ORIGINAL ARTICLE

Coronavirus Outbreak: What the Department of Radiology Should Know

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Abstract

In December 2019, a novel coronavirus pneumonia emerged in Wuhan, China. Since then, this highly contagious coronavirus has been spreading worldwide, with a rapid rise in the number of deaths. Novel coronavirus–infected pneumonia (NCIP) is characterized by fever, fatigue, dry cough, and dyspnea. A variety of chest imaging features have been reported, similar to those found in other types of coronavirus syndromes. The purpose of the present review is to briefly discuss the known epidemiology and the imaging findings of coronavirus syndromes, with a focus on the reported imaging findings of NCIP. Moreover, the authors review precautions and safety measures for radiology department personnel to manage patients with known or suspected NCIP. Implementation of a robust plan in the radiology department is required to prevent further transmission of the virus to patients and department staff members.

Key Words: Coronavirus, CT cut scan, chest, pneumonia, viral, radiography, radiology, outbreak, safety

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BACKGROUND

Coronaviruses are nonsegmented, enveloped, positive-sense, single-strand ribonucleic acid viruses, belonging to the Coronaviridae family [1]. Six types of coronavirus have been identified that cause human disease: four cause mild respiratory symptoms, whereas the other two, Middle East respiratory syndrome (MERS) coronavirus and severe acute respiratory syndrome (SARS) coronavirus, have caused epidemics with high mortality rates.

In December 2019, a new type of coronavirus called 2019 novel coronavirus was extracted from lower respiratory tract samples of several patients in Wuhan, China. These patients presented with symptoms of severe pneumonia, including fever, fatigue, dry cough, and respiratory distress. Novel coronavirus–infected pneumonia (NCIP) is believed to have originated in a wet "seafood market" in Wuhan. The virus, which has been reported in 28 countries as of this writing, has shown human-to-human transmission and is feared to have the potential to cause a pandemic [2,3]. The mean incubation period is estimated to be 5.2 days, which allows air travelers to spread the disease globally [4]. Evidence shows that virus transmission can occur during the incubation period in asymptomatic patients. Moreover, high sputum viral loads were found in a patient with NCIP during the recovery phase [5]. As of February 5, 2020, more than 25,000 confirmed cases have been reported worldwide, with a rapid rise in the number of deaths. The Word Health Organization has announced the outbreak a global health emergency.

Imaging is critical in assessing severity and disease progression in coronavirus infection. Radiologists should be aware of the imaging manifestations of the novel coronavirus infection. A variety of imaging features have been described in similar coronavirus-associated syndromes. In this brief review, we discuss the epidemiologic and radiologic features of coronavirus syndromes, with a focus on the known imaging features of NCIP. In addition, precautions and safety measures for radiology department personnel in managing patients with known or suspected NCIP are discussed.

SARS: EPIDEMIOLOGY AND IMAGING

SARS coronavirus was first recognized in 2003 after a global outbreak originating in southern China. The virus spread to 29 countries globally, affecting 8,422 patients, with a

