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Impact of coronavirus disease 2019 (COVID-19) on trauma surgical education at a level I trauma center

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ABSTRACT

Background: During the coronavirus disease 2019 pandemic, trauma presentations to the emergency room decreased across the country. The goal of this study is to analyze the educational impact of coronavirus disease 2019 on trauma education and training at a level I trauma center.

Methods: Trauma patient presentations were analyzed 6 months before a Tennessee executive stay-at-home order and 6 months after the state executive order. To control for the seasonal trauma volumes, an additional 6 months before the executive order was then analyzed comparing month to month. Total number of presentations, demographics, procedures, airway management, and coronavirus disease 2019 status of patients and residents were analyzed.

Results: The number of trauma presentations were sustained after executive orders at our level I trauma center. There was no significant difference in intubations, central line placements, and chest tube placements before and during the pandemic. Blunt trauma decreased after stay-at-home orders. Of the 36 residents, no residents tested positive during the study period.

Conclusion: Trauma-focused surgical education was not affected at an academic level I trauma center. Understanding that it is region, city, and hospital specific, this study shows that quality trauma education can continue throughout the coronavirus disease 2019 pandemic while keeping trainees safe. Proper airway management, personal protective equipment, social distancing, and coronavirus disease 2019-preventative protocols seem to protect residents from potential harm while allowing them to participate and continue in quality trauma education and training.

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Introduction

Coronavirus disease 2019 (COVID-19) has spread throughout the world and has changed the dynamics in many aspects of life, such as decreased gathering sizes and increased use of masks. In the state of Tennessee, the first documented cases of COVID-19 in the state and Knox County (location of study site) were March 5, 2020, and March 12, 2020. The safety of residents has come to the forefront of discussions, as programs adapt educational and clinical responsibilities during the pandemic. A cross-sectional analysis of New York City residency programs found 45.1% of programs had at least 1 resident with a confirmed case of COVID-19.¹ Trauma

education presents safety issues for surgery residency programs, as residents generally serve a population that presents without known COVID-19 status and has a relatively high likelihood of requiring an aerosol-generating procedure.

Resident education and duties have seen a variety of changes and novel approaches to increase safety during the pandemic. Most residency programs are using virtual conferences as a means to continue education while maintaining social distancing for both residents and attendings.^{2,3} Other programs have used home surgical kits and virtual procedure and skills labs.^{4,5} Many residency programs have also implemented separate resident teams who stay together to limit interactions among residents and limit the possibility of spreading COVID-19.^{6,7} Airway management practices have evolved during the pandemic to minimize exposure during aerosolizing events, like intubations, chest tubes, or any other event or procedure that could produce droplets that could spread COVID-19. Interventions to minimize exposure include video laryngoscopy for intubation and proper personal protective equipment (PPE).^{8–11}

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During the first month of the pandemic, trauma presentations decreased in number^{12–14} in multiple locations, including California, New Zealand, and New Hampshire. Studies examining the trauma population have only examined a brief amount of time during the pandemic,^{12–14} with none of them gathering data longer than a couple months. Surgical volume, surgical consult volumes, and resident education trends have been examined and published.^{2–5,15–17} However, no studies have examined the impact of COVID-19 specifically on trauma education. This is a retrospective review of the impact of COVID-19 on trauma education. The number of trauma patient presentations, performed procedures, and trips to the operating room on initial presentation for 6 months after the stay-at-home orders and 6 months before the stay-at-home orders were examined. The data were also compared with the previous year. We hypothesized that there would be no difference in trauma educational opportunities after the stay-at-home orders.

Methods

Our project was evaluated by the institutional review board (IRB) who deemed the project as exempt status due to the retrospective nature of the project. A total of 11,663 trauma patients presented from April 2019 to September 2020. The total population was separated into 3, 6-month periods by when the stay-at-home orders were enacted: April 2019 to September 2019 (historical comparison to after the stay-at-home orders), October 2019 to March 2020 (before stay-at-home orders), and April to September 2020 (after the stay-at-home orders). April to September 2020 was compared with October 2019 to March 2020 to evaluate the effects of trauma education after the beginning of the Tennessee stay-at-home orders. To control for seasonal fluctuations in trauma volume, April to September 2020 was also compared with 2019 to analyze the effects of stay-at-home orders. Month-by-month trauma patient presentations from April 2019 to September 2019 were compared with April 2020 to September 2020.

Demographic information was available for each patient, including age, sex, and race. COVID-19 status was recorded for each patient who was tested during the study period. Patients who could possibly undergo an operation or had positives on COVID-19 screening were tested for COVID-19. Patients who were not admitted, had a negative screening, or were not undergoing an operation were not tested.

