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A Novel Approach to Fiberoptic Intubation in Patients With Coronavirus Disease 2019

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Purpose: In an effort to protect health care workers at the beginning and end of oral and maxillofacial surgeries, we describe a negative-pressure intubation hood (NPIH) designed to reduce the risk aerosol exposure from fiberoptic intubation (FOI) and extubation. This design is especially important during the Coronavirus disease 2019 era, as it provides greater protection from Severe Acute Respiratory Syndrome-Coronavirus-2 during FOI and extubation, which are some of the most high-risk, aerosol generating procedures of oral and maxillofacial surgery cases.

Materials and Methods: This article describes the step-by-step process of assembling a NPIH for FOI using various supplies found commonly in hospitals and surrounding community retail stores, which include transparent medical dressings, equipment covers, intravenous pole clips, polyvinylchloride pipes and adaptors, copper pipe, and a Buffalo smoke evacuator. We then discuss how to create access ports for the anesthesiologist to insert their arms and FOI instrumentation and provide a demonstration of us using the hood with a manikin on an operating room table.

Results: This study successfully demonstrates a novel technique for performing FOI in a NPIH assembled from basic supplies found commonly among hospital and community retail stores.

Conclusions: This NPIH for FOI is easily made and adaptable to operating room tables, and provides protection against aerosols generated from FOI and subsequent extubation during oral and maxillofacial surgeries.

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J Oral Maxillofac Surg 78:2182.e1-2182.e6, 2020

Coronavirus disease 2019 (COVID-19), which is caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), rapidly overwhelmed hospitals and personal protective equipment (PPE) supply chains around the world during the first half of 2020. An important concern when treating patients with COVID-19 in the operating room (OR) or intensive care unit (ICU) is the risk of aerosolizing viral particles. Securing the airway of these patients and at the same time limiting virus exposure to providers can be challenging. One of the first barrier devices created to improve the safety of endotracheal intubation in

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This work was supported by Department of Anesthesia, Critical Care and Pain Medicine, and the Department of Biomedical Engineering, Massachusetts General Hospital, Boston, MA.

Conflict of Interest Disclosures: None of the authors have any relevant financial relationship(s) with a commercial interest.

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Received May 26 2020
Accepted July 18 2020
© 2020 American Association of Oral and Maxillofacial Surgeons
0278-2391/20/30779-5
https://doi.org/10.1016/j.joms.2020.07.027
Patients with COVID-19 consisted of a rigid box with 2 circular working ports called the “aerosol box”. The effectiveness of the aerosol box was later found by Canelli et al. Since then, other barrier hood designs with disposable clear plastic drapes have emerged, some of which are coupled with smoke evacuators to create an environment with negative pressure.

In addition to direct laryngoscopy, there are many patients, particularly those undergoing surgery in the head and neck region, who require fiberoptic intubation (FOI). FOI involves guiding a fiberoptic camera through the mouth or nose into the trachea before advancing the endotracheal tube. This technique for intubation is commonly used in patients undergoing surgery in the head and neck region. Given the need for the anesthesia providers to maintain the fiberoptic controller above the patient’s head with one hand and guide the fiberoptic cable with the other, there is a need for a new barrier design and protocol to accommodate this unique procedure. To our knowledge, there have not been any prior publications addressing FOI with a negative-pressure intubation hood. Thus, the purpose of this study was to describe a novel approach to fiberoptic barrier intubation in COVID-19 risk patients.

Materials and Methods

The list of equipment needed is as follows (Fig 1):

- Two large and 2 medium transparent medical dressings (Tegaderms, 3M Health Care, St.Paul, MN)
- Equipment cover (aka plastic bag)
- Six intravenous pole clips
- Two Clark adapters
- Two sterile sleeve covers
- Polyvinyl chloride (PVC) hood frame
  - Vertical stand:
    - \( \frac{3}{4} \) inch PVC pipes, 4 feet long \( \times 2 \)
    - \( \frac{3}{4} \) inch copper pipe, 1 foot long \( \times 2 \)
  - Top rectangular visor: PVC pipes 3 feet long \( \times 2 \), 1.5 feet long \( \times 2 \)
  - Connection: threaded male adapters \( \times 2 \), 3-way side outlet PVC elbow \( \times 2 \), 2-way PVC elbow \( \times 2 \), PVC cement
- Buffalo smoke evacuator (Buffalo Filter LLC, Lancaster, NY) and 22 mm open suction tubing

