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Bronchoscopy in children with COVID-19: A case series

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Abstract

Introduction: The coronavirus disease-2019 (COVID-19) era is a challenging time for respiratory teams to protect their patients and staff. COVID-19 is predominantly transmitted by respiratory droplets; in the clinical setting, aerosol generating procedures pose the greatest risk for COVID-19 transmission. Bronchoscopy is associated with increased risk of patient-to-health care worker transmission, owing to aerosolized viral particles which may be inhaled and also result in environmental contamination of surfaces.

Methods: We describe our experience with the use of modified full-face snorkeling masks for pediatric bronchoscopy procedures in four COVID-19 infected children when filtering facepieces/respirators were in limited supply.

Results: Bronchoscopy was urgently required in four children, and could not be delayed until COVID-19 test results were available. During the pandemic peak, when respirators were in short supply, modified full-face snorkel masks (SEAC Libera, SEAC, Italy) were worn by the bronchoscopy team. Each mask was fitted with an O-ring, adapter, and heat and moisture exchanger filter. To date, there have been no COVID-19 infections among the bronchoscopy team staff, whereas the overall Hospital staff COVID-19 prevalence rate has exceeded 13.5% (667/4949).

Conclusion: Emergency bronchoscopy procedures on COVID-19 infected patients or patients with unknown infection status can be safely performed using modified full-face snorkel masks.

KEYWORDS

COVID-19, foreign body aspiration, full-face snorkel masks, pediatric bronchoscopy, PPE, rigid bronchoscopy

1 | INTRODUCTION

The emergence and rapid global spread of severe acute respiratory syndrome coronavirus-2 (SARS-COV-2) resulting in coronavirus disease 2019 (COVID-19) initially reported in Wuhan, China has been well documented. The first case in South Africa was diagnosed on 5 March 2020,[1] but initial transmission rates were low, following enactment of a national lockdown on 27 March 2020. Since the relaxation of lockdown restrictions, the country has experienced exponential increase in COVID-19 infections, with 196 750 confirmed cases in South Africa, and the Western Cape having the highest burden of cases with a total of 69 531 cases (35.3%) on the 5th of July. Tygerberg Hospital, an academic, public hospital in Cape Town, is one of two major

referral hospitals for COVID-19 infected patients in the Western Cape Province. Owing to the limited local and national laboratory capacity for SARS-CoV-2 testing and the huge public demand for testing at the peak of the pandemic in Cape Town, our hospital limited testing of hospitalized children to those presenting with symptoms and signs meeting the national criteria[2] for COVID-19 investigation. The turnaround time for SARS-CoV-2 reverse transcription-polymerase chain reaction (RT-PCR) results at our hospital has varied from 24 to 72 hours for hospitalized patients, and rapid testing before emergency surgery and procedures was not readily available in the first months of the pandemic. Since March 2020, the hospital's pediatric service has screened 768 children for COVID-19, of whom 128 were COVID -19 positive (16.7% test positivity rate); 37/128 (28.9%) required hospital admission.

In community settings, COVID-19 is predominantly transmitted through respiratory droplets, although recent studies suggest that aerosol transmission may also occur.[3-6] In the clinical setting, aerosol generating procedures (AGP) pose the greatest risk for COVID-19 transmission.[7] These procedures include high-flow oxygen delivery (HFO), continuous positive airway pressure delivery (CPAP), intubation, suctioning, and bronchoscopy. The use of these modalities and procedures is associated with increased risk of patient-to-health care worker transmission, owing to aerosolized viral particles which may be inhaled and also result in environmental contamination of surfaces.[8-10]

Although the role of children in the transmission of SARS-CoV-2 in the community is thought to be limited,[11] the risk of transmission to health care workers (HCWs) performing AGPs on COVID-19 infected children is likely to be significant, although,[12] further research is needed. For this reason, children undergoing AGP's should undergo SARS-COV-2 testing preprocedure. In the case of emergency procedures (as described in this case series), and/or where rapid SARS-COV-2 testing is not possible, all HCWs in the procedure room should apply airborne precautions and additional administrative measures, environmental controls, and different personal protective equipment requirements to reduce COVID-19 transmission risk.[13,14] In addition, the phenomenon of asymptomatic COVID-19 infection, particularly in children, poses an additional risk to staff undertaking AGP's, with potential for unexpected transmission of COVID-19 to HCWs.

