Received: 17 May 2020 | Accepted: 21 May 2020

DOI: 10.1111/pan.13932

EDITORIAL

Pediatric Anesthesia WILEY

What's inside the box? Or shall we think outside the box?

1 | INTRODUCTION

With the deadly and highly transmissible SARS-CoV-2 virus causing the COVID-19 pandemic, there is global concern about the danger of contaminating healthcare workers (HCW), particularly during airway management of infected patients. In this edition of *Pediatric Anesthesia*, Bryant and Tobias report a laboratory study where there was up to 99.2% decrease of artificial aerosol particles measured outside compared with inside an enclosed clear intubation box using augmented gas flow (suction).[1]

At first glance, the concept of a barrier over the patient during airway management seems like a simple and logical option in terms of protecting practitioners from viral infection. This concept has inspired a range of barrier solutions to protect HCWs from infection during intubation. Plastic sheets and intubation boxes made of Perspex or cardboard are proposed as aerosol barriers, and their use had been propagated heavily on social media during the first three months of the COVID-19 pandemic. The repeated mentioning of this "simple" solution to the highly feared transmission to HCWs led to a fast global spread without any clinical evidence of efficacy, usability, and decreased transmission rates. It may be that some or all of these ideas have merit, but a scientific approach to their evaluation of benefit and risk has been largely lacking.

2 | DOES A PATIENT BARRIER DECREASE INFECTION POTENTIAL?

It is assumed that placing a barrier over an infected patient during tracheal intubation will decrease their infection potential. There are a number of variables to consider when evaluating infection risk of a virus such as SARS-CoV-2. A detailed theoretical analysis by Nicas et al have examined the source-environment-receptor pathway to estimate the pathogen dose and infection risk to an HCW.[2] The exact concentration of different pathogens in respiratory fluid is unknown. This will depend on time, pathogen, and patient. Using calculations by Nicas et al and applying results from Bryant et al, approximately 4000 pathogens per hour could still escape an intubation box with suction if an infected patient was actively coughing. It is unknown how many pathogens are released from an infected paralyzed patient during tracheal intubation. Although it seems likely and logical that decreasing the viral load with a barrier over the patient could decrease infection potential, there is no current evidence to support this notion.

3 | WHAT IS THE EVIDENCE FOR THE RISK OF AEROSOL RELEASE AND TRANSMITTED INFECTION FROM INTUBATION?

Intubation is reported to be a high-risk procedure for aerosol release and transmission of infection to HCWs. Supporting evidence for this comes from a systematic review.[3] That review, published in 2012, was based on 5 case-control and 5 retrospective cohort studies of SARS-CoV-1 virus infection to HCWs. Tracheal intubation was the only procedure with consistent findings from multiple studies to establish the risk of transmission. Twenty other potential aerosol-generating procedures were discounted as being insignificantly associated with a risk of SARS-CoV-1 transmission. The authors of that study advise that all 10 studies in this review were of low quality according to a GRADE analysis. Based on this evidence for tracheal intubation, and clinical evidence of HCWs with low-level PPE who become infected, it is reasonable to assume a high risk of infection from intubation.

4 | CAN AN AIRWAY BARRIER ISOLATE PATHOGENS?

Particle spread during laryngoscopy with a simulated cough can be studied using fluorescent dye and a manikin. Without an intubation box, PPE worn by the laryngoscopist became extensively contaminated with the dye. The dye was not seen when the experiment was repeated with the box in place.

Trapping virus particles in a box or sheet does not eliminate the virus. The potential for aerosol or droplet spread beyond the box still remains, particularly during extubation. Further clearance of aerosol from the environment depends on surface dropout rate and airflow. Air conditioning is therefore another "barrier" to protect the HCW. The important conclusion is that an airway barrier placed over an infected patient can potentially decrease the viral load, but since we do not know the aerosol viral load or the minimum infectious dose of SARS-CoV-2 and since the barrier might need to be removed in times of difficult airway management, we cannot rely on this barrier to protect HCWs from infection.

5 | HOW EFFECTIVE IS PPE?

During the SARS-CoV-1 epidemic of 2003, HCWs who performed intubation had over 6 times the risk of contracting infection, compared to those who did not intubate. A similar experience was found in China, during the first two months of the COVID-19 pandemic. A report of 44,672 confirmed cases of COVID-19 patients up to February 11, 2020, included secondary transmission to 1716 HCWs (3.8%). Of those, 14.8% were in a severe or critical condition and five died. On February 18, 2020, "Expert Recommendations for Tracheal Intubation in Criticality Ill Patients with Novel Coronavirus Disease 2019" was published by the expert panel of the Airway Management Group of the Chinese Society of Anaesthesiology (CSA), providing guidance for all anesthesiologists in China. [4] These recommendations included specialist intubation teams of experienced anesthesiologists who were trained for donning and doffing of PPE by an approved instructor. Enhanced PPE included a fit-tested N95 mask, a surgical mask, hazmat coverall suit, double gloves, fluid-resistant over gown, hair cover, shoe covers, goggles, and face shield. At the end of the intubation, careful, supervised doffing of PPE may be followed by a shower and oral, nasal, and external auditory canal disinfection. Another measure to minimize transfer of infection between the medical team and their families was to quarantine and monitor the anesthesiologists for 14 days after their duty.

