Cell Transplantation
Volume 30: 1–13

DOI: 10.1177/0963689720987527
journals.sagepub.com/home/cll
SAGE

Application of Plastic Sheet Barrier and Video Intubating Stylet to Protect Tracheal Intubators During Coronavirus Disease 2019 Pandemic: A Taiwan Experience

Hsiang-Ning Luk[1,2,3], Yao-Lin Yang[1], Ching-Hsuan Huang[1], I-Min Su[1], and Phil B. Tsai[4]

Abstract

Since its outbreak in China, the Coronavirus disease 2019 (COVID-19) pandemic has caused worldwide disaster. Globally, there have been 71,581,532 confirmed cases of COVID-19, including 1,618,374 deaths, reported to World Health Organization (data retrieved on December 16, 2020). Currently, no treatment modalities for COVID-19 (e.g., vaccines or antiviral drugs) with confirmed efficacy and safety are available. Although the possibilities and relevant challenges of some alternatives (e.g., use of stem cells as immunomodulators) have been proposed, the personal protective equipment is still the only way to protect and lower infection rates of COVID-19 among healthcare workers and airway managers (intubators). In this article, we described the combined use of a plastic sheet as a barrier with the intubating stylet for tracheal intubation in patients needing mechanical ventilation. Although conventional or video-assisted laryngoscopy is more popular and familiar to other groups around the world, we believe that the video-assisted intubating stylet technique is much easier to learn and master. Advantages of the video stylet include the creation of greater working distance between intubator and patient, less airway stimulation, and less pharyngeal space needed for endotracheal tube advancement. All the above features make this technique reliable and superior to other devices, especially when a difficult airway is encountered in COVID scenario. Meanwhile, we proposed the use of a flexible and transparent plastic sheet to serve as a barrier against aerosol and droplet spread during airway management. We demonstrated that the use of a plastic sheet would not interfere or hinder the intubator's maneuvers during endotracheal intubation. Moreover, we demonstrated that the plastic sheet was effective in preventing the spread of mist and water spray in simulation models with a mannequin. In our experience, we found that this technique most effectively protected the intubator and other operating room personnel from infection during the COVID-19 pandemic.

Keywords

plastic sheet, intubating stylet, airway management, COVID-19

Introduction

A pneumonia of unknown origin was first detected in Wuhan, China, and was subsequently reported to the World Health Organization (WHO) Country Office in China on December 31, 2019. Before long, the WHO declared the outbreak a Public Health Emergency of International Concern on January 30, 2020. On February 11, the WHO announced an official name for this new coronavirus disease: Coronavirus disease 2019 (COVID-19).

Not surprisingly, a shortage of personal protective equipment (PPE) endangering health workers worldwide was reported in March 2020. As the disease spread, the global

[1] Department of Anesthesia, Hualien Tzu-Chi Medical Center, Hualien, Taiwan, ROC
[2] Department of Financial Engineering, Providence University, Taichung, Taiwan, ROC
[3] Department of Anesthesia, National Yang-Ming University Hospital-Yilan, Yilan, Taiwan, ROC
[4] Department of Anesthesiology, Rancho Los Amigos National Rehabilitation Center, Downey, CA, USA

Submitted: October 20, 2020. Revised: December 16, 2020. Accepted: December 20, 2020.

Corresponding Author:
Hsiang-Ning Luk, Hualien Tzu Chi Medical Center, 707, Sec. 3, Chung-Yang Rd., Hualien 97002, Taiwan, ROC.
Email: lukairforce@gmail.com

supply of PPE was rapidly depleted. With limited access to PPE (gloves, medical masks, respirators, goggles, face shields, gowns, and aprons), frontline medical health workers were left poorly equipped to care for COVID-19 patients.

As the COVID-19 outbreak was regarded as an unprecedented event, the WHO launched a new social media campaign titled, "Be Ready for COVID-19," urging people to be safe, smart, and kind. On March 11, the WHO officially declared COVID-19 a pandemic, as shortly after the outbreak occurred in China, Europe and the United States of America also became epicenters for the disease.

As of December 16, 2020, there are 71,581,532 confirmed cases of COVID-19 and 1,618,374 deaths. In Taiwan, the first confirmed case of COVID-19 was reported on January 21, 2020. Fortunately, as of December 16, 2020, there have been only 740 confirmed cases of COVID-19 and 7 deaths in the country. Tragically, there have been more than 90,000 infections worldwide among medical personnel with more than thousands of deaths.

Personal Protective Measures

Based upon prior experiences with severe acute respiratory syndrome (SARS) in 2003[1–4], several academic communities quickly reached a consensus on the guidelines for airway management in COVID-19 patients[5–9]. Highly contagious emergent diseases (e.g., SARS, MERS, and COVID-19) pose serious challenges for the medical professionals who are tasked to perform airway management in infected patients. When a COVID-19 patient's medical condition worsens (e.g., severe hypoxemia, compromised hemodynamics), tracheal intubation and mechanical ventilation are required. Medical specialists are subsequently faced with the challenges of performing airway management procedures in these high-risk individuals[10].

It is beyond the scope of this article to discuss the full-range of issues regarding the airway management in suspected and confirmed COVID-19 patients. However, the safety of patients and medical professionals are priorities of concern during the COVID-19 pandemic[11]. All relevant safety measures, including personal safety precaution, institutional prevention policies against contamination, facilities and resources allocation, personnel training program, etc. should be followed according to consensus guidelines and local workplace policies and regulations. Among them, it is paramount to emphasize the crucial role of PPE for medical professionals who need to perform airway management in COVID-19 patients[12–16]. Sufficient PPE in these situations include: long sleeved waterproof gown, filtering facepiece mask, face shield, helmet, double gloves, eyewear/goggles, boots, and/or positive air pressure respirator. It should be emphasized, however, that not all countries and regions around the world have the same level of economic and medical resources[17]. Therefore, in areas with limited medical resources, practical modifications of personal protection measures may be necessary[18].

Young People Are Not Invincible

Although safety measures like negative pressure isolation rooms, high efficiency filtering algorithms, and standard operation policies are crucial for COVID-19 infection control, the experience and training of the airway management team are likewise essential. Speaking at the COVID-19 media briefing, the Director-General of the WHO said: "Although older people are the hardest hit, younger people are not spared." This statement is pertinent to residents and other trainees in the hospital frontlines who are tasked to care for patients during the COVID pandemic.

In regards to the airway management of COVID-19 patients, guidelines state "airway management in patients confirmed with COVID-19 infection should be performed by the most experienced staff and the best skilled airway manager to achieve the goal of safe, accurate and swift operation and to maximize first-pass success." However, despite careful planning, there may be instances when anesthesia residents who are still undergoing training are required to perform emergency airway management on in-patients during the pandemic. Therefore, we implemented a hands-on airway management training program for the anesthesia trainees in our hospital (Fig. 1). Although all the young residents were ACLS certified and possessed previous experience with airway management, none of them were familiar with the use of second-generation supraglottic airway devices, video-assisted laryngoscopes, and video-assisted intubating stylets.

