome of coronavirus disease 2019 (COVID-19)[1] has strained all aspects of society over the past two years. The discipline of Surgery especially has suffered from reallocation of personnel, cancellation of elective operations,[2] reassignment to medical wards,[3] and decreased revenue generation for surgeons and hospitals.[4] Orthopedic, gastrointestinal, and cardiovascular elective operations account for 33% of health system revenue,[5] not to mention the backlog of surgical cases created with executive mandates and elective surgery cancellation.[6] While elective surgeons were trying to most equitably triage patients for non-urgent surgery,[7–10] Acute Care Surgery (ACS) services were still managing large volumes of urgent and emergent surgical patients. In addition to helping staff inundated medical critical care units, ACS was still treating trauma, emergency general surgery (EGS), and surgical critical care (SCC) patients in a resource constrained and shifting landscape.

In addition to the pandemic, long-standing social inequalities, racial and socioeconomic conflict, resource scarcity, and supply chain breakdowns led to increased violence throughout 2020. Several trauma centers saw decreased overall and blunt volume by up to 22%[11] but increased penetrating rates by up to 30% and increased severity of presentation.[12–16] In other countries the pandemic was associated with decreased intensive care unit (ICU) admission and increased mortality in traumatic brain injury subgroups,[17] however the trauma mortality rate in large US series was similar to pre-pandemic levels.[15,16] Additionally, emergency surgical conditions continued to present, and some evidence demonstrated later presentation and increased severity, possibly due to

☆ Winner of Lowry award for best new member presentation.

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https://doi.org/10.1016/j.amjsurg.2022.10.030
Received 25 March 2022; Received in revised form 23 September 2022; Accepted 13 October 2022
Available online 17 October 2022

fear of COVID exposure or overutilizing the already taxed medical system.[18,19] While EGS trends in utilization, volume, severity, and outcomes varied by country and region during the pandemic,[20–26] it is clear that emergency presentations and operations still occurred at high levels compared to elective surgical counterparts.[27–29] Although several studies have examined trauma or EGS individually, no studies to date have examined the impact of the COVID-19 pandemic on volume and outcomes for multiple aspects of ACS at a population or center level.

Therefore, the aim of this study, was to evaluate the impact of the COVID pandemic on volume and mortality of emergency ACS patients at a Level I trauma center. While the inclusion of SCC patients would have been ideal, no SCC registry was available for this study. Based on anecdotal experience, the authors hypothesized that during the COVID Pandemic EGS and trauma volume would not decrease but mortality may be detrimentally affected by COVID, bed, and resource availability. A secondary aim was to evaluate the outcomes of patients positive for COVID (COVID+) in comparison to negative patients in the EGS and trauma population.

2. Methods

2.1. Patient population and data source

This was a retrospective comparative interrupted times series with a nested case-control study for COVID + utilizing parallel trauma and EGS registries from Atrium Health Carolinas Medical Center from Jan. 1, 2019–Dec. 31, 2020. Atrium Health is comprised of over 50 acute care hospitals in North Carolina, South Carolina, and Georgia. Within the Greater Charlotte Region, there are 13 hospitals, including two Level III and one Level I adult and pediatric trauma center, totaling over 2600 hospital beds. Patient data was only included from Carolinas Medical Center which is the quaternary care referral center, teaching hospital, and the region's only American College of Surgeons verified Level I verified trauma center, with over 1000 combined pediatric and adult beds. It shares a common electronic medical record (EMR), billing software, physician transfer line, helicopter emergency medical services (EMS), and oversight of county-based EMS medical directorship with the region.

The trauma registry is recorded by dedicated abstractors and organized per American College of Surgeons[30] and Trauma Quality Improvement Project guidance.[31] The registry was queried for all patients including pediatric for the time period. The EGS registry was created from a merger of billing and EMR data. The American Association for the Surgery of Trauma (AAST) defined EGS ICD-9 diagnosis codes and ICD-10 translated codes were used to query billing data for the same time period.[32] Inpatient and observation admissions, classified as emergency or urgent encounters, with a EGS diagnosis code in any code position were included. An automated software (MapIt)[33] was used in conjunction with a Delphi process to manually review ICD-9 to 10 conversion.[34] This method has been validated in the National Inpatient Sample as superior to automated software alone.[35] Patients <18 years old and outpatient encounters were excluded for the EGS registry.

For this analysis only EGS patients who underwent one of the most common surgical interventions were included and were grouped into the top seven procedure types that previous work demonstrated account for 80% of all cases, 80.3% of all mortality, 78.9% of all complications and 80.2% of all costs in EGS patients.[36] These procedures are partial colectomy, small bowel resection, cholecystectomy, perforated peptic ulcer disease repair (PPUDR), lysis of adhesions (LOA), appendectomy, and exploratory laparotomy. The procedure codes utilized for selection are reported in Appendix Table 1. This selection was performed to eliminate many non-operative EGS patients that would have overlapping diagnosis codes with critically ill medical patients during the pandemic.

