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## Cardiothoracic Imaging

# Recommendations for coronavirus disease 2019 (COVID-19) prevention and infection control in the radiology department: Chinese experience

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## ABSTRACT

The coronavirus disease 2019 (COVID-19) outbreak, first reported in Wuhan, China, is gradually spreading worldwide. For diagnosis, chest computed tomography is a conventional, noninvasive imaging modality that is very accurate for detection and evaluation of pneumonia and is an important adjunct to real-time reverse transcription polymerase chain reaction diagnosis of the virus. Previous studies have reported typical computed tomography imaging features indicative of COVID-19, such as multifocal ground-glass opacities with or without consolidation. With the sharply increasing demand for computed tomography examination during the outbreak, ensuring appropriate infection control in radiology departments is challenging. Thus, advanced training and education in standardized infection control and prevention practice are essential. The purpose of this brief review is to summarize such training and education for clinical management of this outbreak for radiology department personnel. We will describe standard transmission-based precautions, workflow for computed tomography examination of fever patients, and decontamination management of a radiology department.

Coronavirus disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), was first reported in Wuhan, China [1]. It is spreading fast with increasing numbers of infected patients worldwide. Currently, chest computed tomography (CT) is a conventional, non-invasive imaging modality with high accuracy and speed for early screening, primary diagnosis, and evaluation of disease severity [2]. Individuals with CT signs of pneumonia are recommended for quarantine while RT-PCR is performed in conjunction with a thorough medical evaluation to accurately diagnose COVID-19 [3]. With the sharply increasing demand for CT examination, radiology departments are at high risk site for cross infection with SARS-Cov-2. Therefore, implementation of standardized infection control and prevention practices in radiology departments is critically important [4]. This manuscript outlines recommendations for COVID-19 infection control and prevention pertinent to current radiology practice. Procedures are described for standard transmission-based precautions, appropriate use of personal protective equipment (PPE), CT examination workflow for fever patients, decontamination of reusable medical equipment, and decontamination of commonly exposed surfaces in our experience.

- 1. New management framework and hybrid working teams.** We suggest radiology departments establish an epidemic prevention and control management team to coordinate the radiology department with changes within the hospital. The personnel of the team will be responsible for planning, practicing, and executing any imaging procedure necessary to management of infection risk. Radiology department staff (including radiologists, technicians, nurses, front-line counter staff, and cleaners) should have up-to-date knowledge and standardized operating procedures to minimize hospital-related infection transmission by personnel or by radiology equipment.
- 2. Divide the area and designate specialized imaging equipment.** The department should divide the area into contaminated, potentially contaminated, and clean zones [5]. The contaminated zone includes waiting areas and examination rooms where the suspected or confirmed patients are located. The potentially contaminated zone includes the CT console room, patient examination access areas, and a dressing area for technicians. The clean zone includes the diagnostic office and the rest area. Radiological technicians don and doff PPE in the designated potentially contaminated zone.
- 3. Protection of radiology staff.** SARS-CoV-2 is primarily propagated through respiratory droplets and/or close contact within the

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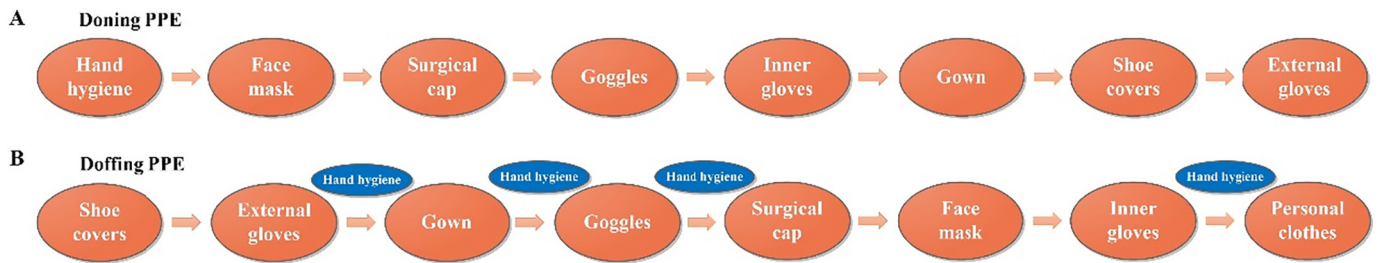


Fig. 1. Recommended sequence for donning (A) and doffing (B) personal protective equipment.