The COVID-19 era is a challenging time for respiratory teams to protect their patients and staff. For COVID-19 infected or suspected patients undergoing AGPs (eg, cardiopulmonary resuscitation), the European Resuscitation Council guidelines advocate for the use of: a long-sleeved gown, a filtering facepiece (FFP3 or N99 respirator; FFP2 or N95 if FFP3 not available); and eye and face protection (full-face shield/visor or polycarbonate safety glasses). Where filtering facepieces are not available, the resuscitation council guidelines recommend use of powered air purifying respirators (PAPR) with hoods.[15] However, owing to global personal protective equipment (PPE) shortages and supply chain challenges, many hospitals have had to procure alternatives to traditional PPE.

2 | METHODS

We describe our experience with pediatric bronchoscopy in four COVID-19 infected children, whose COVID-19 PCR results were not available preprocedure and share our experience of adapting full-face snorkeling masks for use in AGPs when filtering facepieces/respirators were in limited supply.

Permission to report this case series was granted by the Institutional Review Board of the Health Science Faculty of Stellenbosch University (HREC N20/04/013).

2.1 | Case series

2.1.1 | Case 1

A 1 year and 8-month-old male presented with an acute history of difficulty breathing for 1 day. No fever, cough, or choking episode was reported. He was not known to be in contact with persons with COVID-19 or tuberculosis (TB). Upon arrival to casualty he was noted to have severe respiratory distress and was wheezing. Emergency care included metered dose inhaled salbutamol with a spacer and face mask, magnesium sulfate infusion, intravenous dexamethasone, and an intravenous salbutamol loading dose. Nasal-CPAP was started in the emergency room. After an initial brief improvement he worsened and had an asystolic arrest. He was resuscitated and intubated, with re-establishment of circulation after 20 minutes; he was subsequently transferred to the pediatric intensive care unit. His initial chest radiograph showed hyperinflation and no significant parenchymal air-space disease (Figure 1). The sudden onset of symptoms and the initial presentation had raised concerns of foreign body aspiration. Bronchoscopy was performed with a 3.0 mm videoscope via a 4.0 mm endotracheal tube to assess the airway. Bronchoscopy confirmed thick pus in the left and right sided airways but a foreign body was excluded. The child improved rapidly and was extubated to HFO; his SARS-CoV-2 RT-PCR result that had been sent on presentation was confirmed as positive on day 2 of hospitalization. A nasopharyngeal aspirate also collected on admission was positive for rhinovirus and cytomegalovirus (CMV), but a plasma CMV-viral load was undetectable. Bacterial cultures on a tracheal aspirate and Xpert MTB/RIF were negative. The child had no known COVID-19 exposures and his mother's COVID-19 RT-PCR was negative.

2.1.2 | Case 2

A 3 year and 8-month-old girl, known with Gene Xpert MTB/RIF-confirmed pulmonary tuberculosis (PTB), on treatment for the preceding 3 months, presented with progressive lung disease. She had signs of large airway obstruction and increasing coughing but was apyrexial. She had no symptoms of upper respiratory tract infection on admission. On examination she had dullness to percussion and decreased air entry on the right side of her chest. Her chest

