

KSR/KSTR Guidelines for the use of Diagnostic imaging for COVID-19

COVID-19 is an infection caused by SARS-CoV-2, which can result in upper or lower respiratory infections and in some serious cases, pneumonia. Reported early symptoms include dry cough, sore throat, and fever (1), but it can be asymptomatic or present as nonspecific symptoms, such as myalgia, anosmia, and dysgeusia (2). Asymptomatic transmission is known to occur (3); sometimes, the patients only suffer mild symptoms despite extensive pulmonary lesions on imaging, and sometimes the patients undergo rapid deterioration.

The Korean Society of Radiology and the Korean Society of Thoracic Radiology have prepared recommendations for the use of diagnostic imaging for COVID-19 in various clinical scenarios. We have tried to grasp the situation in the real world, aggregated opinions from the chest radiologists, and reviewed available references, in order to suggest the most reasonable recommendations possible at this moment. As circumstances change and new evidences emerge, the recommendations should immediately be modified accordingly.

<Recommendations>

1. The role of imaging studies (chest radiographs, chest CT) as screening tests for COVID-19

- 1) Screening with chest radiographs (CXR) or chest CT is not recommended for asymptomatic individuals visiting COVID-19 screening clinics for epidemiological or other unspecified reasons
- 2) CXR may be considered in patients with respiratory symptoms visiting COVID-19 screening clinics for an early diagnosis of pneumonia or to rule out diseases other than COVID-19.
- 3) CXRs are recommended for patients with fever or respiratory symptoms visiting outpatient safe clinics. However, the use of CXRs to rule out COVID-19 pneumonia is not recommended.
- 4) Chest CT can be done, after weighing individual risks and benefits, in these circumstances:
 - ① when pneumonia is suspected clinically although pneumonia is not definite on CXR,

- ② when there is a high clinical suspicion for COVID-19 but with negative RT-PCR results
- ③ critically ill patients or patients with other diseases who are in need of emergent operations or procedures who cannot wait for RT-PCR results. Non-contrast chest CT is recommended, but contrast-enhanced chest CT may be considered when complications or other diseases are suspected.

2. Guidelines for the use of diagnostic imaging for COVID-19 patients in community treatment centers for isolation

- 1) CXRs may be considered when asymptomatic patients or patients with mild symptoms are admitted to community treatment centers, as a reference for future follow-ups.
- 2) Follow-up CXRs may be performed in patients isolated in community treatment centers, after considering the changes in clinical manifestations of the patient and available resources and manpower for imaging studies.
- 3) When CXRs are performed in community treatment centers, portable x-ray machines or screening buses may be appropriate. A thorough image quality control should be done to maintain images of diagnostic quality, and appropriate measures for radiation protection and safety should be taken, complying with all relevant quality control regulations. For follow-up purposes, it is recommended to perform exams of a same patient using the same machine used for the initial exam.
- 4) Interpretation of the imaging studies should be done by experienced doctors, and interpretation or consultation by board-certified radiologists is recommended.
- 5) When pulmonary infiltrations develop on CXRs performed in community treatment centers, the patients need close clinical monitoring and admission to hospitals may be considered.
- 6) For the safety of medical personnel and prevention of the disease spread, avoid contact with patients if possible, and regular cleaning and disinfecting of equipment should be done.

3. Guidelines for imaging studies for admitted patients with COVID-19

- 1) Imaging follow-up with CXR is recommended for the patients with pneumonia.
- 2) When complications are suspected, chest CT may be considered, after considering the potential risks and benefits.

*** Definition**

- 1) screening clinics: for individuals who have a history of visiting a foreign or dangerous area/dangerous place with or without fever or respiratory symptoms
- 2) outpatient safe clinics: for patients with fever/respiratory symptoms but without clinical or epidemiological suspicion for COVID-19
- 3) community treatment centers: for patients with asymptomatic or mild symptoms identified with COVID-19 through RT-PCR

<Relevant information>

Chest CT findings

In general, the sensitivity of chest CT for diagnosing pneumonia is high, but the specificity for identifying the specific causative pathogens is low. Typical chest CT findings for COVID-19 pneumonia is multifocal peripheral ground-glass opacities (GGO) in both lungs, and they tend to affect the posterior and lower lungs rather than anterior and upper lungs (4-6). Crazy-paving appearance and air-bronchogram may be combined. Pure consolidation, pleural effusion, cavitation, calcification, or lymphadenopathy is relatively rare. Also, although not common, reversed halo sign may be seen (7). COVID-19 pneumonia shows temporal changes over the first month after onset of symptoms (8, 9). As many as 56% of the patient may have normal chest CT scans within first two days of the onset of symptoms, and bilateral peripheral GGO may not be prominent during the early stage of the disease. After three to four days from the symptom onset, the patients will show typical chest CT findings, with increase in the extent and density of the pulmonary infiltrates (consolidation and linear opacities). The peak levels of lung involvement in chest CT may be seen around 10 days from symptom onset and

show gradual decrease after two weeks. Currently, there are no studies on long-term changes of COVID-19 pneumonia, and the evidence for development of pulmonary fibrosis is not definite.

In more severe cases of COVID-19, the extent of pulmonary lesions on chest CT is reported to be larger and denser (consolidation and crazy-paving appearance), with findings suggestive of fibrosis (traction bronchiectasis) and accompanied by lymphadenopathy or pleural effusion (10-12). Currently, there are no known imaging findings related to prognosis of the disease.

