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Air circulation in a gastrointestinal light source box and endoscope in the era of SARS-CoV-2 and airborne transmission of microorganisms

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Authors

Stanislas Chaussade[1,2], Einas Abou Ali[1,2], Rachel Hallit[1,2], Arthur Belle[1,2], Maximilien Barret[1,2], Romain Coriat[1]

Institutions

1 Department of Gastroenterology and Endoscopy Unit, Cochin Teaching Hospital, AP-HP, and University of Paris, Paris, France

2 French Society for Digestive Endoscopy (SFED)

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Georg Thieme Verlag KG, Rüdigerstraße 14, 70469 Stuttgart, Germany

Corresponding author

Professeur Stanislas Chaussade, MD, PhD, President of the French society for Digestive Endoscopy (SFED), and Head of the Gastroenterology and Endoscopy Unit, Hôpital Cochin, GH APHP.Centre, AP-HP, Université de Paris, 27 rue du Faubourg Saint Jacques, 75014 Paris, France

Fax: +33-1-58 41 41 55

stanislas.chaussade@aphp.fr

ABSTRACT

Background and study aims The role that air circulation through a gastrointestinal endoscopy system plays in airborne transmission of microorganisms has never been investigated. The aim of this study was to explore the potential risk of transmission and potential improvements in the system.

Methods We investigated and described air circulation into gastrointestinal endoscopes from Fujifilm, Olympus, and Pentax.

Results The light source box contains a lamp, either Xenon or LED. The temperature of the light is high and is regulated by a forced-air cooling system to maintain a stable temperature in the middle of the box. The air used by the forced-air cooling system is sucked from the closed environment of the patient through an aeration port, located close to the light source and evacuated out of the box by one or two ventilators. No filter exists to avoid dispersion of particles outside the processor box. The light source box also contains an insufflation air pump. The air is sucked from the light source box through one or two holes in the air pump and pushed from the air pump into the air pipe of the endoscope through a plastic tube. Because the air pump does not have a dedicated HEPA filter, transmission of microorganisms cannot be excluded.

Conclusions Changes are necessary to prevent airborne transmission. Exclusive use of an external CO_2 pump and wrapping the endoscope platform with a plastic film will limit scatter of microorganisms. In the era of pandemic virus with airborne transmission, improvements in gastrointestinal ventilation systems are necessary to avoid contamination of patients and health care workers.

Introduction

Gastrointestinal endoscopes contain narrow-gauge channels for aspiration, inflation of air, flushing, and passage of additional equipment for therapeutics. Control guidelines have been reported by various scientific societies [1, 2]. The vast majority of these recommendations focus on cleaning and disinfection of endoscope channels. However, there is no recommendation regarding the risks of air transmission of microorganisms to the patient from the air channel insufflation system. The 2020 pandemic of the novel coronavirus SARS-CoV-2 has raised concerns about risk of virus transmission to staff in healthcare facilities and especially in surgical operating rooms through release of potential infectious particles in laparoscopic smoke or plumes [3].

According to current evidence, the SARS-CoV-2 virus is primarily transmitted between people through respiratory droplets and contact routes (fomites) [4]. The risk of airborne transmission is linked to the presence of microbes within droplet nuclei, which are generally considered to be particles < 5 µm in diameter that can remain in the air for long periods of time and be transmitted to others over distances greater than 1 m. Direct contamination by air, especially in health care facilities, has been shown for several viruses, such as measles, but it also includes some coronaviruses (SARS-COV-1) [5, 6]. In the context of SARS-CoV-2, the World Health Organization recently suggested that airborne transmission may be possible in specific circumstances and settings in which procedures or support treatments generate aerosols [7]. Digestive endoscopy is an aerosol-generating procedure, since air insufflation can cause splash and production of aerosol droplets. In contrast with flexible endoscopes used in ear, nose and throat procedures or bronchoscopy, gastrointestinal endoscopes have a dedicated system to inflate air into the gut lumen. Performing endoscopies in patients with SARS-CoV-2 infection raises the question of the risk of environmental contamination by the virus through the air systems of gastrointestinal endoscopes.

