

Original Article

Gastrointestinal endoscopy infection control strategy during COVID-19 pandemic: Experience from a tertiary medical center in China

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Objectives: Coronavirus disease 2019 (COVID-19) has spread globally and become a pandemic. The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) not only infects the gastrointestinal (GI) tract and causes GI symptoms, but also increases nosocomial transmission risk during endoscopic procedures for aerosol generation. We hereby share our infection control strategies aiming to minimize COVID-19 transmission in the endoscopy center.

Methods: We established our infection control strategies based on the guidance of Chinese Society of Digestive Endoscopy and inputs from hospital infection control experts: admission control through the procedure and patient triage, environmental control to reduce possible virus exposure, proper usage of personal protective equipment (PPE), and scope disinfection and room decontamination. All endoscopic procedures accomplished during COVID-19 outbreak and

progress of stepwise resumption of elective endoscopy procedures were retrospectively reviewed.

Results: Only urgent or semi-urgent procedures were performed during COVID-19 outbreak. After no local new-onset COVID-19 case in Beijing for four weeks, we reopened the endoscopy center for elective procedures and monitored the outbreak continuously while maintaining a sustainable endoscopy service.

Conclusions: It is imperative that all endoscopy centers should establish standard infection control strategies in order to fight COVID-19 pandemic based on national guidance and academic society guidelines and tailor them to individual resources. These measures and setup can also be reserved for future pandemics.

Key words: COVID-19, endoscopy, infection control strategy, personal protective equipment, triage

INTRODUCTION

SINCE DECEMBER 2019, a novel coronavirus designated as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) spread rapidly throughout China and beyond.^{1,2} The outbreak of coronavirus disease 2019 (COVID-19) was declared a global pandemic by the World Health Organization (WHO) on March 11, 2020.^{3,4}

The most common symptoms for COVID-19 include fever, dry cough, and shortness of breath. The incidence of gastrointestinal (GI) symptoms of COVID-19 ranged from

3% (1/41) to 79% (159/201), including anorexia, diarrhea, nausea, vomiting, abdominal pain and GI bleeding,⁵ which may precede the onset of fever and dyspnea by 1–2 days.⁶

It is widely accepted that COVID-19 is mainly spread via droplets and direct contact,⁷ but there is evidence that airborne spread is possible during aerosol generating procedures (AGPs).⁸ Emerging evidence suggests that SARS-CoV-2 can be detected in the feces, which leads to the possibility of transmission via the fecal–oral route.^{9–12} This may be due to the high levels of expression of angiotensin converting enzyme 2 (ACE2) protein in the epithelium throughout the GI tract,¹³ which is a receptor SARS-CoV-2 requires for cell entry.^{14,15}

Nosocomial transmissions were common in pandemic regions of COVID-19: 3.8% of confirmed cases in China were health care personnel (HCP),¹⁶ whose infection rate was approximately three times of that of the general population¹⁷; similar trends have been observed in Italy,

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with an estimated 20% of COVID-19 infections occurring in HCP.¹⁸

Although endoscopy staff are not directly involved during a pandemic, they face great challenge and risk: large viral loads in pulmonary aerosols and even fecal materials, with endoscopy procedure believed to be an AGP.^{19,20} Infection control measures must be implemented to protect both the patient and HCP.

We therefore created our infection control strategies (ICSs) to minimize nosocomial transmission risk since January 24, 2020, when Beijing Municipal Health Commission activated the first-level response mechanism for public health emergencies. Although multiple endoscopy societies and expert groups have offered recommendations and position statements for GI endoscopy during the pandemic,^{19–27} we aim to share local experience on ICS in the endoscopy center.

METHODS

WE ESTABLISHED OUR ICSs based on the guidance of Chinese Society of Digestive Endoscopy (CSDE) and inputs from hospital infection control experts in the Peking Union Medical College Hospital (PUMCH).^{26,28}

Strategies to prevent transmission in the endoscopy center

Admission control

This is the basic yet most important measure to avoid uninfected people contacting those with COVID-19.

Procedures triage. We divided endoscopic procedures into three types: urgent, semi-urgent, and elective, as defined in Table 1.