2.2. Study design

The COVID pandemic began in Wuhan, China in late 2019 but was not prevalent in the United States until March 2020 when it was declared a pandemic by the World Health Organization on March 11th, 2020 and then a national health emergency on March 13th, 2020.[3] Cancellation of elective surgeries, wide spread social distancing, governmental lock-downs, and other pandemic mitigation measures did not become widespread in the United States, and particularly in our area, until April 2020. However, the North Carolina Stay at Home Order went into effect March 30th, 2020.[37] Therefore, April 1st, 2020, was chosen as the delineation date between before the primary exposure of the COVID pandemic (pre-CP) and during the pandemic (CP), as this was when we began seeing effects of healthcare and governmental policy impact our daily practice. The primary outcome of interest was inpatient mortality. Trauma and EGS volumes were evaluated by month from 2019 to 2020 and overall trends of volume and blunt, penetrating volume were analyzed in a month-over-month fashion. Patient characteristics and outcomes were then evaluated on a population level with descriptive, univariate, and multivariate analyses using a pre-post analysis. An evaluation of COVID + vs COVID- status (as cross-referenced with our COVID testing database for test within 30 days of admission) and its association with mortality in each cohort was also evaluated in a nested case-control study analysis during the pandemic era. This principal outcome in this sub-analysis was inpatient mortality by COVID status.

2.3. Variables, diagnosis and procedure code grouping

For the trauma cohort, standard trauma registry variables were collected and analyzed including demographics (age, gender, race, ethnicity), injury type (blunt, penetrating, burn, other), transfer status, presentation physiology [initial Glasgow Coma Scale (GCS), shock index, lactate, base deficit], injury severity score (ISS), revised trauma score (RTS), emergency department (ED) disposition, ICU and hospital length of stay (LOS), discharge disposition, and inpatient mortality. Age was divided into age cohorts per our local trauma alert protocol: pediatric (age 0–14.9), teen (15–17.9), adult (18–64.9), geriatric (65+).

For the EGS cohort patient encounters were identified by ICD-10 billing and procedure codes and linked to demographic (age, gender, BMI, race, ethnicity), clinical data [ED GCS, shock index, white blood count (WBC), and lactate], through our Electronic Data Warehouse. Patients were grouped by diagnosis as defined by the original AAST code-set[32]: resuscitation, general abdominal, intestinal obstruction, upper gastrointestinal (UGI), hepato-pancreatic-biliary (HPB), colorectal, hernia, soft tissue, vascular, cardiothoracic, and other diagnosis category which includes tracheostomy, foreign body, bladder rupture, and other miscellaneous diagnoses. Higher risk surgeries were also group into a high-risk operation variable to analyze these separately and included: exploratory laparotomy, partial colectomy, small bowel resection, and PPUDR, as validated in other EGS series.[38] The primary outcome was inpatient mortality and secondary outcomes were ICU and hospital of LOS.

2.4. Statistical analysis

Data were analyzed using Statistical Analysis Software, version 9.4 (SAS Institute, Inc., Cary, NC), after approval from the Atrium Health Institutional Review Board. Descriptive statistics were reported as means with standard deviations for continuous variables and percentages for categorical variables. Univariate analyses for demographics, secondary outcomes, and inpatient mortality were performed between pre-CP and CP eras for both registries. Only inpatient mortality was examined between COVID+ and COVID- groups. Categorical variables were evaluated using Pearson's chi-squared and Fisher's exact test where appropriate. Continuous and ordinal variables were evaluated using Wilcoxon-Mann-Whitney and the Kruskal-Wallis tests. Multivariable logistic regression was performed for to evaluate the independent association of CP era with mortality, controlling for key confounding variables which were established *a priori*. These variables for trauma included: age group, gender, ISS, ED GCS, injury type, and transfer status. Co-variates for EGS included: age, gender, BMI, high-risk operation, and resuscitation diagnosis group. Odds ratios with 95% confidence intervals were used to report the results of the multivariate regression models. Statistical significance was set at $p < 0.05$, and all reported p values were two-tailed.

3. Results

3.1. Volume and descriptive statistics

There were 14,460 trauma evaluations and 3091 EGS operations over the two-year period. Month over month trauma (both penetrating and blunt) and EGS volume is displayed in Fig. 1. For ease of visualization total trauma and EGS volume is displayed in Fig. 2, and just blunt and penetrating trauma volume is displayed in Fig. 3. Pre-CP trauma volume for April–December averaged 640.3/month while CP volume was similar at 621.4/month ($p > 0.05$). Similarly, EGS monthly volume remained steady from 135.7/month pre-CP to 129.4/month during CP ($p > 0.05$). While total trauma volume during CP was similar, blunt trauma average volume decreased by 7.4% (544.3/month to 504.0/month; $p < 0.001$). Conversely, penetrating volume increased by 31.2% (80.3/month vs. 105.4/month; $p < 0.001$).