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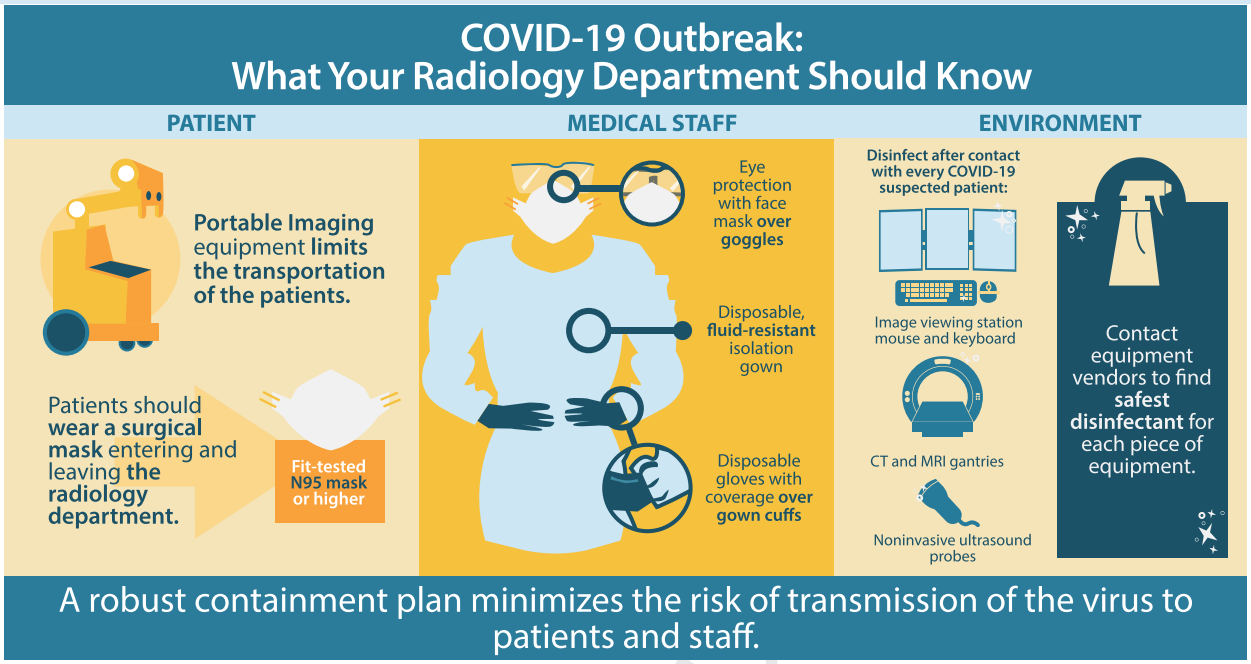
Graphical abstract



mortality rate of 11%. The transmission of this coronavirus occurs via large droplets and direct inoculation [6]. The virus may remain viable for up to 24 hours on dry surfaces, but it loses its infectivity with widely available disinfectants such as Clorox and formaldehyde [7].

Initial chest radiography in individuals with SARS will frequently show focal or multifocal, unilateral, ill-defined air-space opacities in the middle and lower peripheral lung zones [8], with progressive multifocal consolidation over a course of 6 to 12 days involving one or both lungs [9]. Chest CT will show areas of ground-glass opacity and consolidation in involved segments.

MERS: EPIDEMIOLOGY AND IMAGING

MERS coronavirus infection was first reported in Jeddah, Saudi Arabia, in 2012 [10]. Since then, approximately 2,500 laboratory-confirmed human infections have been reported in 27 countries, with a mortality rate reaching more than 30% [11]. The risk for transmission to family members and health workers seems to be low. Despite the potential for epidemics through Hajj pilgrimages in Saudi Arabia, there has not been a notable outbreak recently. It seems that in contrast to the human-to-human pathway as the main route of virus spread in SARS coronavirus, the transmission in MERS coronavirus

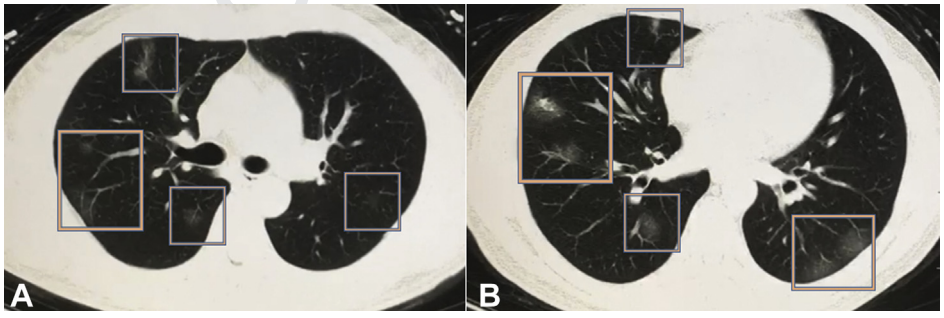


Fig 1. Chest CT scan from a 50-year-old male Chinese patient with a confirmed diagnosis of novel coronavirus-infected pneumonia. The patient presented with low-grade fever, cough, sneezing, fatigue, and lymphopenia. Multiple peripheral ground-glass opacities are present in both lungs (predominant on the right side), with a subpleural distribution. Imaging finding are nonspecific and might be seen with other viral pneumonias as well. Images are courtesy of Min Liu, MD, Department of Radiology, China-Japan Friendship Hospital (Beijing, China).

