



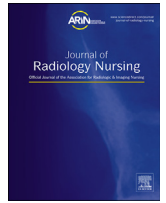
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Feature Article

Coronavirus Disease 2019 Strategies, Examination Details, and Safety Procedures for Diagnostic Radiology Facilities: An Extensive Multicenter Experience in Istanbul, Turkey



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A B S T R A C T

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This study aimed to share our experiences during the coronavirus disease 2019 (COVID-19) pandemic obtained in diagnostic radiology facilities of 5 training research hospitals in the Asian part of Istanbul (North Hospitals). Accordingly, we reported the used examination details, allocation of radiology staff and actions, and safety procedures for patients and radiology staff. As the corporate radiology team serving in these designated pandemic hospitals, examination details and safety procedures of some diagnostic radiology facilities among 5 training research hospitals have been identified in the current study. Our guidelines and preparedness protocol aimed to reduce patient morbidity and infection-related mortality through quick and proper diagnosis to prevent the spread of COVID-19 to our employees, patients, and the general public during the COVID-19 pandemic. Results showed that teamwork is a key factor while providing medical services. In addition, continuous communication efforts and individual responsibilities of radiology staff were remarkable during the COVID-19 pandemic. The recent situation also showed that co-operation of radiology facilities with device manufacturers and applicators is quite significant especially for development of special protocols in the frame of As Low As Reasonably Achievable. The COVID-19 pandemic has tackled several challenges in radiology among radiology departments. Therefore, continuous co-operation plans and motivational actions are highly recommended not only between radiology staff but also between radiology stakeholders and service providers in the future. Technical details of recent investigation can provide useful information about the management of diagnostic radiology departments during the fight with the COVID-19 pandemic in cities with high population density such as Istanbul.

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Introduction

In December 2019, the coronavirus disease 2019 (COVID-19) pandemic was first reported in Wuhan, the largest metropolitan

area in Hubei province, China (Dey et al., 2020). Infected people were exposed to severe acute respiratory syndrome, with a standardized symptoms and complications such as cough, fever, kidney failure, pneumonia, and severe respiratory syndrome in all ages, but

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Declaration of interest and ethical issues: On behalf of authors, I hereby declare that this manuscript (Coronavirus disease 2019 strategies, examination details and safety procedures for diagnostic radiology facilities: An extensive multi-centre experience in Istanbul, Turkey) has not been published elsewhere and is not under consideration by another journal. We have approved the manuscript and agree with submission to *Journal of Radiology Nursing*. There are no conflicts of interest to declare. There are no ethical issue related investigations.

Baris Cavli helped in supervision, investigation, and management; Ceren Ozturk helped in investigation and staff supervision; H.E. Senel helped in investigation and staff supervision; R.B. Pekar helped in clinical management, investigation, and writing original draft; Wiam Elshami helped in writing review & editing and writing original draft; H.O. Tekin helped in supervision, writing original draft, and concept design.

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particularly older adults. COVID-19 has initially occurred in the area close to the animal and seafood markets (Andersen et al., 2020; Ibrahim et al., 2020); it caused animal and human diseases (Ghinai et al., 2020). In humans, several species of coronaviruses are known to cause respiratory infections, ranges from common colds to more severe diseases, such as the Middle East respiratory syndrome and severe acute respiratory syndrome (Van Doremalen et al., 2020; Xu et al., 2020a,b). It is transmitted by inhaling droplets scattered in the environment through coughing and sneezing and direct contact with contaminated air or droplets (Morawska et al., 2020).

In Turkey, the first COVID-19 case was officially announced by the Ministry of Health on March 10, 2020. Then, the Ministry of Health has announced that COVID-19 had spread throughout Turkey on April 1, 2020 and some public hospitals were assigned to serve patients infected with COVID-19 only (Author Anonymous, 2020). Radiology imaging plays an important role in diagnosing, management and treatment of COVID-19 cases (Ding et al., 2020; Long et al., 2020). Chest X-ray and computed tomography (CT) are the common used investigation for COVID-19 (Stogiannos et al., 2020; Zanardo et al., 2020) in addition to lung ultrasound and magnetic resonance imaging (MRI; Moore & Gardiner, 2020). As the corporate radiology team serving in these designated pandemic hospitals, examination details and safety procedures of some diagnostic radiology facilities among 5 training research hospitals have been identified in this study.