In the trauma cohort, most patients were in the adult age group (63.9%), followed by geriatric (19.5%), pediatric (12.4%), and teen (4.2%). Average ISS for those recorded was 10.4 ± 9.3. Patients were discharged home 75.6% of the time and to inpatient rehabilitation at a rate of 7.1%. Average hospital LOS was 5.6 ± 11.8 days, while mean ventilator days were 5.7 ± 8.5, and ICU LOS was 4.8 ± 4.9 days. Trauma inpatient mortality was 3.7% (n = 533). In the EGS cohort the most common operations in decreasing order were LOA, (38.9%), cholecystectomies (32.5%), small bowel resections (12.9%), exploratory laparotomies (12.9%), partial colectomies (11.2%), appendectomies (10.4%), and PPUDR (4.5%). Mean hospital LOS was 8.7 ± 14.5 days. There were 87 EGS deaths (2.8%).

3.2. Trauma by pandemic era

Trauma patient demographics and presentation details by pandemic era are reported in Table 1. On average patients pre-CP were older, with a higher ratio of geriatric patients and lower pediatric and teen patients ($p < 0.001$). There were more male, Hispanic, and African American patients during CP, however there were lower rates of transferred patients ($p < 0.001$ for all). Blunt and burns were a lower percentage with higher rates of penetrating trauma during CP ($p < 0.001$). Trauma patients also presented with increased physiologic derangement including lower GCS and higher shock index and initial lactate ($p < 0.001$).

Trauma patient outcomes by Pandemic era are reported in Table 2. During CP there was an increased rate of initial operating room management by over 25%. There was also a lower relative rate of ICU admission by 11%. However, hospital and ICU LOS and ventilator days remained similar length as pre-CP ($p > 0.05$). In the pandemic there was an increased rate of discharge to home but decreased to inpatient rehabilitation, skilled nursing facilities, and long-term acute care hospitals. Despite the change in baseline characteristics, trauma patient mortality remained the same pre-to during CP (3.7% for both eras; $p = 0.920$).

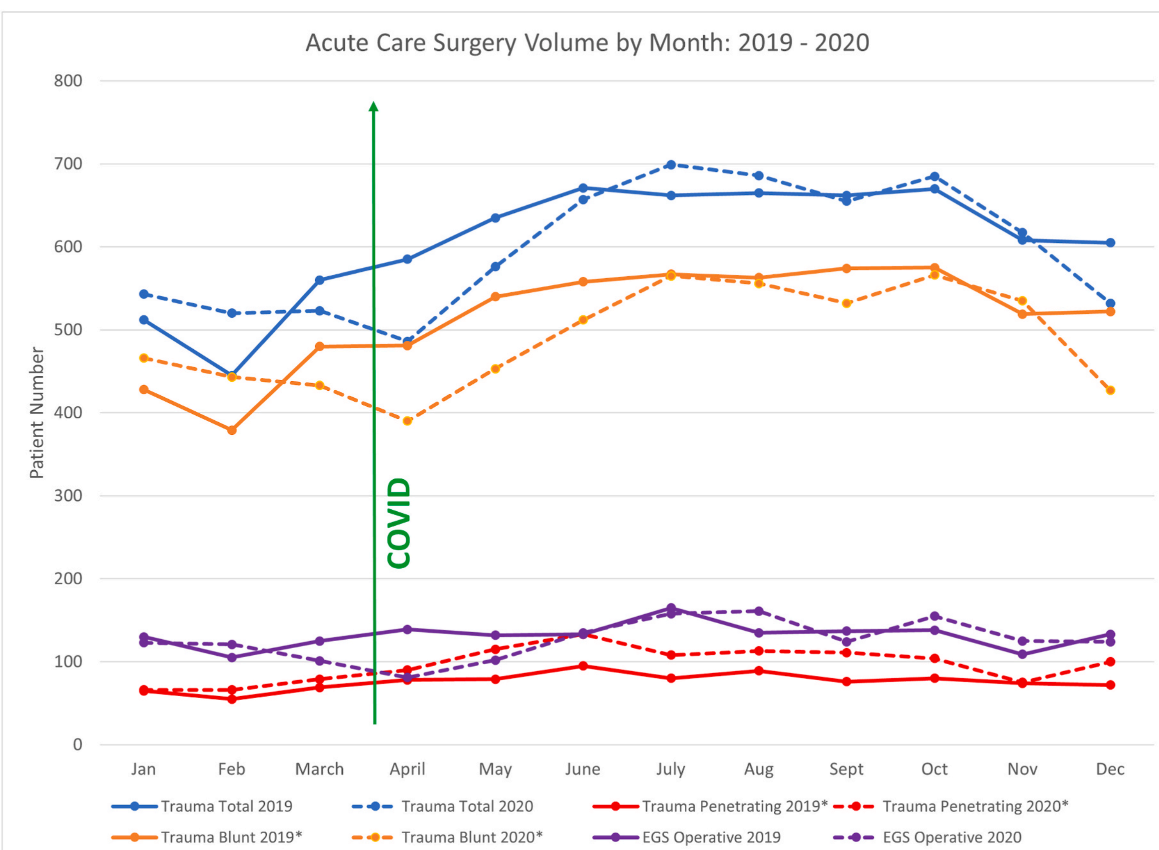

Fig. 1. Pre-COVID Pandemic and during Pandemic Trauma and EGS Operative Volume for 2019 (solid lines) and 2020 (dashed lines). * Indicates statistically different trend for April–December ($p < 0.05$).