In a report from Wuhan by W Yao et al, where recommendations from the CSA guideline were adopted, 202 intubations of COVID-19-positive patients were studied. No transfer of infection was found to any of the 52 anesthesiologists involved in the intubations after the 14-day quarantine and monitoring period. This demonstrates that maximum droplet and airborne precautions can effectively prevent viral transmission. There were no additional airway barriers used in this study (personal communication Prof. Huafeng Wei).

PPE should be regarded as part of a package which includes adequate clothing, fit-tested N95/100 mask and eye protection plus training, handwashing, social distancing techniques and appropriate environmental conditions with surface cleaning, air conditioning, and isolation techniques. There is currently no evidence that the addition of a patient barrier is necessary to improve enhanced PPE.

6 | WHAT ARE THE DISADVANTAGES OF AIRWAY BARRIERS?

Several publications have noted that solid boxes restrict hand and arm motions and increase the time taken to intubate, which may place patients at risk from hypoxemia during intubation. Damage to PPE from arm ports, difficulty using a bougie and other airway adjuncts, adverse influence on first-pass success, viral spread following removal of the barrier, and problems associated with size variability of the patient and laryngoscopist are also listed as potential problems with airway barriers (personal communication R. Kearsley).[5]

A simulated "cannot intubate, cannot ventilate" scenario demonstrates the difference in assistant hands-on time between the absence (8 seconds) and presence (36 seconds) of an airway box (personal communication, Prof. William Rosenblatt https://www.youtube.com/watch?v=LMpxnBEY6QQ).

There is very little clinical evidence concerning the practicality of an airway barrier. The following observations are from Boston Children's Hospital, USA. At the time of writing, 14 COVID-19-positive, or symptomatic children awaiting COVID-19 test results, had been intubated using a barrier method. They were aged between 9 days old and 17 years old. Difficulty with intubation was reported in 4 of 14 children (29%): 1 with multiple attempts at intubation; 3 with prolonged intubation attempts. All intubations were performed by experienced providers. In those 4 cases, the barrier was removed. One of the fourteen children had airway-related pathology (a 9-day-old with a neck mass) and that patient briefly desaturated to 66% on induction. No other patients experienced oxygen desaturation.

To put this into context, since 2012, 1.1% of tracheal intubations performed at Boston Children's Hospital have met criteria for entry into the Pediatric Difficult Intubation Registry. Even though the number of COVID-19-positive or COVID-19-suspected patients is low, it appears that they may have a higher incidence of difficulties during intubation than our background population. The most obvious difference in the techniques to intubate them is the use of an aerosol/droplet barrier. Data collection for these patients is ongoing in order to get a more complete picture as the number of cases performed increases with time.

It is clear that there are many unanswered questions concerning airway barriers. Already, some hospitals have adopted the use of airway barriers in their recommendations and protocols. We caution about the early adoption of these techniques in the absence of any supporting clinical evidence. We also urge clinicians to carefully balance the benefits and risks of adopting techniques which could adversely affect the airway management for any patient. We should rather think outside the box and focus on the safety of the HCW by ensuring appropriate PPE. A patient barrier to aerosol should not become a barrier to safe airway management.

KEYWORDS

airway child, airway difficult, equipment devices

CONFLICT OF INTEREST

BS vUS is a section editor for Pediatric Anesthesia.

FUNDING INFORMATION

BS vUS is partly funded by the Perth Children's Hospital Foundation, the Stan Perron Charitable Trust, and the Frank Callahan Estate.

Paul A. Baker[1,2]
James Peyton[3]
Britta S. von Ungern-Sternberg[4,5,6]

[1]*Department of Anesthesiology, University of Auckland, Auckland, New Zealand*
[2]*Starship Children's Hospital, Auckland, New Zealand*
[3]*Department of Anesthesiology, Critical Care, and Pain Medicine, Boston Children's Hospital, Harvard School of Medicine, Boston, MA, USA*

[4]Division of Emergency Medicine, Anesthesia and Pain Medicine, Medical School, The University of Western Australia, Perth, WA, Australia
[5]Department of Anesthesia and Pain Management, Perth Children's Hospital, Perth, WA, Australia
[6]Perioperative Medicine Team, Telethon Kid's Institute, Perth, WA, Australia
Email: paul@airwayskills.co.nz

ORCID

Paul A. Baker https://orcid.org/0000-0001-9131-8150
James Peyton https://orcid.org/0000-0002-2667-9344
Britta S. von Ungern-Sternberg https://orcid.org/0000-0002-8043-8541

REFERENCES

1. Bryant J, Tobias JD. Enclosure with augmented airflow to decrease risk of exposure to aerosolized pathogens including coronavirus during endotracheal intubation. Can the reduction in aerosolized particles be quantified? *Pediatric Anesthesia*. 2020.
2. Nicas M, Sun G. An integrated model of infection risk in a health-care environment. *Risk Anal*. 2006;26(4):1085-1096.
3. 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(4):e35797.
4. Zuo MZ, Huang YG, Ma WH, et al. Expert Recommendations for Tracheal Intubation in Critically ill Patients with Noval Coronavirus Disease 2019. *Chin Med Sci J*. 2020;27:27.
5. Begley JL, Lavery KE, Nickson CP, Brewster DJ. The aerosol box for intubation in COVID-19 patients: an in-situ simulation crossover study. *Anesthesia*. 2020;12:12.