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ORIGINAL RESEARCH

Success and complications of endotracheal intubation in critical care settings under COVID-19 protocols

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Abstract

Introduction The Covid-19 pandemic has required new protocols for endotracheal intubation mandating cumbersome personal protective equipment and modifications to prior intubation procedures. We assessed the success and complications of endotracheal intubation under such protocols.

Methods We conducted a prospective study of endotracheal intubation in the emergency department, intensive care unit, or ward between September 11, 2018 and June 11, 2020 at two urban hospitals. Using a standardized form, we included basic demographics, intubation techniques, and success, and pre-specified complications, defined as critical (cardiac arrest or failure to intubate) or non-critical. At both sites, Covid-19 intubation protocols took effect on March 11, 2020, and we compared pre-post patients. The primary outcome was first-pass success without complications. Secondary outcomes included first-pass success and complications. We analysed by descriptive techniques.

Results Overall, we collected 1534 patients before March 11, 2020 and 227 after; groups were similar in age and sex distribution. Staff endotracheal intubation increased from 37 to 63%. First pass success was 1262/1534 (82.3%) pre versus 195/227 (85.9%) post, for a difference of 3.6% (95% CI − 1.8–8.0%). First pass success without complications was 1116/1534 (72.8%) pre versus 168/227 (74.0%) post, for a difference of 1.3%, (95% CI − 5.2–7.0%). There were 226 complications pre (14.7%) versus 47 (20.7%) post, for a difference of 6.0%. (95% CI 0.6–12.1%).

Conclusions New pandemic endotracheal intubation protocols did not result in a decrease in first-pass success, or first-pass success without complications.

Keywords COVID-19 · Pandemic · Intubation

Résumé

Introduction La Pandémie de Covid-19 a nécessité de nouveaux protocoles d'intubation endotrachéale exigeant un équipement de protection individuelle encombrant et des modifications aux procédures d'intubation antérieures. Nous avons évalué le succès et les complications de l'intubation endotrachéale dans le cadre de tels protocoles.

Méthodes Nous avons mené une étude prospective de l'intubation endotrachéale dans le service des urgences, l'unité de soins intensifs ou dans un service de soins intensifs entre le 11 septembre 2018 et le 11 juin 2020 dans deux hôpitaux urbains.

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À l'aide d'un formulaire standardisé, nous avons inclus les données démographiques de base, les techniques et le succès d'intubation, ainsi que les complications pré-spécifiées, définies comme critiques (arrêt cardiaque ou échec d'intubation) ou non critiques. Sur les deux sites, les protocoles d'intubation Covid-19 sont entrés en vigueur le 11 mars 2020 et nous avons comparé les patients avant et après. Le principal résultat a été un premier passage réussi sans complications. Les résultats secondaires comprenaient le succès au premier passage et les complications. Nous avons analysé par des techniques descriptives.

Résultats Dans l'ensemble, nous avons recueilli 1534 patients avant le 11 mars 2020 et 227 après; les groupes étaient similaires en termes de répartition par âge et par sexe. L'intubation endotrachéale par le personnel est passée de 37 % à 63 %. Le succès du premier passage était de 1262/1534 (82,3 %) avant contre 195/227 (85,9 %) après, soit une différence de 3,6 % (IC à 95 % –1,8 à 8,0 %). Le succès du premier passage sans complications était de 1116/1534 (72,8 %) avant contre 168/227 (74,0 %) après, soit une différence de 1,3 %, (IC à 95 % -5,2 à 7,0 %). Il y avait 226 complications avant (14,7 %) contre 47 (20,7 %) après, pour une différence de 6,0 %. (IC à 95 % de 0,6 à 12,1 %).

Conclusions Les nouveaux protocoles d'intubation endotrachéale pandémique n'ont pas entraîné de diminution du succès du premier passage ou du succès du premier passage sans complications.

Clinician's capsule

What is known about the topic?
The Covid-19 pandemic has necessitated changes to protocols for endotracheal intubation.

What did the study ask?
Do the new intubation protocols decrease first-pass success without complications?

What did this study find?
Compared with pre-pandemic intubations, pandemic protocols do not result in a decrease in first pass success without complications.

Why does this study matter to clinicians?
Physicians can be reassured that pandemic intubation outcomes appear similar.

Introduction

Endotracheal intubation during the Covid-19 pandemic has required new protocols to mitigate viral transmission risk to healthcare providers. [1–3] These involve meticulous donning of cumbersome personal protective equipment, detailed preparation of isolation room equipment, and avoidance of bag-valve-mask ventilation, which potentially delay time to intervention [4] and increase hypoxia. Anaesthetists in Wuhan reported 89% first-pass success while intubating patients with confirmed Covid-19, although hypoxemia and hypotension were common. [5] It is unclear if this success translates to other settings, where non-anaesthetists may provide endotracheal intubation and protocols may differ. We studied endotracheal intubation before and during the pandemic and hypothesized that new protocols would result in similar success.

