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Comparison of tracheal intubation between sitting position and standing position in COVID-19 patients

A manikin study

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Abstract

It is recommended to use visual laryngoscope for tracheal intubation in a Corona Virus Disease 2019 patient to keep the operator farther from the patient. How the position of the operator affects the distance in this setting is not ascertained. This manikin study compares the distances between the operator and the model and the intubation conditions when the operator is in sitting position and standing position, respectively.

Thirty one anesthesiologists with minimum 3-years' work experiences participated in the study. The participant's posture was photographed when he performed tracheal intubation using UE visual laryngoscope in standing and sitting position, respectively. The shortest distance between the model's upper central incisor and operator's face screen (UF), the horizontal distance between the model's upper central incisor and the operator's face screen, the angle between the UF line and the vertical line of the model's upper central incisor were measured. The success rate of intubation, the duration of intubation procedure, the first-attempt success rate, the Cormack–Lehane grade, and operator comfort score were also recorded.

When the operator performed the procedure in sitting position, the horizontal distance between the model's upper central incisor and the operator's face screen distance was significantly longer (9.5 [0.0–17.2] vs 24.3 [10.3–33.0], $P \leq .001$) and the angle between the UF line and the vertical line of the model's upper central incisor angle was significantly larger (45.2 [16.3–75.5] vs 17.7 [0.0–38.9], $P \leq .001$). There was no significant difference in UF distance when the operator changed the position. Cormack–Lehane grade was significantly improved when it was assessed using visual laryngoscope. Cormack–Lehane grade was not significantly different when the operator assessed it in sitting and standing position, respectively. No significant differences were found in the success rate, duration for intubation, first-attempt success rate, and operator comfort score.

The operator is kept farther from the patient when he performs intubation procedure in sitting position. Meanwhile, it does not make the procedure more difficult or uncomfortable for the operator, though all the participants prefer to standing position.

Abbreviations: AUF = the angle between the UF line and the vertical line of the model's upper central incisor, COVID-19 = Corona Virus Disease 2019, HUF = the horizontal distance between the model's upper central incisor and the operator's face screen, , PPE = personal protective equipment, SARS = severe acute respiratory syndrome, UF = the shortest distance between the model's upper central incisor and operator's face screen.

Keywords: Corona Virus Disease 2019, severe acute respiratory syndrome-CoV-2, sitting, standing, tracheal intubation

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1. Introduction

Corona Virus Disease 2019 (COVID-19) has been spread wildly and rapidly all over the world.[1] COVID-19 has been a serious threat to human health and life due to the high mobility and mortality.[1–3] Based on the existing studies, there is so far no effective medicine or therapeutics. The COVID-19 patients are mainly under supportive and symptomatic treatment.[4] Approximately 5% to 14% of the patients with COVID-19 are critically ill, and 2.3% of them need tracheal intubation for invasive mechanical ventilation.[2,4–6] Meanwhile, many suspected cases and confirmed cases are presented to operate room for selected or emergency surgery. General anesthesia and intubation are required in these cases.

Intubation is considered a particularly high-risk procedure for cross infection of COVID-19 in spite of the sufficient personal protective equipment (PPE).[2,7] The operator has to stay close to the patient during the intubation procedure, and it is highly likely that patients might cough and generate aerosol. As we know, 9% of the operators were infected even though they had good protective equipment during the outbreak of severe acute respiratory syndrome (SARS) in Ontario, Canada in 2003.[8] Similarly, several anesthesiologists in Wuhan has been infected due to the intubation procedure for the COVID-19 patients, though the detailed data are not available yet.[9]

It has been reported that the operator can stay a longer distance from the patient's airway when visual laryngoscope is used for tracheal intubation. In this way, the operator gets less affected by the mouth air from the patient.[10] Thus, visual laryngoscope is recommended when tracheal intubation is required for COVID-19 patients.[9,11] However, is it possible to further increase the distance between the operator and the patient? Will the distance differ when operator is in different position? In this model-based simulation study, we compared the distances between the operator and the patient and intubation conditions when the operator was in the sitting and standing position. Hopefully, the results will help to identify the optimal position for tracheal intubation in COVID-19 patients, which keeps the operators farther from the droplets and aerosol from the patients.