The aim of this study was to investigate the potential risk of airborne transmission into gastrointestinal endoscopes manufactured by Fujifilm, Olympus, and Pentax.

Materials and methods

A questionnaire was developed about air circulation, more precisely, about air inflation into the patient or to ventilate the video image or the light source processor. Questions about the potential risk of microorganism transmission through the air were posed to representatives of Fujifilm, Olympus, and Pentax by telephone and by mail. The circuit of air in the endoscope and in the water tank manufactured by each of the companies was studied. The CO_2 circuit in the endoscope and in the water tank was also studied when CO_2 inflation was done using an external CO_2 pump. Measurement of the temperature inside the light source box was done under normal conditions, after insertion of a surgical mask in the aeration port and after using a plastic film around the endoscopic system with the Fujifilm system.

Results

Regulation of the temperature inside the processor box

Air circulation was studied into the light source box, the video image processo,r and the endoscope. The video image processor was either in a common box with the light source (Pentax Imagina and Optivista, Olympus CV-1500) or in two boxes (EVIS EXERA II CV-180 and EVIS EXERA III CV 190, FUJIFILM XL-4450 Light source and Vp-3500HD processor, ELUXEO 7000 system with BL-7000 and VP-7000).

The light source contained a lamp, either Xenon or LED. The temperature of Xenon light (Fujifilm 7000, Pentax Optivista, EVIS EXERA II CV-180, Olympus CLV-190) was very high (323 °C in our study) and was regulated by a forced-air cooling system to maintain a stable temperature in the middle of the box (25 °C in our study) (normal recommended temperature: 10 °C – 40 °C). Some systems used an LED light source (Olympus CV-1500, ELUXEO system BL-7000), which last years without needing replacement and is associated with a lower temperature inside the light source box (FUJIFILM) or the light source and processor box (OLYMPUS CV-1500). The Pentax Imagina system is the only endoscope platform that offers distally mounted LED lights at the tip of the endoscope.

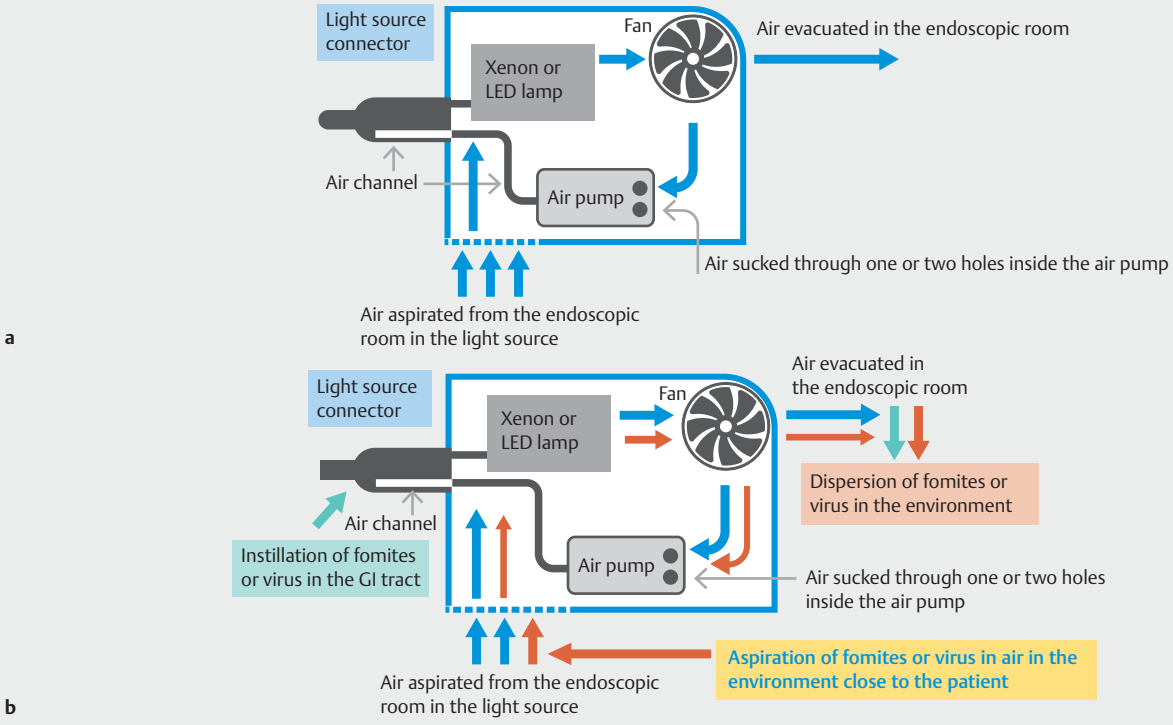
The air used by the forced-air cooling system is sucked from the closed environment of the patient through an aeration port, located close to the light source and evacuated out of the box by one to four fans (▶ **Fig. 1**). The volume of air that goes through the light source box depends on the fan characteristics (diameter and rotation per minute of the ventilator) but may be very high (i. e. FUJIFILM ELUXEO 7000 system: 1.96 m^3/min/ventilator; ie the volume of air going from the box to the room through the two fans is around 240 m^3 for a 1-hour examination). With the Olympus CV-1500, the volume of air that went through the four fans was 136 m^3/hour. For Pentax, the volume of air that went through the light source box was 4.24 m^3/minute for the OPTIVISTA (3 fans) and 2 m^3/minute (1 fan) for the Imagina.