During the COVID-19 outbreak, urgent cases would be finished whenever needed and immediately; semi-urgent

Table 1 Peking Union Medical College Hospital (PUMCH) endoscopy procedure triage during COVID-19 pandemic

Procedure triage	Indications
Urgent	Acute gastrointestinal bleeding Gastrointestinal foreign body Acute cholangitis and severe symptomatic obstructive jaundice due to gallstone or tumor Acute luminal obstruction requiring stenting
Semi-urgent	Tumor diagnosis of highly suspicious cases and tumor staging
Elective	All other procedures, such as routine diagnostic EGD and routine screening colonoscopy

COVID-19, coronavirus disease 2019; EGD, esophagogastroduodenoscopy.

procedures on one fixed day in a week, and the necessity of each case would be discussed; elective procedures would be rescheduled until the outbreak is over.

Patient triage. For every patient needing an endoscopic procedure, we reviewed the COVID-19-related symptoms and obtained a detailed epidemiological history (Fever, Travel history to the pandemic area, Occupation, Cluster of cases, Contact of a suspected or confirmed case, FTOCC). A chest computerized tomography (CT) scan was ordered (Table S1). The presence of at least one criterion would be considered positive for FTOCC, and further COVID-19 testing (reverse-transcriptase polymerase chain reaction, RT-PCR) should be completed.

The urgent cases with a positive RT-PCR test or CT scan suggestive of COVID-19 would receive the endoscopic procedures in the negative pressure room of the surgical operation room outside our endoscopy center. If adequate FTOCC history cannot be assessed, all urgent cases would be considered as “COVID-19 positive” in terms of infection control. The other urgent patients would receive endoscopy in the standard endoscopy rooms.

For urgent cases with a positive RT-PCR test or abnormal CT screening, their situations should be reevaluated post procedure: stable patients would be transferred to a designated hospital in Beijing for COVID-19 management, while unstable patients would receive medical care in the emergency room equipped with a biocontainment unit (Fig. 1).

For outpatients needing semi-urgent procedures, we followed the same strategy. Patients with a positive RT-PCR test or chest CT scan would be transferred to the designated hospital and endoscopic procedure would be rescheduled (Fig. 1).

All patients receiving procedures were followed up for 2 weeks to rule out COVID-19.

Working team simplification. Only necessary endoscopy staff would come to work on a daily basis. All endoscopic procedures should be performed by senior endoscopists and hands-on training should be suspended. Each day, only one endoscopist and one nurse were scheduled to stay in the hospital for urgent procedures. On the fixed day for semi-urgent procedures, the number of endoscopists staffing the center depended on the type and number of procedures, as were the nurses and technicians.

Telehealth consultation. The physicians in our department would take turns to provide telehealth advice and explanation to reduce patients’ concerns and anxiety.