2. Methods

2.1. Participants

The study was performed in The First Affiliated Hospital of Guangzhou University of Chinese Medicine during 1 to 9th April 2020. Since no identifiable data were included in this study, ethical approval was remitted, as indicated by the Ethics Committee of the institute. Thirty one anesthesiologists with minimum 3-years' work experiences participated in the study. The age, sex, body height, personal preference for intubation procedure, and experiences in using UE visual laryngoscope and in certain position (standing or sitting) were recorded.

2.2. Experiment setting

The study was conducted in the post anesthesia care unit. An "AIRSIM" (Trucorp, Belfast, Northern Ireland) manikin was put on a standard transportation bed, which was adjusted at 50 cm height (the same height as the general ward bed). The Cormack–Lehane classification was set to grade 2, which was identified before the intubation procedure by 3 other anesthesiologists who did not participate the study. They assessed the airway using Macintosh Laryngoscope and adjusted the AIRSIM tongue volume by syringe inflation or deflation to set the Cormack–Lehane classification of airway. All the participants had a 10-minutes' training to get familiar with the AIRSIM manikin and intubation instruments.

2.3. Intubation setting

Participants performed intubation procedure using UE visual laryngoscope and wearing standard PPE (Fig. 1) in random sequence by roll dice. Those with a roll of 1 to 3 performed the procedure in the standing position first, and then in the sitting position (on a 50-cm-high chair). Those with rolls of 4 to 6 performed the procedure in the reverse sequence. The disposable blade and tracheal tube were sufficiently lubricated before the procedure. The screen and handle of the visual laryngoscope were covered with a sealed disposable ultrasound probe cover to prevent contamination (Fig. 1). The position of the tracheal tube was confirmed by the view of carina via a flexible intubating scope through the tube.

2.4. Main outcomes

Photos were taken when the operator performed the intubation procedure in standing and sitting position, respectively. Based on the photos, the shortest distance between the model's upper central incisor and operator's face screen (UF), the horizontal distance between the model's upper central incisor and the operator's face screen (HUF), and the angle between the UF line and the vertical line of the model's upper central incisor (AUF) were measured using ImageJ software (Fig. 2).

2.5. Secondary outcomes

The success rate of intubation, the duration of intubation procedure (the time between the insert of the visual laryngoscope into the mouth and insert of the tube through the vocal cord), and the first-attempt success rate were recorded. It was recorded as failure if the operator failed to finish the procedure within 120 seconds. The operator assessed the comfort score using visual analogue scale. The score was determined by the distance on a 10 cm scale between "very uncomfortable" and "very comfortable," providing a score ranging from 0 to 10. The Cormack–Lehane classification of the airway was identified and recorded again when the operator performed intubation procedure using UE visual laryngoscope.

2.6. Statistical analysis

Continuous data were compared by the using paired t test or Mann–Whitney U test. Proportions were analyzed by using Fisher exact test or the Chi-squared test. Analyses were conducted with Prism 8. $P < .05$ was considered statistically significant.

3. Results

Thirty one anesthesiologists were included in the study. All of participants, 13 (41.9%) men and 17 (58.1%) women, had minimum 3-years' working experiences. The average age of the participants was 35.2 ± 6.6. The average body height was 167.5 ± 6.3 cm. All the participants, except 2, were experienced using

Figure 1. UE visual laryngoscope and standard PPE. PPE = personal protective equipment.

Figure 2. Main outcomes measured in different operator positions.

Table 1

Main outcomes.

	Standing intubation (n = 31)	Siting intubation (n = 31)	*P* value
UF distance, cm	31.7 (21.4–44.7)	31.8 (20.8–53.9)	.993
HUF distance, cm	9.5 (0.0–17.2)	24.3 (10.3–33.0)	.000
AUF, °	17.7 (0.0–38.9)	45.2 (16.3–75.5)	.000

AUF angle = the angle between the UF line and the vertical line of the patient's mouth, HUF distance = the horizontal distance between the model's upper central incisor and the operator's face screen, UF distance = the distance between the model's upper central incisor and operator's face screen.

