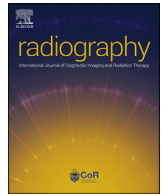




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Technical note

Management of patients with suspected or confirmed COVID-19, in the radiology department



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ARTICLE INFO

Article history:

Received 2 April 2020

Received in revised form

10 April 2020

Accepted 13 April 2020

Available online 20 April 2020

Keywords:

Coronavirus

COVID-19

Radiography

Tomography, X-Ray computed

Infection control

ABSTRACT

Objectives: From December 2019, a novel coronavirus disease named COVID-19 was reported in China. Within 3 months, the World Health Organization defined COVID-19 as a pandemic, with more than 370,000 cases and 16,000 deaths worldwide. In consideration of the crucial role of diagnostic testing during COVID-19, the aim of this technical note was to provide a complete synthesis of approaches implemented for the management of suspected or confirmed COVID-19 patients.

Key findings: The planning of a robust plan to prevent the transmission of the virus to patients and department staff members should be fundamental in each radiology service. Moreover, the speed of spread and the incidence of the pandemic make it necessary to optimize the use of personal protective devices and dedicated COVID-19 equipment, given the limited availability of supplies.

Conclusion: In the management of radiographic and CT imaging, staff should take special precautions to limit contamination between patients and other patients or professionals.

Implications for practice: An isolated imaging room should be dedicated to suspected or confirmed COVID-19 cases, including radiography and CT scanners. This paper will provide guidance concerning disposable protective gear to be utilized, as well as on the cleaning and sanitation of radiology room and equipment.

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Introduction

From December 2019, a novel coronavirus named COVID-19 was reported in China.^{1,2} Human-to-human transmission was subsequently confirmed,^{3,4} and the global number of confirmed cases of

COVID-19 has surpassed 1,500,000 across 184 countries; COVID-19 caused more than 90,000 deaths⁵ within 3 months (up to April 9th, 2020). The World Health Organization (WHO) recognised COVID-19 as pandemic on the March 11th, 2020.⁶ A precise estimate of the mean incubation period for COVID-19 infection is still debated, however the WHO reported an official estimate ranging from 2 to 10 days.⁷ While, a study by Qun et al.² described an average incubation period of 5.2 days, before the onset of the first symptoms.

COVID-19 has proven highly contagious^{8,9} and it mostly spreads through respiratory droplets, but may also be transmitted by touching a surface that is contaminated with the virus.¹⁰ Given the high infectivity, it is vital to identify and promptly isolate subjects with COVID-19. Positive real-time reverse transcriptase polymerase

Abbreviations: CT, computed tomography; PPE, personal protective equipment; SARS, severe acute respiratory syndrome; WHO, World Health Organization.

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chain reaction (RT-PCR) for viral nucleic acid is the reference standard for COVID-19 diagnosis, while sensitivity and specificity of computed tomography (CT) are reported to range from 80 to 90% and 60–70%, respectively.^{11,12} Diagnostic imaging exams, such as chest radiography and CT, are crucial in understanding the severity and disease progression in COVID-19 infection.¹³

In this context, radiologists, radiographers, nurses, and other healthcare professionals or technical support personnel are among the first-line healthcare workers who might be exposed to COVID-19.¹⁴ Therefore, it is vital to adopt the necessary precautions in order to avoid further spread of the virus.

The shortage of personal protective equipment (PPE) and other protection devices is leaving radiologists, radiographers, nurses and other frontline workers dangerously ill-equipped to care for COVID-19 patients and themselves.¹⁵ Thus, it is very important to optimise the use of supplies.

Multiple approaches should be adopted on basis of different variables: the suspected or confirmed COVID-19 patient, the referred diagnostic imaging technique, and the hospital specialisation level on management of infectious and infective patients.

The aim of this technical note was to provide a comprehensive evaluation of different approaches adopted on management of suspected or confirmed COVID-19 patients.

Prevention system for radiology department staff

This technical note is based on our first-hand experience from around Italy and also draws on COVID-19 publications and reports.