Emergency department (ED) disposition to the operating room was recorded during the study period. Interventions pertinent to resident education were tracked when performed during trauma evaluations in the trauma bay or ED. This included the following: central venous line insertion (CVL), endotracheal intubation, and thoracostomy tube placement.

Our institution enacted aerosolizing protective protocols that started at the end of March 2020. Aerosolizing procedures, like thoracostomy tubes and endotracheal intubations, were conducted in a negative pressure room. Staff wore N95 masks, eyewear protection, gowns, and gloves during the aerosolizing procedure. Personnel numbers were limited in the negative pressure room during the procedures. Personnel in the negative pressure room included trauma residents, attending physician, respiratory therapists, and nurses. Rapid sequence intubation (RSI) was performed using a video laryngoscope. If the negative pressure room was occupied, then backup negative pressure rooms were assigned by the core trauma nurse. If all negative pressure rooms were occupied, then a designated sheltered location outside of the ED was assigned.

Resident education at our institution had notable changes during the pandemic. Most conferences were held virtually. The few in-person conferences had a cap on the number of attendants in

order to adhere to social distancing guidelines. The simulation lab had a cap on the number of attendants as well as mandatory masks and gloves when training. Our institution fortunately had the resources and personnel to cover the ED and COVID-19 units without assistance from surgery residents; therefore, surgery residents remained on trauma and surgery rotations.

Statistical analysis

The cohorts of trauma patients were compared on the categorical outcomes of interest using χ^2 analysis. The number of trauma patient presentations, number of operations, number of ED CVL, and number of thoracostomy tube placements were evaluated for each cohort. October 2019 to March 2020 was compared to April to September 2020 using this method. April to September 2019 was also compared to April to September 2020 using this method to control for the seasonal effect on the number of trauma presentations. Frequency and percentage statistics were reported to give context to the inferential analyses. Outcomes were reported per 100 trauma patients. Statistical significance was assumed at a P value of .05, and the χ^2 analyses were performed using SPSS, version 26 (IBM Corp, Armonk, NY). Fisher exact test was used to analyze month-by-month comparison of the number of trauma patient presentations from April to September 2019 to April to September 2020. Statistical significance was assumed at a P value of .05.

Results

The data was reviewed from 6 months before stay-at-home orders and 6 months after stay-at-home orders. A 6-month historical comparison was also done using the previous year. There were 3,510 patients before stay-at-home orders from October 2019 to March 2020 and 4,080 patients after stay-at-home orders. From April to September 2019, there were 4,073 trauma patient presentations. During the 6 months after stay-at-home orders in Tennessee, 10 patients tested positive for COVID-19 during the admission process. No residents in the study location contracted COVID-19 during the study period.

Table I compares the number of trauma educational opportunities per 100 trauma patients between October 2019 to March 2020 and April to September 2020. There were no statistical differences in the number of educational interventions performed between groups. There was a statistically significant decrease in blunt injuries and a significant increase in penetrating injuries after stay-at-home orders. Fewer trauma patients were admitted to intensive care unit after stay-at-home orders. Table II compares the number trauma educational opportunities per 100 trauma patients between April to September 2019 and April to September 2020. There was a statistically significant decrease in the number of operations and blunt injuries after stay-at-home orders.

Table III shows the month-by-month comparison of April to September 2019 to April to September 2020. There was a statistically significant decrease in the number of trauma patient presentations in April and May of 2020. There was also a statistically significant increase in trauma patient presentations in June 2020. The Figure is a line graph demonstrating the trend of the number of trauma patient presentations for April to September 2019 and April to September 2020. Asterisks denote the months with statistically significant differences.

Discussion

A total of 4,080 patients presented as trauma activations in the 6 months after the stay-at-home orders in April of 2020 compared to

Table I
 χ^2 analysis of pre–stay-at-home order and post–stay-at-home order cohorts

Outcome per 100 trauma patients	Before stay-at-home orders (n = 3,509)	After stay-at-home orders (n = 4,080)	P value
Operations	8.6	9.6	.13
ED intubations	2.3	2.4	.62
ED CVL	1.4	1.4	.84
ED CT	2.3	2.7	.35
Blunt injuries*	92.3	90.0	< .001
Penetrating injuries*	5.8	7.3	.01
Deaths	3.5	3.4	.91
Admissions to ICU*	19.9	18.1	.042

CT, thoracostomy tube placement; CVL, central venous line insertion; ED, emergency department; ICU, intensive care unit.

* Denotes statistical significance with P value < .05.