The program consisted of a 3-day, hands-on crash course in the operating room. All 18 trainees (from first-year to fifth-year residents) were supervised by experienced anesthesiologists while performing airway management procedures. The patients were administered anesthesia per routine, including induction agents (propofol and fentanyl) and neuromuscular blocking agents (cis-atracurium, rocuronium, or succinylcholine). Patient status was continually assessed with the use of hemodynamic monitors, as well as bispectral index and train-of-four. The trainees practiced face mask ventilation, video-assisted laryngoscopy, and intubating stylet techniques (e.g., Fig. 2B, C). These procedures were video recorded and played back later during de-briefing.

All the resident trainees demonstrated good clinical performance in airway management during the crash course. They did not encounter difficulties performing face mask and laryngeal mask ventilation. It was apparent that trainees developed proficiency more rapidly performing endotracheal intubation with the video stylet versus the video laryngoscope, with the learning curve for the trainees to successfully use the intubating stylet ranging from one to three cases. In contrast, while video laryngoscopy more often than not produced a clear laryngeal view, the trainees sometimes had difficulty visualizing and inserting the endotracheal tube. In our hospital, more than 90% of the general anesthesia are conducted using an intubating stylet for tracheal intubation (i.e., about 5,000 cases annually). The rest

Figure 1. Incubator for intubators. Airway management hands-on training program for anesthesia trainees in the hospital was immediately implemented after COVID-19 outbreak.

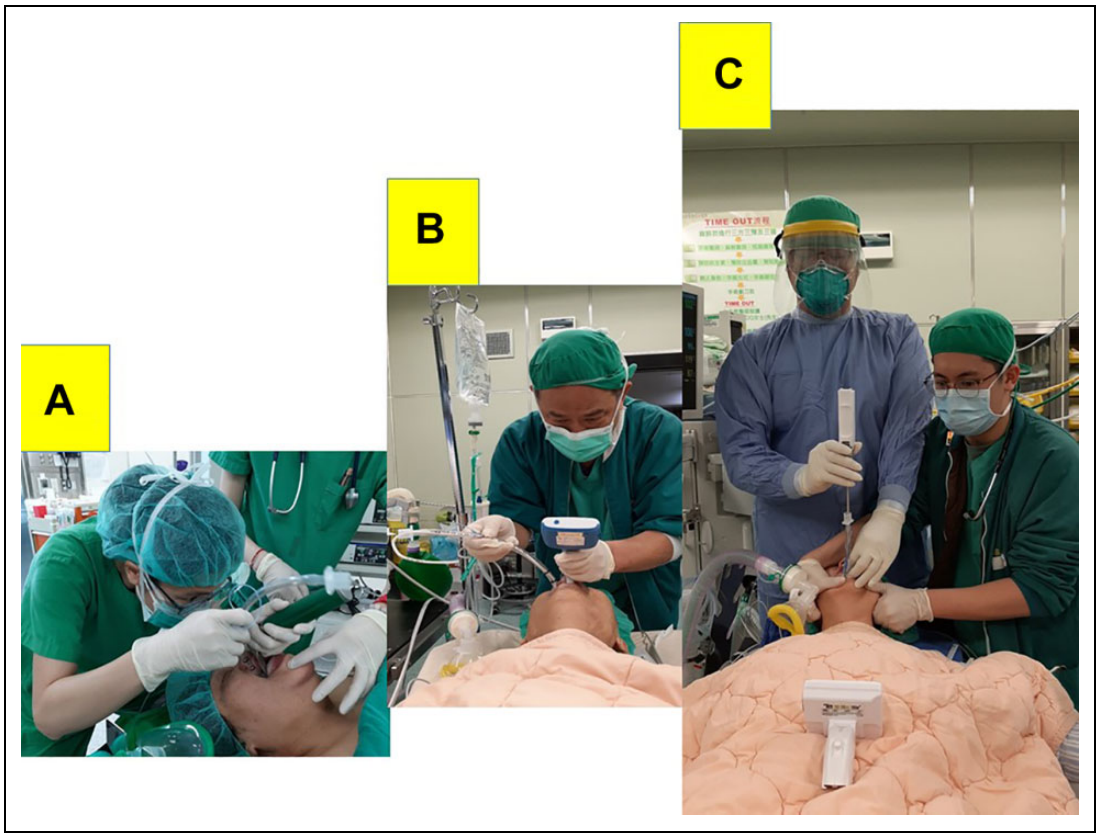

Figure 2. Safe "social distancing" between intubator and patient. Images of routine practice of tracheal intubation with conventional laryngoscope (A), video-assisted laryngoscope (B), and video-assisted intubating stylet (C).

Table 1. Comparison of Video-assisted Laryngoscope and Intubating Stylet.

	Video-assisted laryngoscopy	Video-assisted intubating stylet
Price	More expensive	Low cost
View on video monitor	Wide	Big enough
Wireless camera	Yes	Yes
Flexibility	Rigid	Malleable stylet
Weight	Heavier	Lighter
Lifting the tongue	Required	No need
Stimulation on airway	Significant	Minimal
Mouth-opening required	Much wider	One-finger width
Laryngeal space for inserting endotracheal tube	Required	No need
Damage of dental and soft tissue	More likely	Less
Difficult viewing endotracheal tube tip	Sometimes is a problem	No issue
Difficult inserting the tube into trachea	Need assistance with a curved stylet or bougie	No issue
Safety distance between the intubator and patient	Closer	Further way
For difficult airway scenario	Sometimes good	Better chance of success
Learning curve	Not fast	Quick

of the cases are performed using direct or video-assisted laryngoscopy (Fig. 2A, B), mainly for the purpose of teaching. A comparison between video-assisted laryngoscopy and the intubating stylet technique is detailed in Table 1. In the literature, similar comparisons between direct laryngoscopy and the intubating stylet technique have been made in a mannequin study[19] and in human subjects[20,21]. The parameters for comparison included number and duration of the intubation attempts, success rates, dental and soft tissue trauma, and ease of use. Based upon preliminary observations during this airway training course, the video stylet has the advantages of being easier to use and to master, as well as having a higher rate of first-pass success in tracheal intubation compared to the video laryngoscope.

A Double-edged Barrier Enclosure Box

Immediately after the COVID-19 outbreak and later pandemic, the development of innovative tools was urged by international communities. Those without adequate access to standard PPE for tracheal intubation were compelled to adopt the use of protective barriers. Dr Lai Hsien-Yung proposed a rigid box design (made of clear acrylic sides) for shielding intubators from possible contamination during tracheal intubation (Figs 3A, 4)[22]. Canelli et al. validated the use of this barrier enclosure with a mannequin simulation model and suggested the use of such an "aerosol box" as an adjunct to standard PPE[23]. Slight modifications to the "aerosol box" design appeared in later clinical reports[24–27].

While a rigid box would serve successfully as a barrier to prevent viral transmission from patient to operating room personnel, its capacity to facilitate airway manipulation remains debatable. Canelli et al. indicated in the same article that the box restricted hand movement of the airway manager (see Fig. 3B) and stressed that "the airway operators should be ready to abandon use of the box if airway management proved difficult"[23].

Other authors have also criticized the box's design in restricting the intubator's hand movements[28–30]. In addition, given the box's solid walls and limited access to the patient, the ability of another provider to lend assistance in the event of a difficult airway is also greatly hindered. One author concluded that "the technique is not validated, does not reduce risk, and probably has unintended safety consequences" and "may induce kinesthetic challenges and may increase time to intubation. Boxes are also awkward and could injure patients"[23]. Our group also found these shortcomings to be true when trialing various airway management devices inside a modified "aerosol box" using a mannequin model (Fig. 4).