Methods

Study and setting

This was a prospective cohort at 2 urban teaching hospitals. Each site has approximately 600 acute care beds, 50 intensive care unit (ICU) beds, and 90 000 annual emergency department (ED) visits. Intubations are performed by attending or resident physicians via rapid sequence with a least one nurse (RN) and respiratory therapist (RT) assisting. The research ethics board of Vancouver Coastal Health waived approval.

Patient selection

Since 2018, respiratory therapists have collected data on consecutive patients who are intubated in the ED, ICU, and other non-operating room settings ("wards"). We regularly estimated compliance by interrogating the radiology database for the keywords "intubation" and "endotracheal tube placement" as the reason for radiography, since confirmatory post-endotracheal intubation imaging is mandated. Compliance was 105/131 (78.8%) in January 2019, 104/132 (80.2%) in August 2019, and 111/147 (75.5%) in March 2020.

Protocol

Starting March 11, 2020, all ED endotracheal intubations took place in negative pressure isolation rooms while ICU and ward intubations could take place in regular rooms unless Covid-19 was strongly suspected. An on-call anaesthetist was available at the request of the most responsible physician. While the "before" protocol had no restriction on room attendance, the pandemic protocol allowed only a single physician, RN, and RT to be present, although a

"runner" was assigned to shuttle additional equipment. All four donned personal protective equipment consisting of an N95 mask, eye protection, a surgical gown, and two pairs of gloves.

We recommended video laryngoscopy as the initial technique, but physicians could select other equipment. The team entered the patient room with a modicum of equipment using a pre-loaded airway kit and avoided bag-valve mask ventilation. While physicians previously had wide latitude for induction or paralytic agents, we strongly recommended ketamine 1–2 mg/kg and rocuronium 1.5 mg/kg. After endotracheal intubation placement, RTs attached a viral filter to the circuit. Physicians and RNs were not aware of the study.

Data collection

Using a standardized form, (Online Appendix 1) trained RTs prospectively recorded patient demographics, operator experience, and predictors of difficult laryngoscopy, defined as Cormack-Lehane grade 3 or 4. They collected the endotracheal intubation technique, first-pass success, and pre-specified complications. We grouped complications into critical (cardiac arrest or failure to intubate) or non-critical, including desaturation, mainstem intubation, or esophageal intubation. (Box 1). We divided patients into 2 groups: pre (September 11, 2018 to March 10, 2020), and post (March 11, 2020 to June 11, 2020). We separately assessed ED-based, staff, and resident endotracheal intubations. For the post-group, we accessed patient records to ascertain results from nasopharyngeal swabs or tracheal aspirates to confirm Covid-19 infection.

Box 1 Adverse events

Critical

Cardiac arrest within 5 minutes of induction
Failure to intubate

Non-critical

New oxygen desaturation to less than 92%
Vomiting after induction
Dental or oral trauma due to intubation
Airway trauma due to intubation
Laryngospasm
Esophageal intubation
Right mainstem intubation
Equipment failure (equipment does not work adequately and requires a different piece of equipment; for example the light on a video laryngoscope is ineffective and a new scope is required)

Outcomes

The primary outcome was first-pass endotracheal intubation success without complications. (8) We compared overall first-pass success and critical and non-critical complications.

Analysis

We entered data via REDCap (Vanderbilt University) and analysed via R version 3.6.3. (Foundation for Statistical Computing, Vienna) We could not replace missing data. We describe data using proportions for categorical variables and medians with interquartile ranges (IQR) for continuous variables. We present differences between periods.

Results

We collected 1534 patients in the before-group and 227 patients in the after-group. Mean age was 59 pre- and 60 post; both groups were 34% female. Pre-intubation hypoxia (pre 7.6% vs. post 5.4%) was similar, while difficult airway grades were slightly more common (5.0% vs. 1.7%) in the pre-period. In the post-period, anaesthetists performed more endotracheal intubation, (38% versus 16%, although emergency physician involvement remained stable) resident endotracheal intubation decreased, and video laryngoscopy increased. First pass success and success without complications appeared similar in the ED, and with both staff and residents. (Table 1).

First pass success was 1262/1534 (82.3%) pre versus 195/227 (85.9%) post, for a difference of 3.6% (95% CI − 1.8–8.0%). First pass success without complications was 1116/1534 (72.8%) pre versus 168/227 (74.0%) post, for a difference of 1.3%, (95% CI − 5.2–7.0%). There were 32 critical complications (2.1%) pre and 5 (2.2%) post, for a difference of 0.1%. (95% CI − 3.3 to 1.6%). There were 194 (12.7%) non-critical complications pre and 42 (18.5%) post, for a difference of 5.9% (95% CI 0.8–11.2%), with the difference likely due to equipment issues, particularly with video laryngoscope operation. (Table 1) Overall, 176 patients (77.5%) had Covid-19 tests with 23 (13.1%) positive.