Radiology service requirements

Isolated imaging rooms should be dedicated for the examination of suspected or confirmed COVID-19 patients, including the console and examination rooms for both X-ray and CT. Moreover, all items which are not essential should be removed from these rooms to allow simpler, faster and more effective sanitization. In all cases of suspected or confirmed infection, a dedicated pathway to perform radiological examinations should be planned, along with the appropriate sanitization scheduling for the equipment, as all equipment ought to be sanitized after suspected or confirmed infections.

The use of additional equipment, such as lead-equivalent protection or shielding, restraints and immobilization devices are not recommended in order to limit sources of contamination. If this is not possible (e.g. a pediatric examination with accompanying personnel), it is important to perform deep sanitization.

Dedicated mobile X-ray units should be utilized for imaging suspected or confirmed COVID-19 cases, especially in the intensive care ward and high isolation therapies ward (COVID Units).

Patients case definitions

The WHO¹⁶ defined a suspect, probable, and confirmed COVID-19 case as follows:

Suspected case:

- A patient with acute respiratory illness (fever and at least one sign/symptom of respiratory disease (e.g., cough, shortness of breath), and with no other aetiology that fully explains the clinical presentation and a history of travel to or residence in a country/area or territory reporting local transmission of COVID-19 disease during the 14 days prior to symptom onset;
- A patient with any acute respiratory illness and having been in contact with a confirmed or probable COVID-19 case in the 14 days prior to onset of symptoms;

- A patient with severe acute respiratory infection (fever and at least one sign/symptom of respiratory disease (e.g., cough, shortness breath) and requiring hospitalization and with no other aetiology that fully explains the clinical presentation.

Probable case:

- A suspect case for whom testing for COVID-19 is inconclusive.

Confirmed case:

- A patient with laboratory confirmation of COVID-19 infection, irrespective of clinical signs and symptoms.

Protection levels for healthcare staff

- Minimum requirements include: disposable surgical masks, surgical caps and disposable gloves.
- Suspected COVID-19 case: disposable surgical masks, disposable surgical caps, eye protection (goggles or visor), protective clothing or insulating outer gown, disposable gloves and disposable shoe covers. At the end of the sanitization procedure, it is essential to wash hands and to rigorously apply a sanitizing gel.
- Confirmed COVID-19 case: disposable surgical masks, disposable surgical caps, eye protection (goggles or visor), protective clothing or insulating outer gown, disposable gloves and disposable shoe covers. If aerosol-generating procedures performed on COVID-19 patients, respirator such as N95/99 or FFP2/3 are required. At the end of the sanitization procedure, it is essential to wash hands and to rigorously apply a sanitizing gel.

Table 1 summarises the protection levels for healthcare staff, while Table 2 summarises all recommended types of PPE to be used in the context of COVID-19 disease, according to the setting, personnel, and type of activity.

Considerations regarding the type of disposable medical mask to be adopted

According to the WHO¹⁷ and to the latest scientific evidence,¹⁸ surgical masks may be used as a suitable device to protect healthcare workers. High filtration masks (e.g. N95/99, FFP2/3 or equivalent standard) should be used only for aerosol-generating procedures (e.g. tracheal intubation, non-invasive ventilation, tracheostomy, cardiopulmonary resuscitation, manual ventilation before intubation, bronchoscopy).¹⁹ Therefore, in any radiology unit, healthcare workers should use surgical masks, along with eye protection, gloves and gowns; aprons should also be used if gowns are not fluid resistant.

The staff must be educated on dressing and undressing procedures, in particular on how to properly wear, remove, and dispose of a medical mask.

Considering the rapidly growing imbalance between supply and demand for medical resources (including masks),²⁰ rationing procedures and managing the allocation of available medical resources is advisable.

Cleaning and sanitization of radiology equipment (console and examination rooms)

As stated above, in both the console and the examination rooms, all non-essential items should be removed. In the console room,

Table 1
Protection levels for healthcare staff.

	Surgical masks	Surgical caps	Gloves	Eye protection (goggles or face shield)	Disposable shoe covers	Protective clothing	Medical mask FFP2 or higher ^a
Minimum requirements	✓	✓	✓				
Suspected COVID-19 case	✓	✓	✓	✓	✓	✓	
Confirmed COVID-19 case	✓	✓	✓	✓	✓	✓	✓

In addition to using the appropriate PPE, frequent hand hygiene and respiratory hygiene should always be performed.

