



IAEA support to the radiation protection of patients in the time of the COVID-19 global pandemic

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Received: 3 March 2022 / Accepted: 12 March 2022 / Published online: 2 April 2022

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Abstract

The IAEA contribution to the radiation protection of patients during the global COVID-19 pandemic included a webinar on the use of CT and optimization for COVID-19 pneumonia, a survey with 137 responses from 84 sites across five continents, and a study on the CT utilization, protocols and patient doses with data from 62 healthcare sites from 34 countries. This paper outlines the main results of these efforts, which have been presented in the scientific literature and in several national trainings and international meetings.

Keywords Radiation protection of patients · COVID-19 · Radiography · Computed tomography · Optimization

1 Introduction

For over two years since the COVID-19 outbreak, the subsequently declared global pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has seriously affected the life of everyone on the planet and has had an important societal impact. With no doubt the loss of over five million lives and the health consequences for many survivors have been the major concerns mobilizing medical and public health resources and placing a high pressure on healthcare systems [1]. Further changes included the reduced in-person interactions and travels that have been replaced with virtual communication, work from home and online meetings.

The International Atomic Energy Agency (IAEA) adapted to the new reality while making sure that its important mission for guaranteeing the safe, secure and peaceful uses of nuclear science and technology is not interrupted [2–4]. As an immediate and direct support to combating the COVID-19 disease, the IAEA laboratories offered support for capacity building in the Member States for the diagnostic testing for COVID-19 with the real time reverse transcription–polymerase chain reaction (real time RT–PCR). Equipment and training on the

use of this most accurate nuclear-derived technique has been offered by the IAEA for over 20 years for detecting pathogens, including viruses causing animal diseases as well as zoonotic diseases transferred from animals to humans. Through the Technical cooperation (TC) programme, the IAEA delivered over 2000 RT-PCR and diagnostic kits and related items to 129 countries and territories and provided training for their use to staff of the national laboratories [5].

The IAEA contribution to the response to the pandemic included a series of live sessions (webinars) organized by various IAEA departments, including such for health care providers in nuclear medicine, radiology and radiotherapy facilities, and a contribution to the World Health Organization (WHO) guidance on technical specifications for priority radiological medical devices needed for the management of COVID-19 [6, 7].

The COVID-19 global pandemic presented major challenges for healthcare providers worldwide who had to quickly adapt to the new situation. Diagnostics and treatment follow-up of the respiratory disease caused by the new virus and of the associated complications and post-COVID- conditions involve the use of radiography and computed tomography (CT) among other diagnostic modalities [7, 8]. The appropriate and optimal use of these techniques is based on the radiation protection principles of justification and optimization, which are an integral part of the international recommendations and safety standards [9–11]. Although these principles have proved to contribute to maximizing the benefit to risk ratio for patients, they are not always routinely practiced in medical imaging departments and efforts for strengthening

This article is part of the COVID-19 Health Technology: Design, Regulation, Management, Assessment

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their application have been put in the focus of the Bonn Call for Action issued in 2012 by the IAEA and the WHO [12]. The principles of justification and optimization are equally applicable to the use of imaging for COVID-19.

This paper outlines the IAEA contribution to ensuring radiation protection of patients in the time of the COVID-19 global pandemic.

2 IAEA survey and webinar on the use of CT for COVID-19 pneumonia

In response to requests received from the Member States and concerns over the increased use of CT and associated radiation exposure, on 9 April 2020 the IAEA organized a webinar to discuss the use of CT and protocol optimization for COVID-19 pneumonia, as a part of the regular webinars organized by the Radiation Protection of Patients (RPOP) unit of the IAEA [13]. Speakers were experts from the Massachusetts General Hospital and Harvard Medical School who were also involved in designing the pre-webinar survey.

Prior to the online lecture, the registered participants were invited to respond to an online survey with ten questions, the answers of which informed the preparation of the webinar (Table 1). The recording of the webinar is available for free viewing from the RPOP webinar page [13], and its summary, including the results of the survey have been published by Kalra et al. [14].