Discussion

We prospectively studied 227 endotracheal intubations under Covid-19 pandemic protocols and compared to 1534 prospectively collected patients intubated under traditional protocols. Patients appeared similar, but senior physicians and anaesthetists performed endotracheal intubation more frequently. Despite potential hindrances such as a small team,

Table 1 Baseline variables, operators, techniques, and outcomes

Variable, *n* (%)	Before (*n* = 1534)	After (*n* = 227)	Difference (95% CI)
Demographics			
Female	521 (34.0)	77 (33.9)	− 0.1 (− 6.9 to 6.6)
Mean age (SD)	59 (14)	60 (15)	1 (− 1 to 3)
ICU	482 (31.4)	64 (28.2)	− 3.2 (− 9.4 to 3.6)
Ward	269 (17.5)	30 (13.2)	− 4.3 (− 8.8 to 1.3)
ED	783 (51.0)	133 (58.6)	7.6 (0.4 to 14.5)
Preparation			
Airway assessment performed	975 (63.6)	150(66.1)	2.5 (− 4.5 to 9.1)
Anesthesia called prior to induction	135 (8.8)	81 (35.7)	26.9 (20.5 to 33.7)
Hypoxia	86 (5.6)	8 (3.5)	− 2.1 (− 4.4 to 1.6)
Pre-intubation pause to confirm plan	887 (57.8)	148 (65.2)	7.4 (0.3 to 14.0)
Anesthesia called after induction	19 (1.2)	6 (2.6)	1.4 (− 0.3 to 4.7)
Cormack-Lehane grade			
Grade I	1096 (71.5)	185 (81.5)	10.0 (3.8 to 15.3)
Grade II	288 (18.8)	27 (11.9)	− 7.9 (− 11.2 to − 1.4)
Grade III[a]	65 (4.2)	3 (1.3)	− 2.9 (− 0.4 to 4.4)
Grade IV[a]	12 (0.8)	1 (0.4)	− 0.3 (− 1.1 to 2.1)
Not recorded	73 (4.9)	11 (4.8)	− 0.1 (− 4.1 to 2.5)
Operator seniority			
Medical student	13 (0.9)	0 (0.0)	− 0.9 (− 1.5 to 1.3)
PGY1 or 2	202 (13.1)	7 (3.1)	− 10.0 (− 7.5 to − 12.6)
PGY3 to 5	482 (31.4)	33 (14.5)	− 16.9 (− 11.0to-21.7)
Fellow	167 (10.9)	24 (10.6)	− 0.3 (− 4.3 to 4.8)
Staff	572 (37.3)	144 (63.4)	26.2 (19.0 to 32.8)
Not specified	98 (6.4)	19 (8.4)	2 (− 1.4 to 6.7)
Operator discipline			
EM	624 (40.7)	94 (41.4)	0.7 (− 6.2 to 7.9)
ICU	502 (32.7)	39 (17.2)	− 15.5 (− 20.7to − 9.4)
Anesthesia	240 (15.7)	86 (37.9)	22.2 (15.7 to 29.2)
Other	88 (5.7)	0 (0.0)	− 5.7 (− 7.1 to − 3.4)
EMS	5 (0.3)	0 (0.0)	− 0.3 (− 0.8 to 0.2)
Not recorded	75 (4.9)	8 (3.5)	
Initial technique			
Direct laryngoscopy	528 (34.4)	27 (11.9)	− 22.5 (− 27.0to − 16.9)
Video laryngoscopy	935 (61.0)	190 (83.7)	22.8 (16.6 to 27.8)
Bougie	36 (2.4)	1 (0.4)	− 1.9 (− 2.9 to 0.6)
Bronchoscope	29 (1.9)	1 (0.4)	− 1.5 (− 2.4 to 1.0)
Surgical airway	0 (0.0)	0 (0.0)	0 (− 2.1 to 0.3)
Not recorded	6 (0.4)	8(3.5)	3.1 (1.2 to 6.7)
Overall success			
First-pass success	1262 (82.3)	195 (85.9)	3.6 (− 1.8 to 8.0)
First-pass success with no complications	1116 (72.8)	168 (74.0)	1.3 (− 5.2 to 7.0)
ED success	*N* = 783	*N* = 133	
First-pass success	658 (84.0)	117 (88.0)	4.0 (− 3.1 to 9.2)
First-pass success with no complications	625 (79.8)	108 (81.2)	1.4 (− 6.6 to 7.8)
Staff success	*N* = 572	*N* = 144	
First-pass success	488 (85.3)	125 (86.8)	1.5 (− 5.5 to 7.0)
First-pass success with no complications	462 (80.8)	111 (77.1)	− 3.7 (− 11.8 to 3.3)
Trainee success	*N* = 873	*N* = 66	
First-pass success	712 (81.5)	57 (86.4)	4.8 (− 5.8 to 11.7)
First-pass success with no complications	655 (75.0)	54 (81.8)	6.8 (− 4.5 to 14.8)