Plastic Sheet, a Better Solution

While the pros and cons of using the rigid plexiglass "aerosol box" for tracheal intubation of COVID-19 patients was being debated in the literature in April and May[31,32], our group had conceptualized another technique for barrier protection and presented our findings as early as March 22, 2020[33,34]. The original design for our system came as a result from our prior experience with SARS in 2003[18]. We strove to design a product that would serve as an adjunct to PPE, based on the following features: cost conscious, easy to obtain and fabricate, clear and transparent, flexible but durable, soft and light, waterproof, disposable, easy to discard or abort. Most importantly, the existence of such a barrier should not interfere or hinder the intubator's ability to manipulate the airway while avoiding direct contact with the patient's face and mouth.

Plastic drapes are commonly utilized in the operating room to prevent surgical site infections. However, we proposed their novel use as a barrier against droplet and aerosol contamination during tracheal intubation. As shown in Fig. 5, we first prepared a single-layered, 1 m × 1 m, plastic sheet from an ordinary trash bag. We then cut two small crosses (3 cm × 3 cm and 2 cm × 2 cm, respectively)

Figure 3. Restriction of intubator's hands by a rigid box design. (A) A transparent plastic aerosol box made of acrylic (a courtesy photo from Dr Lai Hsien-Yung). The front façade of the box is open to air and intubator's manipulability is potentially limited. (B) An ancient stock device serves as a metaphor for the restriction of hand movement by the aerosol box design.

Figure 4. Restriction of hand movement even by the aerosol box design indeed must not be understated. The box potentially limited use of all kinds of airway management tools, including video-assisted intubating stylet, inside the rigid box. The transparent aerosol box shown in this figure has been already modified to lighter and taller (50 cm × 55 cm × 36 cm), but still with a wide-open in the front façade which caused potential contamination hazards.

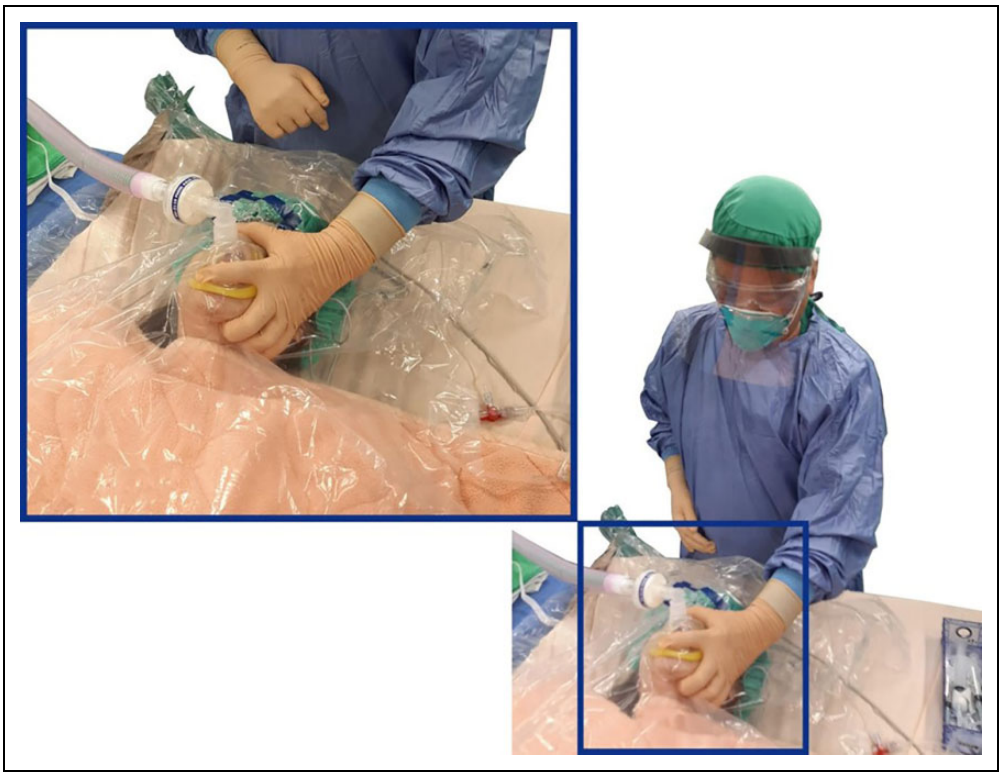

Figure 5. Application of plastic wrap draped on patient's head, face, and upper trunk. With a facial mask underneath the plastic sheet, mask ventilation could be easily performed without air leak (one-hand or two-handed V-E mode).

in this plastic drape. The first cross was for passage of the facemask orifice and connector. The second cross was for passage of intubating stylet/endotracheal tube or laryngoscope. After the patient was sedated, the plastic sheet was draped onto patient's head, face, and upper trunk. Since the plastic drape was transparent and malleable, one could easily hold the facial mask, which lay underneath the plastic sheet from above. In this way, either one-handed or two-handed mask ventilation was easily performed without significant air leak.

The protective role of clear plastic drapes against COVID-19 contamination during tracheal extubation and intubation has been previously discussed[35–41]. Various sizes for the plastic barrier have been proposed, ranging from a small square up to a whole-body covering or even a tent construct[42–46]. Widespread dissemination of information on social media and anesthesia forums has led to numerous suggestions for improvement of design in these protective barriers, from revising the plastic box with more openings to simply using an unmodified plastic sheet for the entirety of the surgical case. It should be stressed that any new method requires careful examination of the risks of adding complexity, reducing dexterity, and inadvertently increasing the risk of transmission after removal or disposal of the barrier. An in situ simulation study has shown that the "aerosol box" might cause more harms because it may increase intubation times and cause damage to conventional PPE[47]. Among all the options, the use of a transparent plastic drape seems to be the least intrusive for airway management and most effective in reducing droplet dispersal (Table 2).

Table 2. Comparison of Barrier Enclosure Design of Rigid Aerosol Box and Soft Plastic Sheet.

	Acrylic rigid aerosol box	Plastic sheet barrier
Accessibility	Needs fabrication	Available anywhere
Affordability	US$50 to 2,000	US$0.3 to 1.44
Size	Bulky	Flat
Texture	Rigid	Soft, flexible, versatile
Weight	Heavy	Light
Waterproof	Yes	Yes
Visibility	Transparent	Transparent
Disposability	No	Yes
Decontamination	Needed	No need
Two circular ports	Yes	No
Hand maneuver	Inside the box	Outside the sheet
Direct contact	Yes	No
Intubator's manipulability	Restricted	No restriction
Contingency plan if any difficulty	Remove the box	Remove the sheet

The video-assisted laryngoscope is a popular tool in many countries and listed on current guidelines as the first