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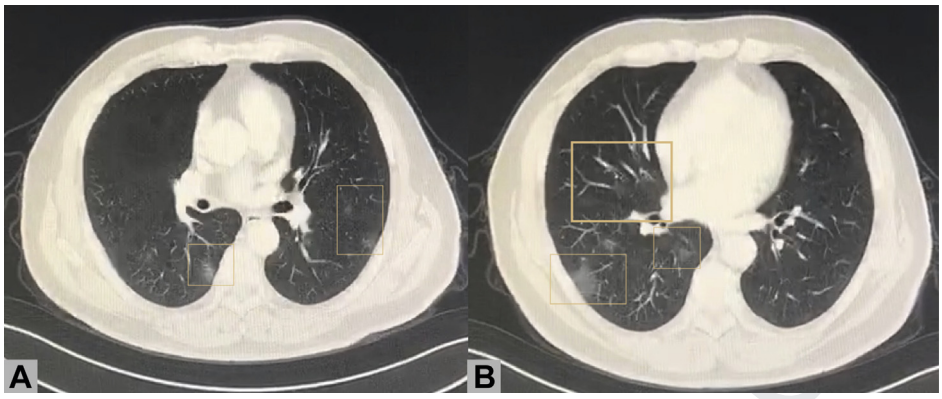

Fig 2. Initial chest CT scan of a 78-year-old male Chinese patient with fever, cough, and fatigue showing multiple small asymmetric peripheral and subpleural areas of ground-glass opacities in the posterior segment of the right upper lobe and the apical segments of the bilateral lower lobes. The imaging findings are highly nonspecific. The diagnosis of novel coronavirus–infected pneumonia was established on the basis of analysis of respiratory secretions. Images are courtesy of Bin Cao, MD, and Yimin Wang, MD, Department of Pulmonary and Clinical Care Medicine, China-Japan Friendship Hospital (Beijing, China).

occurs mainly through nonhuman, zoonotic sources (eg, bats, camels) [12,13].

In 83% of patients with MERS coronavirus infection, initial radiography will show some degree of abnormality, with ground-glass opacities being the most common finding [14]. Likewise, CT will show bilateral and predominantly ground-glass opacities, with a predilection to basilar and peripheral lung zones, but observation of isolated consolidation (20%) or pleural effusion (33%) is not uncommon in MERS [15].

NCIP: WHAT DO WE KNOW?

Patients with novel coronavirus infection present with pneumonia (ie, fever, cough, and dyspnea). Although fatigue is common, rhinorrhea, sore throat, and diarrhea uncommonly occur. A recent report in *The Lancet* described the clinical manifestations of NCIP in 41 patients [16]. According to that report, abnormal chest imaging findings were observed in all patients, with 40 having bilateral disease at initial imaging. This early report on the presentation of the NCIP in intensive care unit patients indicated bilateral subsegmental areas of air-space consolidation, whereas in non–intensive care unit patients, transient areas of subsegmental consolidation are seen early, with bilateral ground-glass opacities being predominant later in the course of the disease (Figs. 1-3). Serial chest radiography of a 61-year-old man who died of NCIP showed progressively worsening bilateral consolidation during a course of 7 days. Another report on 99 individuals with confirmed NCIP described similar imaging findings, with bilateral lung involvement in 75% and unilateral involvement in 25% [17]. Another study of five individuals in a family cluster

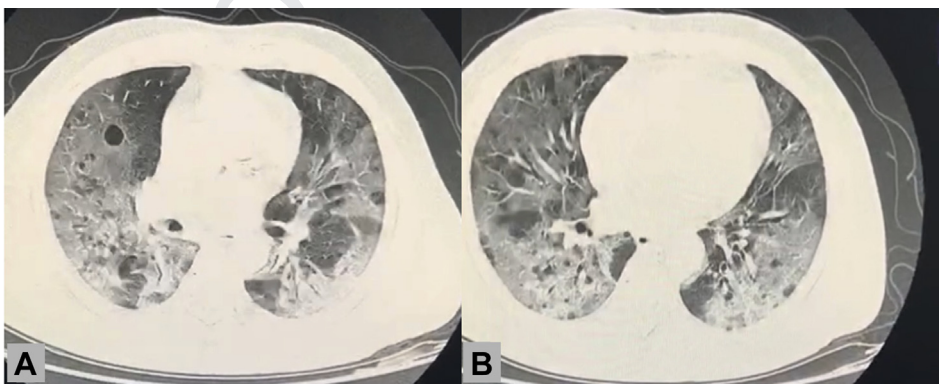

Fig 3. Follow-up chest CT scan of the same patient as in Figure 2, 7 days later. The clinical scenario deteriorated over the course of 7 days, and follow-up chest CT showed extensive confluent ground-glass opacities with areas of consolidation in both lungs. The patient died the same day. Images are courtesy of Bin Cao, MD, and Yimin Wang, MD, Department of Pulmonary and Clinical Care Medicine, China-Japan Friendship Hospital (Beijing, China).

