

● *Original Contribution*

CHINESE EXPERT CONSENSUS ON PROTECTION FOR ULTRASOUND HEALTHCARE WORKERS AGAINST COVID-19

YUKUN LUO,^{*,1} JIANJUN YUAN,[†] MINGHUI LIU,[‡] NIE FANG,[§] JIAO BAI,[¶] XIANG FEI,^{*} YUJIAO DENG,^{*} TENGFEI YU,^{||} JUAN MAO,^{*} HAOHUI ZHU,[†] CHUANG LI,[†] QINGHAI PENG,[‡] MING ZHANG,[‡] SHI ZENG,[‡] GANQIONG XU,[‡] CHENGCHENG NIU,[‡] TIAN TIAN DONG,[§] WEN HE,^{||,1} and JIE TANG^{*},

ON BEHALF OF THE CHINESE ULTRASOUND DOCTORS ASSOCIATION, CHINESE PLA PROFESSIONAL COMMITTEE OF ULTRASOUND IN MEDICINE, BEIJING INSTITUTE OF ULTRASOUND IN MEDICINE, AND CHINESE RESEARCH HOSPITAL ASSOCIATION ULTRASOUND PROFESSIONAL COMMITTEE* DEPARTMENT OF DIAGNOSTIC ULTRASOUND, FIRST MEDICAL CENTER OF CHINESE PLA GENERAL HOSPITAL, HAIDIAN DISTRICT, BEIJING, CHINA; [†] DEPARTMENT OF DIAGNOSTIC ULTRASOUND, HENAN PROVINCIAL PEOPLE'S HOSPITAL, ZHENGZHOU, HENAN, CHINA; [‡] DEPARTMENT OF DIAGNOSTIC ULTRASOUND, SECOND XIANGYA HOSPITAL OF CENTRAL SOUTH UNIVERSITY, CENTRAL CHANGSHA, HUNAN, CHINA; [§] DEPARTMENT OF DIAGNOSTIC ULTRASOUND, LANZHOU UNIVERSITY SECOND HOSPITAL, CHENGGUAN DISTRICT, LANZHOU, GANSU, CHINA; [¶] DEPARTMENT OF DIAGNOSTIC ULTRASOUND, ZHONGNAN HOSPITAL OF WUHAN UNIVERSITY, WUCHANG DISTRICT, WUHAN, HUBEI, CHINA; AND ^{||} DEPARTMENT OF DIAGNOSTIC ULTRASOUND, BEIJING TIAN TIAN HOSPITAL, CAPITAL MEDICAL UNIVERSITY, FENGTAI DISTRICT, BEIJING, CHINA

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Abstract—Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection has caused a worldwide pandemic and poses a serious public health risk. It has been proven that lung ultrasound can be extremely valuable in the diagnosis and treatment of the disease, which could also minimize the number of exposed healthcare workers and equipment. Because healthcare workers in ultrasound departments are in close contact with patients who might be infected or virus carriers, it is extremely important that they be provided sufficient protection. Extremely aggressive protection should be avoided because it might lead to a lack of protection equipment for the hospital. Guidance on proper protection management should be provided in detail, for example, how to choose personal protective equipment, how to disinfect the environment. To address these problems, on behalf of the Chinese Ultrasound Doctors Association, Chinese PLA Professional Committee of Ultrasound in Medicine, Beijing Institute of Ultrasound in Medicine and Chinese Research Hospital Association Ultrasound Professional Committee, the authors have summarized the recommendations for effective protection according to existing hygienic standards, their experience and available literature. After the recommendations were completed, two online conferences were held on January 31, 2020 and February 7, 2020, at which the recommendations were discussed in detail. A modified version of the work was circulated and finally approved by all authors, and is the present *Chinese Expert Consensus on Protection for Ultrasound Healthcare Workers against COVID-19*. (E-mail: lyk301@163.com) © 2020 World Federation for Ultrasound in Medicine & Biology. All rights reserved.

Key Words: COVID-19, Ultrasound, Expert consensus, Protection recommendations.