Before starting this protocol, the hood frame must be fabricated. To do so, \( \frac{3}{4} \) inch PVC pipe is cut into 2 segments that are 4 feet long, 2 segments that are 3 feet long, and 2 segments that are 1.5 feet long. Next, 2 segments of \( \frac{3}{4} \) inch copper pipe of approximately 1 foot in length are inserted halfway into 1 end of each 4-foot PVC segments and secured with PVC cement. These copper pipe segments will allow the hood to fit into the Clark adapters along the OR bed. On the opposite free ends of the 4-foot PVC segments, \( \frac{3}{4} \) inch threaded male adapters were cemented. These 2 pieces will be the vertical supports for the hood. Next, a 3-way side outlet PVC elbow was threaded onto each of the male adapters. Then, a 3-foot PVC segment was used to connect these elbows and unite the 2 vertical supports. Finally, 1.5-foot PVC segments were cemented into the unoccupied openings of the 3-way elbows in a parallel direction. The free ends of these segments were then cemented to the each other via 2-way PVC elbows and the last 3-foot PVC segment.

To construct the hood frame, first insert each copper pipe into a 4-foot PVC segment and secure with PVC cement. These copper pipe segments will allow the hood to fit into the Clark adapters along the OR table. Next, attach \( \frac{3}{4} \) inch threaded male adapters to the free ends of the 4-foot PVC segments, and secure with cement. Attach 3-way elbows to the male adapters, and connect the 2 elbows using a 3-foot PVC segment. Complete constructing the rectangular visor using the remaining PVC segments and elbows. Cement to secure each connection.

With the hood frame assembled, our protocol then begins with setup of the hood. First, attach Clark adapters to both sides of the OR headboard and mount the PVC hood frame with the top rectangular visor projecting toward the foot of the bed (Fig 2A). Open and attach a plastic bag to the rectangular frame using 6 intravenous pole clips (2 per long end, 1 per short end). Allow the bag to drape down and place 1 large transparent medical dressing (such as Tegaderm) on the side facing the provider at the elbow level and another transparent medical dressing on the ceiling of the hood. Cut a slit in the transparent medical dressing at the elbow level for arm entry and a smaller opening in the transparent medical dressing over the patient’s head for the fiberoptic bronchoscope and endotracheal tube to pass through. At this point, the hanging drapes can be maneuvered around the back of the frame to rest on top of it until the patient is lying on the OR table.

Before the patient is taken to the OR, the monitors such as electrocardiogram leads, blood pressure cuff, and pulse oximeter should be placed. This reduces the need to work around the negative pressure hood once inside the OR. Once the patient is taken to the OR, position him or her on the table as needed, which may vary from supine position to sitting upright at 45\(^\circ\) (eg, awake FOI). Next, place all necessary airway equipment for the procedure under the hood, put a mask on patient’s face for preoxygenation of 10 L/
After attaching the Buffalo smoke evacuator tube to the patient’s pillow, turn on the evacuator. Lower the drapes after or before induction, such that the patient’s chest and upper chest is enclosed in the hood. Tuck in the edges to create a sufficient seal to achieve negative pressure, which is noted when the drapes bow inward. This seal can be further improved by placing a blanket across the drape over the patient’s chest. A small leak is tolerable given the smoke evacuators ability to suction at a robust 839 L/minute at its maximum capacity.

With the hood setup and holding negative pressure, the operator should don sleeve covers and double glove before entering the hood. The intubation process may begin with the operator standing at the head of the bed, inserting 1 arm into the hood through the premade slide, and lowering the fiberoptic scope through the other opening from above (Figs 2B,C, Video 1). A second provider at the side of the patient is positioned ready to provide assistance to facilitate intubation as needed.

After intubation, place medium transparent medical dressings over the arm port and bronchoscope port to seal the hood. At this point, keep the hood over the patient for 5 minutes to allow for 98% air clearance under the hood. When it is safe and appropriate to remove the hood, begin by rolling the plastic bag inward to avoid contamination and dispose of it. The frame can
then be either tilted back or removed completely for the surgical procedure.

