Radiology

Managing Radiation Dose from Chest CT in COVID-19 Patients

Manuscript Type: Reviews and Commentary

Choonsik Lee, PhD

Division of Cancer Epidemiology and Genetics, National Cancer Institute, National Institutes of Health

9609 Medical Center Dr, Rockville, MD 20850

Corresponding Author: Choonsik Lee, PhD

choonsik.lee@nih.gov

@leechoonsik

See also the article by Homayounieh et al.

With the coronavirus disease 2019 (COVID-19) pandemic presenting an unprecedented challenge to public health worldwide, the role of radiological imaging to assess persistent pulmonary abnormalities associated with COVID19 has garnered increased attention. Major health and radiology organizations, including the U. S. Centers for Disease Control and Prevention and the American College of Radiology, do not recommend the routine use of chest radiographs or CT scans alone for the diagnosis of COVID-19 without reverse transcription-polymerase chain reaction (RT-PCR) assay or antigen tests due to possible overlaps with other infections and false negatives reported for chest CT. Additionally, patterns of persistent pulmonary abnormalities among COVID-19 patients are only beginning to be understood. Thus, real-world data on the use of radiological imaging in COVID-19 are sparse.

In this issue of *Radiology*, the article by Homayounieh et al. (1) provides valuable descriptive data to begin filling these knowledge gaps by presenting variations in CT utilization, protocols, and dose in COVID-19 patients across 34 countries. The authors surveyed 62 healthcare sites from these countries across four continents covering Africa, Asia, Europe, and Latin America between May and July 2020, in a coordinated effort by the International Atomic Energy Agency. The questionnaire was composed of two parts: twelve general questions on the status of CT use in COVID-19 diagnosis and follow-up, and a fillable data form for CT scan parameters and dose information. The twelve questions were about local prevalence of COVID-19, method of diagnosis, most frequent imaging modality, indications for CT, and specific policies on the use of CT in COVID-19 diagnosis. The dosimetry questionnaire obtained general patient information (age, weight, and clinical indication), CT scanner specification, scan protocols, and radiation dose descriptors including volumetric CT Dose Index, dose-length product (DLP), and cumulative DLP. The authors asked the participating sites to provide the dosimetry data for at least 10 - 20 patients. They removed eight healthcare sites in six countries from the analysis of CT scan protocols and dose where fewer than ten cases were reported.

From the answers to the question, “What is the preferred means of diagnosis of COVID-19 in your hospital?”, the authors found that more than half of the sites (60%, 37 of 62) indicated use of molecular, antigen, or antibody tests as the preferred method of diagnosis of COVID-19. However, a concerning 18% (n=8) and 22% (n=14) of the sites used chest radiography or CT, respectively, as the preferred testing method. As the pandemic continues, additional monitoring of the utilization of radiographic imaging versus virus-specific diagnostic testing is warranted.

The answers to the dosimetry questionnaire for 782 adult patients from 54 healthcare sites in 28 countries showed that 80% (n=43) of the sites are conducting single-phase non-contrast chest CT, whereas multi-phase chest CT examinations are performed in 20% (n=11) of the participating sites in four countries. It must be noted that multi-phase CT examinations, especially in routine chest CT, are reported to be unnecessary for most clinical indications. From the study of data on clinical indications recorded for multi-phase CT collected for 1706 patients from 11 institutions in 18 countries, other authors found that 100% of routine chest CT and 63% of routine abdomen-pelvis CT examinations were unnecessary (2). Karla et al. noted that most publications on chest CT in COVID-19 pneumonia without complication report a single-phase, non-contrast chest CT and there is little use of contrast CT images from multi-phase scans because the clinical findings in COVID-19 pneumonia are mostly restricted to lungs (3). Assuming a scan protocol similar to that with a single-phase scan is used in each of the multi-phase scans, additional phases would multiply the dose a single-phase scan would deliver.

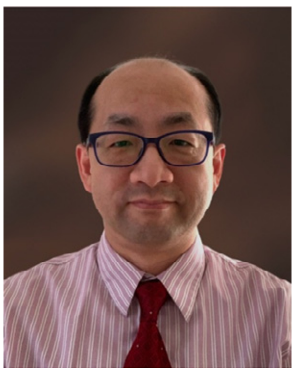
Homayounieh et al. report that there were eight-fold variations (2 - 17 mGy) in median volumetric CT Dose Index and ten-fold variations (76 - 786 mGy-cm) in median DLP across the participating healthcare sites from the same country. Variation was more prominent in median cumulative DLP, ranging from 76 to 1762 mGy-cm. The DLP range per scan (76 - 786 mGy-cm) can be translated into lung dose, 1 - 11 mGy, and effective dose, 1 - 8 mSv, by using volumetric CT Dose Index-to-organ and effective dose conversion factors for adult chest CT (4). The cumulative lung dose and effective dose from the maximum cumulative DLP (1762 mGy-cm) would be up to 25 mGy and 18 mSv, respectively. It should be noted that the volumetric CT Dose Index and DLP per site tabulated in the article are the median of the values for 10 - 20 patients reported from each healthcare site; thus, the actual range of the dose descriptors must be considerably larger. It is also remarkable that about 30% of the patients (n=225) underwent two to eight chest CT examinations in less than a month.