INTRODUCTION

The infection caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Gandhi et al. 2020) has caused a worldwide pandemic (Lu et al. 2020; Zhou et al. 2020) and poses a serious public health risk. The increasing number of patients who had not been exposed to animal markets indicated person-to-person spread of SARS-CoV-2-related coronavirus disease

2019 (COVID-19), and now the disease is thought to spread mainly *via* contact and respiratory droplets, which can cause infections when an infected person coughs or speaks. According to recent reports, increasing evidence indicates that SARS-CoV-2 causes not only pulmonary infection, but also multi-organ failure in severe cases, which might be life threatening (Wang et al. 2020).

Although China took rapid and effective measures to prevent the spread of COVID-19 after its breakout, many healthcare workers were infected because of the lack of understanding of SARS-CoV-2 and the insufficient protective measures taken in the early phase. Thereafter, strict control and effective protection, for

Address correspondence to: Yukun Luo, Department of Diagnostic Ultrasound, First Medical Center of Chinese PLA General Hospital, 28 Fuxing Road, Haidian District, Beijing 100853, China. +86 13701179666. E-mail: lyk301@163.com

¹ Yukun Luo and Wen He contribute equally to this work.

example, standardized workflow including detailed disinfection and protection guidelines, was applied, and the infection rate decreased to almost zero, which illustrates the importance of protection for healthcare staff.

With its advantages of convenience, rapidity, non-invasiveness, absence of radiation and bedside availability, ultrasound (US) examination is a cost-effective real-time technique that has an important role in the diagnosis and treatment of COVID-19 (Antunez-Montes *et al.* 2020; Buonsenso *et al.* 2020a). Ultrasonography of the lungs (Shang and Yuan 2018; Allinovi *et al.* 2020) can reveal signs of pleural sliding, pulmonary edema, lung consolidation, pneumothorax, pleural effusion and other conditions, and is especially valuable for dynamic evaluation of pulmonary lesions during outbreaks of COVID-19 (*e.g.*, previous confirmed lesions, peripheral lesions in particular). Cardiovascular ultrasonography can be used in the quick assessment of cardiac structure and function, volume status and volume responsiveness, cardiac involvement and cardiac function deterioration, presence or not of deep vein thrombosis, scope and nature of thrombosis and signs of secondary pulmonary embolism in early stages (Chen *et al.* 2020; Picard and Weiner 2020; Pulmonary Embolism and Pulmonary Vascular Diseases Workgroup *et al.* 2020). Interventional US can be used to guide puncture and catheterization, which can make the procedure safer and more effective (Carles *et al.* 2018; Bhoumesh *et al.* 2019).

Given that patients undergoing US examination might be infected or may be suspected of being infected (symptomatic or asymptomatic), it is very important to ensure that healthcare staff (including doctors, nurses, medical assistants and technicians) are protected during work. Extremely aggressive protection should be avoided because it might result in a lack of protection equipment for the entire hospital. Guidance on proper protection management, for example, how to choose personal protective equipment (PPE) or how to disinfect the environment, should be provided in detail. To address these problems, on behalf of the Chinese Ultrasound Doctors Association, Chinese PLA Professional Committee of Ultrasound in Medicine, Beijing Institute of Ultrasound in Medicine and Chinese Research Hospital Association Ultrasound Professional Committee, the authors summarized the recommendations for effective protection on the basis of existing hygienic standards, their experience and available literature. After completion of the recommendations, two online conferences were held on January 31, 2020 and February 7, 2020, at which the recommendations were discussed in detail. A modified version of the work was circulated and finally approved by all the authors, and is the present *Chinese Experts Consensus on Protection for Ultrasound Healthcare Workers against COVID-19*.

PROTECTION AND STERILIZATION OF US EXAMINATION AREAS AND US DEVICES

Please refer to [Second Xiangya Hospital of Central South University \(2020a, 2020b\)](#), [Chinese PLA General Hospital \(2020\)](#) and [Expert Team of Peking Union Medical College \(PUMC\) *et al.* \(2020\)](#).

PARTITION OF WORK SPACE

The work space should be divided into two passages and three sections with the participation of hospital infection control personnel (if the existing layout cannot be changed to two passages and three sections, signs and actual isolation barriers can be used for partitions to avoid the cross-infection caused by mixing contaminated areas and clean areas).