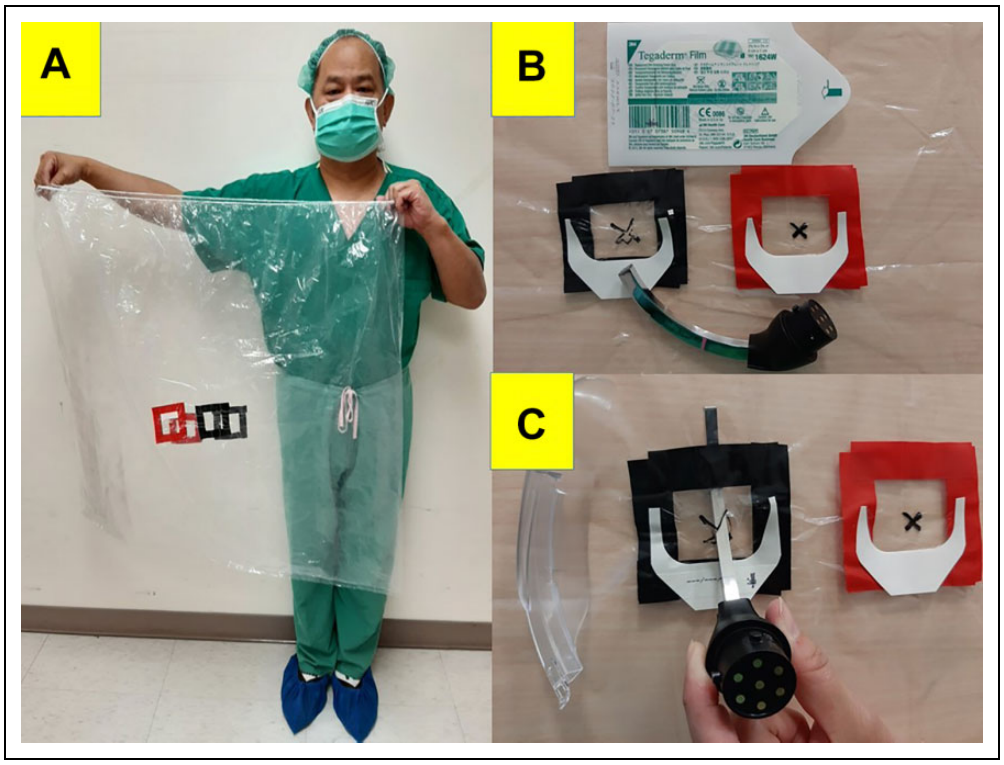

Figure 6. A modified double-layered plastic sheet with two sets of crosses in the drape. The bigger holes (in black area) are for passage of the disposable laryngoscope blade, and the smaller holes (in red area) are for passage of endotracheal tube. The seal of the holes is reinforced with adhesive tapes.

choice airway management device for COVID-19 patients[5–9,12–15,48–52]. Therefore, we adapted the plastic sheet for use with the video-assisted laryngoscope. Given its thin transparent nature, the plastic barrier could be single or double layered, with a double layer theoretically providing more protection against viral contamination. To each layer of the sheet, we cut a set of two crosses. The larger cross (3 cm × 3 cm) was for passage of laryngoscope blade and the smaller cross (2 cm × 2 cm) was for passage of endotracheal tube (Fig. 6A). In order to minimize the leak from the openings, we added adhesive tape to cover the cross areas (Fig. 6B). We subsequently used a needle to puncture a small hole in the adhesive tape to allow the laryngoscope or endotracheal tube to pass through with ease. In order to avoid an unnecessarily large defect in the barrier, we first placed the disposable video laryngoscope blade under the plastic sheet prior to induction. At time of laryngoscopy, we punctured the adhesive tape with the camera module of the video laryngoscope, and then connected the laryngoscope blade to the camera underneath the plastic sheet (Fig. 6C).

Figure 7 demonstrated an example when the patient was intubated with a video-assisted laryngoscope (TUORenKingtaek® video laryngoscope, Henan Tuoren Medical Device Co., Ltd., Henan, China). The disposable blade was first secured to the laryngoscope from the underside of the plastic sheet, and maneuvering of the laryngoscope took place above the barrier. The malleable plastic sheet did not disturb or hinder the tracheal intubation procedure. It should be stressed that the inherent drawbacks of video laryngoscopy (e.g., difficulty viewing the endotracheal tube on the monitor screen and inserting the tube into trachea) still existed when the plastic sheet barrier was used (see Table 1).

Intubating Stylet Better for "Social Distancing"

Although the technique of combining the use of the plastic sheet with a video-assisted laryngoscope is feasible, the video laryngoscope may not be the best choice for tracheal intubation of patients with a highly contagious disease as COVID-19. Several advantages of intubating stylet over the video-assisted laryngoscope are listed in Table 1. Additionally, based on institutional experience, the intubating stylet was easier to learn and develop proficiency. We subsequently incorporated our modified barrier sheet for use with the intubating stylet in order to prevent spreading of droplets from the patient's airway when tracheal intubation was performed. For added protection, we utilized a double-layered plastic drape (Figs 6A, 8A). The larger cross (3 cm × 3 cm, in the area labeled by black tape) was for passage of the face mask orifice/connector. The smaller cross (2 cm × 2 cm, in the area labeled by red tape) was for passage of the stylet/endotracheal tube. This second cross was reinforced with an

Figure 7. Tracheal intubation using video-assisted laryngoscope is performed on top of the double-layered plastic sheet.

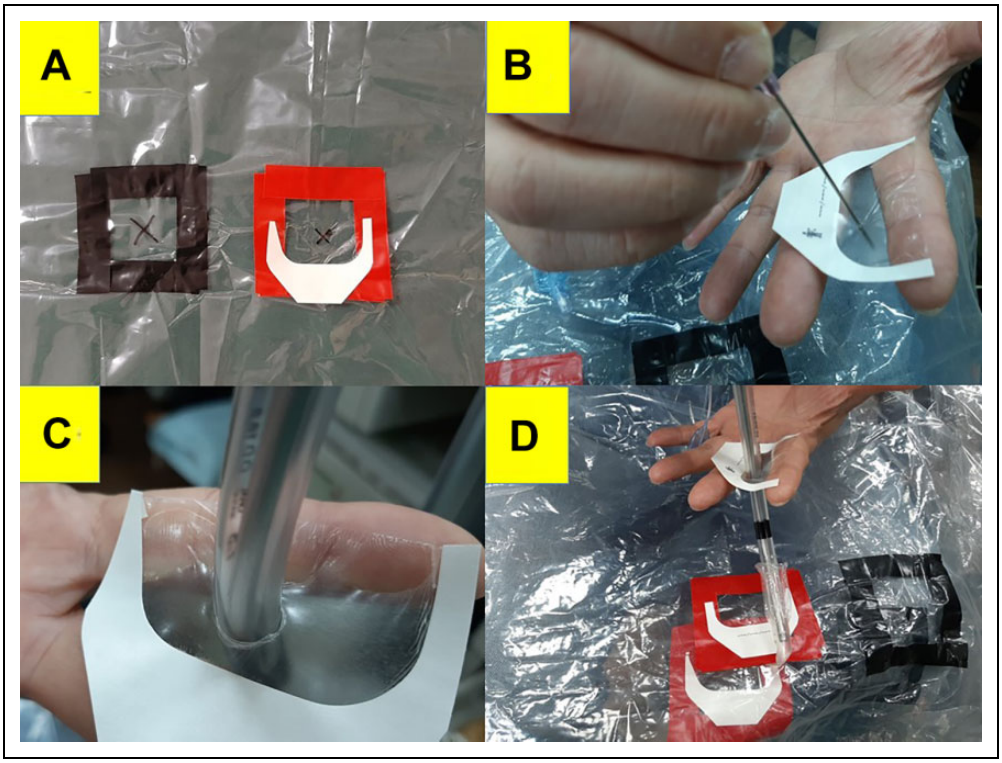

Figure 8. Reinforcement of the holes in the plastic sheet. (A) Preparation of a double-layered plastic sheet. Two sets of crosses on each layer. A bigger cross (in the black square) and a smaller cross (in the red square) were cut with a knife. The smaller cross was then covered with an adhesive tape. (B) A tiny hole was punctured on the adhesive tape with a fine needle. (C and D) Passage of stylet/endotracheal tube did not rupture or crack the tape.

adhesive tape (Figs 6, 8). Because of the adhesive nature of the tape, the hole created by a fine needle (Fig. 8B) would not enlarge with the passage of stylet/endotracheal tube (Fig. 8C, D).