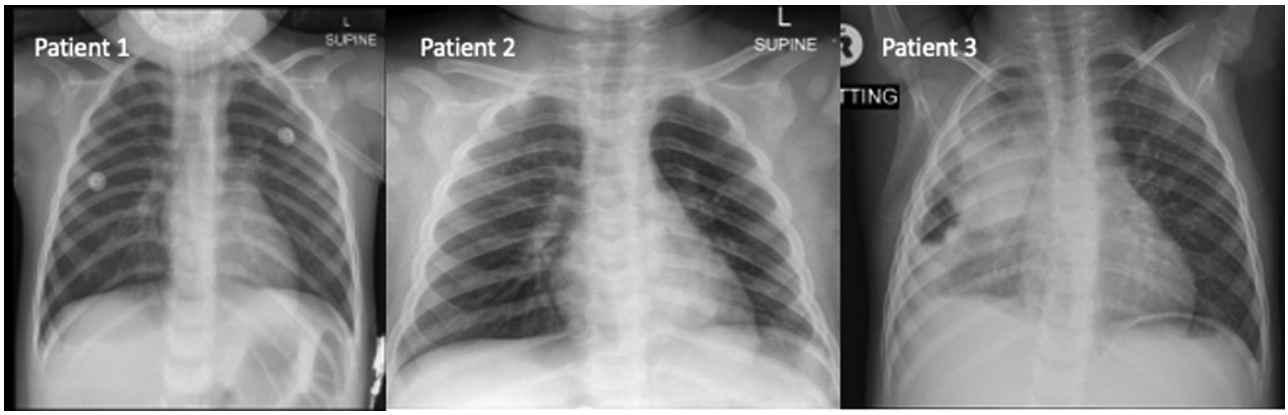

FIGURE 1 Patient 1: Frontal chest radiograph in a high care setting with a well-placed endotracheal tube tip and nasogastric tube tip. Lung volumes are on the large side but this is in the context of positive pressure ventilation which accounts for this. There is no confluent parenchymal air-space disease or any suggestion of an interstitial process. Patient 2: Frontal chest radiograph demonstrating confluent density behind the heart on the left in keeping with left lower lobe air-space disease. Patient 3: Frontal chest radiograph demonstrating extensive confluent air-space disease with some volume loss involving the right upper lobe and right lower lobe. There are features of a right pleural effusion. The bronchus intermedius and possibly right upper lobe bronchus are narrowed suggesting compression by right hilar and subcarinal lymphadenopathy. The trachea is also bowed and displaced to the left in keeping with right paratracheal lymphadenopathy. Features are of airway compression suggest pulmonary TB with associated complications of parenchymal collapse/consolidation and pleural effusion.
TB, tuberculosis

radiograph demonstrated pleural disease and mediastinal lymph node enlargement with airway compression (Figure 1). Bronchoscopy was performed to evaluate the severity of the airway compression and to determine if urgent decompression of mediastinal lymph nodes would be needed. Bronchoscopy was performed with a 4.0-mm videoscope passed via laryngeal mask airway (LMA). She had 50% tracheal compression from the right; bronchus intermedius was 75% compressed medially and laterally. The right upper lobe bronchus was 100% occluded with a granuloma. There were also granulomas in the right lower lobe and lingula. The procedure was completed without complications. Specimens collected for Xpert MTB/RIF during the procedure again confirmed the presence of drug susceptible TB. A SARS-COV-2 RT-PCR test, taken on hospital admission, was confirmed as positive 1 day after the procedure. The child had no known COVID-19 contacts.

2.1.3 | Case 3

Case 3: A 17-month-old boy presented with severe stridor. The medical history was not suggestive of croup and he had had no previous episodes of croup. In the emergency ward, the child coughed out a large object which resembled a plastic cap from a milk bottle. Bronchoscopy was performed with a 3.0-mm videoscope via the nasal route, as the bottle cap appeared incomplete. Bronchoscopy confirmed that the object was lodged between the true vocal cords, with significant swelling and granulation tissue on both cords. The rest of the airway was clear. The following day, the child developed symptoms suggestive of COVID-19 infection (fever and coughing) and COVID-19 was confirmed on RT-PCR. His chest radiograph showed left lower lobe air-space disease (Figure 1). No household contacts were identified. He was discharged 2 days later and made a complete recovery.

2.1.4 | Case 4

A 16-day-old male baby presented with severe progressive life threating inspiratory and expiratory stridor since birth. The baby was HIV-exposed, but uninfected. He had no fever or other respiratory symptoms. Bronchoscopy was performed under anesthesia with 2.8 mm videoscope via the nasal approach in a spontaneously breathing baby. We found bilateral vocal cord palsy and a pulsatile (possibly vascular) compression anterior in the middle third of the trachea. The procedure was completed without complications. A screening COVID-19 RT-PCR test, taken on hospital admission became available the day after the bronchoscopy and was confirmed as positive. No one in the new-born's household contacts had symptoms of COVID -19 infection.

The same group of staff members were involved in all four bronchoscopy procedures including the bronchoscopist, anesthetist, assistant anesthetist, and nursing personnel.

