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“Endoshield”: A Physical Protective Box for Pediatric Endoscopy during the COVID-19 Pandemic

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Background/Aims: The coronavirus disease (COVID)-19 pandemic presents challenges for gastrointestinal endoscopy. Although the virus is transmitted through contact and droplets, aerosol-generating procedures produce aerosols that can spread through airborne routes. Several gastrointestinal societies have released statements to protect patients and health care providers (HCPs). This study describes a barrier box that may be used as an adjunctive device in addition to personal protective equipment during endoscopies.

Methods: A transparent acrylic box called “Endoshield” was created to place over patient’s head and shoulders and was tested for its ease of use for the endoscopist and suitability for patient size and position.

Results: Twelve children (66.67%, male) with a median age of 9 years (range, 2–11 years) underwent emergency or urgent endoscopy between April and June 2020 during the COVID-19 outbreak. The most common presenting symptom was life-threatening gastrointestinal bleeding (8/12, 66.67%), while the rest had urgent symptoms (4/12, 33.33%). The “Endoshield” was suitable for all patient positions (left lateral position: 9/12, 75% and supine position: 3/12, 25%). The patients and HCPs were followed up for their symptoms on day 14, and none of them had any symptoms of concern.

Conclusions: The “Endoshield” is affordable, reusable, and suitable for both positions. **Clin Endosc 2021;54:688-693**

Key Words: Aerosol-generating procedures; COVID-19 pandemic; Endoshield; Pediatric endoscopy

INTRODUCTION

In December 2019, the novel coronavirus SARS-CoV-2 was extracted from the lower respiratory tract samples of several patients with pneumonia of an unknown etiology (later identified as COVID-19) in Wuhan, China.¹ Since then, COVID-19 has rapidly disseminated worldwide. On March 11, 2020, the World Health Organization (WHO) declared

that this outbreak was a pandemic.^{2,3} Although person-to-person transmission occurs mainly through direct contact and air droplets,^{4,5} to date, most endoscopy societies have emphasized that upper and lower gastrointestinal endoscopies are aerosol-generating procedures (AGPs)⁶⁻⁹; therefore, it is possible for airborne transmission to occur during gastrointestinal endoscopy (GIE), which will also increase the risk of COVID-19 transmission. Pediatric gastroenterologists also have a much greater risk than adult gastroenterologists. For example, pediatric endoscopy procedures usually require deep sedation and general anesthesia.¹⁰⁻¹⁶ Because of the breach of personal protective equipment (PPE) during the procedure, the acrylic box named “Endoshield” has been developed as an additional physical barrier tool for improving safety from the perspective of both patients and health care providers (HCPs) during AGPs. There are currently very few published reports about physical barrier boxes, such as “Endoshield”, used during AGPs. The previous studies’ goals were to prevent disease

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transmission during endotracheal intubation^{17,18} and GIE in adults.^{19,20} To date, no studies have evaluated the utility of the box in pediatric settings. Thus, here we report the first study addressing these points.

MATERIALS AND METHODS

The present study was a descriptive analytical study conducted between April and June 2020 and was approved by the Faculty of Medicine’s ethical committee, Khon Kaen University (HE 641065). Informed consent was obtained from the participants’ guardians prior to enrollment.

Patient selection

All patients under 18 years of age who underwent emergent or urgent endoscopy, classified by risk stratification⁸ at a tertiary referral endoscopy center, were invited to participate in the study. Due to the limitations of the confirmation test of the COVID-19 infection kit, universal testing strategies were not affordable for our country. Symptom and exposure questionnaires were applied to determine the risk assessment of probable for COVID-19 infection. The Patients were divided into low and high risk for COVID-19 infection, which translates to different modalities of infectious control (Table 1).⁷ The confirmation test for COVID-19 infection was allowed only in the high-risk group. After completing each procedure, the patients and HCPs were followed up via telemedicine to evaluate their symptoms at day 14.