FFP: Filtering Face Piece.

^a If aerosol-generating procedures performed on COVID-19 patients, respirator such as N95 or FFP2/3 are required.

Table 2
Recommended type of personal protective equipment (PPE) to be used in the context of COVID-19 disease, according to the setting, personnel and type of activity.

Setting	Target personnel or patients	Activity	Type of PPE or procedure
Diagnostic room X-Ray or CT	Healthcare workers (Radiologists, Radiographers, Nurses, other support personnel)	Patient positioning and acquisition of chest X-ray or CT scan.	Surgical mask Gown Gloves Eye protection (goggles or face shield)
	Visitors	Entering the diagnostic room of COVID- 19 patients.	Surgical mask Gown Gloves
	Patients	Entering the diagnostic room of COVID- 19 patients.	Maintain spatial distance of >1 m. Provide surgical mask if tolerated by patient.
	Cleaners	Entering the diagnostic room of COVID- 19 patients.	Surgical mask Gown Heavy duty gloves Eye protection (if risk of splash from organic material or chemicals) Boots or closed work shoes
Diagnostic X-Ray or CT control room	Healthcare workers	Any activity that does not involve contact with COVID-19 patients.	Surgical mask. Maintain spatial distance of >1 m.
Other areas of patient transit (e.g., wards, corridors).	Healthcare workers	Any activity that does not involve contact with COVID-19 patients.	Surgical mask. Maintain spatial distance of >1 m.
	Patients	Waiting for diagnostic exams.	Surgical mask. Maintain spatial distance of >1 m.

If aerosol-generating procedures performed on COVID-19 patients, respirator such as N95 or FFP2/3 are required. In addition to using the appropriate PPE, frequent hand hygiene and respiratory hygiene should always be performed.

PPE: personal protective equipment; CT: computed tomography; COVID-19: COroNaVirus Disease 19; FFP2/3: filtering face piece.

monitors, keyboards, mouse, chairs, control panel and exposure button, and injector console should be covered with waterproof protective material or, alternatively, using transparent adhesive film, as well as the injector pump, and table, and tube control buttons into the examination room. If not possible, all objects must be sanitized at the end of the procedure.

Radiographers, nurses, other healthcare professionals or technical support personnel, and cleaning personnel must be specially trained in the professional cleaning and sanitation of potentially contaminated surfaces. Low or intermediate level disinfectant, such as iodophor germicidal detergent solution, ethyl alcohol (ethanol 75%) or isopropyl alcohol, can be used to disinfect the equipment surface at the end of each examination with suspected or confirmed COVID-19 patient. User manuals of equipment manufacturers state the disinfectant products and procedures to avoid possible functional damage of equipment.

Acquisition of chest radiographs in patients with suspected or confirmed COVID-19

The radiographer must adopt the level of protection previously indicated for the acquisition of chest radiographs in patients with suspected or confirmed COVID-19. It is recommended to use two separate radiographers: one assigned to manage the workstation and the controls (“clean” radiographer), the other assigned to positioning the patient and to explaining the breath hold during the exam (“dirty” radiographer, due to the higher risk for potential

contamination and/or exposure to COVID-19). It is suggested that, whenever there is demand for a chest radiograph for a suspected or confirmed COVID-19 case, the “dirty” radiographer that helps with patient positioning must take the necessary measures to prevent any contamination or repeated acquisitions that would imply further instrument sanitisation. The “clean” radiographer, conversely, remains stationed in the control room. Any accompanying personnel must adopt both protection for biological risk¹⁵ and standard radiation protection devices (lead gown). Patients should wear a surgical mask during the entire examination and if the patient is to be transported to the radiology department for the examination, they must also wear a surgical mask during transport to and from the department.

It is desirable to schedule cohorts of patients of the same type together (for example with proven COVID-19 infection) to minimize changes in the dressing of operating personnel. When possible, imaging should be performed at sites with less foot traffic and with fewer critically ill patients to avoid secondary contamination.