Circulation of the air in the endoscope

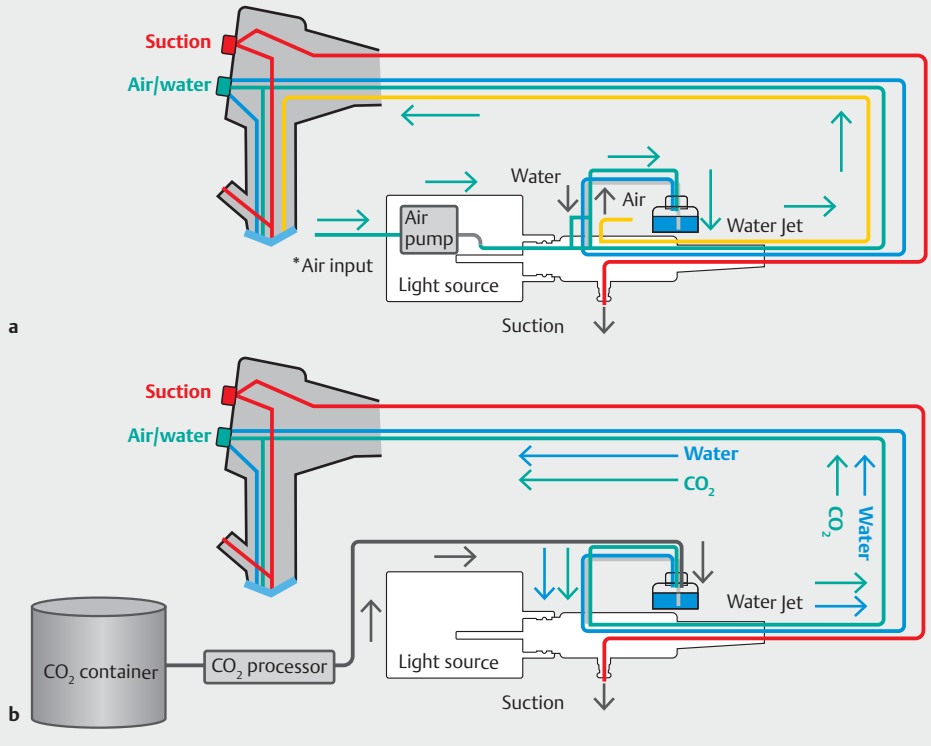
The light source box also contains an insufflation air pump (▶ **Fig. 1**). The air is sucked from the light source box through one or two holes in the air pump and pushed from the air pump into the air pipe of the endoscope through a plastic tube. Information on the characteristics of the air pump in the Pentax and Olympus light source box was not available. The air pump did not have a dedicated HEPA filter to avoid transmission of microorganisms such as bacteria and viruses transmission and is not accessible for microbiological control. The air is insufflated from the air pipe to the distal tip of the endoscope in a dedicated air channel (Fujifilm, Pentax) or in an air/water channel (Olympus) (▶ **Fig. 2a**). Outside the box and inside the endoscope, (except for Pentax system in which air is directly inflated from the air pump in the water tank), a derivation channel is used to inflate air in the water tank and to allow instillation of water in the endoscope through a dedicated water or an air/water channel.