There are two passages, one accessed by healthcare workers and the other by patients.

There should be three sections: clean area, buffer zone and contaminated area. Healthcare workers enter and leave through the clean area, and patients and their relatives enter and leave through the contaminated area; both areas are divided by buffer zones. Healthcare workers should follow the path clean area → buffer zone A → contaminated area when they go to work and the path cross-contaminated area → buffer zone B → clean area when leaving work, which means they should exit the department through the clean area. The order of cleaning should be clean area → buffer zone → contaminated area.

Clean areas are where healthcare workers rest, eat, change clothes and so on. Irrelevant persons are strictly forbidden to enter these areas. Anything used in the examination room, including gowns, masks, hairnets, gloves and shoe covers, cannot be brought into clean areas.

Buffer areas are mainly for preparation, donning of PPE and hand hygiene before work for healthcare workers. These areas also prevent contamination of clean areas by preventing virus spread resulting from direct return to a clean area from a contaminated area. Buffer zone A is for donning PPE, while buffer zone B is for doffing PPE.

Buffer zone B-1 is for removing goggles or protective face shields, gowns, shoe covers, outer gloves, and other items. Buffer zone B-2 is for doffing working coats, isolation gowns, hairnets, inner masks, inner gloves, shoe covers, and other items.

Dedicated trash cans for different classifications of medical wastes should be used to discard used disposable PPE in buffer zone B (*e.g.*, a trash can for protective clothing and a trash can for gloves and masks). Non-disposable protective items (such as

goggles and protective face shields) can be re-used after strict disinfection.

Contaminated areas include triage and appointment areas, waiting halls and US rooms. Figure 1 is a detailed schematic of the arrangement of workspace and proposed flow.

TRIAGE AND APPOINTMENT AREAS

The triage area should have clear signs and be relatively separate. The ground and surfaces of objects in this area should be disinfected with chlorine-containing disinfectant (1000 mg/L) or diluted 84 disinfectant at a ratio of 1:50, once or twice per day or once contaminated.

Staff in the triage area should be provided primary or secondary PPE and wear a surgical mask or medical protective respirator (*i.e.*, N95 mask), goggles or a protective face shield, latex gloves, disposable hairnets, work coats, isolation gowns and disposable shoe covers. Hand hygiene should be strictly performed during consultation. Use of an infrared thermometer is suggested to maintain distance when taking temperature, and electronic instructions are also suggested for guidance for the same reason (Fig. 2).

Appointments for patients should be made in different time slots to reduce the number of patients in the waiting hall. A separate waiting zone should be available especially for pregnant women, children and the elderly, and an appropriate priority of treatment may be provided to special populations to shorten their stay in the department.

Triage

1. Patients and accompanying persons are reminded to wear disposable medical masks to prevent cross-infections, and masks should be provided to those with fever or cough if necessary.

2. Information is collected on symptoms such as fever, dry cough and shortness of breath, as well as medical history, including visits to virus outbreak areas or contact with persons who did.
3. Temperatures of patients and accompanying persons should be double checked using an infrared thermometer (first measurement performed at hospital entrance).
4. Any individual with fever or other suspected symptoms should be reported according to the hospital infection control process, which might necessitate rescheduling of diagnoses or treatments.
5. Examinations for children with suspected or confirmed COVID-19 who are crying and refuse to wear masks can be performed after sedation if necessary. Figure 3 is a schematic of triage and examination.

EXAMINATION ROOMS

Routine patients

1. Rooms should be well ventilated at least once in the morning and once in the afternoon for no less than 30 min each time.
2. The ground and surfaces of objects in the room should be disinfected with chlorine-containing disinfectant (1000 mg/L) or diluted 84 disinfectant at a ratio of 1:50, once or twice per day or once contaminated.
3. The air should be disinfected with UV lamp irradiation for 60 min (or an air disinfection machine if possible) after the end of daily diagnosis and treatment activities.
4. A strict terminal disinfection should be performed after transferring a suspected or confirmed case, using 3% hydrogen peroxide spray for air first and then chlorine-containing disinfectant (1000 mg/L) for ground and surfaces.

