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Major article

Reusing personal protective equipment (PPE) did not increase surgical site infection in trauma surgical patients during the COVID-19 pandemic: A retrospective cohort study in Michigan Trauma Centers

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A B S T R A C T

Background: Reuse of personal protective equipment (PPE), masks more specifically, during the COVID-19 pandemic was common. The primary objective of this study was to compare pre-pandemic surgical site infection (SSI) rates prior to reuse of PPE, to pandemic SSI rates after reuse of PPE in trauma surgical patients.

Methods: A retrospective cohort analysis collected from the Michigan Trauma Quality Improvement Program database was performed. The pre-COVID cohort was from March 1, 2019 to December 31, 2019 and post-COVID cohort was March 1, 2020 to December 31,2020. Descriptive statistics were used to assess differences between variables in each cohort.

Results: Nearly half (49.8%) of our cohort (n = 48,987) was in the post-COVID group. There was no significant difference in frequency of operative intervention between groups ($p > .05$). There was no significant increase ($p > .05$) between pre- and post-COVID cohorts for superficial, deep, or organ space SSI when reuse of masks was common.

Conclusion: Reuse of PPE did not lead to an increase in SSI in surgical patients. These findings are consistent with previous studies, but the first to be described in the trauma surgical patient population. Studies such as this may help inform further discussion regarding PPE usage as we continue to emerge from the current pandemic with the continuous threat of future pandemics.

During the COVID-19 pandemic, hospitals across the world were tasked with rationing the use of Personal Protective Equipment (PPE); given that the demand far outstripped the worldwide supply. In May 2020, the Royal College of Surgeons of England found that a third of United Kingdom surgeons did not have access to enough masks, gowns, or eye protection.[1] Similar trends were seen in the United States, with approximately 20% of health care providers reporting significant lack of PPE availability.[2] Protocols to preserve this valuable resource were frequently altered to accommodate the overwhelmingly low supply. Over the course of the pandemic, policy largely focused on preserving supply by reusing facemasks and other items of PPE.[3] In the pre- COVID-19 pandemic era, common surgical practice involved single use PPE for each procedure. However, as the pandemic progressed, health care providers were encouraged to reuse PPE (eg, masks) and other accompanying items repeatedly.[3,4]

PPE, including masks, is universally recommended in the operating room as a means to prevent surgical site infection (SSI) and maintain sterility.[5] During the COVID-19 pandemic, the American College of Surgeons extended this recommendation to include N95 masks as a measure to mitigate spread of viral particles in those confirmed or suspected to have COVID-19.[6] Trauma surgical patients carry unique risk factors that can contribute to developing SSI. Hollow viscus injury, BMI > 30, blood transfusion, and injury severity score greater than 16 have been shown to increase the risk of SSI.[7] Well known mitigation strategies such as perioperative antibiotics, glycemic control, maintaining normothermia, adequate oxygenation, etc. are regularly employed to prevent SSI and are well supported in the

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literature.[8] Given the repetitive use of PPE during the COVID-19 pandemic and the perceived role it plays in reducing SSI, rates of infection in trauma patients were of relevant interest during this time period.

Reports from multiple surgical disciplines and institutions across the globe have reported unchanged or fewer SSIs during the pandemic era.[9-13] Given this reporting, the primary objective in this study was to compare SSI rates prior to reuse of PPE (masks) vs SSI rates after reuse of PPE to determine if PPE reuse affected outcomes related to SSI in trauma surgical patients. Further, we were also interested in evaluating if secondary outcomes such as hospital length of stay (LOS), varied according to cohort.

METHODS

IRB approval was obtained prior to initiation of this study. No direct human interaction occurred during this study and anonymity was maintained. Thus, individual participant informed consent was not needed. For this study, we followed the definition used by the Centers for Disease Control and Prevention for SSI. SSI is defined as postoperative infections that have occurred within 30 days in superficial, deep incisional, or deep organ spaces.[14]

This work was based on a retrospective cohort study limited to the collection of existing data from the Michigan Trauma Quality Improvement Program database. Michigan Trauma Quality Improvement Program is a collaborative quality initiative between 29 American College of Surgeons verified Level I and II trauma centers in Michigan. Data are collected from trauma registries at each hospital. Trained registrars then abstract the data and submit in 4 month intervals to the coordinating body. The data set included 48,987 patients and multiple variables containing information on several demographic and relevant clinical characteristics (eg, patient age, mechanism of injury, injury severity score, comorbidities, operations performed) as well as hospital admission and discharge date. Cohorts were assigned such that patients admitted between March 1, 2019, and December 31, 2019, were placed in the pre-COVID group (ie, control group) and patients admitted from March 1, 2020, to December 31, 2020, were placed in the post-COVID group (ie treatment group). No interaction with the patient or their identifiable medical record occurred during the course of this study.