Proposals for decreasing risk of microorganisms transmission

Considering the potential risk of insufflation of non-filtered air directly into the oropharynx and gut, it appeared of interest to propose some changes to prevent these risks. First, it may be necessary to avoid mobilization and diffusion of virus particles or fomites in the endoscopic room by the ventilators located in the processor and the light source box. To reduce the risk of diffusion, a surgical mask was positioned in the aeration port and used to filter the air suck in the light source box of a FUJIFILM light source. Under this condition, the temperature inside the light source box increased sharply from 24 °C to 35 °C in 20 minutes and the air entered the box through multiple ports due to



▶ **Fig. 1** **a** Circulation of air (blue arrows) inside the light source processor. **b** Circulation of contaminated air inside the light source processor (blue and red arrows).



▶ **Fig. 2** **a** Circulation of air from the processor to the tip of the endoscope. **b** Circulation of CO_2 from the processor to the tip of the endoscope with a CO_2 insufflator.

▶ **Fig. 3** Endoscopic system with a plastic film around the light source and the processor box.

inadequate sealing. To counterbalance this effect, we exchanged the surgical mask for a plastic film around the endoscopic system to create a barrier around the aspiration and the ventilation airport (▶ **Fig. 3**). Of note, enough was left outside the endoscopic platform and inside the plastic to allow for air sufficient to regulate the temperature and make ventilators efficient enough to maintain a stable temperature. In such conditions, using a FUJIFILM light source system with a LED lamp, the temperature rose from 25 °C to 29 °C in 15 minutes and was stable for more than 2 hours. In the same conditions using a FUJIFILM light source system with a Xenon lamp, the temperature rose from 25 °C to 41 °C in 30 minutes. The experiment was stopped because a high temperature (> 40 °C) is associated with potential risk of damaging the microprocessors and light source.

The second proposal is use of an external CO_2 pump (▶ **Fig. 2b**). A CO_2 pump would avoid the first two pitfalls and prevent insufflation of non-filtered air in the water tank and the air channel of the endoscope. External CO_2 pumps are frequently used in gastrointestinal endoscopy and should be systematically used to avoid insufflation of contaminated air directly into a patient's digestive tract.

Discussion

Health care professionals in endoscopy units are at increased risk of infection from SARS-CoV-2 [8] and infection prevention has been shown to be effective in ensuring the safety of both health care professionals and patients. The ESGE recommendations published in 2018 specified that microorganisms may be spread from one patient to another or from patients to staff members by inadequately reprocessed equipment, but there is no description and no recommendations about the risk of transmission of microorganisms in the air through a gastrointestinal endoscope [2].