UE visual laryngoscope to perform tracheal intubation on both patients and AIRSIM Manikin. These 2 participants only had the experiences using UE visual laryngoscope on patients. All the participants, except 2, had experiences performing the procedure in position of both sitting and standing. These 2 participants only had the experiences in the position of standing. All the participants preferred to perform the procedure in standing position.

The main outcomes are presented in Table 1. There was no significant difference in UF distance when the operator changed the position. The HUF distance was significantly longer when the operator performed the procedure in sitting position (24.3 [10.3–33.0] vs 9.5 [0.0–17.2], $P \leq .001$). The AUF angle was significantly larger at the same time (45.2 [16.3–75.5) vs 17.7 [0.0–38.9], $P \leq .001$).

The secondary outcomes are presented in Table 2. The Cormack–Lehane classification was significantly improved when it was reassessed by the operator using the UE visual laryngoscope in both sitting position and standing position. There was no significant difference in the Cormack–Lehane classification when the operator was in different positions. No significant differences were found in the success rate, duration for intubation, first-attempt success rate, and comfort visual analogue scale score.

There was a positive correlation between AUF and the operator's body height in position of sitting ($r = 0.537$). There was a negative correlation between AUF and body height when standing ($r = -0.417$) (Fig. 3).

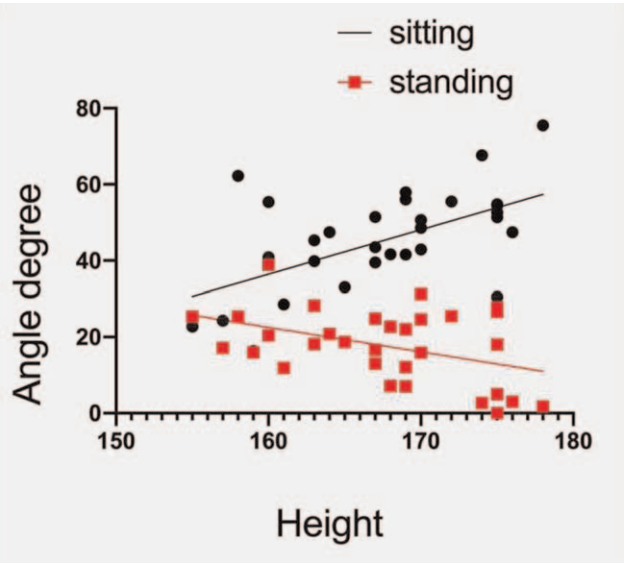

Figure 3. The correlation between AUF angle and the operators' body height in different position. AUF = the angle between the UF line and the vertical line of the model's upper central incisor.

4. Discussion

Tracheal intubation is a common procedure performed in the department of anesthesiology, intense care unit, and emergency. The operator is at high risk for contacting the droplets and aerosol from the patient during the procedure,[5,12] which is the main cause of cross infection.[13] To avoid the droplets and aerosol from the patients' mouth, emerging studies and guidelines have presented recommendations for the procedure of tracheal intubation for COVID-19 patients when establishing artificial airway.[7,9,11,14–16] The operator should wear PPE for sufficient protection. Muscle relaxants and sedatives should be administrated, if possible, to ensure sufficient neuromuscular blockage. Choose visual laryngoscope for intubation as far as possible.

However, the procedure is frequently performed outside the operating room without muscle relaxants especially in emergency cases.[17] Even when the muscle relaxants and sedatives are administrated, the operators are still likely cross infected by the air from the patient's mouth.[10] On the other hand, there is no recommendation for the position of the operator when he is performing tracheal intubation. In this study, we measured and compared the distances between the operator and the patient when the operator performed intubation procedure in position of sitting and standing, respectively. We also compared the intubation conditions when the operator was in different positions. We aimed to investigate if the distances and the intubation conditions were affected when the operator changed his position and to find the optimal position for tracheal intubation procedure on COVID-19 patients.