In order to confirm and prove the concept that intubation with the video stylet (Trachway®, Markstein Sichtec Medical Corporation, Taichung, Taiwan) was feasible when a double-layered plastic sheet covered the patient, we first

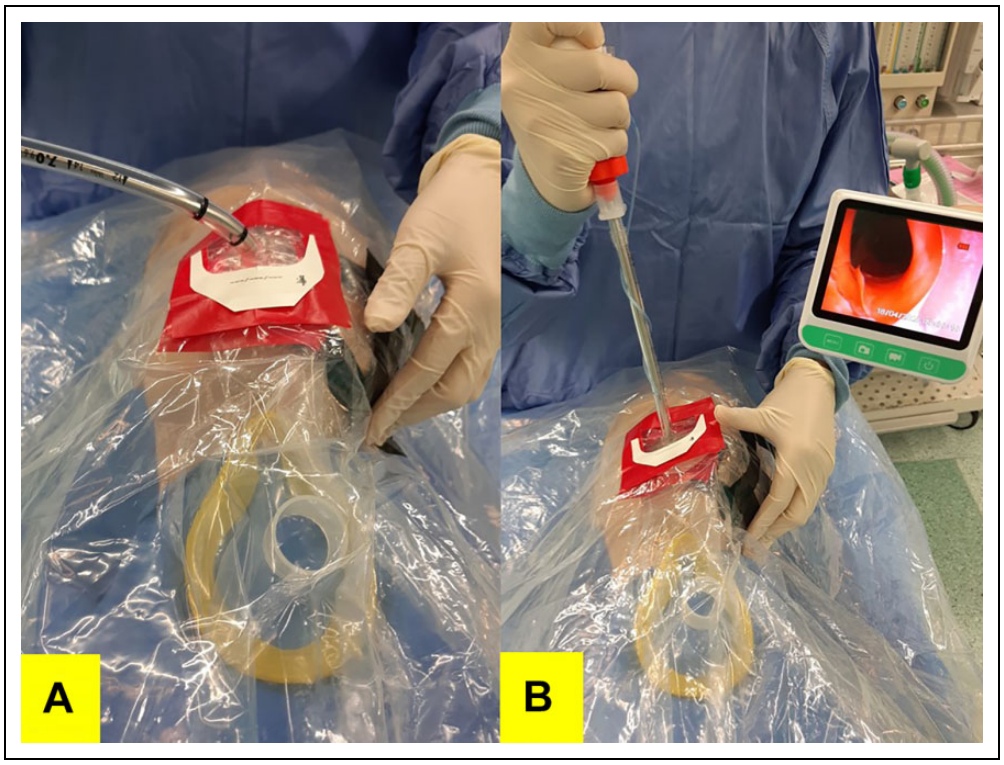

Figure 9. Simulation of tracheal intubation using intubating stylet when the mannequin was covered by a double-layered plastic sheet. (A) Stylet/endotracheal tube passed the adhesive tape hole smoothly. (B) Tracheal intubation was guided by a clear view on a wireless video monitor.

tested our technique in a mannequin model. Figure 9 demonstrated such a scenario. The intubation procedure proceeded as smoothly with the use of plastic sheet as without one being utilized. During the COVID-19 pandemic period, we occasionally encountered suspected or unconfirmed patients who were scheduled for surgery. To err on the side of caution, we donned appropriate PPE, and then applied the plastic sheet barrier and intubating stylet technique to perform tracheal intubation in these patients. Figure 10 shows an example in which we intubated a febrile (39.5°C) patient who was scheduled to receive emergency orthopedic surgery. Equipped with appropriate PPE, and with the airway assistant providing jaw-thrust to the patient, the intubator proceeded with tracheal intubation, guided by a wireless video monitor mounted on his helmet. Because of unique design of the intubation stylet, the airway manager could simply hold the stylet, and under the guidance of the images on the video monitor, advance the endotracheal tube into the trachea. It is worthy to mention that, using the intubating stylet technique, the intubator could keep a reasonable "social distance" from the patient (Figs 2C, 9B, 10B). Maintaining as much distance as possible from the patient's airway, together with PPE and the plastic sheet barrier, reduces the chance of viral transmission from the patient's airway droplets and secretions. The use of the plastic sheet was found to not hinder the intubator's maneuvers of the video stylet (Figs 9B, 10B).

Validation of Plastic Sheet Barrier and Intubating Stylet Technique

The COVID-19 pandemic has resulted in the innovation of numerous medical products and techniques. However, because of rapid dissemination of information, many initial claims have gone unverified. Therefore, we performed two tests to validate our combination technique of using the video stylet with a plastic barrier sheet. First, we used a medical nebulizer to simulate aerosol production from the patient's airway. We filled the reservoir with hot water and nebulized the water into mist (which is composed of small droplets of water suspended in air). Then, we used a bag valve mask to propel the mist through the mannequin's airway in order to simulate the episodes of coughing and bucking (Fig. 11). Without a plastic sheet, a visible mist was observed from the mannequin's nose and mouth (Fig. 11A). In contrast, when the mannequin's head and upper trunk were covered with a plastic sheet, the mist was not appreciated above the drape (Fig. 11B). To further illustrate whether plastic sheet barrier could prevent spreading of larger respiratory droplets during periods of coughing, sneezing, or bucking, hot water spray with the mannequin was used as a validation model. Hot water spray was detectable by an infrared thermography machine. Figure 12 shows that the hot water spray was easily detected by infrared imaging (Fig. 12A) and