2.2 | PPE during bronchoscopy

Modified full-face snorkel masks (SEAC Libera, SEAC, Italy) were worn by the bronchoscopy team from the start of the COVID-19 pandemic in South Africa as PAPR respirators were unavailable at Tygerberg Hospital. Initially N95 respirators and visors were worn but this distorted bronchoscopy views, especially during interventional procedures. The SEAC full-face snorkel mask has

separate inhalation and exhalation circuits, with one-way exhalation valves, ensuring CO_2 clearance. The snorkel was removed and replaced with a three-dimensional (3D) printed adapter (provided with the mask from the supplier), with an O-ring inserted in a groove at the base of the adapter. A heat and moisture exchanger (HME) filter (Clear Guard, Intersurgical, South Africa) was attached to the adapter (Figures 2, 3, and 4). Face fit testing, as per the manufacturer's specifications, was performed for each HCW to determine the size of mask and optimal strap position. The rapid suction test (quantitative negative pressure test) was performed to confirm seal at each donning episode. This test was performed by placing a hand over the filter and inhaling deeply. If the mask sealed adequately, a vacuum would be created inside the mask (due to the mask's low internal volume) and a sensation of stifling would be experienced. The mask was cleaned with quaternary ammonium wipes or a 0.1% hypochlorite solution. Standardized donning, doffing, and mask decontamination procedures were developed and implemented. The HME filters were exchanged every 7 days unless damaged or clearly wet. To date, there have been no COVID-19 infections among the bronchoscopy team staff, whereas the overall Tygerberg Hospital staff COVID-19 prevalence rate has exceeded 13.5% (667/4949) (personal communication Dr Jack Meintjes).

2.3 | Bronchoscopy anesthetic technique

Four children were anesthetised for flexible bronchoscopy (FB) with SARS-CoV-2 results that turned out to be positive after the procedures were performed. Preoperatively the children were screened for COVID-19 and all were asymptomatic. In our institution anesthesia for airway procedures, which include bronchoscopy, mandate the wearing of PPE, which usually (pre-COVID-19) consisted of an N95 respirator, face shield/visor, or eye protective goggles and an unsterile waterproof gown.

FIGURE 3 A, Standard N95 mask and visor and (B) SEAC Liber during bronchoscopy at Tygerberg Hospital [Color figure can be viewed at wileyonlinelibrary.com]

Additional infection prevention measures implemented during the COVID-19 pandemic included the wearing of surgical face masks by patients and caregivers (source control), and only allowing the patient and caregiver to enter the bronchoscopy theater once all preparations are complete, thereby, reducing the exposure time for staff. Induction of anesthesia, on the lap of a parent, is completed with sevoflurane gas induction, fraction of inspired oxygen (FiO_2) of 0.5 in air. Standard American Society of Anesthesiologists monitoring was applied, including capnography. Intravenous access was established and alfentanil 10 μg/kg administered to obtund the airway reflexes and the response to placement of a LMA. The LMA was held in position by the anesthetist ensuring a tight seal. Spontaneous breathing was maintained with positive pressure ventilation by hand, only when necessary, to prevent the potential of aerosol generation. Placement of a Rusch Mainz Universal Adapter between the anesthetic breathing circuit and the LMA ensured a sealed channel for both bronchoscopy and ventilation while minimizing the risk for aerosolization.

Lignocaine 1% was injected onto the vocal cords via FB working channel, to a maximum dose of 9 mg/kg. Baseline oxygen saturations were above 96% for all the children, and no desaturation episodes