Since the height of the bed in most wards is 18 to 22 in.,[18] a 20-ins'.' (50.8 cm) high bed was used in our study. The chair was always adjusted at 50.8 cm height throughout the whole study to ensure the comfort of the operator and the consistency of the study.

It has been reported that the droplets diffused up perpendicular to the incisor teeth when the volunteers cough in supine position, and the average total jet spreading angle is 23.98°.[19] In our study, the AUF angle is larger than the jet spreading angle when the operator is in sitting position. It is conversely when the operator is in standing position (Fig. 4). Together with the increased AUF angle, HUF distance is also significantly longer when the operator is in sitting position. To some extent, the longer HUF distance and the larger AUF angle keep the operator farther from the range of the droplets' path (Fig. 4).

Table 2

Secondary outcomes.

	Standing intubation (n = 31)	Siting intubation (n = 31)	*P* value
Success rate (%)	31 (100.0)	31 (100.0)	1
Intubation time, s	20.7 ± 3.2	22.6 ± 5.4	.098
Cormack–Lehane grade 1/2/3/4	22/9/0/0*	18/13/0/0*	.288
First-attempt success rate	30 (96.8)	28 (90.3)	.612
Comfort VAS score	5.6 (4.0–7.0)	5.9 (4.0–8.0)	.150

VAS = visual analogue scale.

* $P < .0001$, compared with the Cormack–Lehane grade that was assessed before the procedure.

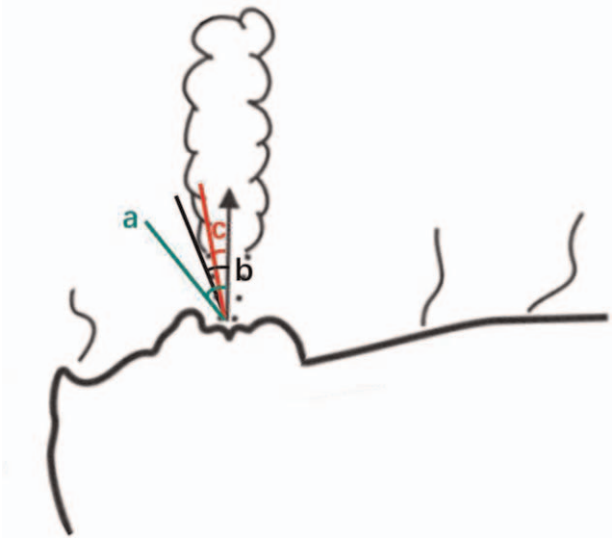

Figure 4. The path of the droplets from the patient. A: the AUF angle in sitting position; B: the average droplets spreading angle; C: the AUF angle in standing position. AUF = the angle between the UF line and the vertical line of the model's upper central incisor.

At the same time, the UF distance is not significantly different when the operator performed the procedure in different positions. That is to say, the optical line didn't become longer with the longer HUF distance. The visual laryngoscope makes it easier for the operator to get a better vision, since the Cormack–Lehane classification is significantly improved, which is consistent to the other study.[20] Thus, the position of the operator has no effects on the exposure or view of glottis. Consistently, it is found in our study that the position of the operator has no effects on the success rate of tracheal intubation and the duration of intubation. Given above, it does not make it difficult for the operator to perform the procedure in sitting position, though all the participants prefer to perform the procedure in standing position.

Nowadays, the health care workers usually perform the tracheal intubation procedure with PPE. The hood is heavy and the eye patches often fog up. What is more, the operator might be very nervous when caring COVID-19 patients. All these make it inconvenient for the operator.[21,22] Based on our experiences from simulation training and the experiences reported by the anesthesiologists in Wuhan, it is extremely difficult to perform tracheal intubation with PPE. The intubation team in Wuhan was once called perdue, because of the great difficulty and high risk of the procedure. The operator might feel exhausted after the procedure.[22] Thus, it is important to make it comfortable as far as possible. In our study, the sitting position does not make it uncomfortable for the operator, based on the comfort score.