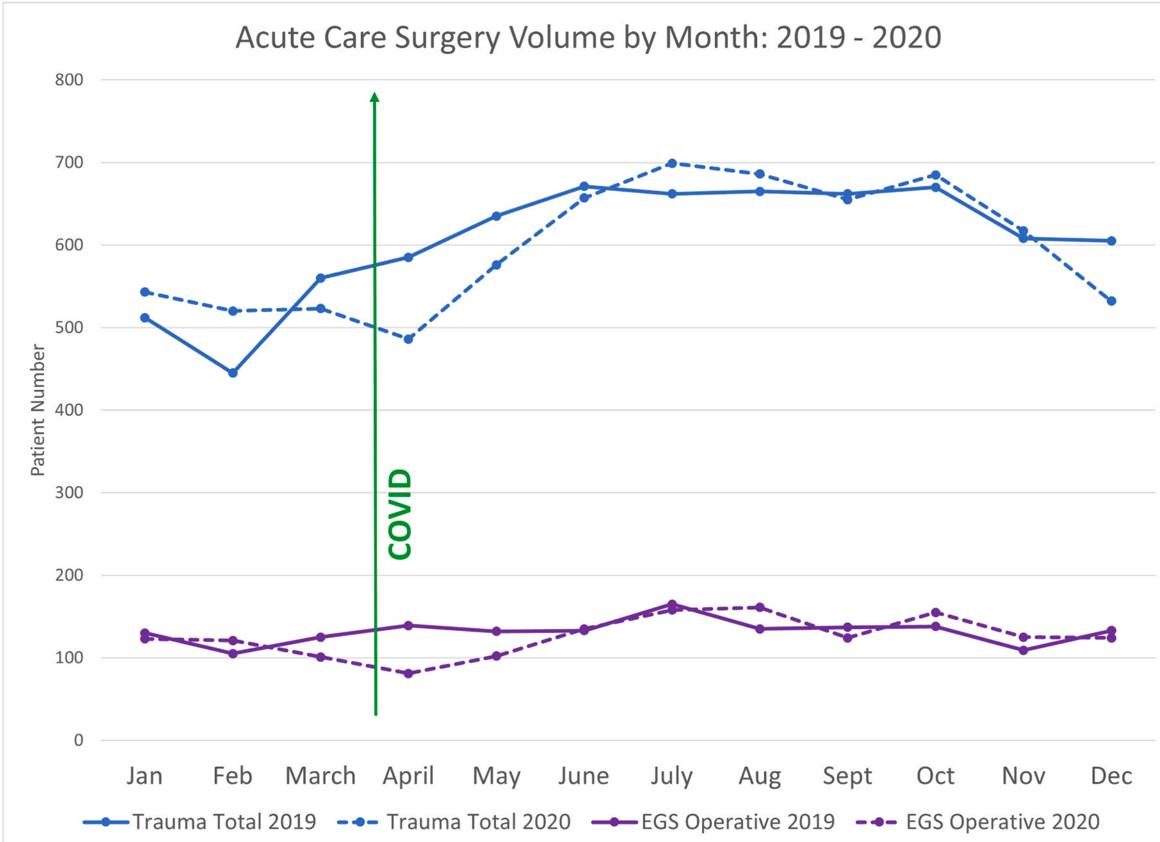

Fig. 2. Pre-COVID Pandemic and during Pandemic Total Trauma and EGS Operative Volume for 2019 (solid lines) and 2020 (dashed lines). * Indicates statistically different trend for April–December ($p < 0.05$).

There were 1278 (22.8%) trauma patients who underwent COVID testing during 2020. Of these, 57 (4.5%) were positive. Five of these COVID + patients died (8.8%) which was statistically similar to the COVID- rate of 6.5% (79/1221); $p = 0.417$.

3.3. *EGS by pandemic era*

EGS patient characteristics by Pandemic era are presented in Table 3. There was similar average age and gender distribution, however, there were more African American and Hispanic operations during CP ($p < 0.05$). Most of the AAST diagnosis groups remained similar, however there were lower rates of general abdominal and hernia diagnosis groups ($p < 0.05$). Additionally, there was similar physiologic presentation with equivalent ED GCS, shock index, and initial lactate ($p > 0.05$ for all).