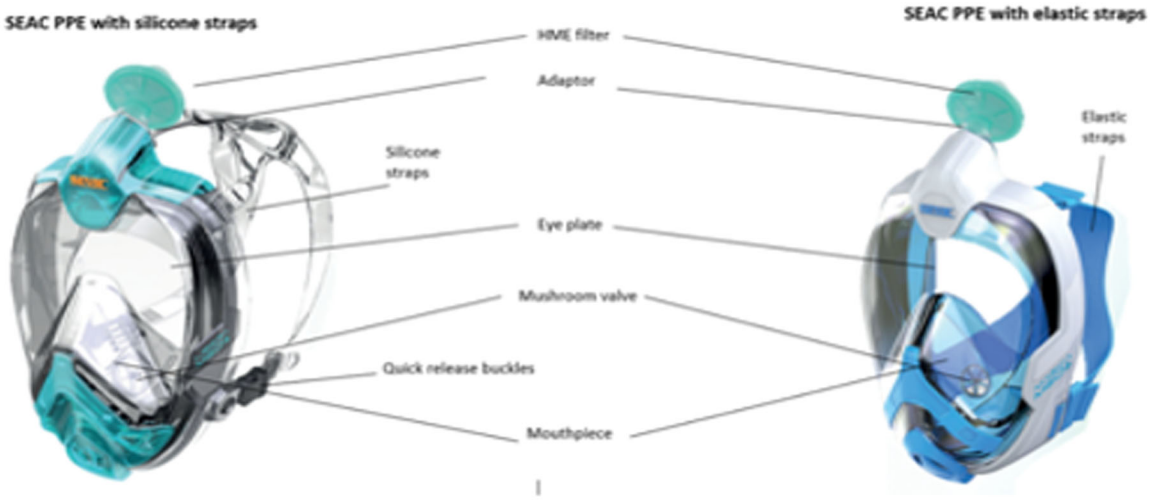

FIGURE 2 A, SEAC Libera PPE mask (silicone straps) and (B) SEAC Magica (material straps) PPE mask. PPE, personal protective equipment [Color figure can be viewed at wileyonlinelibrary.com]

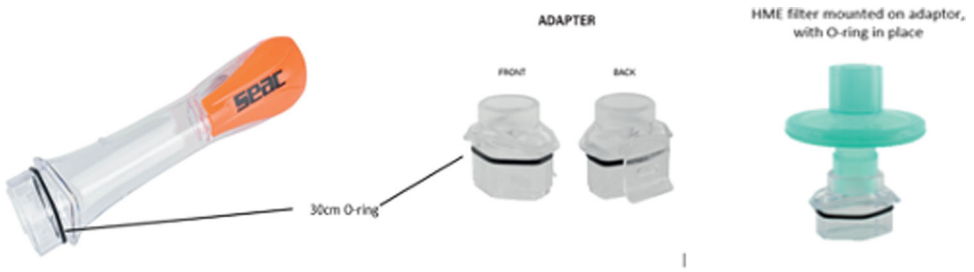

FIGURE 4 Modifications to face mask: detach snorkel, attach adapter with O-ring in groove and place HME filter on top of adapter. HME, heat and moisture exchanger [Color figure can be viewed at wileyonlinelibrary.com]

were recorded during the course of the anesthesia with the maximum FiO_2 of 0.5. The procedures were uneventful lasting between 5 and 10 minute and the LMAs were removed under deep sevoflurane anesthesia. Once stable the patients were transported to the recovery room in the left lateral head down recovery position breathing spontaneously. An oxygen face mask with an FiO_2 of 0.4 was applied if pulse oximetry readings were less than 94%. Patients returned safely to the ward with no complications. All bronchoscopy and patient monitoring equipment and the bronchoscopy theater surfaces were cleaned as per hospital COVID-19 cleaning protocols.

3 | DISCUSSION

We have described four cases of pediatric COVID-19, where COVID-19 was not clinically suspected, but urgent bronchoscopy was required, requiring adaptation of bronchoscopy and anesthetic technique as well as type of PPE used.

None of these cases were suggestive of COVID-19 infection upon presentation to hospital. Two of the cases presented with a history of possible foreign body aspiration, one with congenital stridor and one with complicated PTB and progressive airway obstruction. Owing to the severity of the clinical presentation, it was not possible to wait for the COVID-19 result before these procedures. This highlights the difficulty of doing bronchoscopy in the COVID-19 era, as it is often clinically necessary and urgently indicated.

The fast transmission rate of SARS-CoV-2 virus, long incubation period and asymptomatic spread have led to a large number of deaths. Especially in the older population with underlying comorbidities.[16] What is of particular concern is the spread of SARS-COV-2 to HCW who are thought to have an increased risk to acquire infection.