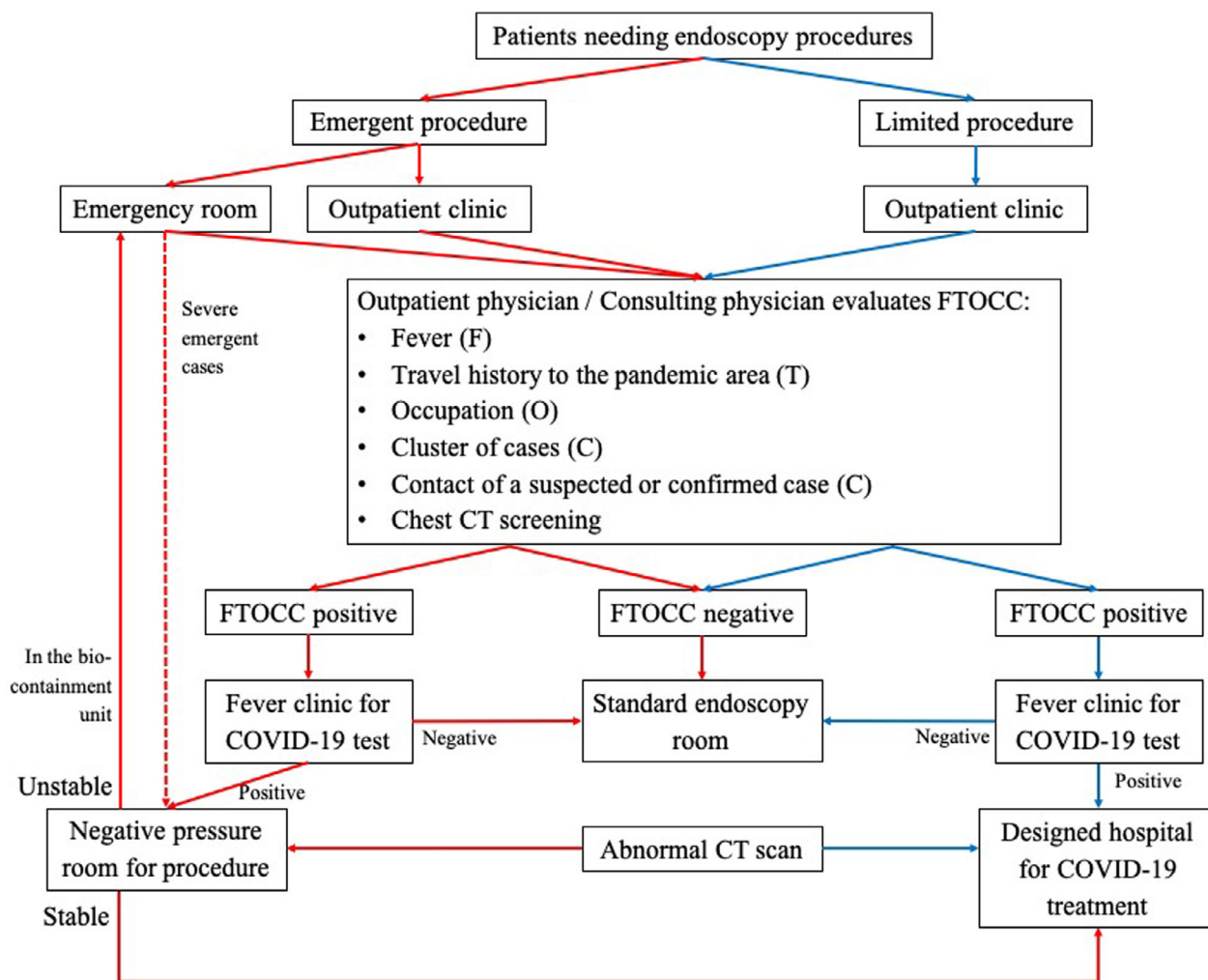


Figure 1 The triage of patients by the infection risk of COVID-19. Red arrows indicated the flow of urgent cases and blue arrows indicated the flow of semi-urgent cases. If adequate FTOCC history cannot be assessed for emergency, all urgent cases should be considered as “COVID-19 positive” for infection control. Abnormal CT scan referred to the CT findings suggestive of COVID-19. Abbreviations: CT, computerized tomography; COVID-19, coronavirus disease 2019; FTOCC, fever, travel history to the pandemic area, occupation, cluster of cases, contact of a suspected or confirmed case.

Endoscopy center environmental control

Workspace management. The different routes of staff and patients in the endoscopy center were clearly marked. Workflow modification also required one-way passages for the transportation of used/contaminated equipment (such as endoscope) to avoid cross-contamination. At the patients’ entrance, a triage station was set and non-contrast thermometer and alcohol-based sanitizer were provided. We assigned a room for each specific type of endoscopy (one room for upper GI endoscopy and another for colonoscopy). The staff would don personal protective equipment (PPE) in

the change room before entering the procedure room and doff used PPE into the lidded medical trash bins and finish hand hygiene before getting back to the change room. We temporarily changed the endoscopy center outlay for maximal compliance with these requirements (Fig. 2).

Patient management. Besides the patient, only one family member was allowed into the center after the previous patient had left. When the patient and family member entered the center, their body temperature was taken and they were suggested to clean hands with sanitizer and wear masks throughout their stay.

Staff management. All staff should practice hand hygiene correctly and wear masks. On arriving, they changed into scrubs and work shoes and then PPE; and changed back after taking a shower before leaving the center. When in the office and dining room, a proper social distance would be kept (at least 1–1.8 m).

Procedure room decontamination. Air ventilation was enhanced via opening of the fresh air dampers. Mobile high efficiency particulate air (HEPA) units were added to augment the total air change rates in each procedure room.

After each case, a single-use bed sheet was changed and decontamination measures with alcohol- or chlorine-based solutions would be performed to clean the surface of bed rails, bedside tables, furniture and floor in frequent contact with patients, and also endoscopy instruments (Table 2). The next case should be scheduled after half an hour for full decontamination.

