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Frequency and Analysis of Unplanned Extubation in Coronavirus Disease 2019 Patients

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Objectives: To determine if patients with coronavirus disease 2019 had a greater number of unplanned extubations resulting in reintubations than in patients without coronavirus disease 2019.

Design: Retrospective cohort study comparing the frequency of unplanned extubations resulting in reintubations in a group of coronavirus disease 2019 patients to a historical (noncoronavirus disease 2019) control group.

Setting: This study was conducted at Henry Ford Hospital, an academic medical center in Detroit, MI. The historical noncoronavirus disease 2019 patients were treated in the 68 bed medical ICU. The coronavirus disease 2019 patients were treated in the coronavirus disease ICU, which included the 68 medical ICU beds, 18 neuro-ICU beds, 32 surgical ICU beds, and 40 cardiovascular ICU beds, as the medical ICU was expanded to these units at the peak of the pandemic in Detroit, MI.

Patients: The coronavirus disease 2019 cohort included patients diagnosed with coronavirus disease 2019 who were intubated for respiratory failure from March 12, 2020, to April 13, 2020. The historic control (noncoronavirus disease 2019) group consisted of patients who were admitted to the medical ICU in the year spanning from November 1, 2018 to October 31, 2019, with a need for mechanical ventilation that was not related to surgery or a neurologic reason.

Interventions: None.

Measurements and Main Results: To identify how many patients in each cohort had unplanned extubations, an electronic medical records query for patients with two intubations within 30 days was performed, in addition to a review of our institutional quality and safety database of reported self-extubations. Medical charts were manually reviewed by board-certified anesthesiologists to confirm each event was an unplanned extubation followed by a reintubation within 24 hours. There was a significantly greater incidence of unplanned extubations resulting in reintubation events in the coronavirus disease 2019 cohort than in the noncoronavirus disease 2019 cohort (coronavirus disease 2019 cohort: 167 total admissions with 22 events—13.2%; noncoronavirus disease 2019 cohort: 326 total admissions with 14 events—4.3%; $p < 0.001$). When the rate of unplanned extubations was expressed per 100 intubated days, there was not a significant difference between the groups (0.88 and 0.57, respectively; $p = 0.269$).

Conclusions: Coronavirus disease 2019 patients have a higher incidence of unplanned extubation that requires reintubation than noncoronavirus disease 2019 patients. Further study is necessary to evaluate the variables that contribute to this higher incidence and clinical strategies that can reduce it.

Key Words: anesthesia; coronavirus disease 2019; extubation; intensive care unit; intubation; sedation; unplanned extubation

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Unplanned extubations of critically ill patients are always hazardous to the patient; but, during the outbreak of coronavirus disease 2019 (COVID-19), these events pose an additional significant risk to exposed healthcare workers (HCWs). The literature of unplanned endotracheal extubations in ICUs reveals significant variability in published rates (1–3). A 2012 review of 50 published studies found that unplanned extubation occurred at a rate of 0.1–3.6 events per 100 intubation days (1) and other studies reporting rates of 3–9.5 events per 100 patients (4, 5). Reintubation increases the risk of tracheal injury

complications, pneumonia, and pneumothorax (6). Patients with unplanned extubation requiring reintubation tend to have longer ICU stays, extended time under mechanical ventilation, and a higher likelihood of needing chronic care if they survive (7).

It was perceived that a greater than expected number of these events were occurring in the COVID-19 patient population at our hospital and that the COVID-19 patients exhibited lower levels of sedation when using standard sedation protocol. This idea was supported by a letter to the editor by Berkow et al (8), which stated that unplanned extubation events might occur at a higher rate in COVID-19 patients. Considering this background information, the extent of this crisis in Detroit, MI, and the stresses on available resources, a retrospective cohort analysis was performed to define the rate of unplanned extubations, resulting in reintubations in intubated COVID-19 patients compared with a historic control group of intubated, non-COVID-19 patients (pre-COVID-19 crisis). Based on our observations of the unique pathology of COVID-19 patients, it was hypothesized that there is a higher frequency of unplanned extubations resulting in reintubation in this population.