EGS operative type and outcomes are reported in Table 4. There were similar rates of lower risk surgeries like appendectomy and cholecystectomy but higher rates of exploratory laparotomy by 25% and PPUDR by 47% ($p < 0.05$). Overall, there was an almost 18% increase in high-risk operations; $p = 0.003$. Despite this, hospital LOS, discharge destination, and inpatient mortality (4.0%) were all similar to pre-CP values. Additionally, when just high-risk operation mortality was evaluated, this was also the same pre-CP (8.8%).

During 2020, 962/1165 (82.6%) EGS patients underwent COVID testing, however only 35 (3.6%) were COVID+. There were 2 deaths in COVID+ and 24 in COVID- patients (5.7 vs 2.6%), which was statistically similar rate of mortality in this operative EGS population; $p = 0.244$.

3.4. *Multivariate*

Trauma and EGS multivariate analysis results for inpatient mortality are reported in Table 5. Pandemic era was not associated with inpatient mortality for either cohort. However, in the trauma cohort geriatric patients had almost 7 times the odds of death as younger adults. Higher ISS, lower GCS, and penetrating trauma was associated with increased mortality ($p < 0.05$ for all). Transfer patients actually had a protective effect with 50% less odds of death; $p < 0.001$. EGS inpatient mortality was associated with older age, and higher risk operations had 2.5 times the odds of death; $p < 0.001$ for all. The most highly associated factor with inpatient death was AAST Resuscitation diagnosis group (OR 20.27, 95% CI: 11.57–35.52), which is highly correlated to sepsis, shock, and organ failure diagnoses.

4. Discussion

Despite government shutdowns, "stay at home" mandates, and social distancing, surgical emergencies still occur and these acutely ill and injured patients sought medical help regardless of the pandemic. Acute Care Surgeons unique skills were leveraged in the pandemic to provide the best care for our patients under sub-optimal circumstances. Specifically, governmental and healthcare response to the pandemic highlighted the need for physicians who are highly adaptable, cool under pressure, comfortable with time sensitive scenarios, with the ability to stay flexible in a fluid, dynamic situation. During the pandemic ACS served their core purpose, and also flexed to help medical intensivists, emergency medicine colleagues, and trained their fellow elective surgeons for trauma and critical care coverage. Our study provides a unique insight into this role and the population we serve, as it is the first study, to our knowledge, to examine the COVID pandemic's impact on multiple aspects of ACS with both trauma and EGS inclusion. Additionally, with over 17,500 patients, and a secondary analysis of COVID + correlation with mortality, these results offer a robust evaluation of ACS