Table 1 (continued)

Variable, *n* (%)	Before (*n* = 1534)	After (*n* = 227)	Difference (95% CI)
Complication summary			
Critical	32 (2.1)	5 (2.2)	− 0.1 (− 3.1 to 1.4)
Non-critical	194 (12.7)	42 (18.5)	5.9 (0.8 to 11.2)
Total	226 (14.7)	47 (20.7)	6.0 (0.7 to 12.2)
Complications			
None	1347 (87.8)	192 (84.6)	3.2 (− 1.4 to 9.0)
Desaturation after induction	126 (8.2)	19 (8.4)	0.2 (− 3.3 to 4.9)
Vomiting/aspiration after induction	21 (1.4)	7 (3.1)	1.7 (− 0.2 to 5.2)
Dental trauma	0 (0.0)	0 (0.0)	0 (− 2.1 to 0.3)
Airway trauma	11(0.7)	0 (0.0)	− 0.7 (− 1.3 to 1.4)
Laryngospasm	5 (0.3)	0 (0.0)	− 0.3 (− 1.8 to 0.8)
Mainstem intubation	3 (0.2)	0 (0.0)	− 0.2 (− 1.9 to 0.7)
Esophageal intubation	18 (1.2)	2 (0.9)	− 0.3 (− 2.4 to 1.3)
Equipment failure	10 (0.7)[b]	14 (6.2)[b]	5.5 (2.8 to 9.7)
Unable to intubate	20 (1.3)	2 (0.9)	− 0.4 (− 1.5 to 0.2)
Cardiac arrest	12 (0.8)	3 (1.3)	0.5 (− 0.6 to 3.4)

SD standard deviation, *ICU* intensive care unit, *ED* emergency department, *PGY* post graduate year, *EMS* emergency medical services

[a]Grades III/IV considered difficult airway

[b]3 and10 equipment failures, respectively were due to problems with video laryngoscopy, such as battery or screen failure

cumbersome personal protective equipment, and lack of bagging, first-pass success without complications was similar in both periods. Critical complications were similar. Results were similar in the ED, and among both staff and residents. This assists clinicians by reporting that new protocols do not appear to decrease endotracheal intubation success.

Importantly, first-pass success increases with operator training, and staff physicians performed a greater proportion of endotracheal intubation in the post-period. It is possible that residents would have less success and more complications. Increased video laryngoscopy may also have assisted. Given lengthy preparation time and lack of bag-mask ventilation, complications such as desaturation might be expected to increase in the post-period, but we did not demonstrate this. The slight increase in complications appeared related to issues with the video laryngoscope., although the clinical significance is unclear.

A chart audit of 52 anaesthetists of 202 endotracheal intubations at 2 Wuhan hospitals reported an 89% first-pass endotracheal intubation success [5]. However, these patients appeared sicker, as pre-intubation oxygen saturation was less than 90% in three-quarters of patients. Of note, anaesthetists only performed 38% of our endotracheal intubations post-pandemic; and ED-based, staff, and resident endotracheal intubation success appeared similar across both time periods.

This was a 2-centre pre-post study that may have an insufficient sample size, especially when assessing rare complications. Compliance review indicates we missed some endotracheal intubations, but it is unclear whether "missed" patients had systematically worse outcomes. There was no quality assurance check, and some forms may have been partially completed. We did not record potentially important factors including endotracheal intubation indication or airway assessment, and this may confound results. We did not record blood pressure and could have missed hypotensive episodes; nor did we record continuous vital signs and patients in one period may have undergone more serious complications. We did not describe mortality beyond the peri-intubation period.

Conclusion

Despite different equipment and lack of bagging, new pandemic endotracheal intubation protocols did not result in a decrease in first-pass success, or first-pass success without complications.

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Author contributions JY and JT conceived the registry and conceived the study with assistance from DG, RM, FS, and RS. EN and LF supervised data collection. KD and CR performed data analysis, assisted by FS and RS. JT, JY, DG, and RM provided input on the interpretation of study findings. KD and FS drafted the article, and all authors provided input on revisions. All authors approved the manuscript. FS takes responsibility for the manuscript.

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Compliance with ethical standards

Conflict of interest The authors declared that they have no conflict of interest.

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