MATERIALS AND METHODS

After obtaining approval and a waiver of informed consent from our Institutional Human Subjects Review Board, a search of the electronic medical record (EMR) (EPIC; Epic Systems Corporation, Verona, WI) was performed to identify all patients diagnosed with COVID-19 who were intubated for respiratory failure from March 13, 2020 (date of first institutional COVID intubation), to April 12, 2020, representing a time period of 30 days. COVID-19 diagnosis was made by reverse transcription polymerase chain reaction (RT-PCR) of a nasopharyngeal sample conducted on a RT-PCR platform validated by the Henry Ford Clinical Microbiology Laboratory. The COVID-19 unplanned extubation group was selected by identifying those patients who self-extubated and required reintubation within 24 hours by two methods: 1) EMR query for patients with two intubations during the 30-day time period and 2) review of our institutional quality and safety database of reported unplanned extubations. The medical charts of all COVID-19 patients identified as an unplanned extubation were manually reviewed by board-certified anesthesiologists to confirm that the unplanned extubation and reintubation within 24 hours were accurate. All of the patients included in this cohort had an end date of intubation in their medical record, either because they were deceased, had been removed from intubated mechanical ventilation, or received a tracheostomy.

A historic control group of non-COVID-19 patients was selected from a 12-month period preceding the onset of the COVID-19 crisis (November 1, 2018, to October 31, 2019). A different time period from that of the COVID-19 cohort was selected, because this analysis required the same number of total ventilator days for each cohort. There were very few non-COVID patients admitted from March 12, 2010, to April 13, 2020, with 80–90% of ICU beds occupied by COVID-19 patients. In order to have the same number of total intubated days in both groups, it was necessary to look at a longer time frame. Additionally, as

COVID-19 testing was not being performed at the hospital prior to early March, 2020, it would be impossible to verify whether patients in the several months prior to this date were infected with COVID-19. The criteria for selection were: 1) admission to the medical ICU with respiratory etiology, 2) need for mechanical ventilation due to hypoxemic respiratory failure/acute respiratory distress syndrome, and 3) ventilation needs were not related to a surgical procedure or had a neurologic reason for the intubation. Patients were identified through a query of our EMR and quality database as above. The same process of chart review and evaluation for unplanned extubation was performed for this non-COVID-19 historic control group. Only patients requiring reintubation within 24 hours were included to remove patients who self-extubated during a weaning protocol from the analysis.

For this study, unplanned extubation was defined as removal of the endotracheal tube by action of the patient and required reintubation within 24 hours (9). Endotracheal tube cuff herniation and other issues with the endotracheal tube cuff or pilot balloon malfunction, requiring intervention, were not included as unplanned extubation events. An intubated day included: 1) any calendar day with documented mechanical ventilation on or following the date of intubation or 2) arrival to the ICU of an intubated patient from an outside medical facility, and intubated days ended on the date of extubation, tracheostomy, or death. None of the patients in the COVID-19 cohort were still orally intubated at the time of analysis. For each of the patients identified, the following demographic data were collected: sex, age, weight, body mass index (BMI), and race.

Numerical variables were summarized with mean and SD or median and interquartile range and compared using two-sample *t*-test or Wilcoxon rank-sum test. Categorical variables were summarized with frequencies and proportions and compared using Chi-square test or Fisher exact test. A *p* value of less than 0.05 was considered statistically significant.

RESULTS

We identified 167 COVID-19 patients and 326 non-COVID-19 cohort patients. The demographic breakdown of the patients in each group is presented in **Table 1**. Total intubated days were similar in both groups: COVID-19 = 2505 days and non-COVID-19 = 2451 days (**Table 2**). The mean duration of intubation was greater in COVID-19 patients than in non-COVID-19 patients (15.0 and 7.5 d, respectively; $p < 0.001$) (**Table 1**).

When the results are expressed in terms of the number of patients with at least one event over the total number of patients, the frequency in COVID-19 patients was 10.8% (18 patients with at least one event out of 167 total patients; 95% CI, 6.5–16.5%) and in non-COVID-19 patients 4.0% (13 patients with at least one event out of 326 total patients; 95% CI, 2.1–6.7%). The 95% CI for the difference of the frequency between the two groups was 1.1–12.4% and the difference is statistically significant with $p = 0.006$ (**Table 1**).