Table II
 χ^2 analysis of 2019 versus 2020 cohorts

Outcome per 100 trauma patients	Before stay-at-home orders (n = 4,073)	After stay-at-home orders (n = 4,080)	P value
Operations*	11.3	9.6	.01
ED intubations	2.5	2.4	.93
ED CVL	1.4	1.4	.99
ED CT	2.8	2.7	.78
Blunt injury*	91.9	90.0	.004
Penetrating injury	6.7	7.3	.35
Death	3.3	3.4	.82
Admissions to ICU	18.8	18.1	.47

CT, thoracostomy tube placement; CVL, central venous line insertion; ED, emergency department; ICU, intensive care unit.

* Denotes statistical significance with P value < .05.

Table III
Volume of trauma patients

Time	2019 (% within y)	2020 (% within y)	P value
April*	638 (15.7%)	491 (12.0%)	< .0001
May*	730 (17.9%)	656 (16.1%)	.0270
June*	643 (15.8%)	737 (18.1%)	.0066
July	705 (17.3%)	732 (17.9%)	.4675
August	693 (17.0%)	747 (18.3%)	.1310
September	664 (16.3%)	717 (17.6%)	.1321

* Denotes statistical significance with P value < .05.

3,510 from the 6 months before stay-at-home orders and 4,073 from April to September of the previous year. There were no differences in rates of resident intubations, resident central line placements, and resident chest tube placements. ED disposition to the operating room and blunt trauma decreased compared with the previous years. There was no difference in ED disposition to the operating room in the 6 months before stay-at-home orders. These results demonstrate sustained educational opportunities during the pandemic in regards to performing procedures as well as performing trauma evaluations. No residents evaluating trauma patients during this period were diagnosed with COVID-19, which demonstrates that trauma services were conducted safely and effectively during this period.

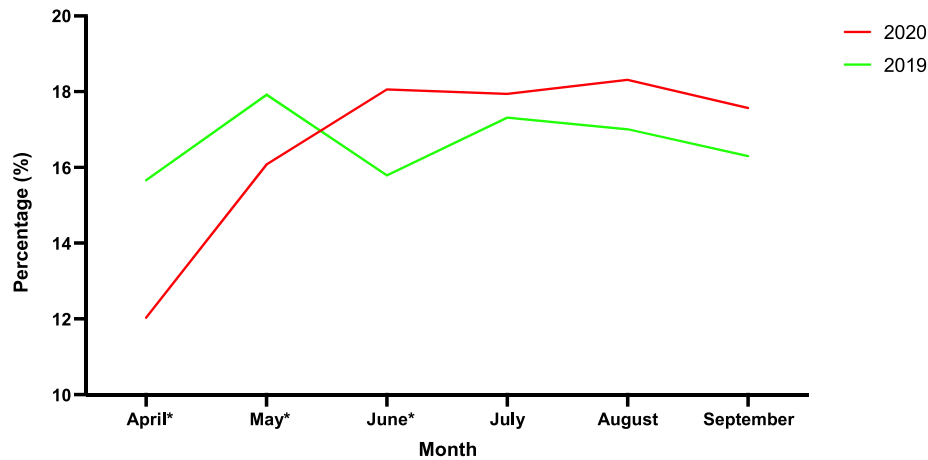
In order to minimize the spread of COVID-19, aerosolizing procedures have been examined in order to maximize safety. Proper airway management including avoiding inadequate seal during ventilation and minimizing cardiopulmonary resuscitation before intubation can decrease aerosolization.¹¹ Other recommendations include minimizing bag–valve–mask ventilation and flow of oxygen, covering patients with surgical masks, RSI with video laryngoscope, and earlier intubation, with some institutions intubating patients before they enter the hospital.^{8–10} In accordance with safety concerns, our institution has developed more protocols to minimize transmission, outlined in the methods section. Every patient

requiring chest tube placement or intubation is brought to the negative pressure room, where the procedures are performed. RSI is performed using a video laryngoscope to maximize distance from the patient. Once a definitive airway or chest tube is achieved, the patient is transferred back to the trauma bay to finish the trauma survey. These practices minimize the risk of aerosolizing transmission to trauma residents and staff since COVID-19 status of the patient is unknown.

During the period of this study, our division did not test all trauma admissions, only patients going to the operating room, for a procedure, or symptomatic for COVID-19. After the study, our institution started testing all trauma patients who will be admitted to the hospital or have surgery performed, to protect staff on the floor and to know the status of the patients. This accounts for a low number of patients who tested positive for COVID-19 at the time of the study. The true number of trauma patients with COVID-19 was probably higher. Availability of screening COVID-19 testing improved as resources improved throughout the pandemic.