Use of personal protective equipment

In our center, full PPE includes disposable work cap, surgical masks/N95 respirators or equivalent, face shield/goggles, disposable protective clothing/gown, gloves and shoe covers. We suggested graded protection strategy in our

center (Table 3). The endoscopists, nurses and anesthetists in the endoscopy rooms should wear full PPE (the Fig. S1). We used double gloving and changed N95 respirator masks regularly (every 4 h) or if visibly polluted. We also kept fine records of the stock and usage of PPE to guarantee supply for our staff.

Proper donning and doffing of PPE is extremely important for maximum protection (refer to <https://www.cdc.gov/coronavirus/2019-ncov/hcp/using-ppe.html> for detailed and graphic instructions; Table S2). All staff should be trained by infection control experts and should supervise each other.

Scope disinfection

After each procedure, all endoscopes and reusable accessories would be placed in the yellow-color plastic bag immediately and sent to the disinfection room, where it would receive the standard cleaning, disinfection and reprocessing protocols as usual, during which the scopes were manually cleaned under water firstly and then transferred to the automatic cleaning machine (Siemens, Endoclen-NSX; using ortho-phthalaldehyde as the disinfectant). The technicians in the disinfection room should also wear PPE properly due to the possibility of aerosolization.

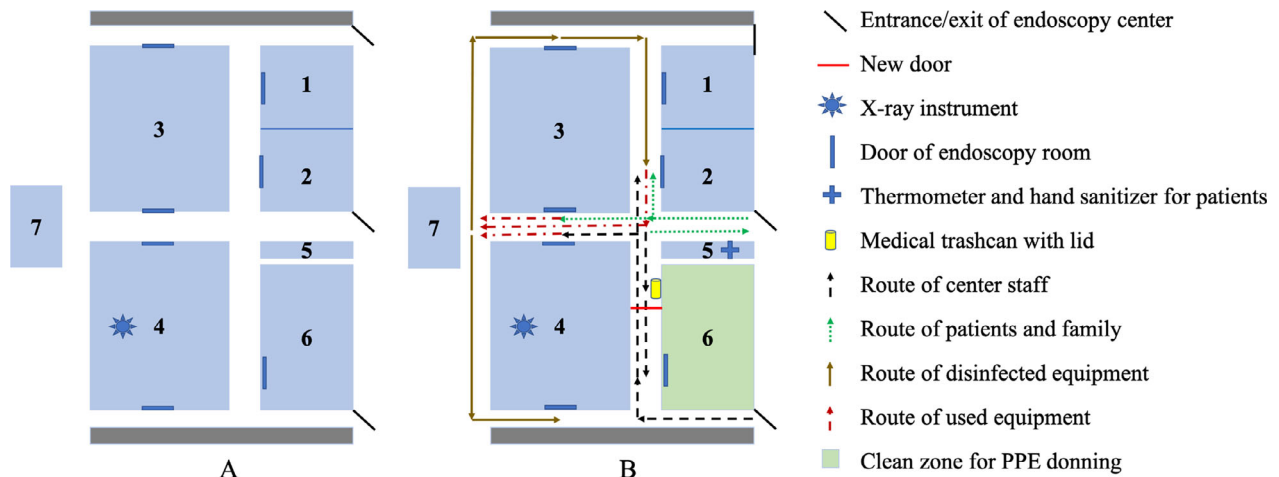


Figure 2 The outlay changes of the endoscopy center for the infection control strategy. Picture A: Rooms 1–4 (blue area) were procedural rooms before pandemic; Room 7 was the disinfection room. Picture B: During pandemic Room 2 and 4 were employed (Room 2 for colonoscopy, and Room 4 for upper GI endoscopy). With one entrance (black) closed and a new door (red) assembled, we partially separated the routes of center staff (black arrows with dotted line) and patients (green arrows with dotted line), and created a clean zone (green area) as the change room for the staff to put on PPE before entering procedural rooms. A triage station (cross) was set at the patient's entrance and non-contact thermometer and alcohol-based sanitizer were provided. The workflow was also shown (brown arrows for disinfected equipment, and red arrows with dotted line for used equipment). Note the partial overlap of routes of staff, patients and used equipment. Abbreviations: GI, gastrointestinal; PPE, personal protective equipment.