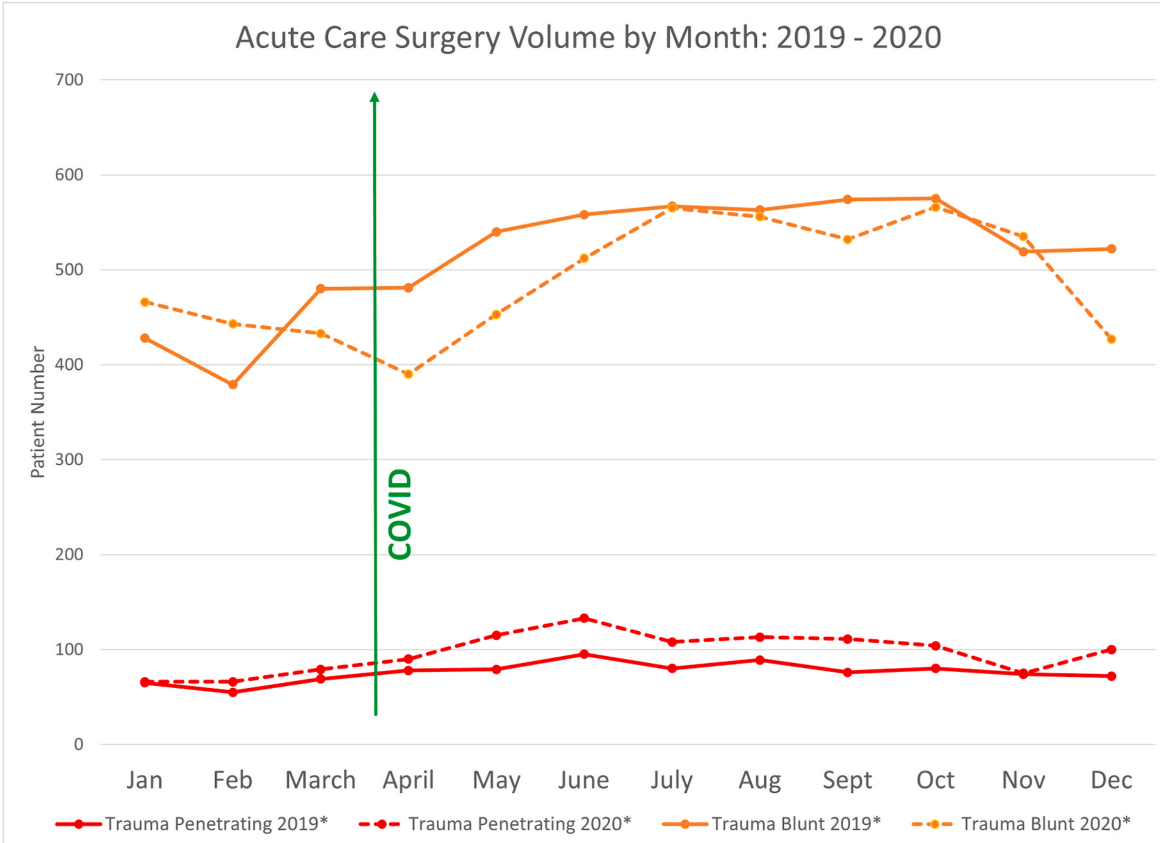

Fig. 3. Pre-COVID Pandemic and during Pandemic Penetrating and Blunt Trauma volumes for 2019 (solid lines) and 2020 (dashed lines). * Indicates statistically different trend for April–December ($p < 0.05$).

performance during the pandemic. Despite increased physiologic derangement on evaluation, and higher rates of penetrating injury, trauma and EGS patient mortality was equivalent before and during the COVID pandemic.

The current literature on trauma volume and distribution during the pandemic varies by site with some sites having similar overall volume,[39] some with stable volume and increased penetrating percentage,[15,16] and others having overall decreased volume but increased rates of penetrating injury.[11,14] This study's results fit into the second group, and despite relative increased penetrating volume by 32%, and 25% increase in requiring initial operative intervention, mortality remained stable at 3.7%. This is similar to rates reported in the pandemic at Level I centers from 3.3 to 4.7%.[14,15,40] While overall COVID testing rates were lower in the trauma cohort, mortality approached 1/10th of the population for COVID + trauma patients; similar to the inpatient mortality rate of 9.1% found by Kaufman et al.[40]

Unique to these findings is a decreased ICU admission for a more physiologically deranged population, indicating triage and admission for more critically ill patients to lower levels of monitoring. This point reflects our experience on the ground with lack of adequate ICU bed availability despite temporary ICU expansion. Additionally, increased operative penetrating (with concomitant decreased blunt) volume also was likely associated with decreased traumatic brain injury, spinal cord injury, and potentially decreased long-term ICU need. In addition to lack of bed availability, ventilators and ICU supplies during CP were scarce, however, operative availability for EGS and trauma was prioritized, and cases triaged by clinical leaders according to a thoughtful selection criterion of acuity, disease process, and expected LOS. This also allowed the health system to maintain outpatient procedure volume and revenue. These facts indicate that despite resource constraints, lack of hospital and ICU bed availability, the trauma team and system were still able to deliver high quality care to our patients to prevent excess mortality. While other endpoints such as detailed complications, unplanned ICU readmission or operations, and failure to rescue could possibly be elevated due to lack of initial ICU care, those data are not currently available in both registries to evaluate those effects; but processes to include them is ongoing.

Similarly, the EGS population had equivalent mortality rate before and during the pandemic. Previous analysis of our center have shown that during the pandemic overall rates of EGS patients decreased,[41] but operative volume remained similar, indicating likely less presentation of non-operatively managed disease processes and patients. These are similar to findings of Dick et al. who saw a 58% decrease in EGS admission but increased operative rate (19–42%), as well as increased presentation severity.[20] While several other studies saw decreased operative rates during the pandemic,[21–23,26,42] this study is one of the first to demonstrate a similar rate of operative EGS before and during the COVID Pandemic. Additionally, severity of presentation was similar with equivalent ED GCS, WBC, and initial lactate. Interestingly, the mortality rate for COVID + patients was similar to that of negative patients and far below the mortality rates of COVID + EGS patients in the current literature of 15.1% recently published from the international multicenter COVIDSurg Collaborative.[43] Likely this lower result is related to the increased denominator of tested patients in our series, as universal testing was initiated for all EGS operative cases mid-2020. With 82.6% of the EGS pandemic population having undergone peri-operative testing, many asymptomatic patients may have been recorded. Mandatory testing in the trauma population was not performed given our patient volumes, however, testing was more selective based on screening for symptoms or high acuity.

For both cohorts, hospital LOS was similar, and trauma ICU LOS and ventilator days were also equivalent. EGS patients had similar rates of

Table 1
Trauma patient characteristics pre- and during COVID pandemic.