The endoscopy was performed under general anesthesia in all patients. They were not stable enough to undergo deep sedation due to emergent or urgent conditions, underlying diseases, or other complications.¹⁰⁻¹⁶

“Endoshield” information

To minimize droplets and airborne particles that could contaminate HCPs during AGPs, a transparent acrylic plastic box was placed so that it covered the patient’s head and shoulders. This box, called “Endoshield”, was tested to confirm its suitability and fit for all positions (left lateral position for general endoscopy procedures and supine position for endoscopic esophageal dilatation and percutaneous endoscopic gastrostomy [PEG]). A schematic of the three dimensions and a general overview are presented in Figs. 1 and 2, respectively.

The acrylic plastic box measures 0.45 m (width) × 0.50 m (length) × 0.50 m (height) with a 3 mm wall thickness.

Recently, an acrylic box for endotracheal intubation (not described here) has been used for intubation in adults; however, it was difficult to apply to pediatric patients. Thus, only standard PPE was used in pediatric circumstances. When sedation was established by an anesthesiologist, the mouthpiece was placed on the patient’s mouth, the endoscopic nurse also assisted in maintaining the patient’s position, and vital signs were monitored. “Endoshield” was applied to the patient by placing it over their head and shoulders; GIE was then performed and upon completion of the procedure, the “Endoshield” was removed. Lastly, the endotracheal tube was extubated by an anesthesiologist.

After the AGPs, the “Endoshield” was washed with water, and then 70% alcohol was applied to both the inner and outer parts for decontamination.

Statistical methods

Continuous and categorical variables are described as medians (and interquartile ranges) and frequencies (%), respectively.

Table 1. Risk Assessment Base on Symptom and Exposure Questionnaires for Probable COVID-19 Infection in Endoscopy Patients

Risk assessment of probable COVID-19 infection	
Low risk	Asymptomatic (eg, fever, respiratory symptoms, anosmia, or diarrhea) AND No contact with high-risk or confirmed COVID-19 positive person AND No travel to or residence in the high-risk area of COVID-19 during 14 days before
High risk	Presence of symptoms (eg, fever, respiratory symptoms, anosmia, or diarrhea) OR Travel to or residence in the high-risk area of COVID-19 during 14 days before OR Contact with high-risk or confirmed COVID-19 positive person

These criteria may change rapidly with time so it is essential to use the latest information.

Adopted from Chiu et al.⁶ and Gralnek et al.⁷

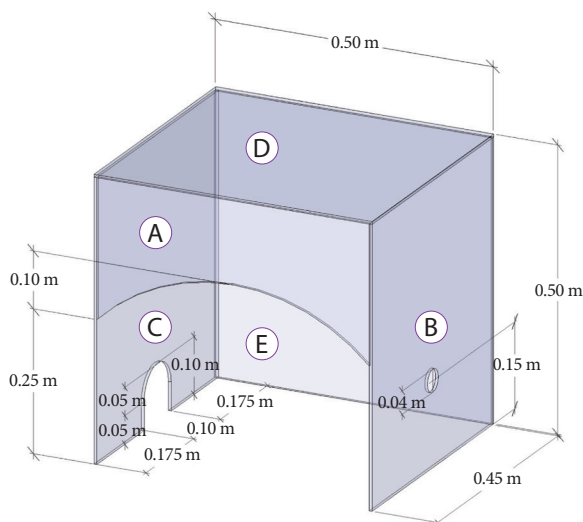


Fig. 1. A three-dimensional schematic of “Endoshield”. (A) Wall A: Consists of a curved plastic board for covering the patient’s head and shoulders. A transparent, thin, and soft plastic sheet (not shown in the Figure) was attached to the front of the wall to minimize droplet and aerosol distribution. (B) Wall B: It is a wall for the endoscope insertion, with a small round opening, 4 cm in diameter and 15 cm above the bottom of the wall. (C) Wall C: It is the wall for airway equipment, with a semi-circular port 10 cm in diameter in the base of the wall. The design allows the respiratory support apparatus from the patient to pass through the port to connect with the anesthesiology machines. (D) and (E) Wall D and E: They are the top and back wall with no specific features.