Considering recent literature studies on the experiences of the COVID-19 pandemic, the guideline and preparedness protocol aimed to reduce patient morbidity and infection-related mortality through quick and proper diagnosis to prevent the spread of COVID-19 to our employees, patients, and public. Moreover, we also concentrated on health protection, administration of critical equipment, including personal protective equipment (PPE) and personnel allocation. In this paper, we also discuss the knowledge, services and used policies for the radiology community's benefits. A dynamic process and action plan have been applied during our daily experiences in the COVID-19 pandemic. As guidelines continue to evolve due to the increasing knowledge of the current pandemic, we hope that our local expertise allows other organizations to plan their COVID-19 management and for potential similar pandemics in the future.

Allocation of Radiology Staff and Actions

The current study reports the examination details and safety procedures of some diagnostic radiology facilities from five major Training and Research Hospitals in the Asian part of Istanbul (North Hospitals). Istanbul has been known as the most crowded city in Turkey. Places providing tertiary care services constitute the highest level of health services in cases of serious illnesses and important tests. Tertiary treatment services are provided in training and research hospitals, as well as private and university hospitals.

As of March 11, when the case was first reported, public hospitals were determined as pandemic hospitals, and accordingly, inpatient admission was reduced to a minimum. In normal circumstances, a total of 20 scanners were used to perform radiological examinations (8 CTs, 9 MRIs, and 3 mammography machines) by 169 active radiographers in this field but as a result of the COVID-19 pandemic, one of the CT scanners was set up for emergency patients, whereas another one was set up for patients infected with COVID-19 only. In the current situation during the pandemic, the number of MR examinations reduced from 120 per day to 15–20 studies, and the number of the mammographic examination was decreased from 20 to 1 examination per week. The adherence to national and international guidelines to reduce non-urgent radiology examination lead to the reduction of patient numbers in the radiology

department (Department of Health, 2020; Jacobi et al., 2020). The decrease in radiology examination was global and noted in multiple countries (Akudjedu et al., 2020; Elshami et al., 2020). On the contrary, the number of patient chest X-rays and CT scans increased; this was expected. This is because chest X-ray and CT has a great role in diagnosing COVID-19, and follow up (Wong et al., 2019; Xu et al., 2020a,b).

Therefore, technical details of recent investigation can provide useful information about the management of diagnostic radiology departments during the fight with the COVID-19 pandemic in cities with high population density such as Istanbul. The action plans can be classified into two main headings: measures taken for the protection of health personnel and protection of patients.

Radiographers

In the normal workflow, radiographers were routinely assigned among devices such as CT, MRI and mammography to provide vocational dynamism and experience sharing. For example, a radiographer working on a CT device for a certain period of time was assigned to the MR unit within the planning schedule. However, with the spread of COVID-19, the work lists were checked, and schedule prepared in such a way that changing workspaces was not allowed. In this case, radiographers responsible for a particular device are ensured to work on that device continuously by going out of the normal routine practice. Two radiographers were assigned to operate the CT device used to test patients with COVID-19. Radiographers also established a work organization, one radiographer operates the console during the first half the working day and the other radiographer deals with patient positioning and communication, and they will exchange their role in the second half of the working day. Apart from the patient consent form and patient admission task, no other procedures were allowed. In this way, the area was restricted for the two radiographers only in order to eliminate the risk of contamination and prevent possible contamination from different devices. During COVID-19, it was essential to stop routine changes in work schedule and limit number of workers dealing with suspected or confirmed cases to minimize the risk of possible contamination among the staff (Lancaster et al., 2020).

Furthermore, MRI used to be done at night to serve normal patients only. Night-shift radiographers in MR facilities were provided to support the CT department. Three shift systems were introduced, and the importance of their own health and welfare was explained.

Radiologists

The three shifts working system has been provided for radiologists (8-hr works). Moreover, radiologists must complete the report for patients diagnosed with COVID-19 as emergency reporting within 2 hr. Moreover, annual leaves have been provided for radiologists with chronic health issues in high-risk level without waiting for the routine vacation period. Some hospital activated the teleradiology plans to allow radiologists to report from home in case of quarantine (Cheng et al., 2020).