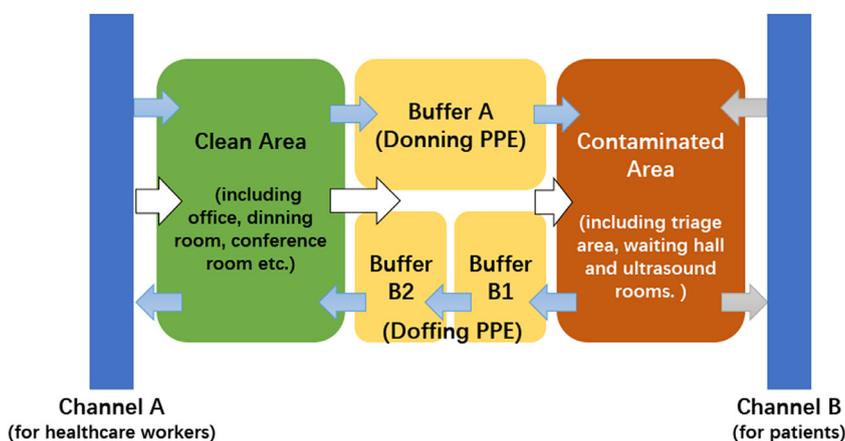


Fig. 1. Detailed schematic of the arrangement of workspace and proposed flow. PPE = personal protective equipment.



Fig. 2. Distance was maintained while taking temperatures or giving instructions. (a) Electronic instructions for examination can be read after scanning the Quick Response (QR) code (arrow). (b) An infrared thermometer was used for taking temperature.

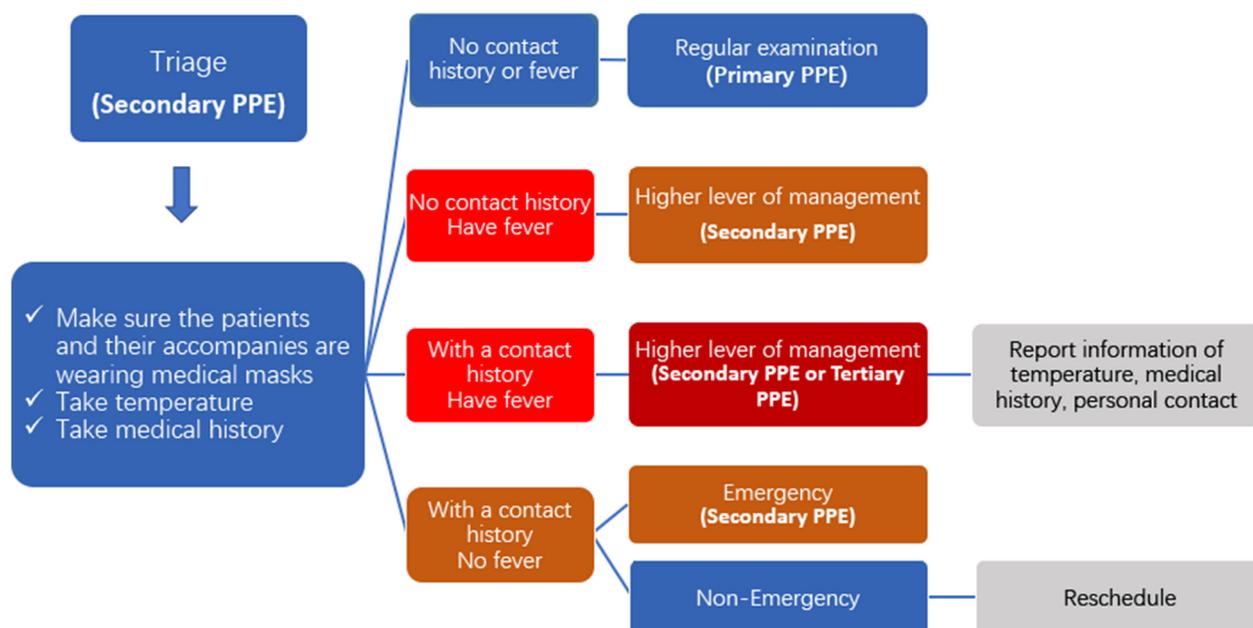


Fig. 3. Schematic of triage and examination. PPE = personal protective equipment.