Fig. 2. Use of the “Endoshield” during a gastrointestinal endoscopy. After sedation was established, “Endoshield” was applied to the patient by placing it over their head and shoulders. The endoscope was inserted through a small round opening, 4 cm in diameter and 15 cm above the bottom of the wall. The respiratory support apparatus from the patient pass through the port to connect with the anesthesiology machines via a semicircular port 10 cm in diameter.

RESULTS

This research presents a descriptive case series of 12 children (66.67% male) with a median age of 9 years (range, 2–11 years) who underwent emergency or urgent endoscopy according to risk stratification⁸ between April and June 2020, which was during the COVID-19 outbreak. The vast majority of patients experienced life-threatening gastrointestinal bleeding requiring emergency endoscopy (8/12, 66.67%), while the rest of the patients underwent urgent endoscopy (4/12, 33.33%). All patients were screened, triaged, and stratified by symptom and exposure questionnaires for risk assessment before AGPs according to guidelines by international gastroenterology societies^{6–9,21–23} and the Thai Association of Gastroenterology and Endoscopy (TAGE).⁹ All of the patients were classified into the low-risk group for COVID-19 infection; hence, they had not been tested for it. The “Endoshield” was applied and was found to be suitable for all patients’ positions (left lateral position: 9/12, 75% and supine position: 3/12, 25%). The median times for the endoscopy procedure in the left lateral position, supine position, and overall were 14.15 min (range, 10.50–15.49 min), 19.59 min (range, 16.0–39.0 min), and 15.39 min (range, 11.54–18.06 min), respectively. After completing each procedure, the patients and HCPs were followed up for symptoms via telemedicine on day 14, and none of them had any symptoms of concern (Table 2).

Table 2. Patient Characteristics, Risk Stratification, Position, and Endoscopy Procedures

Patient	Age, yr (gender)	Underlying disease	Presenting symptom	Risk stratification	AGPs	Position
1.	0.3 (M)	BA	Life-threatening GIB	Emergency	EVS	Left lateral
2.	1 (M)	BA	Life-threatening GIB	Emergency	EVS	Left lateral
3.	3 (M)	CHF	Life-threatening GIB	Emergency	EVL	Left lateral
4.	5 (M)	EHPVT	Life-threatening GIB	Emergency	EVL	Left lateral
5.	9 (M)	EHPVT	Life-threatening GIB	Emergency	EVL	Left lateral
6.	9 (M)	EHPVT	Life-threatening GIB	Emergency	EVL	Left lateral
7.	15 (M)	BA	Life-threatening GIB	Emergency	EVL	Left lateral
8.	18 (M)	Lymphoma, CMV esophagitis	Life-threatening GIB	Emergency	Endoscopic clips	Left lateral
9.	1 (F)	None	Foreign body ingestion ^{a)}	Urgent	Endoscopic removal	Left lateral
10.	9 (F)	Medulloblastoma	Severe PEM ^{b)}	Urgent	PEG	Supine
11.	10 (F)	MMA	Severe PEM ^{b)}	Urgent	PEG	Supine
12.	12 (F)	Achalasia	Severe dysphagia	Urgent	Endoscopic esophageal dilatation	Supine

Ages are expressed as years.

AGPs, aerosol-generating procedures; BA, biliary atresia; CHF, congenital hepatic fibrosis; CMV, cytomegalovirus; EHPVT, extrahepatic portal vein thrombosis; EVL, endoscopic variceal ligation; EVS, endoscopic variceal sclerosis; GIB, gastrointestinal bleeding; MMA, methylmalonic acidemia; PEG, percutaneous endoscopic gastrostomy; PEM, protein energy malnutrition.