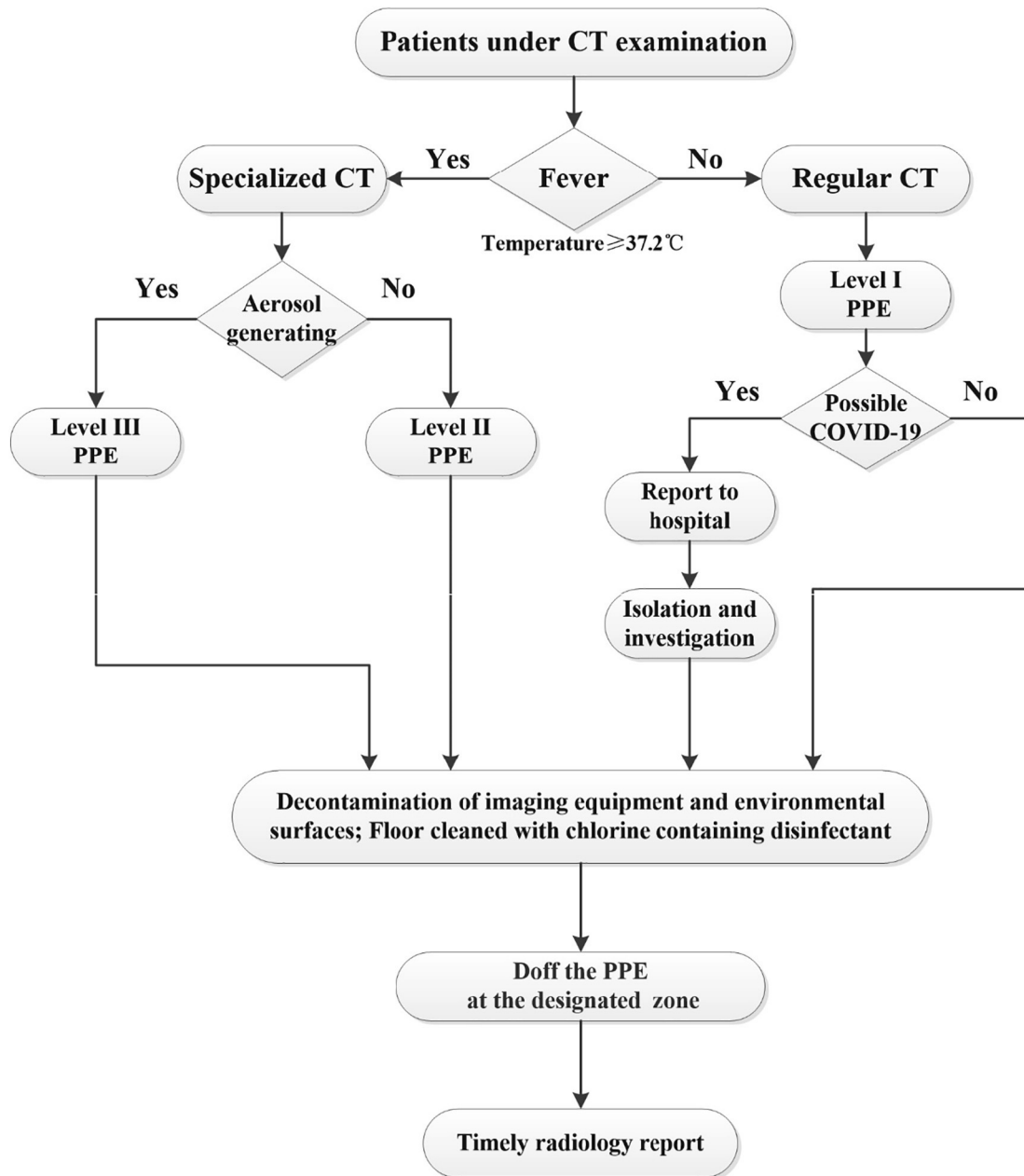


Fig. 2. Flowchart for CT examination for epidemic prevention and control.