Acquisition of chest CT scan in patients with suspected or proven COVID-19

Radiographers must adopt the level of protection previously indicated for the acquisition of chest CT in patients with suspected or confirmed disease. As per radiographic examinations, it is suggested to acquire CT examinations with the simultaneous use of

two radiographers: one assigned to manage the workstation and the controls, the other assigned to positioning the patient and explaining procedure and the breath-hold during the exam. If not possible due to a limitation of personnel, other support healthcare personnel may be requested to assist the radiographer appointed to conduct the examination. Any accompanying personnel must adopt both protection for biological risk¹⁵ and standard radiation protection devices (lead gown). Again, patients should wear a surgical mask throughout the examination and also during transport if the examination is being performed in the radiology department.

Chest CT, in particular high-resolution CT, represents a valuable tool to identify patients with COVID-19 infections at an early stage when clinical symptoms may be unspecific or sparse.¹² Studies have suggested the use of chest CT for screening for COVID-19 for patients with clinical and epidemiological features compatible with COVID-19 infection particularly when RT-PCR testing is negative.¹¹ CT is easily available and can be used to screen patients for rapid confirmation of SARS-CoV-2 infected novel coronavirus pneumonia because CT, especially high-resolution CT, has the advantages of high spatial resolution, freedom of disturbance from other structures outside the scanning plane and the ability to display lesion details in multiple planes, especially demonstrating the progression during the early stage from illness onset.²¹

For every suspected patient, chest CT is indispensable for definitive diagnosis and re-examination. According to the National Health and Health Commission, patients with COVID-19 also underwent follow-up high-resolution CT scans for evaluating the progression of the disease after a short period of standardized treatment. The mean interval time from initial to follow-up examinations was 7 days (range, 3–13 days).²²

According to the WHO and Centers for Disease Control and Prevention guidelines, chest radiography and CT were the major diagnostic components when SARS was prevalent.²³

Presently, non-contrast high-resolution CT is considered the first-line imaging modality in highly suspected cases, and it may be helpful for monitoring imaging changes during treatment.^{21,24,25} Thus, CT is considered one of the main imaging modality for diagnosing and for monitoring the care of patients with COVID-19 pneumonia, as emerging global health emergency.²⁶

CT imaging technique

High-resolution Chest CT examinations should be obtained with the following scan parameters:^{25,27,28}

- Tube voltage of 100 kVp or 120 kVp, with automatic tube current modulation (40–400 mA or 100–200 mAs) or fixed tube current;
- Pitch, 0.75–1.5 and collimation, 0.5–5 mm.

All CT images should be reconstructed using:

- Sharp kernel (high spatial resolution algorithm) and a window width and level of 1000–1500 HU and –500 to –650 HU, respectively, for lung parenchyma, and 300–350HU and 20–50HU, respectively, for mediastinum;
- Reconstruction matrix of 512 × 512, slice thickness of 0.5–5 mm and an interval of 75% approximately.

The scanning range is from the apices to the level of posterior costophrenic angle. All CT scans should be performed without intravenous contrast agent injection,¹² with the patients in a supine position during breath-holding at full inspiration. Before each CT acquisition, the dedicated radiographer covers the entire surface of the CT couch with a disposable sheet.

It is very important that patients wear a mask during all imaging examinations, and that radiographers maintain, when possible, a distance of more than 1 m from suspected or known COVID-19 patients. Respiratory droplets from affected individuals have the greatest risk of transmission within 91 cm, but they can travel up to 183 cm from their source.¹⁴

As healthcare centers are prone to becoming a place of spread for COVID-19, early detection of suspected or confirmed cases, and limiting exposure of healthcare workers, employees and patients, especially critically ill patients, is crucial.²⁹ In particular, in imaging departments, adopting common protocols for patient management and sanitization may help minimize the issue of contagion, while maximizing resources dedicated to patient care.

Conflict of interest statement

The authors report no declaration of conflict of interest. The authors alone are responsible for the writing and content of this paper.

Acknowledgments

This technical note has been conducted on behalf of the Italian Federation of Radiographer Scientific Societies (FASTeR). We would like to thank the INMI Lazzaro Spallanzani IRCCS, Rome, for providing us the internal operating procedures useful in writing this document. We would like to thank Alessandro Tombolesi, Jacopo Negri and Oscar Brazzo for their contribution.

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