Some studies have suggested the use of low-dose chest CT protocols for COVID-19 patients. Kang et al. (5) implemented a low-dose CT scan protocol that did not result in significant sacrifice of the signal-to-noise and contrast-to-noise ratios that would be achieved with general scan protocols. Their low-dose protocol delivered a DLP and effective dose of 14.5 mGy-cm and 0.203 mSv, respectively, which are much lower than the DLP (129.1 mGy-cm) and effective dose (1.81 mSv) of a standard chest CT scan protocol. Agostini et al. (6) also proposed a low-dose chest CT protocol with a DLP of 19.5 mGy-cm and an effective dose of 0.28 mSv, which are similar to those of Kang et al. The lowest median effective dose (1 mSv) derived from the DLP in the 54 healthcare sites surveyed by Homayounieh et al. is about four- to five-times greater than that of the proposed low-dose protocols. This comparison shows that low-dose chest CT scan protocols have not been widely adopted for COVID-19 follow-up.

Ionizing radiation including x-ray emitted by CT scanners is classified as a carcinogen, which may damage DNA and cause cancer. The level of dose and age at exposure are two important effect modifiers of cancer risk from ionizing radiation. The risk of cancer caused by moderate to high doses of ionizing radiation is well established, whereas risks from low-dose exposures less than 100 mGy, where dose from CT scans mostly belong to, are controversial. The incidence of COVID-19 has shown remarkable age disparities with markedly higher proportion of cases in adults (7). The risk for developing a radiation-related cancer is substantially lower for an adult compared to a child who is more sensitive to radiation and has a longer life expectancy. Nevertheless, the recently published monographs on epidemiological studies of low dose ionizing radiation and cancer risk report positive excess relative risk (ERR) at 100 mGy for adults. Based on the meta-analysis of the 13 epidemiological studies on adults who received mean cumulative doses of less than 100 mGy, the authors report the meta ERR at 100 mGy of 0.029 (95% CI = 0.011 to 0.047) for solid cancers and 0.16 (95% CI = 0.070 to 0.250) for leukemia (8).

Homayounieh et al. acknowledged the limitations of the study. First, the study involved a relatively small number of patients (10-20 patients per site), which may limit the generalizability of the findings. However, it is understandable considering the high workload of the medical staff at healthcare sites during this unparalleled pandemic and the manual data collection process adopted by the study. Nonetheless, the study still provides valuable data which are otherwise not available and underscores the importance of future studies for larger number of patients using more sophisticated survey techniques. Another limitation acknowledged by the authors is the unknown accuracy of the reported dose descriptors from the participating healthcare sites. Large-scale CT dose surveys often rely on manual reporting techniques, where reporters tend to submit general scan protocols rather than the one used for patients at the individual level. Direct access to electronic dose records would be the best way to accurately estimate the dose level and can be sought in future studies.

In summary, the descriptive study by Homayounieh et al. reports the wide variation in the use of CT and radiation doses associated with COVID-19. To the question, “Do you have a dedicated CT protocol for COVID-19 patients?” half of the sites answered “Yes.” However, considerable variations in scan protocols are observed in healthcare sites worldwide, and the current level of radiation dose is much greater than that of the proposed low-dose CT scan protocols. It will be crucial for future studies on CT dose during COVID-19 follow-up to directly access electronic radiation records, which will enable more accurate estimation of dose and allow for rapid collection of a larger number of patients. Furthermore, it will be also important to assess the risks and benefits of follow-up chest CT scans in the context of COVID-19.



Dr. Choonsik Lee is a Senior Investigator and Dosimetry Unit Head at the Division of Cancer Epidemiology and Genetics, National Cancer Institute, National Institutes of Health. His research interests focus on the development of computational human phantoms and its application to dosimetry for patients undergoing computed tomography and fluoroscopy procedures. Dr. Lee is a full member of multiple Task Groups in the International Commission on Radiological Protection.

References

1. Homayounieh F, Holmberg O, Umairi R. Variations in CT Utilization, Protocols, and Radiation Doses in COVID-19 Pneumonia: Results from 28 countries in the IAEA study. Radiology. In Press.

2. Rastogi S, Singh R, Borse R, et al. Use of Multiphase CT Protocols in 18 Countries: Appropriateness and Radiation Doses: Canadian Association of Radiologists Journal. SAGE Publications Sage CA: Los Angeles, CA; 2020.

3. Kalra MK, Homayounieh F, Arru C, Holmberg O, Vassileva J. Chest CT practice and protocols for COVID-19 from radiation dose management perspective. Eur Radiol. 2020;http://link.springer.com/10.1007/s00330-020-07034-x. Accessed October 20, 2020.

4. Lee C, Kim KP, Bolch WE, Moroz BE, Les Folio. NCICT: a computational solution to estimate organ doses for pediatric and adult patients undergoing CT scans. Journal of Radiological Protection. 2015;35(4):891–909.

5. Kang Z, Li X, Zhou S. Recommendation of low-dose CT in the detection and management of COVID-2019. Eur Radiol. 2020;30(8):4356–4357.

6. Agostini A, Floridi C, Borgheresi A, et al. Proposal of a low-dose, long-pitch, dual-source chest CT protocol on third-generation dual-source CT using a tin filter for spectral shaping at 100 kVp for CoronaVirus Disease 2019 (COVID-19) patients: a feasibility study. Radiol med. 2020;125(4):365–373.

7. Davies NG, Klepac P, Liu Y, Prem K, Jit M, Eggo RM. Age-dependent effects in the transmission and control of COVID-19 epidemics. Nature Medicine. Nature Publishing Group; 2020;26(8):1205–1211.

8. Hauptmann M, Daniels RD, Cardis E, et al. Epidemiological Studies of Low-Dose Ionizing Radiation and Cancer: Summary Bias Assessment and Meta-Analysis. JNCI Monographs. 2020;2020(56):188–200.