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with NCIP [18] described bilateral patchy ground-glass opacities, with more extensive involvement of lungs parenchyma in older family members. The reported imaging features most closely resemble those of MERS and SARS. No pleural effusion or cavitation has been reported so far in confirmed cases of NCIP, but pneumothorax was reported in 1% of patients (1 of 99) in a study by Chen et al [17]. Overall, the imaging findings are highly nonspecific and might overlap with the symptoms of H1N1 influenza, cytomegalovirus pneumonia, or atypical pneumonia. The acute clinical presentation and history of contact with a novel coronavirus-infected patient or history of recent travel to an eastern Asian country (eg, China) should raise clinical suspicion for the diagnosis of NCIP. Although further investigations on the clinical and radiologic aspects of the novel coronavirus are ongoing, imaging will continue to be a crucial component in patient management.

PRECAUTIONS FOR RADIOLOGY DEPARTMENT PERSONNEL

Radiographers are among the first-line health care workers who might be exposed to 2019 novel coronavirus. Diagnostic imaging facilities should have guidelines in place to manage individuals known or suspected novel coronavirus infection. The novel 2019 coronavirus is highly contagious and is believed to transmit mostly through respiratory droplets, but there is uncertainty as to whether the virus can be transmitted by touching a surface or an item that is contaminated (ie, a fomite). A thorough understanding of the routes of virus transmission will be essential for patients' and health care professionals' safety. Droplets have the greatest risk of transmission within 3 ft (91.44 cm), but they may travel up to 6 ft (183 cm) from their source [19]. For the purpose of diagnostic imaging in individuals with NCIP, whenever possible, portable radiographic equipment should be used to limit transportation of patients. On the basis of experience with SARS, the use of a satellite radiography center and dedicated radiographic equipment can decrease the risk for transmission from known infected individuals. If a patient needs to be transported to the radiology department, he or she should wear a surgical mask during transport to and from the department. The Centers for Disease Control and Prevention guidelines for SARS coronavirus recommended respiratory protection using a fit-tested N95 mask or higher or a surgical mask if an N95 mask is unavailable. In addition, the droplet precaution instruction recommends appropriate personal protective equipment, including a disposable isolation gown with fluid-resistant characteristics, a pair of disposable gloves with coverage over gown cuffs, eye protection with goggles, and probably a face mask over goggles [20]. In a study of 254 medical staff members who had been exposed to SARS coronavirus, the risk for virus transmission was significantly reduced by using droplet and contact precautions [21].

CT and MR machine gantries, noninvasive ultrasound probes, blood pressure cuffs, and image viewing station mice and keyboards need to be disinfected after every contact with suspected patients. According to the Spaulding classification of the Centers for Disease Control and Prevention and FDA, these surfaces need to be either washed with soap and water or decontaminated using a low-level or intermediate-level disinfectant, such as iodophor germicidal detergent solution, ethyl alcohol, or isopropyl alcohol. Environmental services staff members need to be specifically trained for professional cleaning of potentially contaminated surfaces after each high-risk patient contact [22]. Radiology departments should contact their equipment vendors to find the safest disinfectant for each piece of equipment in use.

US health care imaging facilities need to be prepared for the escalating incidence of new cases of coronavirus. If appropriately prepared, radiology department staff members can take greater measures to manage the impact of the coronavirus outbreak on the facility and personnel. A multidisciplinary committee should convene to outline guidelines for imaging facility personnel to prevent virus spread thorough human-to-human contact and the department equipment. Implementation of a robust plan can provide protection against further transmission of the virus to patients and staff members.

TAKE-HOME POINTS

- The imaging features of NCIP are highly nonspecific and are more often bilateral with subpleural and peripheral distribution and range from ground-glass opacities in milder forms to consolidations in more severe forms.
- If properly prepared, radiology department personnel can take greater measures to manage the impact of the coronavirus outbreak on the department and staff.
- Continued data collection and larger epidemiologic studies are needed for both a full range of imaging findings and routes of transmission.

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