Medical Secretary

The medical secretary was ensured to perform remote reporting and continue work from home. As the polymerase chain reaction (PCR) test was released late, the thoracic CT report was requested to be released quickly; therefore, the emergency reporting system was activated, and the working shift system was organized on a 24/7 basis. The number of personnel was reduced. Moreover, their paid annual leave has been provided without waiting for the routine

vacation period. However, those who want to go on free leave were assisted. By giving administrative permission to those who do not have such leave rights, number of personnel was planned to be minimum. Accordingly, list of personnel possibly infected with COVID-19 was created.

Cleaning Staff

The procedures and principles followed in radiology units were shared with the cleaning staff at the beginning. In routine practice, room ventilation and chemical disinfection studies, carried out once every half an hour, were shortened to once every 10 min cleaning of the radiology investigation room is usually performed after each patient (Mossa-Basha et al., 2020). It is worth mentioning that aforementioned cleaning staff transactions were reorganized on 7/24 basis.

Personal Protective Equipment Training and Accommodation

Due to the rapid spread of the coronavirus case in Europe and increased deaths, the importance of not engaging in some daily behaviors were announced to all personnel with the trainings provided by the chief physician and occupational health teams as of March 1, 2020. These daily behaviors mainly included many interactions such as close contact and hugging between the staff due to sincerity. As of March 1, PPE was provided, and awareness was raised through trainings for personnel protection from the first day. Trainings were provided by organizing disposable gloves, patient gowns, surgical masks, glasses and food, thus protecting them from patients with COVID-19. The health personnel were not allowed in the same room with >2 or 3 people, and the personnel were kept away from each other as much as possible. The working manner of health personnel was assessed by the workplace doctor and occupational health teams. Online trainings, scientific viral updates and psychological support trainings were organized. The contact of active or healthcare professionals with elderly or those with family members with cancer conditions in their homes was not allowed. Thus, hotel or pension accommodation was provided for those working staff. Moreover, health personnel who became positive for the PCR test were followed after hospital treatment and their condition was monitored. Necessary measures were taken according to instructions from the Ministry of Health.

Computed Tomography and X-Ray Workflow

In March, with the rapid spread of the disease, clinicians concentrated on thoracic CT in a large number of patients with COVID-19. In March and April, an average of 1,300 CT examinations was performed daily in our 5 major hospitals. Approximately 800 of these examinations were thoracic CT examinations, and nearly 200–250 cases were positive, or radiologically suspected patients. Therefore, CT units were identified as medium-to high-risk areas. In these conditions, it was necessary to take the highest level of protection measures for staff in radiology department and particularly CT units. Accordingly, we have supplied and stored PPE for all staff immediately and provided on room disinfection and ventilation and use of protective equipment. Cleaning, disinfection, and ventilation after each patient was performed by trained cleaners to support patient safety and clean safe environment to reduce the spread of infections.

An algorithm was created in order to request the thoracic CT examination by contacting the hospital administration. Patients with fever >38°C or respiratory rate of 22/min or oxygen saturation of <93% or with oxygen shortage in the CT device were recorded. On the contrary, CT examination protocols were updated considering

the guideline of Turkish Republic Ministry of Health Public Health General directorate of COVID-19. Accordingly, full-dose thoracic CT protocols for 50-y-old and obese patients and low-dose thoracic CT protocols for patients aged <50 y were established and started to be applied with the approval from radiologists. In addition, ultra-low-dose protocols were created in accordance with the standards to perform thoracic CT examinations among pregnant patients. Thoracic CT examinations of pregnant patients were performed with the approval of our radiologists.

Hospitals providing radiology services on the Asian side of Istanbul serve approximately 5 million people. With the onset of the pandemic, results of the PCR tests came out late, the test reliability was quite low (60%) and the direct chest X-ray did not rule out the disease completely. During the treatment guides of the Ministry of Health, the treatment should be initiated immediately, including those suspected with COVID-19. These conditions made the thoracic CT review attractive to achieve the fastest and most accurate results.