Before the end of the procedure, a second hood is made for extubation. However, instead of placing 1 large transparent medical dressing at the elbow level and 1 large transparent medical dressing above the patient, 2 large transparent medical dressings are placed at the elbow level on the provider side for standard endotracheal extubation. The remainder of the extubation procedure mirrors the steps described for intubation.

If the provider needs to intubate from the front of the patient instead of behind the patient, the only modification would be to place the large transparent medical dressing at the elbow level on the side of the hood in front of the patient instead of behind the patient. Also, in the case of an airway emergency, additional ports into the hood can be quickly created by taping large transparent medical dressings, creating a cut, and inserting one’s arm. If the hood interferes despite these efforts, it can be quickly removed by loosening the Clark adapters and lifting up and away from the patient.

**Discussion**

As health care providers continue to treat patients with COVID-19, they must modify existing high-risk procedures to make them safer. FOI has been categorized as a high-risk procedure because of the high probability of coughing and dissemination of viral particles. Because of the frequency of FOI, especially in oral and maxillofacial surgery, we believe our revised protocol will protect the OR team. To our knowledge, this is the first protocol described for FOI within a negative pressure hood designed to guide providers treating patients with COVID-19.

**INDICATION FOR FOI**

FOI is most often indicated, and considered by many to be the gold standard, for the intubation of patients with difficult airways and is often performed when the patient is awake before the administration of general anesthesia.

There are many factors leading to a difficult airway, including unique head and neck anatomy, trauma, cervical spine instability, difficulty with prior intubation, or anticipated difficulty with direct laryngoscopy on the basis of physical examination. A meta-analysis of over 50,000 patients with normal airway anatomy on preoperative examination found difficulty with intubation in 5.8% of cases. However, in oral and maxillofacial surgery, in which the surgical field is closer to the airway and mouth opening is commonly affected by the disease process, difficult intubations have been reported to comprise 15.4 to 16.9% cases.

Although the oral and maxillofacial surgery literature lacks incidence data of overall use of FOI, many individual studies of a specific procedure type have been reported. One study of 264 trauma patients with facial fractures found FOI used in 55.21% of cases. Another study of 26 patients with deep neck infection reported that FOI was used for 25 patients with 1 patient receiving a tracheostomy. In a report of 500 head and neck cancer patients undergoing surgery, 320 of them underwent FOI. In another study of 36 patients undergoing surgery for temporomandibular joint ankylosis, 22 (61.1%) had airways secured by FOI. In addition, many of these studies involved nasal intubation over oral intubation. One report of 634 elective maxillofacial surgeries found that 579 patients were intubated nasally. Given that many authors advocate for fiberoptic nasal intubation over conventional nasotracheal intubation, there appears to be ample need for FOI in oral and maxillofacial surgery. Although our hood is especially beneficial for awake FOI because of expected coughing and aerosol generation, this protocol is equally effective for both awake and sleep patients by either oral or nasal route of FOI.

Compared with direct laryngoscopy, FOI has several advantages including the ability to visualize the entire airway, the control to navigate around pathology, the versatility to be used for nasal or oral intubation, and ability to reduce spinal manipulation. Few studies have compared FOI directly against other devices. One report of FOI versus intubating laryngeal mask airway (ILMA) found similar success in securing the airway, but ILMA failed in patients with prior head and neck cancer treated with cervical radiotherapy, suggesting FOI was superior for these patients. Another study comparing ILMA and oral FOI for awake intubation found success rates of 84 and 96%, respectively. Overall, despite the absence of evidence of FOI’s superiority in all scenarios, there is sufficient literature to indicate that it is an effective method of intubating and a favorable choice for the difficult airways of many patients undergoing oral and maxillofacial surgery.

**NEGATIVE-PRESSURE INTUBATION HOOD**

There have been several barrier intubating hood designs created so far. Our study proposes using a negative pressure design, which is disposable and has been validated in 2 recent studies. Lang et al. using a humidifier to replicate aerosol production, reported that the particle count at the clinician’s head level decreased from 700 to 18 L\(^{-1}\) with the use of the negative pressure patient isolation hood. They also reported a 65% decrease in the particle count inside the hood with a smoke evacuator suctioning at 230 L/minute. Without the evacuator or humidifier...
turned on, it took 183 minutes for the particle count in the hood to clear by 98%, compared with 5 minutes with negative pressure applied. This study presented our hood design for aerosol containment and provided guidance for the time course of how long the hood should remain in place after intubation or extubation to achieve a considerable reduction in particle count. In addition, Matava et al. also reported that the disposable plastic drapes of intubation hoods could be rolled up and disposed of without causing additional contamination to health care providers, thus further validating the safety of disposable drape hoods and our design.