^{a)}Foreign bodies have been classified by the NASPGHAN clinical report as urgent.²³

^{b)}Urgent initial nutrition support.⁸

DISCUSSION

Recent knowledge shows that the major routes by which novel COVID-19 spreads are human-to-human transmission, including direct and indirect contact and droplets; airborne transmission is also possible, especially during aerosol generation, such as during GIEs. Due to the limitations of protective equipment, shortage of PPE, and lack of accurate and available COVID-19 tests in our country, the TAGE recommends obtaining the patient's information to determine the risk before performing AGPs. This includes fever (body temperature >37.5°C), travel history, occupational risk, contact history with confirmed infected patients, and close contact with un-

familiar people.⁹ Nevertheless, in pediatric cases, screening by symptom-based questionnaires does not represent the actual status of COVID-19 infection because most children are asymptomatic or have only mild disease.¹⁰⁻¹⁶ All of the above limitations, especially the lack of protective supplies, must be overcome in crises. To prevent and minimize the spread of the disease, we used a simple, affordable, and reusable plastic box as a physical protective barrier for both patients and HCPs during AGPs, such as GIEs. The first published research in adults on physical barrier boxes involved transmission prevention during endotracheal intubation and airway procedures. Canelli et al.¹⁸ developed a transparent plastic box to protect HCPs performing endotracheal intubations. To achieve

this, they put fluorescent dye in a balloon in a mannequin's pharynx and burst it to simulate a cough in humans; they then illuminated the area with ultraviolet light to detect the spread of the dye. They found no macroscopic dye outside the box. However, the use of a protective box also restricts the operator's movement. Bianco et al.²⁴ designed a box similar to that used by Canelli et al.¹⁸, an "Aerosol Box" for endotracheal intubation purposes. They retrospectively analyzed six COVID-19-positive patients who underwent emergency surgical procedures wherein a box was used while the patient was intubated. Bianco et al. discussed that the box might have some limitations, such as box size and construction.²⁴ For endoscopy purposes, Ljubicic et al.²⁰ reported using a plexiglass barrier box to improve safety during endoscopic retrograde cholangiopancreatography. Nevertheless, they did not specifically test for efficacy, but the box was similar to a previous one used for intubation purposes. In one experimental study on the effectiveness of a box to minimize droplet and aerosol spreading during GIEs, Campos et al.¹⁹ designed an acrylic box and tested its effectiveness by using fluorescent dyes and a similar method reported by Canelli et al.¹⁸ They proved not only its potential benefit in protecting HCPs from air droplets but also its feasibility and practicality during the procedure. In a recent publication, Sagami et al.²⁵ created a barrier box to prevent droplets from spreading during endoscopy. Their methodology was identical to that of Canelli et al.¹⁸ and Campos et al.,¹⁹ whereby they used fluorescent dyes to prove its efficacy. One real patient underwent an upper GIE without conscious sedation in the left lateral position. Neither discomfort nor any change in vital signs was detected. They concluded that the box could reduce the droplets spreading during GIE. To date, no previous studies have reported differences in adult and pediatric populations. In the pediatric setting, the patients have specific characteristics, such as the necessity of general anesthesia, being small in size, and having specific conditions that affect surgical positions. Our study revealed that the median time spent on endoscopy procedures with the "Endoshield" in the supine position was slightly longer than that in the left lateral position group. This was due to the more difficult endoscopy procedures such as PEG and endoscopic esophageal dilatation in the supine position group, as shown in Table 2. The present study revealed the feasibility of a pediatric size box, namely "Endoshield", as an adjunct tool with PPE for endoscopy. This is the first innovative device that is suitable for pediatric endoscopy. Even though our study did not prove the efficacy and safety of the box, we did prove that "Endoshield" is suitable for children of different sizes and different surgical positions and is convenient to use with anesthetic equipment. This box can be used as an additional physical protective de-

vice during pediatric endoscopy procedures as well as in those undergoing endoscopy under deep sedation. The benefit of this box is that it not only minimizes disease transmission but also works suitably in the supine position of patients, a feature that no prior studies have mentioned. Further, large and well-designed studies specific to pediatric patients that focus on the efficacy of the box to prevent transmission are warranted.

Conflicts of Interest

The authors have no potential conflicts of interest.

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