Computed Tomography Protocol

However multiple publications reported single-phase, non-contrast chest CT (Kalra et al., 2020) but the guideline on specific CT protocols for patients with suspected or known COVID-19 was not clear (Agostini et al., 2020; Kang, Li, Zhou, 2020). It was recommended to reduce patients' dose and the low dose protocol was suggesting by many institution (Radpour et al., 2020) and it proves its reproducibility and accuracy (Dangis et al., 2020). The application of low-dose and ultra-low-dose CT examinations were used in the region because follow-up thoracic CT examinations were requested by clinicians, especially for most patients infected with COVID-19 and it is noted that one patient may underwent thoracic CT at least two or even three times. This situation has encouraged us to use ultra-low-dose COVID-19 protocols for follow-up patients. Working with device manufacturers, ultra-low-dose CT examination protocols were followed for 16 and 64 slices devices (Table 1). We performed examination reports and CT images (Figures 1–4) with hospital radiologists and evaluated with their feedbacks with device applicators. As a result of discussions with radiologists, no significant difference was observed in the interpretation of the CT images obtained from the ultra-low-dose protocol. Moreover, the best-quality images were obtained at the lowest possible dose, namely, to apply the ALARA principle in the best way. As a result of excessive increase in the number of patients who underwent thoracic CT, we discussed with the hospital administration the necessary cleaning measures that could not be taken, and many patients were in the same environment. Therefore, special action plans were used to reduce the radiation exposure dose for patients. The used actions can be listed as follows:

- Dose optimizations were performed.
- The protocols were revised by expert teams of CT and IT manufacturers.
- The protocol was approved by the radiologists.
- This feature was used in devices with automatic dose modulation feature. Before taking the scanogram images, the patient was positioned correctly in the CT Iso Center.
- A 1-mm volumetric thin section and high-resolution algorithms were applied to the protocols.
- The most appropriate rotation and pitch values have been adjusted to minimize breathing artifacts.
- In devices with iterative reconstruction feature, the noise rates of low-dose images have been minimized.

Table 1
Technical details of examination parameters and protocol types

Low-dose Torax CT protocol: 16 slices devices	Low-dose Torax CT protocol: 64 and over 64 slices devices	Ultra-low-dose Torax CT protocol: 16 slices devices	Ultra-low-dose Torax CT protocol: 64 and over 64 slices devices
100 KVp 110 mA Manual mA dose system Pitch: 1.3/1.2 Rotation time (s): 0.8/0.75 CTDI _{vol} : 3.45 DLP: 122.72 mGy ED = DLP × dose conversion factor (k)	100 KVp Minimum 60 to maximum 120 mA Automatic mA dose system Pitch: 1.3/1.5 Rotation time (s): 0.5/0.6 CTDI _{vol} : 1.09 DLP: 42.54 mGy ED = DLP × dose conversion factor (k)	80 KVp 50 mA Manual mA dose system Pitch: 0.8/0.75 Rotation time (s): 0.75/0.8 CTDI _{vol} : 0.81 DLP: 21.03 mGy ED = DLP × dose conversion factor (k)	80 KVp 40 mA Manual mA dose system Pitch: 1.3/1.2 Rotation time (s): 0.5/0.75 CTDI _{vol} : 0.38 DLP: 13.91 mGy ED = DLP × dose conversion factor (k)
122.72 × 0.014: 1.7 mSv ED	42.54 × 0.014: 0.5 mSv/ED	21.03 × 0.014: 0.3 mSv/ED	13.91 × 0.014: 0.2 mSv/ED

CT = computed tomography; CTDI_{vol}= computed tomography dose index; DLP = dose length product; ED = effective dose.

- Pediatric protocols were used in pediatric patients according to the age range and weight ratio, and if necessary, manual dose adjustment could be made.
- Pediatric CT device scanning reserved for COVID 19 was not performed, and patients were instructed to undergo CT scanning where patients with COVID-19 were not allowed.
- By meeting with device manufacturers, the infrastructure that allows remote device monitoring has been established, and any malfunction has been resolved through telephone interventions for possible malfunctions.
- In reporting, although some of our radiologists read the reports with the remote reporting system from home, some of them had to be in the field for hospital cases especially in interventional radiology and made their reports to the hospital.