Responses to the survey were received from 137 professionals from 84 sites across five continents: 76 from Europe, 23 from Asia, 23 from North America, 7 from Africa and 5 from South America. Among them, 110 participants (80%) responded that their healthcare facilities had already received patients with known or suspected COVID-19

infection, while the remaining 27 (19%) either did not know or had not received such patients.

About 51% and 48% of respondents indicated that chest radiography and CT, respectively, were the most frequently used imaging procedures at their facility for COVID-19 patients, and just one selected the use of lung ultrasound. Information regarding the country of survey participants was not obtained and may have influenced the survey responses due to differences in access to technology.

Most respondents (66%, 84/127) indicated that they used CT for diagnosis of suspected COVID-19 pneumonia, followed by assessing severity of infection (62%, 79/127), complications (51%, 65/127) and treatment response (28%, 35/127) (Fig. 1).

Most participants indicated that they often (53%, 69/130) or always (20%, 26/130) use chest CT for diagnosis of suspected COVID-19 pneumonia. Out of 123 respondents, 101 (82%) indicated that they always or usually acquire only one non-contrast chest CT scan series in COVID-19 pneumonia, although 18% (22/123) use contrast-enhanced CT with 2–3 scan phases. A majority of responses (55%, 64/117) indicated that chest CT exams for COVID-19 in their sites were associated with the same dose as a routine chest CT ($CTDI_{vol}$ of 5–10 mGy), whereas low-dose protocol ($CTDI_{vol} < 5$ mGy) was used in 43% (50/117) of the facilities, and the remaining 3% (3/117) used high dose protocol of $CTDI_{vol} > 10$ mGy.

The questionnaire was used to collect specific questions from the participants, which, along with the questions received during the live session, have been answered during the webinar.

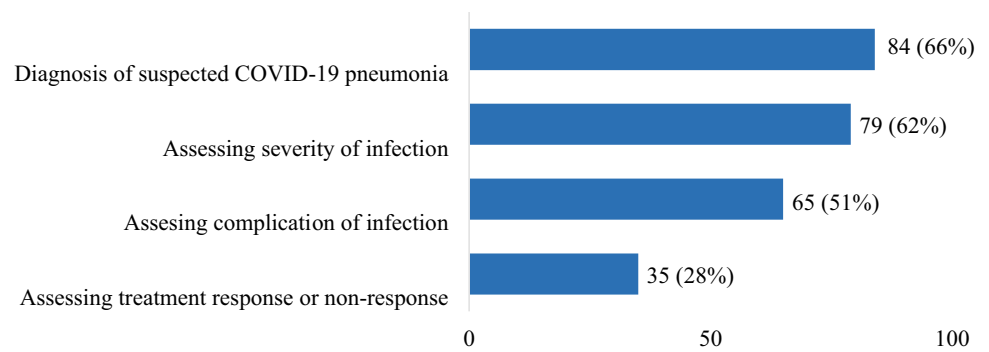
The webinar on COVID-19 and Chest CT: Protocol and Dose Optimization on 9 April 2020 attracted high interest, with over 1600 registrations from over 100 countries, 1203

Table 1 Questions in the online survey on the use of CT for COVID-19 pneumonia used to inform preparation of the IAEA webinar on 9 April 2020

Questions

1. Has your hospital or center received patients with known or suspected COVID-19 infection?
2. Which of the following imaging tests do you use most frequently in patients with known or suspected COVID-19?
3. How often do you use chest CT for diagnosis of suspected COVID-19 pneumonia?
4. How many patients with known or suspected COVID-19 infection have been scanned in your hospital or center?
5. In patients with known or suspected COVID-19 infection, what do you use chest CT for?
6. When performing chest CT in patients with known or suspected COVID-19 infection do you give intravenous contrast injection to the patient?
7. How many scan series (not reconstructions) do you acquire for chest CT in patients with known or suspected COVID-19 infection?
8. Which of the following scan series do you acquire for chest CT in patients with known or suspected COVID-19 infection? (Four options available)
9. What do you think about radiation dose for chest CT in patients with known or suspected COVID-19 infection, compared to dose from the routine chest CT?
10. What is the typical radiation dose from chest CT exams for COVID-19 in your site?