The dataset was assessed for missingness. Density plots were created to assess normality of interval data and counts. Frequencies were calculated for categorical data to gauge overall balance. Descriptive statistics were performed on all variables across and between cohorts. We estimated the mean and standard deviation of normally distributed interval data, the median and interquartile ranges of skewed interval data, and the counts and frequencies of categorical data. Patient characteristics were then tested to determine evidence for statistical differences between the 2 cohorts using t-tests (Mann-Whitney, if skewed) for continuous variables or Chi-squared (Fisher exact tests if small, expected counts) for categorical variables. All statistical analysis were carried out in R statistical programming language.[15]

Unadjusted outcomes were compared between the 2 periods using chi-squared or Fisher exact tests. To account for the possibility that the patient population may have changed during the COVID-19 period, propensity scores were estimated using gradient boosted machines in which the “treatment” is the cohort group, and the patient characteristics, age, race, and sex are the features. The propensity scores were converted to weights, and the primary outcomes were compared using the weighted version of the Chi-squared test. There are limited guidelines for how to combine imputation with propensity score analyses, hence we used list-wise deletion with regards to age, race, and sex, in our calculation of propensity scores (N = 48,987).

RESULTS

Our cohort (n = 48,987) was split such that 49.8% were in the post-COVID group. Across both groups, 86.9% identified as white and 53.6% were male. The median age was 66.4 years. Blunt injury was the most common mechanism of injury (94.8%). On presentation to the emergency department, the average patient was hypertensive (systolic blood pressure 144 mm Hg) but otherwise had vital signs within normal limits. Median injury severity score (ISS) was 9. Neurologic exam revealed Glasgow Coma Scale score of 15 (E4V5M6). Less than 10% required emergent intubation in the field or emergency department.

Patients presented with serious injury in 54.9% of cases as defined by the abbreviated injury scale . Injuries rated as moderate, severe, critical, and maximum followed in frequency. Laparotomy, thoracotomy, sternotomy, neck exploration, amputation, and or pelvic packing surgery for hemorrhage control was rare. Once admitted, 1% or less of patients had abdominal compartment syndrome, abdominal fascia left open, acute kidney injury, acute respiratory distress syndrome, cardiac arrest and CPR, catheter associated UTI, deep SSI, enterocutaneous fistula, organ space SSI, osteomyelitis, sepsis, superficial SSI, or wound disruption. Patients spent a median of 3.8 (1.99-6.14) days in the hospital (ie, LOS).The most common medical comorbidities among our cohort were COPD (9.34%), diabetes (15.7%), and tobacco use (24.1%). Antiplatelet therapy (27.8%) was more common than anticoagulant therapy (1.2%).

When comparing the continuous data between cohorts, our analysis showed that age, LOS, O_2 saturation, injury severity score (ISS), blood pressure, pulse, temperature, and respiratory rate differed significantly between the pre- and post-COVID cohorts. The average blood pressure ($p < .001$), median age ($p < .001$), and LOS ($p = .04$) were higher in the pre-COVID cohort, whereas the average pulse ($p < .001$), temperature ($p < .001$), oxygen saturation ($p < .001$), ISS ($p < .001$), and respiratory rate ($p < .001$) were higher in the post-COVID cohort. The average BMI did not differ statistically ($p = .103$) between cohorts (Table 1).

For certain demographic variables, we found that the proportion of patients admitted to the hospital by race and sex differed by cohort. The admission rate among Black patients was higher in the post-COVID cohort (9.7%) than pre-COVID (8.6%, $p < .001$). White (86.4%) and other race (3.9%) patients had a lower admission rate in the post-COVID period than the pre-COVID era (87.3% and 4.2% respectively, $p < .001$). Women were admitted less frequently post-COVID ($p < .001$), while men saw an increase ($p < .001$) in admission rate.