To prevent unnecessary radiation exposure, standardization of CT examination requests of patients matching the items in

the algorithm were prepared. Accordingly, the follow-up of CT examinations and mentioned principles were observed in the clinical environment. It was organized to guide patients during CT examinations with fever of >38°C, respiratory rate of >22 beats/min, or oxygen saturation of <93% or oxygen deficiency. Currently, patients with COVID-19 are examined at doses as low as 0.5 mSv. Ultra-low-dose protocols were created in accordance with the standards to perform thoracic CT examinations of pregnant patients performed with the approval of our radiologists. These patients are examined at doses as low as 0.2 mSv. During extensive actions, we strongly considered the radiation dose fact of patients as in normal circumstance. Finally, radiographers and IT managers were informed whether patients were pregnant before the scan. Patients undergoing CT required filling of consent form completely from the pregnant patient, and its approval and signature were obtained. Request form with signature and stamp was provided

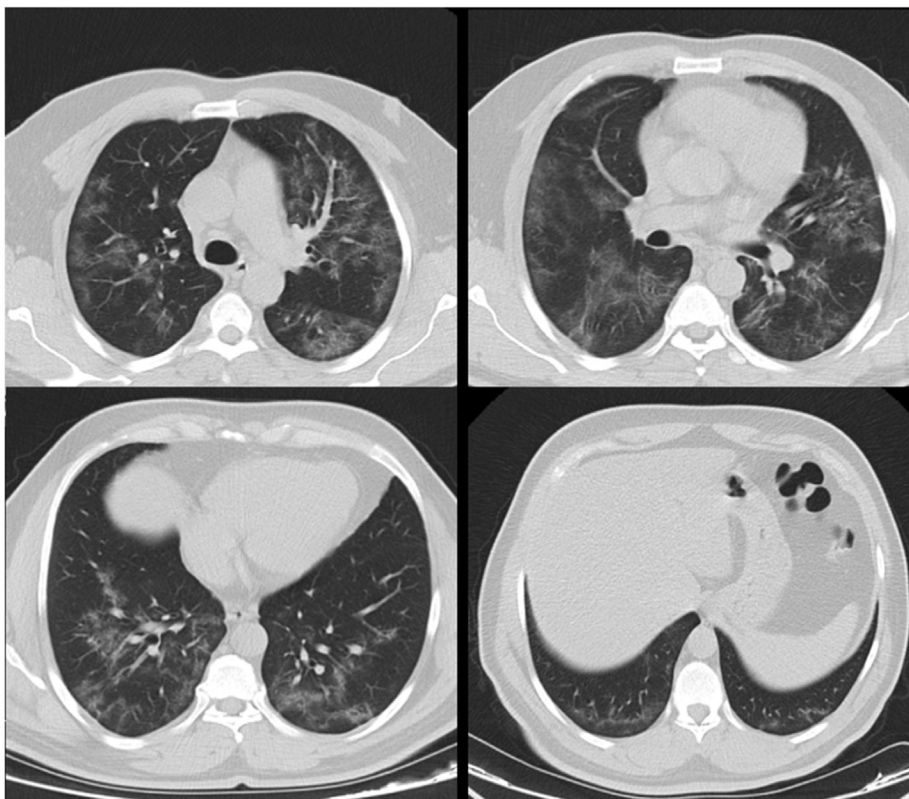


Figure 1. An image obtained from low-dose Torax CT protocol using 16 slices CT device during the examination of COVID-19 positive patients. CT, computed tomography.