	Pre-Pandemic	Pandemic	p value
n = 14,460	n = 8866 (%)	n = 5593 (%)	
Age (Mean ± STD)	41.8 ± 24.4	39.7 ± 23.1	<0.001
Pediatric (0–14.9)	12.6	12.1	<0.001
Teen (15–17.9)	4.5	4.0	
Adult (18–64.9)	66.4	62.4	
Geriatric (65+)	17.0	21.0	
Male	63.5	66.2	<0.001
Race			
African American	31.3	34.9	<0.001
Asian	1.6	1.1	
Caucasian	53.5	50.4	
Native American	0.3	0.3	
Other	13.3	13.3	
Insurance			
Medicaid	16.2	13.2	<0.001
Medicare	19.4	15.5	
Private	45.0	47.4	
Self	18.0	22.2	
Other	1.4	1.7	
Hispanic	7.9	10.1	<0.001
Injury Type			
Blunt	84.9	81.1	<0.001
Penetrating	12.7	17.0	
Burn/Other	2.4	1.9	
Transfer	31.0	28.4	<0.001
ED GCS	13.8 ± 3.2	13.6 ± 3.3	<0.001
Shock Index	0.7 ± 0.3	0.8 ± 0.3	<0.001
Revised Trauma Score	11.80 ± 0.7	11.84 ± 0.7	<0.001
Injury Severity Score	10.3 ± 9.4	10.5 ± 9.2	0.106
Initial Labs			
Lactate (mmol/L)	2.7 ± 3.3	3.0 ± 2.4	<0.001
Base Deficit (mEq/L)	3.4 ± 3.9	3.2 ± 3.5	0.011

ED: Emergency Department; GCS: Glasgow Coma Scale.

Table 2
Trauma outcomes pre- and during COVID pandemic.

	Pre-Pandemic	Pandemic	p value
n = 14,460	n = 8866 (%)	n = 5593 (%)	
ED to OR	8.0	10.1	<0.001
ICU Admission	19.9	17.7	<0.001
ICU Length of Stay	4.8 ± 5.1	4.8 ± 4.8	0.406
Ventilator Days	5.7 ± 8.8	5.7 ± 8.2	0.630
Hospital Length of Stay	5.6 ± 12.4	5.6 ± 10.9	0.209
Discharge Disposition			
Home	74.0	78.2	<0.001
Rehabilitation	7.4	6.5	
Skilled Nursing	8.2	4.6	
LTACH	0.7	0.5	
Other	6.0	6.5	
Inpatient Mortality	3.7	3.7	0.920

ED: Emergency Department; OR: Operating Room; ICU: Intensive Care Unit; LTACH: Long Term Acute Care Hospital.

Table 3
Operative emergency general surgery patient characteristics pre- and during COVID pandemic.

	Pre-Pandemic	Pandemic	p value
n = 3091	n = 1926 (%)	n = 1165 (%)	
Age (Mean ± STD)	54.5 ± 17.4	53.6 ± 18.2	0.244
Male	46.1	44.6	0.416
BMI (kg/m^2)	29.4 ± 7.7	29.3 ± 8.2	0.002
Race			
African American	26.3	30.6	0.023
Asian	1.3	1.3	
Caucasian	65.4	59.5	
Native American	0.6	0.9	
Other	6.4	7.7	
Hispanic	5.2	6.3	0.015
AAST Diagnosis Group			
Cardiothoracic	10.0	11.1	0.355
Colorectal	23.9	24.4	0.777
General Abdominal	69.4	65.1	0.013
Hernia	22.8	18.9	0.012
HPB	35.5	36.6	0.516
Obstruction	26.8	26.2	0.730
Resuscitation	14.9	15.6	0.571
Soft Tissue	7.8	7.0	0.411
Vascular	7.5	8.5	0.319
Upper Gastrointestinal	19.8	20.2	0.784
Other	1.3	1.3	0.918
ED GCS	13.2 ± 3.1	13.2 ± 3.4	0.233
Shock Index	0.7 ± 0.27	0.8 ± 0.3	0.056
Initial Labs			
WBC (10^9/L)	11.2 ± 6.6	10.6 ± 6.0	0.003
Lactate (mmol/L)	3.0 ± 2.6	2.9 ± 2.9	0.923

ED: Emergency Department; GCS: Glasgow Coma Scale; WBC: White Blood Count.

Table 4
Operative emergency general surgery patient surgeries and outcomes pre- and during COVID pandemic.

	Pre-Pandemic	Pandemic	p value
n = 3091	n = 1926 (%)	n = 1165 (%)	
Operation			
Appendectomy	10.1	10.8	0.511
Cholecystectomy	32.2	32.9	0.716
Exploratory Laparotomy	11.8	14.8	0.017
Lysis of Adhesions	41.0	35.5	0.002
Partial Colectomy	10.9	11.8	0.465
Perforated Peptic Ulcer Repair	3.8	5.6	0.031
Small Bowel Resection	12.3	14.0	0.163
High Risk Operation	33.8	39.1	0.003
Hospital Length of Stay	8.8 ± 15.3	8.6 ± 13.1	0.721
Discharge Disposition			
Home	84.8	86.1	0.614
Rehabilitation	3.3	3.4	
Skilled Nursing	4.3	3.5	
LTACH	1.7	1.4	
Other	1.8	1.6	
Inpatient Mortality	4.1	4.0	0.927
High Risk Operation Mortality	8.8	8.8	1.0

High Risk are exploratory laparotomy, partial colectomy, perforated peptic ulcer repair, and/or small bowel resection.

discharge destination, while trauma patients during the pandemic had much lower rates of discharge to skilled nursing, rehabilitation, and long-term care facilities. Skilled nursing facilities had an almost 44% decrease in discharge rate, likely due to outpatient bed availability and decreased throughput of facilities that was seen throughout the pandemic. While LOS was not significantly increased despite the decreased throughput, this was likely related to fewer complex blunt polytrauma patients and increased rates of treatable operative penetrating injures. Additionally, more rapid than normal discharge to "hospital at home," telemedicine, and community paramedicine programs also facilitate earlier discharge of appropriate lower acuity patients. These results emphasize the need for improved coordination of care across the continuum of treatment to optimize the systems resources and patients' ultimate destination. Currently, little coordination exists outside the state and regional trauma systems, and, more robust systems are needed to enact lasting and meaningful change to regional planning.