As several patients had more than one event, the reintubation rate was also calculated (defined as the number of reintubation events divided by number of intubations). The reintubation rate in COVID-19 patients was 12.9% (22 reintubation events out of 171 total intubations; 95% CI, 8.2–18.8%). The reintubation rate in non-COVID-19 patients was 4.3% (14 reintubation events

TABLE 1. Distribution of Demographics, Reintubation Events, and Intubated Days in All Patients Studied

Patient Characteristics	All	COVID-19 (n = 167)	Non-COVID-19 (n = 326)	p
Race, n (%)				
Caucasian	156 (31.6)	13 (7.8)	143 (43.9)	< 0.001
African/American	267 (54.2)	130 (77.8)	137 (42)	
Others/unknown	70 (14.2)	24 (14.4)	46 (14.1)	
Sex, n (%)				0.015
Female	195 (39.6)	53 (31.7)	142 (43.6)	
Male	298 (60.4)	114 (68.3)	184 (56.4)	
Patients with at least one reintubation ^a , n (%)	31 (6.3)	18 (10.8)	13 (4)	0.006
Body mass index, mean (sd)	30.87 (10.17)	33.14 (9.55)	29.7 (10.29)	< 0.001
Age, mean (sd)	62.99 (15.2)	64.05 (14.59)	62.45 (15.49)	0.226
Intubated days, mean (sd)	10.05 (9.94)	15 (11.72)	7.52 (7.78)	< 0.001

COVID-19 = coronavirus disease 2019.

^aA reintubation event refers to a reintubation after self-extubation within 24 hr.

out of 327 total intubations; 95% CI, 2.4–7.1%). The 95% CI for the difference of the reintubation rate between the two groups was 2.7–14.5% and the difference was statistically significant with $p < 0.001$ (Table 2).

The COVID-19 group contained a higher proportion of males, higher BMI, and higher proportion of African Americans than the historic non-COVID-19 group. The demographic distributions of the reintubated and nonreintubated COVID-19 and non-COVID-19 patients are shown in Tables 3 and 4, respectively. Within the COVID-19 group, there were no significant differences in demographic distribution between the patients who had at least one unplanned extubation event requiring reintubation and the nonreintubated patients (Table 3).

DISCUSSION

The main finding of our study was a significantly greater Frequency of unplanned extubations resulting in reintubations in our COVID-19 patient population compared with our control

TABLE 2. Occurrence of Reintubations in Coronavirus Disease 2019 and Noncoronavirus Disease 2019 Patients

Reintubations	COVID-19 (n = 167)	Non-COVID-19 (n = 326)	p
Total reintubation ^a	22	14	
Total intubated days	2505	2451	
Reintubations ^a per 100 intubated days	0.878	0.571	0.269
Reintubations ^a per patient	0.132	0.043	< 0.001

COVID-19 = coronavirus disease 2019.

^aA reintubation event refers to a reintubation after self-extubation within 24 hr.

group (10.8% vs 4.0%; $p = 0.006$), but the rate of events per 100 intubated days was not significantly different (0.88 with 95% CI, 0.55–1.32 vs 0.57 with 95% CI, 0.31–0.96; $p = 0.269$).

In a 2012 review of 50 published studies, unplanned extubations, including self-extubations and accidental extubations by a HCW during care, occurred at a rate of 0.1–3.6 events per 100 intubation days (1). The risk factors identified as associated with unplanned extubations included male sex (odds ratio [OR] = 4.8), Acute Physiology and Chronic Health Evaluation score ≥ 17 (OR = 9.0), chronic obstructive pulmonary disease, restlessness/agitation

TABLE 3. Demographics, Intubated Days, and Reintubation Frequency in Coronavirus Disease 2019 Patients

Patient Characteristics	COVID-19 Patients		p
	Reintubated (%)	Nonreintubated (%)	
Race, n (%)			
Caucasian	0 (0)	13 (8.7)	0.532
African American	15 (83.3)	115 (77.2)	
Other/unknown	3 (16.7)	21 (14.1)	
Sex, n (%)			
Female	7 (38.9)	46 (30.9)	0.673
Male	11 (61.1)	103 (69.1)	
Body mass index, mean (sd)	35.26 (7.92)	32.89 (9.72)	0.158
Age, mean (sd)	62.44 (18.12)	64.24 (14.17)	0.804
Intubated days, mean (sd)	15.67 (12.15)	14.92 (11.7)	0.751