Table 2 Peking Union Medical College Hospital (PUMCH) endoscopy room environmental decontamination during COVID-19 pandemic

Work area	Decontamination method	Decontamination frequency
Endoscopy instruments, operating table, electrosurgical workstation, nursing trolley, computer table	1000 mg/L chlorine-containing disinfectant, keep for 30 min and then wipe with clean water; 75% alcohol for computer monitor and metal parts.	After each case
Room wall and floor	1000 mg/L chlorine-containing disinfectant, then mop with clean water after the ground is dry; Or use ultraviolet light to sterilize for 1 h; Finally open the window for ventilation.	After each case
Room air	-unit ultraviolet).	Continuously working

COVID-19, coronavirus disease 2019; HEPA, high efficiency particulate air.

Table 3 Peking Union Medical College Hospital (PUMCH) endoscopy center graded personal protection standards during COVID-19 pandemic

Work areas	Protection level	Personal protection equipment
Reservation area (behind window)	Level 1	Work cap, surgical mask, glove (when necessary)
Triage station area (open) and nurse station	Level 1	Work cap, surgical mask, glove, gown (when necessary; AAMI level 1)
Procedural room	Level 3	Work cap, N95 respirators or equivalent, face shield/goggles, impermeable protective clothing (AAMI level 3), double gloves and shoe cover
Negative operation room (for confirmed or suspected cases)	Level 3	Work cap, N95 respirators or equivalent, face shield/goggles, impermeable protective clothing (AAMI level 3), double gloves and shoe cover
Scope disinfection room	Level 3	Work cap, N95 respirators or equivalent, face shield/goggles, impermeable protective clothing (AAMI level 3), double gloves and shoe cover
Patients and their family	Level 1	Surgical masks, hands hygiene with sanitizer when entry and exit

AAMI, Association for the Advancement of Medical Instrumentation; COVID-19, coronavirus disease 2019.

Note that the protection level provided here was advised by the hospital infection control office of the PUMCH based on the guideline of National Health Commission and local PPE resource: level 1 for general clinic and ward, level 2 for fever clinic, and level 3 for isolation ward for confirmed or suspected COVID-19 cases, endoscopy center, and operation room.

All endoscopic procedures accomplished during the COVID-19 outbreak are retrospectively reviewed and the indications are listed. The progress of resumption of elective endoscopy service is also recorded.

RESULTS

Procedures postponed during COVID-19 outbreak

THERE WERE ABOUT 3, 128 endoscopic procedures postponed from January 24 to March 20, 2020, among which there were 1, 803 screening esophagogastroduodenoscopy (EGD), 1, 221 screening colonoscopy and 104 endoscopic ultrasound for submucosal lesions. Since resumption of elective service, we have

finished 1, 822 postponed cases, with others rescheduled in the list.

Procedures accomplished during COVID-19 outbreak

From January 24, 2020, to March 30, 2020, we accomplished 127 cases following the aforementioned ICS, among which there were 92 urgent cases, mainly due to GI bleeding, GI tract foreign bodies, and acute cholangitis due to gallstone, and 35 cases of semi-urgent procedures (Table 4).

All urgent cases received initial treatment in the emergency room where the FTOCC history, chest CT and/or RT-PCR test were finished. Among the urgent cases, 19 cases underwent both chest CT and RT-PCR test because of

positive FTOCC (18 cases for fever, and one case for traveling history), but none were found to be COVID-19 cases. All semi-urgent patients received chest CT screening (no positive FTOCC cases) without positive results.

Resumption of daily endoscopy service

With no new local COVID-19 cases reported for about 4 weeks in Beijing, we have begun the elective endoscopy service since March 30, 2020, with a modified patients triage strategy: patients of urgent procedure undergo both chest CT and RT-PCR test to determine whether to receive procedure in the negative pressure room; patients of semi-urgent or elective procedure undergo RT-PCR test within one week before the procedure, and they will receive endoscopy after staying in Beijing for 14 days with negative RT-PCR results.

Other items of strategy (working team simplification, center environmental control, use of personal protective equipment, scope disinfection) are still followed in our center probably until the response mechanism for public health emergencies is terminated.

With limited supplies of PPE, initially only 25% of the normal capacity compared to pre-COVID-19 levels was

restored and only three procedure rooms opened for half a day, and we aimed at a stepwise manner. In late April, after the first-level response mechanism for public health emergencies was adjusted to the second-level and with more stable PPE supplies, we have increased to 50% of normal capacity.

DISCUSSION

THE SARS-CoV-2 is spreading rapidly throughout the world. The GI endoscopists face great challenges and risks: high viral loads in the aerosols generated from the upper airway and the fecal materials. There is significant and unrecognized exposure of the endoscopist's face to potentially infectious samples during procedures.²⁹ During the SARS outbreak, droplets from infected patients could reach persons located 6 feet or more.³⁰ So, the ICS must be established and followed in the endoscopy centers to avoid nosocomial transmissions.