radiology department [6]. Exposure can occur during patient registration, history recording, transportation, radiologic examination, or in the waiting area. The greatest risk is transmission via droplets within 91.44 cm (3 ft) of the source individual [7]. PPE includes a surgical cap, goggles, a surgical or N95 face mask, a

filtering face piece respirator (N95), gloves, a fluid-impermeable gown, coveralls, and shoe covers. It is important to use appropriate precautions based on anticipated exposure risk [7]. A detailed summary of the proper use of different PPE levels is provided in Table 1. The recommended sequence for donning and doffing PPE is



**Fig. 3.** A, photograph of personal protective equipment for Level II radiologic technician protection in a CT scanner room. B, technician in a console room during CT examination of a patient infected with SARS-CoV-2. C, radiological technician wiping the surface of a CT table with disinfectant.

**Table 1**

Personal protective equipment for health care personnel in a room suspected or confirmed to be positive for COVID-19.

Level	Personal protective equipment	Radiology staff	Comments
I	Surgical cap, surgical face mask, coveralls, fluid-impermeable gown; hand hygiene must be performed.	Radiologist	Limited entering potential contaminated zone. Virtual or telephone consultations are used instead of clinical meeting
II	Surgical cap, goggles or face shield, N95 face mask, fluid-impermeable gown, double layer of nitrile gloves, shoe covers; hand hygiene must be performed.	Specialized radiological technician for fever patients, nurses, frontline counter staff, and cleaners	Engaged in activities close contact with suspected or confirmed patients
III	Surgical cap, face shield, N95 face mask, powered air respirators or N95 respirator, fluid-impermeable gown, double layer of nitrile gloves, shoe covers; hand hygiene must be performed.	Specialized radiologic technician for fever patients	Engaged in aerosol-generating procedures and high-risk activities

shown in Fig. 1. For health care personnel who will be in contact with suspected or confirmed COVID-19 patients, PPE must cover all skin and clothing and must be changed between patient encounters. Hand hygiene is always performed before and after the use of PPE.

4. **Staff management plan.** Preventative measures, including general education and training, and proper decontamination of radiological equipment, should be taken. Personnel working within the contaminated zone are strictly prohibited from entrance into the potentially contaminated or clean zones. In addition, documentation (e.g. temperature measurement) indicating appropriate infection control practices and procedures should be made available to the radiographers to enforce implementation. With evidence of fever, cough, or other respiratory symptoms, radiographers should timely report to hospital infection control personnel.
5. **Fever patient management plan.** Patient screening in fever clinics includes measurement of fever (temperature  $\geq 37.2$  °C), travel, contact history, and symptoms. One important measure for prevention of SARS-Cov-2 transmission within the radiology department is to reduce the fever patient's stay within the department as much as possible. We recommend dedicated routes to transfer infectious patients in and out of radiology services. Patients with respiratory symptoms (e.g., fever, cough) must wear a surgical or N95 face mask during transportation and examination. If an isolation room is not available in the radiology department, suspected or confirmed COVID-19 patients should be separated from others by at least 6 ft in common waiting areas.
6. **Procedure and workflow for examination.** We recommend dedicated CT scanners for examination of patients suspected or confirmed to have SARS-CoV-2 infection. To assess COVID-19 pneumonia, two radiological technicians are desirable for CT scanning. Using PPE one technician prepares the patient on the CT imaging table, while the other technician operates the CT console. Workflow for chest CT examination is shown in Fig. 2.
  - a. The fever clinic notifies technicians within the receiving department

of the patient's arrival and necessary transmission-based precautions.