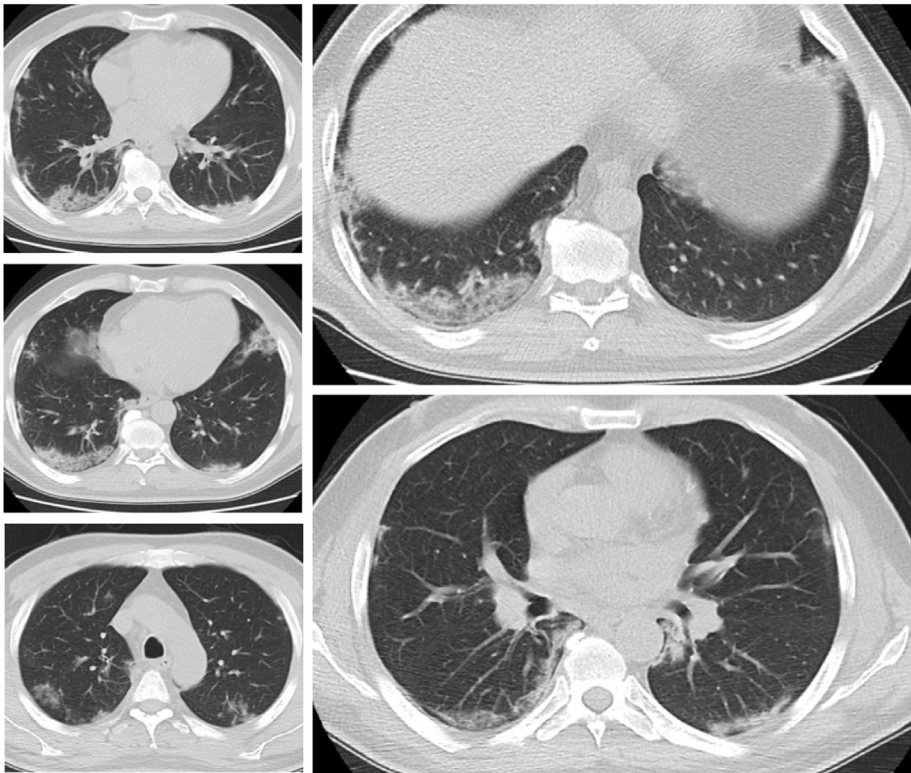


Figure 2. An image obtained from low-dose Torax CT protocol using 64 slices and >64 slices device during the examination of COVID-19 positive patients. CT, computed tomography.

by the requesting physician. To prepare scanning for patients, especially the abdominal region was protected with a lead apron, and scanning was carried out with the ultra-low-dose protocol.

Reflections

Reflections of the experiences gained during this pandemic process are very important in terms of evaluating future issues. In

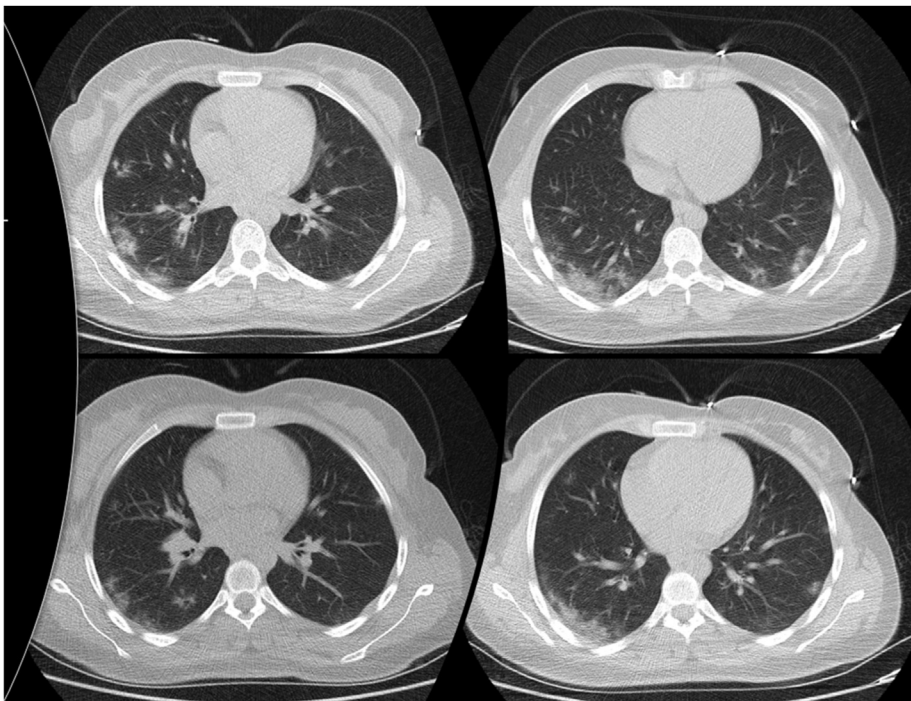


Figure 3. An image obtained from ultra-low-dose Torax CT protocol using 16 slices CT device during the examination of COVID-19 positive patients. The ultra-low-dose protocols and obtained images were evaluated with service providers and radiologists. CT, computed tomography.