We set a procedures triage system to sort endoscopic procedures into three categories: urgent, semi-urgent, and elective. The urgent cases, like acute GI bleeding and foreign body, even for confirmed COVID-19 cases, should

Table 4 Peking Union Medical College Hospital (PUMCH) endoscopy procedures during COVID-19 pandemic between January 24 and March 30, 2020

	2020		2019	
	Urgent procedures (N = 92)	Semi-urgent procedures (N = 35)	Urgent procedures (N = 105)	Non-urgent procedures (N = 5006)
Male (%)	62 (67.4)	23 (65.7)	61 (58.1)	2663 (53.2)
Age (years)	62.6 ± 14.6	60.8 ± 12.4	53.3 ± 13.4	63.3 ± 14.0
Procedure type				
EGD	66	9	83	2542
Colonoscopy	9	9	14	2036
EUS	0	17	0	264
ERCP	17	/	8	109
Double-balloon enteroscopy	/	/	/	8
Capsule endoscopy	/	/	/	47
Indications				
GI bleeding	61	/	86	0
Foreign body	11	/	11	0
Acute cholangitis	9	/	7	0
Severe symptomatic obstructive jaundice	8	/	1	0
Acute sigmoid volvulus	4	/	0	0
Tumor staging	/	12	/	44
Tumor diagnosis	/	23	/	219

COVID-19, coronavirus disease 2019; EGD, esophagogastroduodenoscopy; ERCP, endoscopic retrograde cholangiopancreatography; EUS, endoscopic ultrasound; GI, gastrointestinal.

Note that the endoscopic procedures of the same period in 2019 were also shown as urgent or non-urgent procedures for comparison.

not be delayed. Semi-urgent cases, such as potential or confirmed cancer cases, may be difficult to reschedule. We scheduled a fixed day of the week (every Monday) to manage these cases after careful review and thorough screening for COVID-19. For elective procedures, there is a broad consensus that they should be rescheduled (Table S3).^{19–27} But the risk of progression to advanced disease is indeterminate for early-stage GI cancer if delayed up to months;^{31,32} while colonic polyps of different size will probably not progress in months.^{33,34} So, we started endoscopic treatment for early-stage GI cancer/colonic polyps after resumption of elective service.

Assessment of infection risk before endoscopy is important. We suggested that all patients requiring endoscopy should be evaluated for FTOCC. As was suggested in the CSDE guidance, we routinely ordered screening chest CT scan prior to endoscopy, which was a fast and effective screening tool.^{35–38} Considering the possibility of initial false negative result of RT-PCR test (within 1014 patients undergoing both chest CT and RT-PCR test, 413 patients had negative RT-PCR results, 74.6% (308/413) among whom had positive chest CT findings),^{36,39} we suggest patients with suggestive CT scan results should be treated as COVID-19 cases in the pandemic areas. But this strategy may be difficult to generalize due to issues relating to cost, resources, and accessibility.

It should be also noted that the patient triage strategy based on the infection risk is ever-changing according to the epidemic condition. For the estimated low local prevalence of COVID-19 after no new local case for four weeks, we turned to a new strategy to triage patients of elective and semi-urgent procedures based on RT-PCR results together with the 14-day quarantine, which would minimize the possibility of nosocomial transmission caused by the COVID-19 patients with a false negative result. With the negative predictive value increasing with decreasing prevalence, one negative result of RT-PCR can probably exclude COVID-19 in the majority of cases.^{39,40} A recent guidance recommends a molecule test for COVID-19 within 48 h of a scheduled procedure,⁴¹ which is reasonable for reducing the infection risk between the test and procedure, especially for areas with a relatively high prevalence. With enough availability of RT-PCR test, our practice in PUMCH could be improved in this way (shorten the period between test and procedure to 2–3 days).