- b. Radiology workers must don PPE that fully covers all body surfaces (Fig. 3A) and then prepare for operation of the imaging equipment. CT table tops, which come into direct contact with patients, must be covered with a replaceable sheet.
- c. Once the patient is positioned by the clinician, the technician prepares the patient on the CT imaging table, following detailed protocols for CT scanning. The recommendation is to guide patients to the appropriate position on the examination bed by intercom (Fig. 3B). Artificial intelligence-assisted localization technologies for advanced imaging modalities can be used to avoid close contact with fever patients.
- d. At the completion of each radiological examination, the replaceable sheet on the CT table must be replaced to avoid cross infection. Proper decontamination of imaging equipment and environmental surfaces must be completed for protection of the next patient. The technicians remove and dispose of PPE in the designated potentially contaminated zone according to infection control guidelines, which includes examination room hand hygiene.
- e. To facilitate rapid reporting of chest CT results, technicians flag such cases into new dedicated worklists and then notify radiologists to determine typical imaging features (multifocal ground-glass opacities with or without consolidation in the peripheral zone of the lung) indicative of COVID-19. Radiology personnel ensure timely sharing of accurate and useful information with ordering clinicians through picture archiving and communication systems.
- f. Patients from different groups (e.g., inpatient, outpatient, emergency, and febrile) are segregated by place or time with minimal crossover. If there are several suspected or confirmed patients to be tested within the same period, it is recommended to CT scan suspected COVID-19 patients first and then confirmed patients.
- g. When an asymptomatic infected patient with typical imaging features indicative of COVID-19 is identified in a non-febrile patient, radiology staff must immediately report this finding to the hospital.

The suspected patient must be sent to the fever clinic for isolation and further investigation.

**7. Decontamination of radiology equipment and the examination room.** SARS-Cov-2 can be inactivated by ultraviolet light, high temperature (56 °C for 30 min), conventional disinfectants such as 75% alcohol, chlorine containing disinfectants, and peracetic acid [7].

- a. Equipment surface cleaning: Our institution uses wipes saturated with 2000 mg/L chlorine containing disinfectant or 75% alcohol to clean surfaces and equipment used in the care of COVID-19 patients. This cleaning is accomplished at least twice a day for a period of 30 min (Fig. 3C). The tables and chairs in the waiting areas are wiped and disinfected with 250–500 mg/L chlorine containing disinfectant at least once a day.
  - b. Floor cleaning: For the disinfection of the floor in a contaminated procedure room, 2000 mg/L chlorine containing disinfectant is applied twice a day.
  - c. Disinfection of air: The hall and examination room should be continuously sterilized with a circulating air sterilizer. Ultraviolet light is an adjunctive measure to decontaminate equipment and air for 30–60 min immediately after fever patient contact. Finally, 6% hydrogen peroxide vapor decontamination (4 mL/m<sup>3</sup>) is completed and then ventilated after disinfection.
  - d. Disinfection of goggles: Goggles are cleaned with disinfectant wipes, and then soaked in 75% alcohol for 1 h or in 1000–2000 mg/L chlorine containing disinfectant for 30 min. The goggles are then cleaned with water and dried.
  - e. Medical waste disposal: All patient care waste is treated as infectious medical waste. To minimize infection transmission, used PPE should be disposed in the contaminated zone. The outer side of the gown is turned inward, rolled and then discarded into a designated container. It is recommended to spray the outer packing surface with 1000 mg/L chlorine containing disinfectant.
- Radiography procedures and the decontamination of mobile radiography units related to CT examination: X-ray analysis has limited value in screening or early diagnosis of COVID-19, but can be used to evaluate disease progression in critical patients. For bedside radiology in an isolation room, the technician wears Level III PPE. The portable X-ray detector is double bagged by using fluid-impermeable plastic material and cleaned twice with disinfectant wipes at the completion of radiography [8].

Transmission of SARS-Cov-2 can occur during almost any portion of a radiologic examination. Thus, it is imperative that the radiology staff understands the infection control methods and implementation precautions to minimize the risk of transmission. With a comprehensive approach to radiology preparedness, the radiology department can effectively join the battle against the current outbreak of COVID-19.

**Declarations of competing interest**

None.

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