Fig. 1 Responses to the survey question “In patients with known or suspected COVID-19 infection, what do you use chest CT for?”



live attendees and many more viewing the recording. The professions represented included radiologists, radiographers, medical physicists, radiation protection specialists, and students.

The questions answered during the webinar are listed in Table 2 and the reader is referred to their answers and related discussion in the paper published by Kalra et al. [14].

The speakers in the webinar reviewed available evidence and recommendations published to date and recommended that when indicated, chest CT should be performed with a low-dose, single-phase protocol using fast scanning techniques to minimize motion artifacts. The experts proposed scan parameters for acquiring low-dose chest CT with the CT scanners of four main CT vendors [14].

3 IAEA study on CT utilization, protocols and radiation doses in patients with COVID-19 pneumonia

Between May and July 2020, the IAEA coordinated a retrospective data collection study with the objective to understand the CT utilization for COVID-19 patients, CT acquisition protocols used, and radiation doses to patients from

CT. The study was prepared under the supervision of Dr. M. Kalra and his team from the MGH Boston.

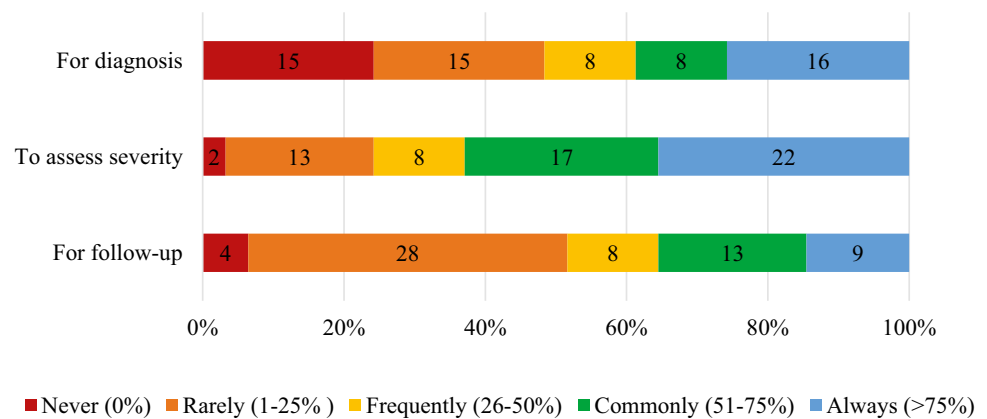
A standard survey form was distributed to all interested facilities, and data were centrally collected and analyzed. The survey included two parts: 1) a questionnaire with 12 questions, and 2) a standard form for scan parameters and dose-related information in patients with known or who were suspected of having COVID-19 pneumonia. The questions in the survey aimed to clarify the utilization of CT and other imaging tests, the frequency of the use of CT for the same patient, availability of a written policy regarding use of CT for COVID-19 pneumonia, use of a dedicated CT protocol for COVID-19 patients, the most frequently used CT protocol. Collected de-identified data pertaining to 10–20 patients per site included general information (patient age, weight, clinical indication), CT equipment (CT make and model, year of installation, number of detector rows), scan protocols (body region, scan phases, tube current and potential), and radiation dose quantities computed tomography dose index ($CTDI_{vol}$) and dose length product (DLP) indicated by the equipment. Results and their analyses are presented in the paper by Homayounieh et al. [15], and the main findings are summarized here.