Not every endoscopy center is built with the principles of maximal infection control. In our center, changes were made for maximal compliance with these requirements: to separate the entrance/exit of staff and patients; to assign room for specific endoscopic procedures; to replace the change room to ensure all staff entering endoscopy room with PPE; to separate gown-up and gown-down areas; to provide one-

way passages for the transportation of used/contaminated endoscopes. We suggested a triage station at the patients' entrance to monitor body temperature and sanitize their hands. All patients and family members were suggested to wear masks, which was proven effective for reducing transmission risk.⁴²

All endoscopic procedures are AGPs. The upper GI endoscopy carries a risk for aerosolization for patient's cough and vomiting, while possible aerosolization happens when passing instruments through the working channel of colonoscopy. Meanwhile, virus shedding is very high in the upper airway, which meant high viral loads are likely in the aerosol.⁴³ So, AGPs could possibly lead to airborne transmission of SARS-CoV-2.⁴⁴ Almost all guidance suggests proper PPE usage during procedures, with N95 respirators or equivalent recommended; a meta-analysis also showed a benefit from N95 respirators over standard masks in SARS.⁴⁵ But other evidence showed that surgical masks were also effective.⁴⁶ So, we suggested graded PPE usage (Table 3); in certain situations a surgical mask was enough, and full PPE usage in procedures, irrespective of upper or lower GI tract endoscopy, was necessary. The N95 respirator should be changed every 4 h.²³ The US CDC has issued recommendations allowing for extended use and limited re-use of N95 respirators if supplies become depleted.⁴⁷ We believed that extended use or re-use of N95 respirators should be handled with great care for difficulty in maintaining structural integrity and risk of contamination.^{48,49}

Patient's discomfort and retching may be minimized by adequate sedation to reduce aerosol generation in the upper GI endoscopy. But as a high-risk AGP, intubation should be handled with great care by experienced anesthetists after airway assessment, during which modified rapid sequence induction is strongly recommended and proper PPE like N95 respirator, or powered air-purifying respirator, is obligatory.⁵⁰ Only the anesthesia team would remain in the procedural room during intubation if possible.

Ideally, negative pressure rooms should be used for the endoscopic procedures of confirmed or suspected COVID-19 cases.⁸ If negative pressure rooms are unavailable, portable industrial-grade HEPA filters may be a reasonable alternative to enhance air filtration during intubation and extubation.^{51,52}

SARS-CoV-2 is shed to the environment as expired particles, during toileting and through contact with fomites, and survival of virus on surfaces can last for hours to days.^{8,53} So, each endoscopy center should have a detailed plan for standard room disinfection with routine disinfectants effective against SARS-CoV-2.⁵⁴ Standard hand hygiene procedures before and after each case should be practiced, which was proven to be beneficial during SARS.⁵⁵

The scope disinfection should follow the standard cleaning endoscopic disinfection and reprocessing protocols.^{56,57} Evidence has shown that SARS-CoV-2 was readily inactivated by commonly used disinfectants.⁵⁴ To reduce aerosol formation, scopes should be manually cleaned under water surface.²³ Technicians in the disinfection room should wear N95 respirators when reprocessing equipment used in COVID-19 cases.

Finally, stepwise resumption of elective endoscopic procedures will always be a concern. Under the modified ICS, we have begun our elective procedures after no new local COVID-19 case for about 4 weeks, although being only 25% of the normal capacity initially. The resumption of endoscopy service depended on the following factors: (i) the number and epidemic curve of confirmed COVID-19 cases locally; (ii) the availability of medical equipment, especially PPE; and (iii) the accumulated volume of postponed endoscopy cases (Table S3).²² The administrators of endoscopy centers should monitor the pandemic closely and modify the ICS accordingly to keep a sustainable and effective service.

In conclusion, it is imperative that all endoscopy centers establish standard infection control strategies to ensure that proper measures are in place to protect patients and staff during COVID-19 pandemic. We suggest consulting local hospital infection control experts for detailed risk assessment before implementing the infection control measures.

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CONFLICT OF INTERESTS

AUTHORS DECLARE NO conflict of interests for this article.

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SUPPORTING INFORMATION

ADDITIONAL SUPPORTING INFORMATION may be found in the online version of this article at the publisher's web site.

Figure S1 Personal protective equipment with N95 or equivalent in the procedural room. Note the impermeable protective clothing (AAMI level 3) and double gloves. Abbreviations: AAMI, Association for the Advancement of Medical Instrumentation.

Table S1 Patient checklist for COVID-19 suggested by Chinese Society of Digestive Endoscopy.

Table S2 The whole progress of donning and doffing of personal protective equipment.

Table S3 Summary of guidance for endoscopy during the COVID-19 pandemic from International/National Societies of Gastroenterology/Gastrointestinal Endoscopy.