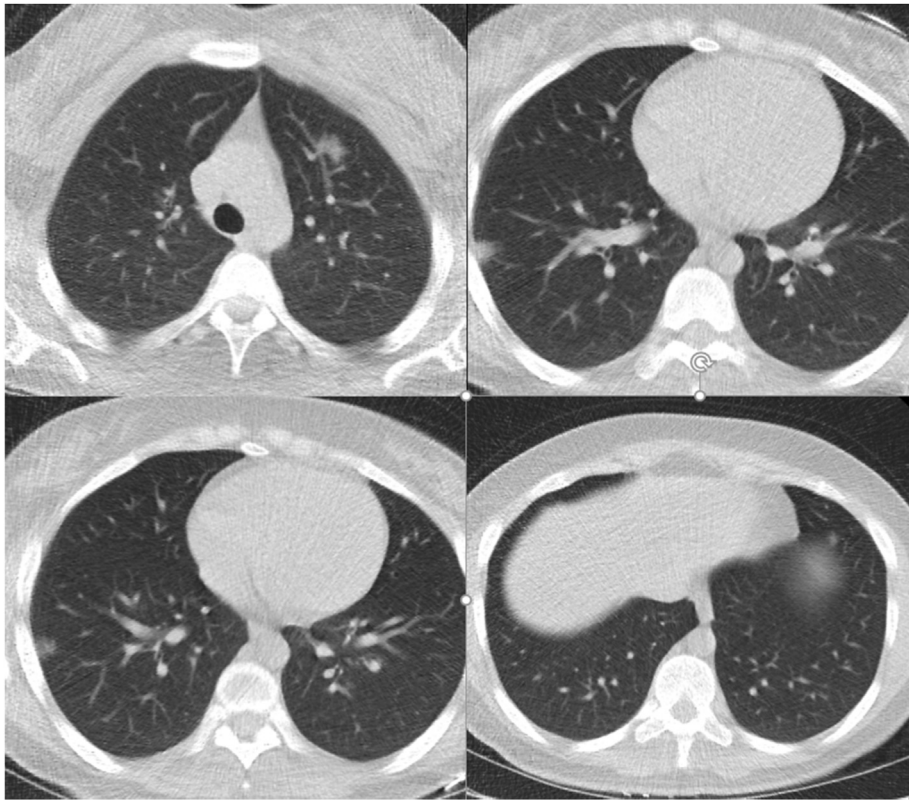


Figure 4. An image obtained from ultra-low-dose Torax CT protocol using 64 slices and >64 slices device during the examination of COVID-19 positive patients. The ultra-low-dose protocols and obtained images were evaluated with service providers and radiologists. CT, computed tomography.

In addition to aforementioned actions and strategies, we also analyzed some of the issues experienced during the COVID-19 pandemic and that we should be more cautious in the future. For example, one of the most important experience we have from the COVID-19 pandemic is that the radiology department should have sufficient stocks for PPE such as gowns and protective masks. At the beginning of the pandemic process, we had very serious problems with the provision of these PPE. Accordingly, the absence of PPE forced us to be in contact with other sources of supply. This caused us to spend the more time and effort on issues such as procuring equipment and finding new suppliers. Of course, it will be beneficial to coordinate with suppliers that follow a fixed price policy within the framework of legal agreements in the future.

Conclusion

Istanbul has been known as the most crowded city in Turkey. The places requiring tertiary care services are the ones that require serious tests, important examination and constitute the highest level of the health process. In this study, we reported the examination details and safety procedures of some diagnostic radiology facilities from five major Training and Research Hospitals in the Asian part of Istanbul (North Hospitals). Recent pandemic situation has showed that teamwork is a key factor while providing medical services. In addition, continuous communication efforts and individual responsibilities of radiology staff were remarkable during the COVID-19 pandemic. The recent situation also showed that co-operation of radiology facilities with device manufacturers and applicators is quite significant especially for the establishment of special protocols in the frame of As Low As Reasonably Achievable.

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