The first transmission to HCW was described in January 2020 and the first reported fatality related to COVID-19 was an otolaryngologist from Wuhan, China.[17] The airways of infected patients with COVID-19 have been shown to have a very high viral load.[18] Airway procedures result in the aerosolization of the virus, thus placing HCWs at high-risk of infection.[13,14,19] It has been recommended that only essential procedures be performed during the COVID-19 pandemic and that the appropriate PPE be used and personnel should be limited to only essential staff.[20]

The SEAC Libera (SEACSUB, Italy) full-face snorkel mask (with adapter) was fitted with an Intersurgical Clear-Guard filter (Intersurgical, South Africa) and have been adapted by replacing the snorkel with a 3D printed adapter and the addition of a bacterial/viral filter (Figure 2). The SEAC PPE mask conforms to the provisions of the EU regulation 425/2016 regarding PPE. These masks are ideal for PPE due to their ability to withstand the intrusion of water. The silicone face skirt is hypoallergenic and the mask has a low internal volume. The safety of the SEAC mask is ensured by separate air inlet and outlet channels, thereby, decreasing breathing effort, simulating natural breathing, and preventing CO_2 retention. End-tidal CO_2 ($ETCO_2$) and ETO_2 have shown to be stable in two case studies with only single participants[21,22] as well as in similar masks that have been used in endoscopic procedures.[23,24]

Bronchoscopy has a very limited role in the management of COVID-19 positive children because most have mild disease and do not require bronchoscopy. Xia et al[25] reported that COVID-19 disease in children is characterized by mild pneumonia, with only 10% of patients developing tachypnea. Pneumonic changes were confirmed by chest CT-scan as in most children the chest x-ray appearance was normal.

Noninvasive testing can confirm the diagnosis of COVID-19 and bronchoscopy is, therefore, seldom required. Rigid bronchoscopy should be avoided, due to the increased risk of droplet spread during the COVID-19 pandemic.[26] Rather, flexible bronchoscopy should be performed first in COVID-19 positive individuals or in unknown cases, to determine if rigid bronchoscopy is indicated. Foreign bodies can also be removed with flexible bronchoscopy, if required. Aerosolization during bronchoscopy via LMA can be reduced by covering the swivel connection with plastic tape or Tegaderm. Collecting bronchoalveolar lavages may increase the risk of droplet spread for HCWs involved. This should be done with care and only if it will benefit the patients.

At the peak of the epidemic in South Africa the demand for testing was extremely high, significantly delaying test results. It became impractical to wait for these results before bronchoscopy, especially seeing that the bronchoscopy procedures mentioned were urgently indicated. These bronchoscopies were performed under strict precautions, as with any patient who is a person under investigation. All bronchoscopy patients with an unknown COVID-19 status should be regarded as potentially COVID-19 infected and

TABLE 1 Pediatric bronchoscopy in COVID-19

Patient number	Age	Presentation	Indication	Procedure	Finding
1	1 y 8 mo	Acute history of difficult breathing	To exclude foreign body aspiration	FOB 3.0 mm via ET	Bilateral inflammation and pus in the airways
2	3 y 8 mo	Complicated PTB with progressive airway obstruction	To determine degree of airway involvement for possible surgical intervention	FOB 4.0 mm via LMA	50% tracheal compression bronchus intermedius 75% compressed from both medially and laterally. The right upper lobe bronchus was 100% occluded with a granuloma. Granuloma in the right lower lobe and lingula bronchi
3	17 mo	Severe atypical croup needing intubation	To exclude foreign body aspiration	FOB 3.0 mm via nasal approach	Confirmed that the object was lodged between the cords as there was significant swelling and granulation tissue on both cords
4	16 d	Severe progressive stridor since birth	To determine cause of stridor	FOB 2.8 mm via nasal approach	Bilateral vocal cord palsy and anterior vascular compression of the trachea

Abbreviations: COVID-19, coronavirus disease-2019; ET, end tidal; FOB, flexible fiberoptic bronchoscope; LMA, laryngeal mask airway; PTB, pulmonary tuberculosis.

managed as per the policies for COVID-19-positive cases. We advocate that full PPE (as described above) should be worn by all staff involved in pediatric bronchoscopy during the COVID-19 pandemic. Currently, there are no specific pediatric COVID-19-related guidelines published for bronchoscopy.[26,27]

4 | CONCLUSION

Bronchoscopy is a high-risk procedure, with great potential for hospital-acquired COVID-19 exposure and infection among HCWs during the COVID- 19 pandemic. Bronchoscopy can be done performed in children with COVID-19 if infection prevention protocols are strictly adhered to and HCWs wear appropriate PPE at all times. Modified full-face masks are a practical and safe alternative to filtering facepieces for use in bronchoscopy (Table 1).

CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

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