5. Equipment such as US devices and computers should be cleaned with wipes with 75% alcohol or 3% hydrogen peroxide disinfectant/disinfecting, once or twice per day.
6. Disinfection of US probes: (i) Probes and cables can be disinfected using 75% alcohol/disinfectant wipes (such as acidic electrolyzed water or hydrogen peroxide disinfecting wipes) to prevent cross-infections before and after the examination of each patient. (ii) Probes can also be disinfected using an ultrasonic probe disinfection machine by placing the probe into the probe groove of the disinfection machine, if applicable (the probes can be re-used after 30 s of automatic disinfection).
7. Supplies for patient's examination: Bed sheets, pillowcases and other items should be changed and disinfected with disinfectants or subjected to high-temperature disinfection at least twice a day or immediately after contamination. Use of disposable bed sheets to prevent cross-infections are recommended where applicable for certain healthcare institutions.
8. Disposal of medical supplies: To prevent outbreaks, hand hygiene should be performed before and after removing masks. Medical wastes such as the disused masks and hairnets should be disposed of in the medical trash can (yellow). The trash can should be disinfected twice a day using 75% alcohol or chlorine-containing disinfectant.

Patients suspected of having or confirmed as having COVID-19

1. Room environment: US examination at the bedside in the isolated area is preferred for a suspected or confirmed patient; an examination room in an isolated area may be built where applicable, or the patient can be provided with appropriate protective equipment in a room specialized for fever patients or in the isolation ward and go to the specialized room for examination accompanied by a special person *via* the specified route. Air disinfection should be performed strictly using 3% hydrogen peroxide spray or ultraviolet lamp irradiation for 60 min each time after completion of examination in the specialized room; and a human-friendly plasma air disinfection machine can be placed in the room if applicable. Beds for diagnoses, door knobs, object surfaces and the ground should be wiped with chlorine-containing disinfectant (1000 mg/L) once contaminated. If the surface of the environmental object or the ground is contaminated with obvious contaminants (blood, secretions, vomit and excrement), 5000 mg/L chlorine-containing disinfectant should be used to carefully remove the contaminants and wipe the contaminated areas for disinfection.
2. Ultrasound system and computers: (i) The US system should be one designated for examinations of confirmed and suspected patients. (ii) Protective additions to the US system, such as protective sleeves for probes and a transparent plastic protective cover for the machine that completely covers the monitor and operation panel without affecting the movement of the trackball, can be used. (iii) For the exclusively used US system, the plastic cover should be changed daily after work, and the protective sleeves for probes should be changed for each patient. (iv) Wiping disinfection (75% alcohol or 3% hydrogen peroxide or wipes containing these disinfectants) should be performed once or twice after the examination for probes and cable, machine, monitor, operation panel or the surface of its protective cover, workstation computer (including the monitor and computer case), keyboard and mouse.
3. If exclusive use of the US system is not feasible, the following are recommended: (i) The protective covers for machine, monitor and operation panel and protective sleeves for US probes should be changed after every examination. (ii) Strict wiping disinfection should be performed once or twice after every examination for probe and cable, display, operation panel, the workstation computer (including the monitor and computer case), keyboard, and mouse, using 75% alcohol or 3% hydrogen peroxide or disinfecting wipes containing these ingredients.

4. Disposal of supplies for patient examinations and medical supplies ([National Health Commission \[NHC\] 2020](#)). All wastes of patients and protective equipment for healthcare workers should be considered as infectious medical wastes and placed in a dedicated packaging bag or sharps container for medical wastes. The packaging bag or sharps container should be packed with another bag if it is contaminated by infectious wastes. The used disposable gowns and protective equipment once used should be collected by classification without squeezing. Each packaging bag and sharps container should be attached or affixed with a label that indicates the hospital department where the medical wastes originates, date, category and a note marking “Coronavirus Disease 2019” or its abbreviated form “COVID-19.” Before leaving the contaminated area, the surface of the packaging bag should be disinfected with 2000 mg/L chlorine-containing disinfectant (note: the spray should be even) or packed with another packaging bag dedicated for medical wastes.