Table 2 Questions in the online survey on the use of CT for COVID-19 pneumonia used to inform preparation of the IAEA webinar on 9 April 2020

Questions

- Should we use high-resolution CT (such as for diffuse lung disease with scanning in inspiratory and/or expiratory phases) in patients with suspected COVID-19?
- Can radiation dose be reduced when there is an additional need to perform CT angiography (for pulmonary embolism) after the initial non-contrast CT?
- Should we consider chest CT or radiography in healthcare workers to diagnose COVID-19 when other recommended tests are limited or unavailable?
- Is it acceptable to perform chest CT with arms by the side of the patient to minimize patient contact with CT technologists or other healthcare workers?
- What is the correct dose for chest CT for patients with COVID-19?
- How do we perform chest CT for suspected COVID-19 in pregnant patients?
- How to scan children with suspected COVID-19 infection?

Fig. 2 Responses to the survey questions “How often do you use CT for initial diagnosis of patients with suspected COVID-19 infection, to assess severity of disease, or for follow-up of COVID-19 infection?”



Responses to the survey were received from 62 healthcare sites from 34 countries, and 54 sites from 28 countries provided data of 782 patients. Most healthcare facilities (63%) had a substantial burden of patients (> 100 patients) with known or suspected COVID-19 infection, out of which 28% had over 1000 patients.

Out of 62, 37 (60%) indicated use of either antigen or antibody tests as the primary method of diagnosis of COVID-19 infection; 22% (14/62) used CT and 18% (8 of 62) used radiography as the primary methods of diagnosis. Chest radiography was the most commonly performed imaging test in 60% of sites for diagnosis and follow up of patients.

CT was frequently used for initial diagnosis of COVID-19 pneumonia, with 52% of answers indicating the use of CT in 26%–100% of patients (Fig. 2). The same figure shows that chest CT was commonly used for assessing disease and for routine follow-up of patients with COVID-19 pneumonia.

As expected, the use of CT in hospital-admitted patients with COVID-19 (63%) was greater than that used with outpatients (23%).

Half of the facilities used a dedicated CT protocol for imaging patients with COVID-19 infection. Non-contrast chest CT was the most common protocol (in 67%) followed by reduced-dose non-contrast chest CT with radiation dose less than the routine or general chest CT protocol (20%).

There were eightfold variations in median $CTDI_{vol}$ and tenfold variations in median DLP across multiple participating health care sites even from the same country [15]. CT dose index varied based on CT vendors (7–11 mGy),

number of detector rows (8–9 mGy), year of CT installation (7–10 mGy), and reconstruction techniques (7–10 mGy). Multiphase chest CT examinations performed at 20% of sites were associated with higher dose length product compared with single-phase chest CT examinations performed in 80% of sites.

Although most patients (71%; 557 of 782) underwent a single CT examination, there were 29% who underwent 2 and more CTs in a period of less than a month (Table 3), from which the total DLP accumulated up to 1644 mGy.cm.

The study identified a need to establish specific guidelines and recommendations on the frequency of CT and specific scan protocols to minimize the effects of cumulative radiation exposure from multiple CT and multiphase CT protocols [15]. Such an example protocol for different CT vendors equipment was proposed during the IAEA webinar and is presented in Kalra et al. [14].

4 Other IAEA activities during the pandemic

The results of the two IAEA surveys on the use of radiation imaging for COVID-19 were disseminated through the published articles [14, 15], the webinar [13], and were further presented in a number of local trainings, meetings and conferences. Individual feedback was provided to the participating facilities and expert advice was offered on request to specific facilities.

Table 3 Extent of change in $CTDI_{vol}$ and DLP with the number of CT examinations per patient

Parameter	1 CT exam	2 CT exams	3 CT exams	4 CT exams	5–8 CT exams
Number of patients	557	124	65	18	18
Days between first and last CT	-	9 (10)	14 (12)	21 (13)	29 (25)
Median (IQR) $CTDI_{vol}$ (mGy)	8 (6)	9 (7)	11 (8)	10 (8)	7 (4)
Median (IQR) cumulative DLP (mGy.cm)	303 (260)	736 (641)	1207 (941)	1569 (1110)	1644 (1990)

Authors' contribution Authors equally contributed.

Funding No special funding.

Data availability Not applicable.

Code availability Not applicable.

Declarations

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication All authors agree with this submission.

Conflicts of interest No conflict.

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