There are several factors influence the main outcomes of the study. First, the distances are influenced by the height of the apparatus. In our study, the bed and the chair were set to the same height of the bed used in our ward, so as to stimulate the actual clinical practice. It is expected that the result can be applied to general clinical situations in emergency ward, clinical apartment, intense care unit, operation room, etc. Secondly, the distances are influenced by the body height of the operator. The average body height of the participants in our study is approximates to that of Chinese adults, according to the latest Chinese nutrition and chronic disease situation report released in 2020. On the other hand, we analyze the relationship between the body height and the AUF angle. It is found there is a positive correlation between the AUF angle and the body height when the operator is in sitting position. On the contrast, there is a negative correlation between AUF angle and body height when the operator is in standing position. Thus, the operator with higher body height might gain more advantages when he performs the procedure in sitting position. Thirdly, there are errors with measurements due to the photograph bias, which may influence the main outcomes. To minimize the bias, the participants were in the same site to perform the procedure and the camera was put in the same site to take the photograph.

There are several limits in our study. Firstly, this is a manikin study, which is not fully the same as real clinical practice. To simulate the general clinical situation, the participants performed the procedure wearing standard PPE, the bed and chair were set to the general height, and the Cormack–Lehane score was set to classification 2. However, the posture of the operator is likely to vary with the actual height of the bed and the chair and the various patient characters (such as difficult airway, body movement, and mobility of cervical spine, etc), especially when the operator is caring emergency patients with mental pressure and great tension. Secondly, we only measure the distances and the angles between the operator and the manikin. However, coughing and droplets jetting are not simulated, which is not achievable on the manikin used in our study. It is also difficult to get these data during actual intubation procedure due to ethics issues. Thus, we use the data reported in the literature. Last but not the least, though the operator is kept farther from the patient with the longer distance and the larger angle, it is different from actually decreasing the incidence of cross infection. Farther study is needed to find if significantly less droplet and aerosol can touch the operator with the longer distances and the larger angle. Moreover, the risk of cross infection is determined by multiple factors besides the exposure to the droplet and aerosol (e.g., if the operator follows standard procedure to sterilize and undress the suit afterwards). We would say the longer distances and the larger angle decrease the possibility of droplets projecting directly to the face shield, which is a risk of vital transmission.[8]

It is no doubt that PPE is the most important and necessary measure to protect acquiring SARS-CoV-2 during intubation. The current guidelines have stated the standard procedure for intubation in COIVD-19 patients (such as PPE, intubation instruments, ventilation mode, and medicine administration, etc). However, there is no recommendation for the operator position when performing the procedure. In this study, we find the operator is kept farther from the patient by easily changing his position with no additional costs. It does not make any difficult or discomfort for the operator, even though all of participants prefer to perform the procedure in standing position. Thus, it is worth considering to perform intubation procedure in sitting position not only for the COVID-19 patients, but for the patients with infectious diseases of respiratory tract. Future study should investigate the efficiency of the sitting position in clinical practice.

5. Conclusions

The operator is farther from the patient when he performs the intubation procedure in sitting position. Meanwhile, it does not

make it difficult or uncomfortable for the operator despite of his preference of standing position.

Author contributions

All authors read and final approval of the manuscript.
Conceptualization: Yong Wang, Yun Shi, Wuhua Ma.
Data curation: Yong Wang.
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Funding acquisition: Yong Wang.
Investigation: Yong Wang, Yong-Xing Li, Ming Zhong, Yue-Rong Zhuang, Wei Huang.
Writing – original draft: Yong Wang, Yun Shi.
Writing – review & editing: Yong Wang, Yun Shi.