Detailed suggestions for the disinfection of different areas are summarized in [Table 1](#).

PROTECTION FOR HEALTHCARE WORKERS DURING WORK

Please refer to [First Medical Center of PLA General Hospital \(2020\)](#) and [Second Xiangya Hospital of Central South University \(2020a, 2020b, 2020c\)](#).

PROTECTION DURING EXAMINATIONS FOR ROUTINE PATIENTS

Attire for ordinary US examination

Employ the primary PPE, including work coat, disposable work hairnet, latex gloves, and surgical mask (change every 4–6 h); if necessary, employ secondary PPE such as an isolation gown, medical protective mask and goggles or face shield. Strict hand hygiene should be performed during the examination.

Attire for interventional US (including bedside interventional US) and intracavitary US

Employ the primary PPE, including surgical mask, disposable work hairnet, latex gloves, surgical gown/work coat; if necessary, use an isolation gown, medical protective mask, goggles and face shield. The same protection should be provided for participants such as medical assistants and nurses as for physicians who remain in the same room. Given that the spread of SARS-CoV-2 through the digestive tract remains unclear, transrectal US and transesophageal US should be replaced with percutaneous US during outbreaks. For intracavitary

Table 1. Detailed suggestions for disinfection of different areas

Area	Suggestion	Frequency
Triage Room for routine examination	Environment	1 or 2 times/day or any time it is contaminated
	Environment	1–2 times/day or any time it is contaminated 2 times/day After work everyday
Equipment	Probe	1 or 2 times/day After examination for each patient
	Supplies	After examination for each patient Half a day or immediately change once contaminated
	Environment	After examination for each patient
	Equipment	Any time once contaminated Any time once contaminated
Probe	Equipment	Remove after examination for each patient After examination for each patient
	Supplies	After examination for each patient After examination for each patient

gynecologic ultrasound, the probe and cable should be disinfected after every examination, and the disposable sterile sheet and probe sleeve should be changed routinely.

Disposal of medical wastes

Used disposable items should be placed in trash cans (bags) dedicated for medical wastes. Goggles (anti-fog type) should be soaked in electrolyzed oxidizing water for 5 min or in chlorine-containing 1000 mg/L disinfectant for 30 min; the face shield should be wiped with 75% medical alcohol; the working coat should be changed daily or placed under ultraviolet light in the dressing room for 30 min; work shoes should be disinfected with ultraviolet light when necessary.

DIAGNOSTIC AND THERAPEUTIC US FOR PATIENTS FROM AN OUTBREAK AREA OR UNDER QUARANTINE

Work attire

Employ the secondary PPE, including a medical protective mask (N95 respirator or higher), goggles or face shield, latex gloves, disposable work hairnet, work attire or two-piece surgical gown, isolation gown and disposable shoe covers. The same protection provided for participants such as medical assistants and nurses should be provided for physicians who remain in the same room. In view of the fact that there some SARS-CoV-2 carriers are asymptomatic, healthcare institutions, where applicable, may prepare protective clothing, boot covers and other items, in addition to basic secondary PPE. There should be two persons to cooperate with and supervise each other when donning and doffing protective equipment; video instructions should be provided if possible.

Examination process

Enter the room in attire consistent with the protection requirements. Strictly perform hand hygiene during work. Disinfect the US probe, cable, devices and relevant non-disposable items immediately after the examination. Disinfect the bedside US system after each patient. Disinfect the room after the examination, before leaving the room.

DIAGNOSTIC AND THERAPEUTIC US FOR SUSPECTED OR CONFIRMED PATIENTS

Work attire

Employ the secondary PPE, including wearing a medical protective mask (N95 respirator or higher), goggles or face shield, latex gloves, disposable work hairnet, work attire or two-piece surgical gown, isolation gown and disposable shoe covers. The same protection

provided for participants such as medical assistants and nurses should be provided for physicians who remain in the same room. Considering the existence of non-symptomatic COVID-19 patients, healthcare institutions should prepare protective clothing, boot covers, and other items in addition to basic secondary PPE.