Positive air insufflation during endoscopic procedures in the oropharynx could be associated with aerosolization and potential risk of SARS-CoV-2 diffusion in the close environment of patients (fomites) and in the air. Numerous infectious agents (tuberculosis, measles, chickenpox, SARS-CoV-1, MERS-CoV) are also recognized to be transmissible via the airborne route, either by short- or longer-range aerosols. Airborne transmission recently has been identified as a route for the spread of SARS-CoV-2 virus. Because gastrointestinal endoscopes have a dedicated system for inflating air into the gut lumen, we decided to investigate air circulation into gastrointestinal endoscopes from the light source and the processor box to the tip of the endoscopes.

As has been shown previously, hospital surfaces surrounding patients (especially in intensive care units [ICUs]) could be contaminated by SARS-CoV-2 or other microorganisms [9, 10]. In the study done by Razzini et al [10], air samples collected in an ICU close to the patients were positive for SARS-CoV-2 RNA but the virus also was found on the surfaces of medical equipment (2/3, 66.7 %) and on touch screens, shelves (2/5, 40.0 %), door handles (1/3, 33.3 %), and bedrails (1/3, 33.3 %). Recently, it has been shown that Sars-CoV-2 was viable in the air of a hospital room used by COVID-19 patients [11].

Our study shows that the system for ventilation of air into the light source or the processor box could favor mobilization of fomites in the area surrounding patients and the endoscopic system and could promote air dispersion of virus in the endoscopic room. The absence of a HEPA filter in the light source box could be associated with contamination of the box and/or the air pump and then could be a vector for air transmission of SARS-CoV-2 or other viruses to health care workers or to others patients because it has been demonstrated that patients with respiratory manifestations of SARS-Cov-2 produce aerosols in the absence of aerosol-generating procedures that contain vi-

able SARS-CoV-2, and these aerosols may serve as a source of transmission of the virus [11].

However, demonstrating that endoscopic procedure can generate aerosols and that it is possible to recover viral RNA from air does not prove aerosol-based transmission of SARS-CoV-2 during endoscopy. Ten years ago, Van den Broek PJ [12] in an editorial published in Endoscopy suggested risk of bacterial aerosol during removal of biopsy forceps during colonoscopy despite having no hard data showing that air was a relevant route of transmission in the endoscopic room. The number of microorganisms present in the air of an endoscopic room depends on the quality of air, the number of people present, the type of activities going on in the room and probably the type of patients present. Our proposition for a plastic film around the endoscopic system to create a barrier around the aspiration and the ventilation of air and the endoscopic room is only aimed at limiting the risk of diffusion of microorganisms in the endoscopic room. Ideally, it seems necessary to urgently imagine a new system for circulating HEPA-filtered air around the light source and processor box used in endoscopy as has has been done for insufflation of CO_2 in laparoscopic surgery.

As there is no possibility of performing routine microbiological or virus sampling inside the light source box or the air pump system, patient-to-patient transmission cannot be excluded. This contamination is facilitated by insufflation of air directly into the oropharynx or the small intestine, where SARS-CoV-2 receptors are present. No cases of airborne contamination through gastrointestinal endoscopes have been reported but prevention of this putative risk must be anticipated because air samples collected in the ICU close to infected patients were positive for SARS-CoV-2 RNA [10]. The balance of currently available evidence highlights weaknesses in ventilation of the light source box and also in the insufflation air pump system. The use of an external CO_2 pump [13] is an effective measure to avoid insufflation of contaminated air in the patient through the air, water, or air/water channel. Implementation of this recommendation would be efficient, inexpensive, and could be done immediately.

Conclusion

In conclusion, our study showed that circulation of air in a gastrointestinal endoscope had some weaknesses that could favor diffusion of the virus in the environment of the endoscopic room or which could be a vector for diffusion of virus or other microorganisms to health care workers and to patients. Companies developing an endoscopic system must design a modified system for circulation of HEPA-filtered air to decrease the potential risk of nosocomial infections because it has been demonstrated that engineering control of risk is better than personal protective equipment in prevention of microorganism transmission.

Competing interests

The authors declare that they have no conflict of interest.

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