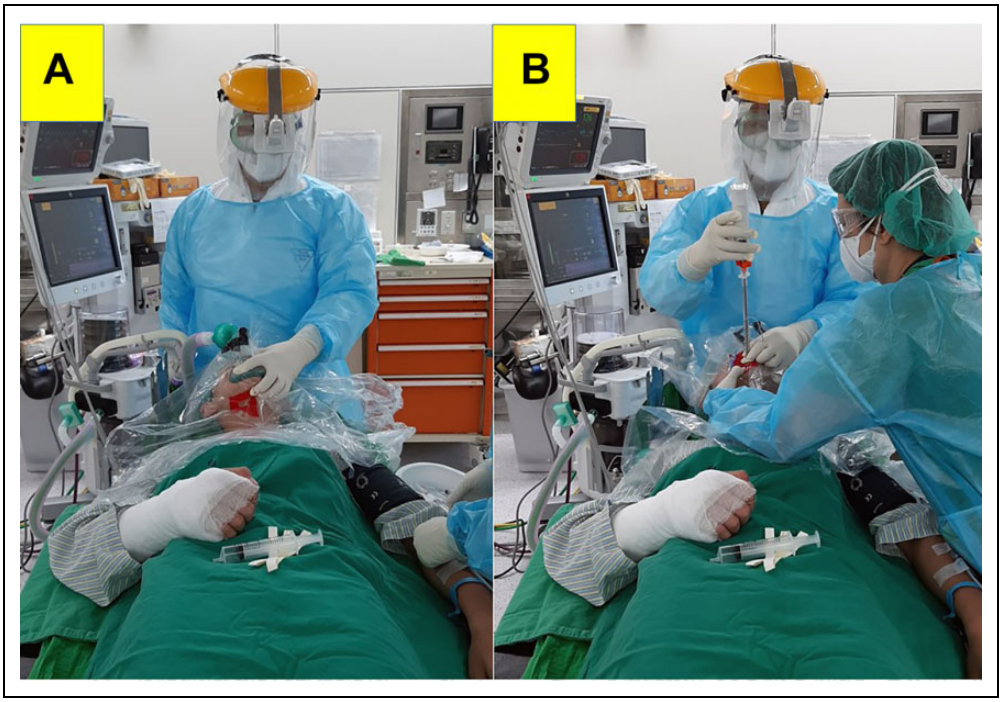

Figure 10. A real-world practice of intubating stylet technique and plastic sheet barrier in a febrile patient receiving emergency orthopedic surgery during COVID-19 pandemic. (A) The face mask was mounted onto the patient underneath the plastic sheet without any air leak. The intubator's hands had no direct skin contact with the patient's face. (B) The tracheal intubation was performed with an intubating stylet. The image of airway anatomic structure was viewed from a wireless video monitor mounted on the intubator's helmet. Distance between the intubator and the patient was maintained as far as possible.

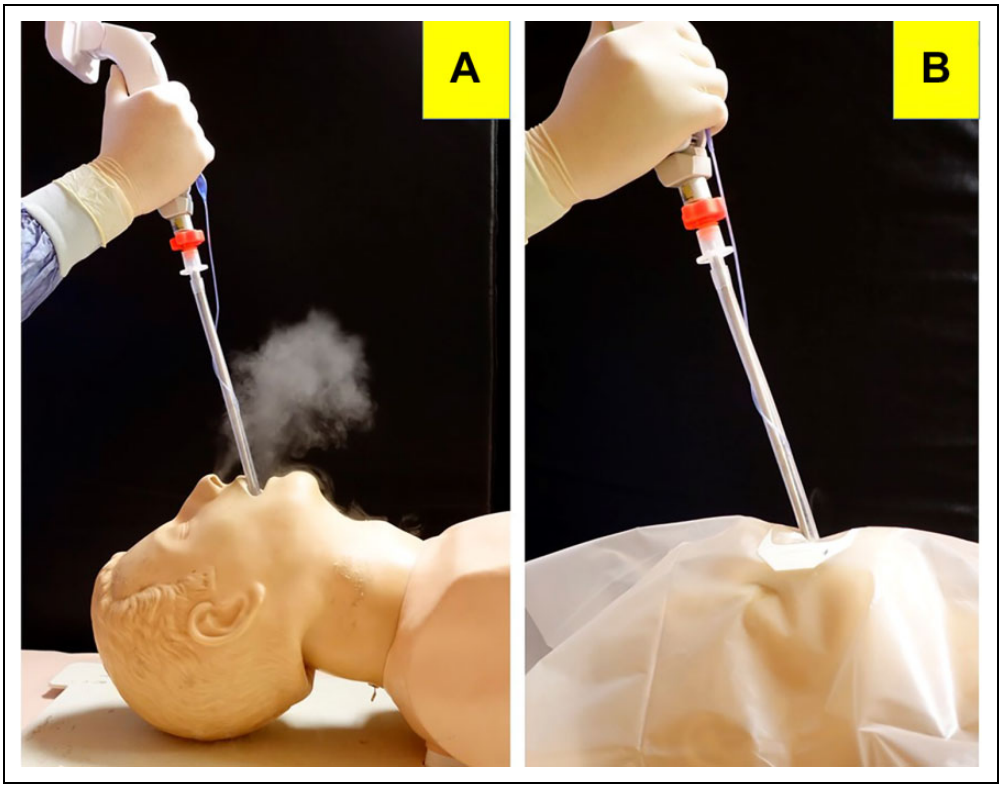

Figure 11. Simulation model of water mist produced by a nebulizer to mimic water droplets caused by coughing or bucking. Spreading of mist in the absence (A) and the presence (B) of plastic sheet coverage onto a mannequin's head and upper trunk. An intubating stylet was inserted into mannequin's airway.

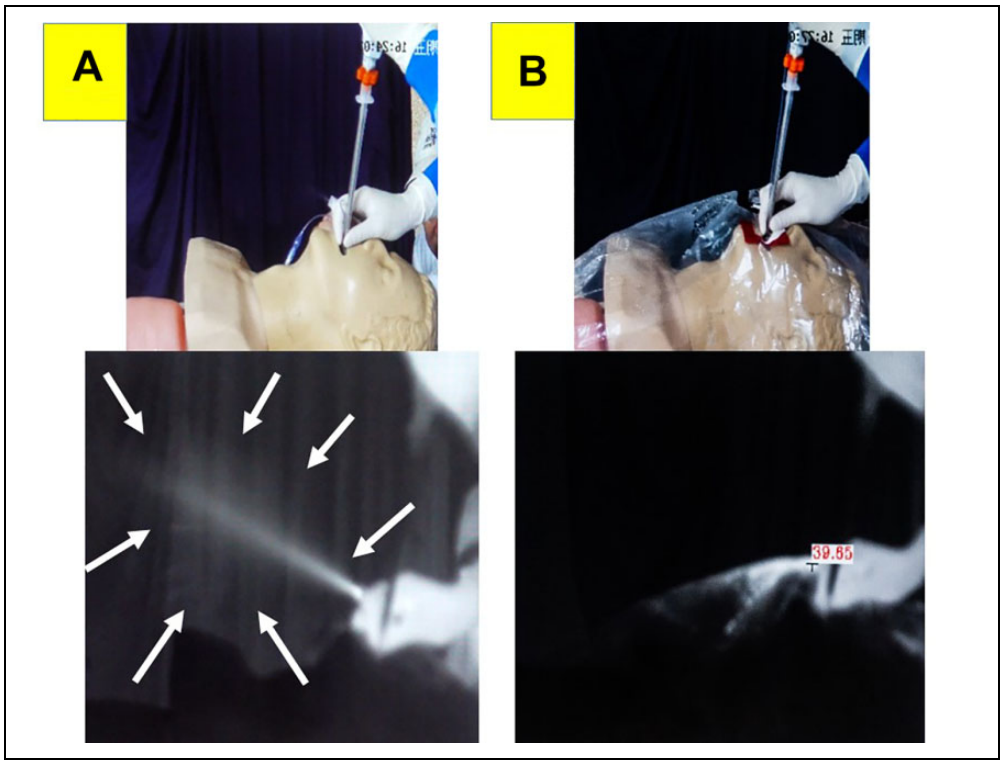

Figure 12. Simulation model of water spray to mimic coughing and bucking in the mannequin. Without (A) and with (B) coverage of plastic sheet over the mannequin's head and neck. Tracheal intubation was performed with intubating stylet technique. Arrows indicate the spreading of the water spray. Imaging was acquired by an infrared thermography machine.

prevented from entering the environment with application of the plastic sheet barrier (Fig. 12B).