Patient's attire and requirements

Patients should wear surgical masks. Use of a bedside US system is recommended. Patients should, where applicable, be accompanied by a specified person *via* the specified route to the dedicated room or the isolated ward for bedside examination. The surface of the used wheelchair or patient trolley, if any, should be disinfected with 1000 mg/L chlorine-containing disinfectant.

Examination process

Enter the room in attire that strictly conforms to the protection requirements; hand hygiene should be strictly performed during the work; probes, cable, devices and relevant non-disposable items should be disinfected immediately after the examination; disinfect the entire room and all medical waste before leaving the room, sanitize hands strictly following the rules of hand hygiene and remove the protective equipment conforming to relevant requirements. It is recommended that the dedicated bedside US system not be used for examinations in isolation wards.

Although not widely employed in China, pocket devices and wireless probes have recently been reported and have proven to be helpful in minimizing the number of healthcare workers and medical devices exposed to suspected or confirmed cases of COVID-19 (Buonsenso et al. 2020a, 2020b; De Rose et al. 2020; Inchingolo et al. 2020). If these portable devices are available, their use (with disposable plastic covers) in bedside examinations of suspected or confirmed patients is highly suggested.

Previous studies have suggested that lung US examination might guide therapeutic decisions and procedures in patients with COVID-19 in many critical settings (Allinovi et al. 2020; Soldati et al. 2020), for example, general practitioners' offices, nursing homes, emergency departments, general internal medicine wards, pulmonology wards, hemodialysis units and obstetric and pediatric departments. In these settings, pocket devices and wireless probes are also highly suggested, and protection of the healthcare worker or disinfection of relative machine should not only be in line with the above suggestions, but should also fulfill the needs of special clinical settings, which might require multidisciplinary discussion and is beyond the scope of the present study.

Table 2. Detailed suggestions for different types of protection of healthcare workers

Area	Protection
Triage	Primary or secondary PPE
Routine examination	Primary or secondary PPE
Interventional ultrasound or intracavitary ultrasound	Primary or secondary PPE
Examination of patients with contact history	Secondary PPE
Examination of suspected or confirmed patients	Secondary PPE
Examination in environments with possibility of aerosol generation	Tertiary PPE

PPE = personal protective equipment.

DIAGNOSTIC AND THERAPEUTIC US IN THE ENVIRONMENT WITH POSSIBILITY OF GENERATION AND SPREAD OF AEROSOL

Work attire

Employ the tertiary PPE, including a medical protective mask (N95 respirator or higher), full-face respirator or higher-level powered air-purifying respirator (positive pressure headgear), latex gloves, disposable work hairnet, two-piece surgical gown, isolation gown, disposable shoe covers and protective clothing and boot covers.

Examination

A bedside US system should be used and attire that strictly conforms to the protection requirements should be worn before entering the room. Hand hygiene should be strictly performed during the work. Probes, cable, devices and relevant non-disposable items should be disinfected immediately after the examination. The entire room and all medical waste should be disinfected before leaving the room. Hand hygiene should be strictly performed and PPE should be removed in line with the relevant requirements.

Detailed suggestions for different types of protection of healthcare workers are summarized in Table 2.

SUMMARY

As stated above, lung US examinations may be performed in many critical settings (Allinovi et al. 2020; Soldati et al. 2020), and protection of healthcare workers might necessitate further multidisciplinary discussion. In addition, in a rapidly changing pandemic, all these suggestions might seem imperfect or even incorrect in the future. However, the aforementioned suggestions are the expert consensus based on existing hygienic standards, our experience and available literature, and were strictly followed during the past few months. Among all of these suggestions, the most important is to keep a clear idea

about what is contaminated and what is not, to minimize unnecessary exposure and to prevent further spread of the disease. We admit that there may still be some points for which additional evidence is needed; however, we remain confident in concluding that, with proper protection and management, lung US examination can offer valuable information for diagnosis and treatment of COVID-19 with a minimized risk of infection.

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Conflict of interest disclosure—The authors declare that they have no competing interests.

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