TABLE 4. Demographics, Intubated Days, and Reintubation Frequency in Noncoronavirus Disease 2019 Patients

Noncoronavirus Disease 2019 Patients			
Patient Characteristics	Reintubated ^a (%)	Nonreintubated ^a (%)	<i>p</i>
Race, <i>n</i> (%)			
Caucasian	7 (53.8)	136 (43.5)	0.685
African American	4 (30.8)	133 (42.5)	
Other/unknown	2 (15.4)	44 (14.1)	
Sex, <i>n</i> (%)			
Female	7 (53.8)	135 (43.1)	0.633
Male	6 (46.2)	178 (56.9)	
Body mass index, mean (sd)	28.12 (6.21)	29.77 (10.42)	0.772
Age, mean (sd)	60.08 (18.11)	62.55 (15.4)	0.695
Intubated days, mean (sd)	14.08 (11.67)	7.25 (7.48)	0.009

^aA reintubation event refers to a reintubation after self-extubation within 24 hr.

(OR = 3.3–30.6), lower sedation level (OR = 2.0–5.4), higher consciousness level (OR = 1.4–2.0), and use of physical restraints (OR = 3.1). Reintubation rates ranged from 1.8% to 88% of unplanned extubations. Thirteen studies assessed preventative measures for avoiding unplanned extubations. These studies focused on data collection tools, standardization of procedures, staff education, staff surveillance, and the identification and management of high-risk patients. These studies reported reductions in unplanned extubation rates ranging from 22% to 53%. Unplanned extubations are a particular problem with pediatric patients. After a children's hospital instituted quality improvement measures, their unplanned extubation rate of 1.2 per 100 ventilator days was reduced to 0.3 per 100 ventilator days (10). The best methods of securing the endotracheal tube and use of physical restraints remain controversial issues (1).

Expressing unplanned extubations as events per 100 intubated days is a common way to report this problem, but it does not tell the whole story when expressing information about COVID-19 patients. This study indicated that there were 2.5–3 times more unplanned extubations requiring reintubation in COVID-19 patients than that in the control group. Each of these events exposed both HCWs and the patients to avoidable risks and was stressful events. COVID-19 patients remained intubated twice as long as the control cohort. During prolonged illness, many of them grew weaker and died, suggesting that the initial time period after intubation may be the highest risk period. This was not further evaluated, and the degree of sedation required for these two different sets of patients was not analyzed in this study.

On extensive chart review of these self-extubation events in COVID-19 patients, most of these events were unwitnessed, where teams were alerted about self-extubation via ventilator alarms. Although this hospital did not have any provisions of

telemedicine/surveillance in the ICUs, there are other hospitals in our system that used make-shift surveillance systems with baby monitors to watch closely intubated COVID-19 patients. Implementation of additional monitoring methods could allow for more rapid response, but the impact is uncertain and requires further study.

There were several limitations to this study. The population included patients treated at a single hospital. Further investigation is needed to determine if the higher frequency of these events in COVID-19 patients is observed at other medical centers. As this was a retrospective chart review, any confounding variables that were not available in the patient EMR could not be incorporated into the analysis. The authors are conducting a prospective study that will allow for collection of additional relevant data and will allow for inferences to be made regarding causality. A matched design would have been ideal to correct for confounding variables; however, this was not possible since this was a retrospective observational study. Another limitation was that it was only possible to report intubated days, but not ventilator days, as ventilator days can continue after a tracheostomy and patients may be discharged to LTAC on ventilator, and that mechanical ventilation data are not available in the medical record. Additionally, reviewers were not blinded to the patients' COVID-19 status and a single reviewer was assigned per chart, although the main end point of unplanned extubation was not subjective or ambiguous, so this was unlikely to introduce bias during data collection. Despite the limitations of this study, these previously unreported findings lay the groundwork for a more robust analysis and the development of clinical strategies that will reduce the frequency of unplanned extubation in COVID-19 patients.

CONCLUSIONS

In summary, our findings indicate that, for various reasons, COVID-19 patients have a greater frequency of unplanned extubation that requires reintubation within 24 hours than non-COVID-19 patients. It will be important to evaluate what factors contribute to the increased frequency in COVID-19 patients and what clinical measures can decrease the occurrence of these dangerous events.

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