References

[1] Organization, W.H.O. Coronavirus Disease (COVID-19) Pandemic; 2020. Available at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019. Accessed April 17, 2020.
[2] Wu Z, McGoogan JM. Characteristics of and important lessons from the coronavirus disease 2019 (COVID-19) outbreak in China: summary of a report of 72 314 cases from the Chinese Center for Disease Control and Prevention. JAMA 2020;323:1239–42.
[3] Livingston E, Bucher K. Coronavirus disease 2019 (COVID-19) in Italy. JAMA 2020.
[4] Wang D, Hu B, Hu C, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China. JAMA 2020;323:1061–9.
[5] Guan WJ, Ni ZY, Hu Y, et al. C. China Medical Treatment Expert Group forClinical characteristics of coronavirus disease 2019 in China. N Engl J Med 2020.
[6] Yang X, Yu Y, Xu J, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. Lancet Respir Med 2020; 8:475–81.
[7] Wax RS, Christian MD. Practical recommendations for critical care and anesthesiology teams caring for novel coronavirus (2019-nCoV) patients. Can J Anaesth 2020;67:568–76.
[8] Caputo KM, Byrick R, Chapman MG, Orser BJ, Orser BA. Intubation of SARS patients: infection and perspectives of healthcare workers. Can J Anaesth 2006;53:122–9.
[9] Chen X, Liu Y, Gong Y, et al. C.A.o.A. Chinese Society of AnesthesiologyPerioperative management of patients infected with the novel coronavirus: recommendation from the Joint Task Force of the Chinese Society of Anesthesiology and the Chinese Association of Anesthesiologists. Anesthesiology 2020;132:1307–16.
[10] Chen C, Hei Z, Xing J, et al. Laryngoscopic techniques modulate anaesthesiologists' perception of halitosis in patients: a randomised controlled trial. Eur J Anaesthesiol 2019;36:918–23.
[11] Meng L, Qiu H, Wan L, et al. Intubation and ventilation amid the COVID-19 outbreak: Wuhan's experience. Anesthesiology 2020;132: 1317–32.
[12] Nissen K, Krambrich J, Akaberi D, et al. Long-distance airborne dispersal of SARS-CoV-2 in COVID-19 wards. Sci Rep 2020;10:19589.
[13] Tran K, Cimon K, Severn M, Pessoa-Silva CL, Conly J. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. PLoS One 2012;7: e35797.
[14] Zuo M, Huang Y, Ma W, Xue Z, Zhang J, Gong YJCMSJ. Expert recommendations for tracheal intubation in critically ill patients with noval coronavirus disease 2019. Chin Med Sci J 2020;35:105–9.
[15] Chen KB. The Taiwan Society of Anesthesiologists Issues COVID-19 endotracheal intubation recommendation, and mild to moderate sedation practice guidance. Asian J Anesthesiol 2020;58:55–6.
[16] Yao W, Wang T, Jiang B, et al. Emergency tracheal intubation in 202 patients with COVID-19 in Wuhan, China: lessons learnt and international expert recommendations. Br J Anaesth 2020;125:e28–37.
[17] de Alencar JCG, Marques B, Marchini JFM, et al. First-attempt intubation success and complications in patients with COVID-19 undergoing emergency intubation. J Am Coll Emerg Physicians Open 2020;1:699–705.
[18] Tzeng HM, Yin CY. The staff-working height and the designing-regulation height for patient beds as possible causes of patient falls. Nurs Econ 2006;24:323–7. 279.
[19] Tang JW, Liebner TJ, Craven BA, Settles GS. A schlieren optical study of the human cough with and without wearing masks for aerosol infection control. J R Soc Interface 2009;6(suppl):S727–36.
[20] Ruetzler K, Rivas E, Cohen B, et al. McGrath video laryngoscope versus macintosh direct laryngoscopy for intubation of morbidly obese patients: a randomized trial. Anesth Analg 2020;131:586–93.
[21] Zheng H, Li S, Sun R, et al. Clinical experience with emergency endotracheal intubation in COVID-19 patients in the intensive care units: a single-centered, retrospective, descriptive study. Am J Transl Res 2020;12:6655–64.
[22] Canelli R, Connor CW, Gonzalez M, Nozari A, Ortega R. Barrier enclosure during endotracheal intubation. N Engl J Med 2020;382: 1957–8.