Lang et al. found that high-risk aerosol-generating procedures such as high-flow nasal cannula can be safely used with an ICU-tailored version of the hood design. Using a humidifier and high-flow nasal cannula at 70 L/minute, particle counts decreased from 155 without the smoke evacuator on to 50 particles/L when the evacuator was at maximum suction of 839 L/minute. The particle counts also decreased by more than half with the use of negative pressure. Finally, the time needed to filter out 99% of the particles decreased from 87 to 9 minutes at 60% evacuator capacity and 6 minutes at 80% evacuator capacity. This study verified safe containment of aerosol-generating procedures using this hood design.

Importantly, we chose to use the Buffalo suction device as opposed to other manufacturers because it is an institutional preference within our ORs, but more importantly because it uses an ultralow particulate air (ULPA) filter, which has 99.9995% efficiency rating for removal of 0.12 μm or larger diameter particles. Compared with high-efficiency particulate air filter, which has 99.97% efficiency rating for removal of 0.3 μm or larger diameter particles, the ULPA filter is more efficient and the best choice for SARS-CoV-2, which has a viral particle size range of 0.065 to 0.125 μm. If patients need to use these hoods outside the OR where the Buffalo system may not be available or need to be transported through the hospital within a negative pressure hood, mobile suction devices, such as the Neptune smoke evacuator system, could be considered. Given the ubiquitous presence of patients with COVID-19 throughout the hospital, a mobile suction system may allow even greater implementation of this protocol.

Overall, these studies suggest that our negative pressure hood could effectively reduce aerosol particle exposure to the provider during aerosol-generating procedures, similar to awake FOI. With the use of this hood and appropriate donning of PPE, the provider performing FOI should be more protected against exposure to viral particles, thus decreasing the risk of nosocomial SARS-CoV-2 infections.

ADVANTAGES AND DISADVANTAGES

An advantage of this design is that it is inexpensive and disposable, which keeps cost low. Despite needing to create 2 hoods per OR case, this low-cost design uses available resources and helps reduce additional PPE use at a time when PPE is difficult to procure and implicates its potential use throughout the hospital, including ICUs.

A concern with using a hood for intubation is the ability to gain rapid access to the patient during an airway emergency. Depending on the urgency of the situation, additional transparent medical dressings and cuts can be made anywhere along the walls of the hood for quick patient access by 1 or more providers simultaneously. This feature has the advantage over other rigid plastic designs that restrict access to the plastic cutouts incorporated into the hood designs. If an airway issue calls for a more rapid response, the hood can be instantly removed altogether by loosening the 2 Clark adapters. In addition, the ability to create access ports anywhere on the hood walls also makes it more versatile during intubation. Although our protocol primarily focuses on accessing the patient from behind and above, some upright awake FOI may be easier with access from the front of the patient and above, which is made possible by the soft plastic drapes.

A limitation of this design is the extra OR time needed. Given that surgery around the head and neck likely necessitates removal of the hood, the breaking down and setting up of the hood for intubation and again for extubation is seemingly unavoidable. Our experience shows that once the protocol for hood assembly is completed, the actual intubation process itself takes roughly as long as without barriers. However, additional OR time is needed for 5 minutes of waiting at the end of intubation and extubation for the smoke evacuator to remove viral particles before removing the hood. Therefore, the added case time is estimated to be around 10 to 12 minutes per patient. Another disadvantage of our design includes the need to replace the ULPA-grade filter of the smoke evacuator, which adds cost to the use of the hood.

COVID-19 has provided an impetus for innovation. In the specialties of anesthesia and oral and maxillofacial surgery, it has led us to innovate and design a negative pressure patient intubation hood for FOI of patients with difficult airways. Our hood design has been reported by prior studies, and this study shows how additional modifications can expand its use to FOI. Through implementation of our negative pressure patient intubation hood, we have been able to more safely serve our patients and safeguard the well-being of our frontline health care providers.
Supplementary Data

Supplementary video associated with this article can be found in the online version, at https://doi.org/10.1016/j.joms.2020.07.027.

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