Considerations in chest CT exams

Chest CT should be performed in COVID-19 confirmed patients only when there are clear indications for CT, after weighing the risks and benefits. Appropriate infection control procedures should be done to ensure safety of the medical personnel and prevent the spread of the disease. In order to minimize the contact between the patient and medical personnel, noncontrast CT is recommended. Because the patient may not be able to hold breath sufficiently, it is advisable to shorten the scan time and increase temporal resolution. Standard or low-dose chest CT protocol may be used, depending on the body habitus of the patients. Unnecessary radiation exposure should be minimized. Scan range should be from the lung apices to the lung bases, which should be scanned in a single breath-hold at maximum end-inspiration. Image reconstruction with a slice thickness less than or equal to 3 mm using a high-spatial-frequency algorithm is recommended in order to better identify ground-glass opacity. When a follow-up exam is needed, the use of ultra-low dose CT protocol may be considered. There are no definite benefits of contrast-enhanced CT, but contrast-enhanced CT may be considered when necessary.

Low dose portable X-ray equipment and mobile cone-beam CT

Image quality control should be done for portable x-ray machines used in medical institutions or x-ray machines on screening buses, and appropriate measures for radiation protection and safety should be taken, complying with all relevant quality control regulations. Lately, low dose portable x-ray equipment that are small enough to be held with hands are being used in some public health centers. As there are no data on the image quality of CXRs acquired with these equipment, it should be used with caution. For the purpose of monitoring the

changes in imaging findings of same patients, the use of low dose portable x-ray equipment may be considered.

Mobile cone-beam CT has lower temporal resolution than standard CT, making it prone to degraded image quality due to respiratory motion artifacts. Also, whole lungs cannot be examined with mobile cone-beam CT, and there are no imaging findings or accuracy of the exam reported in the literature. Evaluation of the use of cone-beam CT for chest imaging has not been done, and there is no evidence for its usefulness in evaluation of complications of COVID-19 patients.

References

1. Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX et al. Clinical characteristics of coronavirus disease 2019 in china. *N Engl J Med* 2020
2. Baig AM, Khaleeq A, Ali U, Syeda H. Evidence of the covid-19 virus targeting the cns: Tissue distribution, host-virus interaction, and proposed neurotropic mechanisms. *ACS Chem Neurosci* 2020
3. Bai Y, Yao L, Wei T, Tian F, Jin DY, Chen L et al. Presumed asymptomatic carrier transmission of covid-19. *JAMA* 2020
4. Chung M, Bernheim A, Mei X, Zhang N, Huang M, Zeng X et al. Ct imaging features of 2019 novel coronavirus (2019-ncov). *Radiology* 2020;295:202-207
5. Song F, Shi N, Shan F, Zhang Z, Shen J, Lu H et al. Emerging 2019 novel coronavirus (2019-ncov) pneumonia. *Radiology* 2020;295:210-217
6. Yoon SH, Lee KH, Kim JY, Lee YK, Ko H, Kim KH et al. Chest radiographic and ct findings of the 2019 novel coronavirus disease (covid-19): Analysis of nine patients treated in korea. *Korean J Radiol* 2020;21:494-500
7. Zu ZY, Jiang MD, Xu PP, Chen W, Ni QQ, Lu GM et al. Coronavirus disease 2019 (covid-19): A perspective from china. *Radiology* 2020:200490
8. Bernheim A, Mei X, Huang M, Yang Y, Fayad ZA, Zhang N et al. Chest ct findings in coronavirus disease-19 (covid-19): Relationship to duration of infection. *Radiology* 2020:200463
9. Pan F, Ye T, Sun P, Gui S, Liang B, Li L et al. Time course of lung changes on chest ct during recovery from 2019 novel coronavirus (covid-19) pneumonia. *Radiology* 2020:200370
10. Hosseiny M, Kooraki S, Gholamrezanezhad A, Reddy S, Myers L. Radiology perspective of coronavirus disease 2019 (covid-19): Lessons from severe acute respiratory syndrome and middle east respiratory syndrome. *AJR Am J Roentgenol* 2020:1-5

11. Wu J, Wu X, Zeng W, Guo D, Fang Z, Chen L et al. Chest ct findings in patients with corona virus disease 2019 and its relationship with clinical features. Invest Radiol 2020
12. Zhao W, Zhong Z, Xie X, Yu Q, Liu J. Relation between chest ct findings and clinical conditions of coronavirus disease (covid-19) pneumonia: A multicenter study. AJR Am J Roentgenol 2020:1-6
13. Mossa-Basha M, Meltzer CC, Kim DC, Tuite MJ, Kolli KP, Tan BS. Radiology department preparedness for covid-19: Radiology scientific expert panel. Radiology 2020:200988
14. <https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Recommendations-for-Chest-Radiography-and-CT-for-Suspected-COVID19-Infection>
15. <https://thoracicrad.org/wp-content/uploads/2020/03/STR-ASER-Position-Statement-1.pdf>
16. <https://www.childrens.health.qld.gov.au/wp-content/uploads/PDF/guidelines/guidelines-for-chest-imaging-of-paediatric-patients-during-COVID-19.pdf>
17. <https://www.rcr.ac.uk/college/coronavirus-covid-19-what-rcr-doing/rcr-position-role-ct-patients-suspected-covid-19>
18. <https://www.bsti.org.uk/standards-clinical-guidelines/clinical-guidelines/covid-19-bsti-statement-and-guidance/>