An aerosol is a grouping of small liquid or solid particles floating in the air and coronavirus drifts through the air in microscopic droplets. It should be emphasized that most generated particles (aerosol and droplets) range in size from 0.7 to 10 μm, while the new coronavirus, SARS-CoV-2, is approximately 0.1 μm in diameter (60 to 140 nm)[53]. Therefore, results from the two simulation models we used in this study are limited to larger sized particles (mist and water spray, 10 to 100 μm, respectively) and cannot be extrapolated to the smaller aerosols produced by live patients. Fluorescent tracers and dyes for leak detection have been used to evaluate the barrier efficiency of the "aerosol box" and "plastic sheet," although the size of the surrogate particles was not described. Ultraviolet fluorescent powder (5 to 100 μm in size) has also been used as a surrogate for viral particles in order to simulate aerosolized contamination and droplets dispersal[54]. At this time, a valid simulation model demonstrating aerosol spread remains lacking.

Conclusion

With the outbreak of COVID-19 and subsequent global pandemic, tough issues included response capacity building, global emergency supply system, medical therapy, innovative products, and equitable access, availability and affordability of the necessities. In this article, we describe the combined use of a plastic sheet as a barrier with the intubating stylet for tracheal intubation in patients needing mechanical ventilation. Our department has used the video stylet for the majority of endotracheal intubations at our institution for years. Although video-assisted laryngoscopy is more popular and familiar to other groups around the world, we believe that the video-assisted intubating stylet technique is easier to learn and master. Advantages of the video stylet include the creation of greater working distance between intubator and patient, less airway stimulation, and less pharyngeal space needed for endotracheal tube advancement. All of the above features make this technique reliable and superior to other devices, especially when a difficult airway is encountered.

Since the use of the "aerosol box" (made of acrylic) as a barrier enclosure to prevent operating room contamination was originally introduced, serious safety concerns about the box design have been raised. The rigid box might restrict the intubator's hand movements and limit maneuvering of the airway or repositioning of the patient what a difficult airway situation occurs. Alternatively, we proposed the use of a flexible and transparent plastic sheet to serve as a barrier against aerosol and droplet spread during airway management. We demonstrated that the use of a plastic sheet would

not interfere or hinder the intubator's maneuvers during endotracheal intubation. Moreover, we demonstrated that the plastic sheet was effective in preventing the spread of mist and water spray in simulation models with a mannequin.

In conclusion, we proposed the use of the plastic sheet as a barrier to prevent possible droplets contamination from COVID-19 patients and utilized the intubating stylet to perform trachea intubation procedure under this barrier. In our experience, we found that this technique most effectively protected the intubator and other operating room personnel from infection during the COVID-19 pandemic.

Acknowledgments

The authors expressed their gratitude to Hualien Tzu-Chi Medical Center for its full support.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

ORCID iD

Hsiang-Ning Luk https://orcid.org/0000-0002-3994-6624

References

1. Wong E, Ho KK. The Effect of severe acute respiratory syndrome (SARS) on emergency airway management. Resuscitation. 2006;70(1):26–30.
2. Cooper A, Joglekar A, Adhikari N. A Practical approach to airway management in patients with SARS. CMAJ. 2003;169(8):785–787.
3. Kamming D, Gardam M, Chung F. Anaesthesia and SARS. Br J Anaesth. 2003;90(6):715–718.
4. 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(2):122–129.
5. Cook TM, El-Boghdadly K, McGuire B, McNarry AF, Patel A, Higgs A. Consensus guidelines for managing the airway in patients with COVID-19. Guidelines from the Difficult Airway Society, the Association of Anaesthetists the Intensive Care Society, the Faculty of Intensive Care Medicine and the Royal College of Anaesthetists. Anaesthesia. 2020;75(6):785–799.
6. Matava CT, Kovatsis PG, Summers JL, Castro P, Denning S, Yu J, Lockman JL, Von Ungern-Sternberg B, Sabato S, Lee LK, Ayad I, et al. Pediatric airway management in Coronavirus Disease 2019 Patients: Consensus guidelines from the Society for Pediatric Anesthesia's Pediatric Difficult Intubation Collaborative and the Canadian Pediatric Anesthesia Society. Anesth Analg. 2020;131(1):61–73.
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(5):568–576.
8. Chen X, Liu Y, Gong Y, Guo X, Zuo M, Li J, Shi W, Li H, Xu X, Mi W, Huang Y. Chinese Society of Anesthesiology, Chinese Association of Anesthesiologists. Perioperative 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(6):1307–1316.
9. Gong Y, Cao X, Mei W, Wang J, Shen L, Wang S, Lu Z, Yu C, Che L, Xu X, Tan J, et al. Anesthesia considerations and infection precautions for trauma and acute care cases during the Coronavirus Disease 2019 pandemic: recommendations from a task force of the Chinese Society of Anesthesiology. Anesth Analg. 2020;131(2):326–334.
10. Ng K, Poon BH, Puar THK, Quah JLS, Loh WJ, Wong YJ, Tan TY, Raghuram J.COVID-19 and the risk to health care workers: a case report. Annals of Intern Med. 2020;172(11):766–767.
11. Editorial. COVID-19: protecting health-care workers. Lancet. 2020;395(10228):922.
12. Zhang H, Bo L, Lin Y, Li F, Sun S, Lin H, Xu S, Bian J, Yao S, Chen X, Meng L, et al. Response of Chinese anesthesiologists to the COVID-19 outbreak. Anesthesiology. 2020;132(6):1333–1338.
13. Meng L, Qiu H, Wan L, Ai Y, Xue Z, Guo Q, Deshpande R, Zhang L, Meng J, Tong C, Liu H, et al. Intubation and ventilation amid the COVID-19 outbreak: Wuhan's experience. Anesthesiology. 2020;132(6):1317–1332.
14. Luo M, Cao S, Wei L, Tang R, Hong S, Liu R, Wang Y. Precautions for intubating patients with COVID-19 infections. Anesthesiology. 2020;132(6):1616–1618.
15. Yao W, Wang T, Jiang B, Gao F, Wang L, Zheng H, Xiao W, Yao S, Mei W, Chen X, Luo A, et al. Emergency tracheal intubation in 202 patients with COVID-19 in Wuhan, China: lessons learnt and international expert recommendations. Br J Anaesth. 2020;S0007–S0912(20):30203–30208.
16. Ortega R, Gonzalez M, Nozari A, Canelli R. Personal protective equipment and Covid-19. N Engl J Med. 2020;382(26):e105.
17. World Health Organization. Rational use of personal protective equipment for coronavirus disease (COVID-19) and considerations during severe shortages. Interim guidance. (WHO/2019-nCov/IPC_PPE_use/2020.3) Post Acceptance: April 6, 2020.
18. Chang KA, Luk HN, Jawan B, Lu HF, Chen HS, Chen CL. Modified protective suits for anesthesiologists performing tracheal intubation for severe acute respiratory syndrome patients in Taiwan. Anesthesiology. 2004;100(6):1630–1631.
19. Ong J, Lee CL, Huang SJ, Shyr MH. Comparison between the Trachway video intubating stylet and Macintosh laryngoscope in four simulated difficult tracheal intubations: a manikin study. Tzu Chi Med J. 2016;28(3):109–112.
20. Lin YC, Cho AH, Lin JR, Chung YT. The Clarus Video System (Trachway) and direct laryngoscope for endotracheal intubation with cricoid pressure in simulated rapid sequence induction intubation: a prospective randomized controlled trial. BMC Anesthesiol. 2019;19(1):33.
21. Chang PY, Hu PY, Lin YC, Chen HY, Chiang FY, Wu CW, Dionigi G, Lu IC. Trachway video intubating stylet allows for