Blunt injury rates decreased from pre- to post-COVID while the rate of penetrating injuries increased ($p < .001$). More patients received respiratory assistance in the post-COVID cohorts relative to the pre-COVID cohort ($p < .001$). Pre-existing conditions such as smoking, diabetes, and peripheral arterial disease were statistically

Table 1
Descriptive statistics of continuous data between cohorts showing the means or medians and "(standard deviation)" or "[IQR]," respectively

Variable	Pre-COVID	Post-COVID	*p*-value
BP (mm Hg)	144.7 (28.65)	143.53 (28.5)	<.001
Pulse (bpm)	85 (18.47)	86.26 (19.11)	<.001
Temperature (F)	98 (0.79)	98.03 (0.82)	<.001
Resp. Rate (bpm)	18.43 (3.53)	18.63 (3.79)	<.001
BMI (kg/m2)	46.51 (12.01)	46.69 (12.21)	.103
Age (y)	68 [47.81, 82]	65 [42, 80.78]	<.001
LOS	3.81 [2.03, 6.11]	3.78 [1.96, 6.16]	.04
O2 Sat. (%)	97 [95, 99]	98 [95, 99]	<.001
ISS	9 [8, 12]	9 [8, 13]	<.001

p-values corresponding *t*-test or Mann U Whitney test results are also reported.

different between cohorts. The rate of those with diabetes was lower (p = .001) in the pre-COVID cohort while there were higher rates of tobacco use ($p < .001$) and peripheral arterial disease (p = .032) in the post-COVID cohort. Notably, there was no difference in COPD rates between cohorts (p = .057). Abbreviated injury scale did not vary significantly with cohort ($p > .05$).

There was no difference in the frequency of surgical intervention (laparotomy, sternotomy, thoracotomy, extremity/neck exploration, amputation, and pelvic packing) between the 2 cohorts ($p > .05$). Open abdominal fascia at the completion of the initial laparotomy occurred more frequently in the post-COVID group (p = .002). Finally, our analysis revealed that after accounting for potential population differences between cohorts, infection rates did not increase from pre- to post-COVID for any of the infection types (ie, superficial (p = .978), deep (p = .416), organ space infections (p = .973)).

DISCUSSION

The primary objective of this study was to compare SSI rates prior to reuse of PPE to SSI rates after reuse of PPE to determine if PPE reuse affected outcomes related to superficial, deep, or organ space wound infections in trauma patients. There were significant differences between cohorts in demographic variables, vital signs on presentation, mechanism of injury, hospital LOS, and ISS. Despite this, there was no statistically significant difference in the frequency of surgical intervention between cohorts. Furthermore, we saw no increase in superficial, deep incisional, or deep organ space SSI in the pre- and post-COVID cohorts after PPE was reused.

Based on our review of the literature, this is the first study investigating SSI rates in trauma surgical patients in the pre- and post-COVID eras. Our findings are consistent with previously published studies investigating SSI rates in other surgical populations. Repetitive use of surgical masks was not shown to increase SSI in pediatric general surgical cases.[13] This was further substantiated among adult patients undergoing operations across all surgical subspecialties in a single center study conducted by Malhotra et al.[9] They concluded that elimination of single use PPE was associated with a 3% decrease in SSI rate despite an increase in surgical volume and number of contaminated/dirty cases.

There are other factors that may also be contributing toward this finding. Ishibashi et al. investigated SSI in patients undergoing surgical resection for gastrointestinal cancers.[10] They found a significant decrease in the number of SSIs in their post-pandemic cohort. They contributed this decrease to an increase in use of hand sanitizer and other forms of hand hygiene seen during the pandemic. A reduced hospital length of stay was also posited as a reason fewer SSIs were observed.[10] We demonstrated a significantly shorter LOS in the post-COVID cohort, but we did not notice a significant decrease in SSI. In a monocentric study of adult patients undergoing both emergency and elective surgical general surgical procedures and found to be COVID-19 negative, Losurdo et al. also demonstrated a significant decrease in postoperative SSIs.[11] Mandatory use of PPE and absence of hospital visitors were found to be significant contributors to this decrease in observed infections.

Our study is limited in that our cohort was created from a multi-institutional database with varying COVID mitigation strategies. We were unable to assess compliance of hand hygiene among health care providers or visitors, visitor policies, or the magnitude of change in PPE use in pre- and post-COVID cohorts at each institution. Although not standardized between institutions, there was definite change in PPE use from single use to multiple re-uses during the time period chosen. To the best of our knowledge, masks were the only form of PPE routinely used multiple times. Furthermore, our study was isolated to institutions in Michigan; where there is a significant Caucasian population and an abundance of blunt trauma. For this reason, our findings may be poorly applicable to more racially diverse regions and communities with higher rates of penetrating trauma.

As we continue emerging from the COVID-19 pandemic, policy regarding PPE use and other mitigation strategies will continue to evolve. We were able to demonstrate no significant increase in SSI despite reusing PPE. Studies such as this one could help guide these discussions moving forward and may ultimately lead to a reduced financial burden on institutions.

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