One of the most important safety adjuncts has been required masks and eyewear protection. N95 masks, medical masks, or simple cloth masks have proven to be 99.9%, 97%, and 95% effective, respectively, at limiting transmission.¹⁸ Ocular transmission has been demonstrated with COVID-19, which can lead to access of the nasolacrimal system leading to hematogenous or respiratory transmission.¹⁹ Past coronavirus research identified the presence of coronavirus by polymerase chain reaction in tears and is suspected to potentially cause conjunctivitis.^{20,21} The combination of past and present research pointing to ocular transmission has led to recommendations for protective eyewear, which is mandated by our institution.^{22,23} The combination of proper PPE and screening has helped minimize transmission and recognize risk of transmission in order to create a safe environment for trauma residents and staff.

Our trauma presentation trends are similar to the current literature. Our study demonstrated a decrease in trauma patient presentations during the first 2 months after the stay-at-home



* Denotes statistical significance with p-value <.05

Fig 1. Line graph of trauma presentations per month as percentage of yearly volume. (Color version of figure is available online.)

orders compared with the prior year. The decrease was followed by a significant increase in June and a nonsignificant difference in the total number of patients when comparing 2019 to 2020. New Zealand had a decrease of 43% in all injury-related admissions and a 50% reduction in major injury.¹² Kamine et al showed an overall decrease in trauma admissions including motor vehicle crash and nonmotor vehicle crash admissions.¹³ Santa Clara County, California also showed a 4.8-fold decrease in trauma activations in the 15 days after stay-at-home orders.¹⁴ Our study also demonstrates an increase in the number of presentations for the 6 months after COVID-19 stay-at-home orders compared with the 6 months prior, demonstrating a return to normal volume by comparing 2019 data. In comparison to these studies, our study included a longer collection period and one with lower COVID-19 mortality rates. Lower COVID-19 mortality rates are inversely related to patient presentations, contributing to our increased volume compared to the 6 months before the stay-at-home orders.²⁴ Seasonal variations in trauma exist, with volume increasing based on the amount of sunlight,^{25–27} which may account for the slight increase in trauma volume during the pandemic as compared to the 6 months prior. This prompted comparisons to 2019, which were consistent. Our sustained trauma volume contributes directly to trauma education by having opportunities to conduct trauma surveys. The number of trauma presentations also directly correlate with procedures and operations, which are vital to surgery resident education and development.

Trauma procedures after the stay-at-home orders showed no statistically significant differences compared with 2019 or the 6 months prior. ED disposition to the operating room did not demonstrate a significant difference after the stay-at-home orders compared to the 6 months prior; however, there was a significant difference compared to 2019. Trauma has trended toward more nonoperative management over the last 2 decades, and our institution demonstrates this trend from 2019 to 2020.^{28,29} Death rate and disposition to the intensive care unit showed no significant differences between 2019 and 2020, with fewer operations performed in 2020. An alarming trend was the increase in penetrating trauma shown by a statistically significant increase after stay-at-home orders compared to the 6 months prior. The total number was increased in 2020 compared to 2019 but did not demonstrate statistical significance. This trend has been demonstrated by studies conducted in Washington, DC, Philadelphia, and London with similar results.^{30–32} Future pandemics may lead to similar trends.

This paper did have some limitations. After the conclusion of the period, COVID-19 cases continued to rise, with the highest number of hospital cases occurring during the months after the study. Extensions of this study can be performed to see if results change. During November and into January, the number of COVID-19 cases continued to rise at our institution, which may alter the number of positive cases of presenting trauma patients. Our institution has used virtual conferences and checkouts in order to continue educational activities. Possible future interventions that could increase resident safety demonstrated in the literature include creating resident teams and isolating each one in order to create more distance as well as creating more resident workrooms for increased distance.^{16,17} Future projects may examine efficacy of COVID-19 screening in the trauma population and the rate of COVID-19 in trauma presentations.

In conclusion, the pandemic has changed the landscape of resident education. Most programs are using a virtual format for educational activities. Trauma education has not seen a decrease in patient presentations or procedures during the 6 months after the onset of the pandemic. The risk of COVID-19 transmission can be minimized by using the proper PPE, mindful risk reductions in aerosolizing procedures, and COVID-19 screening, which creates a safer environment for residents as well as other health care workers. Future pandemics may provide additional challenges and examining the responses to COVID-19 will help programs adapt. Trauma education has continued during the pandemic without new deficiencies and remains a vital aspect of surgery education.

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Conflict of interest/Disclosure

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