During CP there were similar rates of lower risk EGS surgeries such as appendectomy and cholecystectomy, but higher rates of exploratory laparotomy and PPUDR likely indicating more severe presentation of disease that was not captured and/or sequela of increased stress ulcers.

Table 5
Multivariate analysis for inpatient mortality.

	OR	95% CI	p value
Trauma			
Pandemic era	0.96	0.76–1.22	0.758
Female (ref Male)	0.86	0.66–1.11	0.248
Age (ref Adult)			
Pediatric	1.07	0.66–1.74	0.071
Teen	0.72	0.38–1.38	0.003
Geriatric	6.89	5.03–9.50	<0.001
Injury Severity Score (per point)	1.06	1.05–1.07	<0.001
ED GCS (per point)	0.70	0.69–0.72	<0.001
Penetrating (ref Blunt)	3.39	2.50–4.60	<0.001
Transfer	0.48	0.37–0.62	<0.001
Emergency General Surgery			
Pandemic Era	0.79	0.49–1.29	0.349
Age (per point)	1.03	1.01–1.04	<0.001
BMI (per point)	0.99	0.97–1.03	0.223
Female (ref Male)	0.66	0.41–1.07	0.089
High Risk Operation	2.54	1.48–4.36	<0.001
AAST Resuscitation Group	20.27	11.57–35.52	<0.001

Higher level of contamination and later presentation could also account for these findings, possibly leading to open over laparoscopic surgery, however this data is not available to definitively report. The transfer status variable definition for EGS patients changed during this time period and was unable to be reported herein, however, rates of transfer were anecdotally greatly decreased during the pandemic given the bed saturation of all facilities. This could have skewed the patient presentation at our quaternary facility to less transferred severe and comorbid patients, shifting these higher risk operations and associated outcomes onto the community hospitals in our region. Pandemic era was not associated with increased mortality in the EGS or the trauma cohorts on multivariate analysis after controlling for significant confounders. While several expected factors were related to mortality, these factors like age and ISS have been well demonstrated in prior literature, and importantly had similar association regardless of patients presenting during the pandemic.

There were several limitations to the study based on the retrospective nature of the trauma and EGS registries. While the trauma registry benefits from dedicated abstractors the EGS registry is based on billing data merged with EMR clinical data and may be incomplete for certain pertinent variables. Missing data, especially for laboratories, could have been missing not at random, and therefore variables with low fidelity were not used in the multivariate model. Additionally, outcomes measured were only for inpatient stay and readmission and longer-term outcomes, including patient reported outcomes, were not available. For COVID testing data not all patients were tested, especially in the trauma population, and therefore the true number of COVID + patients and associated mortality may be skewed.

These combined results again emphasize that Acute Care Surgeons provided best quality care to emergent and urgent patients, even during a pandemic. Every day the Acute Care Surgeon has to deal with triage and resource management in every decision, as we cope with an epidemic of gun and interpersonal violence, domestic abuse, and social injustices. Added to that the difficult choice of which dying patient goes to the operating room first, which infection gets treated first, and which person gets the last ICU bed. Therefore, it is not surprising that Acute Care Surgeons were able to adapt to COVID and makes those difficult choices during the pandemic. Surgical emergencies truly never stop, and they did not stop despite lockdowns, shut downs, and stay at home orders. To make our response easier, more streamlined, and better coordinated, surgeons need to advocate for systems of care and coordination in regions, states, and nationally to address our current traumas, our current emergencies, and for the next pandemic, or the next war.

5. Conclusions

During the first year of the COVID pandemic trauma and EGS operative volume remained similar to pre-pandemic levels, however, trauma had lower volume blunt and higher volume penetrating injuries. Despite more physiologic derangement on presentation, trauma mortality was similar to pre-CP levels (3.7%) as was EGS mortality (2.9–3.0%). COVID + mortality rate of was 8.8% in trauma and 3.7% in EGS patients. In the face of significant hardships, bed availability, and resource constraints during the first year of the pandemic, emergency surgical and trauma patients had excellent and uncompromising quality care by Acute Care Surgeons.

Funding

There was no funding source for the study. None of the authors have any relevant financial conflicts of interest to disclose.

Conflicts of interest

The authors have no conflicts of interest related to this work.

Disclosures

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2022.10.030.

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