optimization of electromyographic endotracheal tube placement for monitored thyroidectomy. Gland Surg. 2017;6(5):464–468.
22. Tseng JY, Lai HY. Protecting against COVID-19 aerosol infection during intubation. J Chinese Med Association. 2020;83(6): 582.
23. Canelli R, Connor CW, Gonzalez M, Nozari A, Ortega R. Barrier enclosure during endotracheal intubation. N Engl J Med. 2020;382(20):1957–1958.
24. Rahmoune FC, Yahia MMB, Hajjej R, Pic S, Chatti K. Protective device during airway management in patients with Coronavirus Disease 2019 (COVID-19). Anesthesiology. 2020; 75(6):785–799.
25. Lai YY, Chang CM. A carton-made protective shield for suspicious/confirmed COVID-19 intubation and extubation during surgery. Anesth Analg. 2020;131(1):e31–e33.
26. Moraga FAL, Moraga EL, Moraga FL, González AJ, Celaya JMI, Gallegos JAO, Espinoza JAB. Aerosol box, an operating room security measure in COVID-19 pandemic. World J Surg. 2020;44(7):2049–2050.
27. Chahar P, Dugar S, Marciniak D. Airway management considerations in patients with COVID-19. Cleveland Clinic J Med. Epub ahead of print 15 May 2020.
28. Rosenblatt WH, Sherman JD. More on barrier enclosure during endotracheal intubation. N Engl J Med 2020;382(20):e69.
29. Kovatsis PG, Matava CT, Peyton JM. More on barrier enclosure during endotracheal intubation. N Engl J Med 2020;382(20):e69
30. Gould C, Alexander P, Allen C, McGrath B, Shelton C. Protecting staff and patients during airway management in the COVID-19 pandemic. Br J Anaesth. 2020;125(3):e292–e293.
31. Malik JS, Jenner C, Ward PA. Maximising application of the aerosol box in protecting healthcare workers during the COVID-19 pandemic. Anaesthesia. 2020;75(7):974–975.
32. Kearsley R. Intubation boxes for managing the airway in patients with COVID-19. Anaesthesia. 2020;75(7):969.
33. Luk HN. A simple modified barrier measure for airway management during COVID-19 outbreak. Ru J Anaesthesiol Reanimatol (Anesteziologiya i reanimatologiya). 2020;(2):80–81.
34. Yang YL, Huang CH, Luk HN, Tsai PB. Adaptation to the plastic barrier sheet to facilitate intubation during the COVID-19 pandemic. Anesth Analg. 2020;131(2):e97–e99.
35. Matava CT, Yu J, Denning S. Clear plastic drapes may be effective at limiting aerosolization and droplet spray during extubation: implications for COVID-19. Can J Anaesth. 2020;67(7):902–904.
36. Endersby RVW, Spencer AO, Ho ECY, Goldstein DH, Schubert E. Clear plastic drapes for aerosol-generating medical procedures in COVID-19 patients: Questions still remain. Can J Anaesth. 2020;67(10):1465.
37. Rehm M, Eichler J, Meidert AS, Briegel J. Protecting healthcare workers: use of a body covering transparent sheet during and after Intubation of patients with Covid-19. Anesth Analg. 2020;131(2):e111–e112.
38. Tsai PB. Barrier shields. Not just for intubations in today's COVID-19 world? Anesth Analg. 2020;131(1):e44–e45.
39. Brown S, Patrao F, Verma S, Lean A, Flack S, Polaner D. Barrier system for airway management of COVID-19 patients. Anesth Analg. 2020;131(1):1.
40. Montoya MP, Chitilian HV. Extubation barrier drape to minimise droplet spread. Br J Anaesth. 2020;125(1):e195–e196.
41. Babazade R, Khan ES, Ibrahim M, Simon M, Vadhera RB. Additional barrier to protect healthcare workers during intubation. Anesth Analg. 2020;131(1):e47–e48.
42. Kinjo S, Dudley M, Sakai N. Modified Wake Forest type protective shield for an asymptomatic, COVID-19 non-confirmed patient for intubation undergoing urgent surgery. Anesth Analg. 2020;131(2):e127–e128.
43. Laosuwan P, Earsakul A, Pannangpetch P, Sereeyotin J. Acrylic box versus plastic sheet covering on droplet dispersal during extubation in COVID-19 patients. Anesth Analg. 2020; 131(2):e106–e108.
44. Au Yong PS, Chen X. Reducing droplet spread during airway manipulation: lessons from the COVID-19 pandemic in Singapore. Br J Anaesth. 2020;125(1):e176–e178.
45. Cubillos J, Querney J, Rankin A, Moore J, Armstrong K. A multipurpose portable negative air flow isolation chamber for aerosol-generating procedures during the COVID-19 pandemic. Br J Anaesth. 2020;125(1):e179–e181.
46. Endersby RVW, Ho ECY Spencer AO, Goldstein DH, Schubert E. Barrier devices for reducing aerosol and droplet transmission in COVID-19 patients. Advantages, disadvantages and alternative solutions. Anesth Analg. 2020;131(2):e121–e123.
47. Begley JL, Lavery KE, Nickson CP, Brewster DJ. The aerosol box for intubation in COVID-19 patients: an in-situ simulation crossover study. Anaesthesia. 2020;75(8):1014–1021.
48. Orser BA. Recommendations for endotracheal intubation of COVID-19 patients. Anesth Analg. 2020;130(5):1109–1110.
49. Zeidan A, Bamadhaj M, Al-Faraidy M, Ali M.Videolaryngoscopy intubation in patients with COVID-19: How to minimize risk of aerosolization? Anesthesiology. 2020;133(2):481–483.
50. Brewster DJ, Chrimes N, Do TB, Fraser K, Groombridge CJ, Higgs A, Humar MJ, Leeuwenburg TJ, McGloughlin S, Newman FG, Nickson CP, et al. Consensus statement: Safe Airway Society principles of airway management and tracheal intubation specific to the COVID-19 adult patient group. Med J Aust. 2020;212(10):472–481.
51. Dalli J, Khan MF, Marsh B, Nolan K, Cahill RA. Evaluating intubation boxes for airway management. Br J Anaesth. 2020; 125(3):e293–e295.
52. Chen C, Shen N, Li X, Zhang Q, Hei Z. New device and technique to protect intubation operators against COVID-19. Intensive Care Med. 2020;46(8):1627–1629.
53. Zhu N, Zhang D, Wang W, Li X, Yang B, Song J, Zhao X, Huang B, Shi W, Lu R, Niu P, et al. China Novel Coronavirus Investigating and Research Team. A novel coronavirus from patients with pneumonia in China, 2019. N Engl J Med. 2020;382(8):727–733.
54. Gardiner C, Veall J, Lockhart S. The use of UV fluorescent powder for COVID-19 airway management simulation training. Anaesthesia. 2020;75(7):964–965.