The Role of Chest Computed Tomography Imaging in Patient Management During the Coronavirus Disease Pandemic in Saudi Arabia: A Cross-sectional Study

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Abstract
Objectives: This study aimed to investigate the role of chest computed tomography (CT) imaging in patient management during COVID-19 pandemic in Saudi Arabia.
Materials and Methods: A questionnaire including 39 multiple-choice questions was distributed to radiologists and radiographic technologists through social media in Saudi Arabia during 13-23 May 2020, after obtaining the ethical approval.
Results: The results from 33 hospitals in Saudi Arabia showed that the role of CT's in managing COVID-19 patients was limited to only around 9% of 3049 patients who underwent chest CT. In addition, the CT technologists were exposed to infection with coronavirus in 6 (18%) radiology departments, whereas in the other 27 departments, the CT technologists were not exposed to the infection with the virus.
Conclusions: Despite their high sensitivity, CT scans have played a limited role in the management of COVID-19 and may not be a practical approach to perform routine screening.
Keywords: Computerized tomography imaging, COVID-19, Pandemic, Chest

Introduction

A new coronavirus called "severe acute respiratory syndrome coronavirus 2" (SARS-CoV-2; previously known as "2019 novel coronavirus") was found in the cases of viral pneumonia in Wuhan, Hubei, China in December 2019. In subsequent months, COVID-19 spread rapidly within and outside the province of Hubei and also to other countries (1-3). At the time of writing this article (May 2020), there were more than 30 000 confirmed COVID-19 cases and nearly 184 deaths in Saudi Arabia. Now developed in many regions and cities with sustained group transmission, the goal of the Ministry of Health (MOH) has shifted from containment to mitigation of COVID-19 (4). As a result, efforts are now centered on minimizing the frequency of COVID-19 cases, morbidity, and mortality by trying to break the transmission chain through social distance and forced quarantine. Rapid and reliable methods of detection and identification are required that can be used in local hospitals and clinics responsible for COVID-19 diagnosis and patient care.

Reverse transcription polymerase chain reaction (RT-PCR) is an acceptable testing method for diagnosing COVID-19, but it has some limitations, such as its shortage around the world, long waiting time (few days) for results, and variation of reported sensitivities. In addition, some radiology studies have found that chest computed tomography (CT) imaging has higher sensitivity than RT-PCR for detecting COVID-19 (5). On this basis, the correct use of imagery has been considered in each of the scenarios. The primary focus of this study was to use thoracic imaging with CT.

Thoracic imaging with CT is a key tool for the diagnosis and management of pulmonary diseases, but its role in the management of COVID-19 in Saudi Arabia has been poorly defined. Therefore, in this study, we sought to investigate the task of chest CT imaging in patient diagnosis and management during the COVID-19 pandemic in Saudi Arabia. The importance of this study is to help competent authorities in finding a proper diagnostic tool for COVID-19 and show the role of chest CT in diagnosis of COVID-19 in Saudi Arabia, as we require a more rounded view on that role worldwide which is still controversial. CT may exhibit typical evidence of viral pneumonia and therefore help the clinical diagnosis (6).

Materials and Methods

This cross-sectional study is performed across the hospitals in Saudi Arabia during the COVID-19 pandemic after receiving the approval of the Institutional Review Board and Department of Radiological Sciences at Inaya Medical College (No RAD/192/1, at meeting No 7), Riyadh. To obtain an overview of the role of chest CT

in patient management during the COVID-19 pandemic, we developed a 39-item (3-section) questionnaire that covers the major aspects of the CT use in managing COVID-19. An online survey tool was utilized to design the questionnaire, and the questionnaire link was distributed through social media to 100 radiologists and CT technologists of the radiology departments around the country. The time limit to fill out the questionnaire was 10 days via the online survey tool and sending a reminder message with the questionnaire link three days prior the deadline (date started May 13, 2020). The authors did not participate in this study. Data were acquired anonymously, except for the participants' designation (radiologists or CT technologists).

Questionnaire

The questionnaire contained 39 questions spread over three sections, covering various aspects of the role of CT during the COVID-19 pandemic. The questions were in multiple-choice and short-answer formats. The first section consisted of nine demographic questions, including the names of the participants, their administrative regions, cities, and professions, names of hospitals, and participants' years of experience. In the second section, the participants were asked some questions pertaining to the facilities they work in (general hospital, specialist hospital, isolation hospital, and medical service center), number of active COVID-19 cases, number of patients examined by chest CT, system on which chest CT is implemented, and number of chest CT scans done on suspected patients. Other questions were related to the indications for chest CT and technical aspects of the scan (for example, the use of contrast agent). The last questions were related to the reporting and interpretation of chest CT data sets (for example, the overall duration and software tools used) and the participants' opinions about the effectiveness of chest CT in managing COVID-19. The last section focused on measuring the participants' level of awareness of COVID-19. Through this section, we sought to understand the role played by the Ministry of Health in issuing plans to manage radiology departments as well as providing PPE to counter this new pandemic. The questionnaire is available at https://docs.google.com/forms/d/1qL151hk4H02RqozGraKizgn0cEASfdQbaQnzOJqeOKE/edit?ts=5eac3541.

Inclusion Criteria

All radiologists and technologists in Saudi Arabia who participated in professional social media groups were included.

Exclusion Criteria

Radiologists and technologists who did not participate in professional social media groups were excluded from the study.

Statistical Analysis

Statistical analysis was done utilizing Microsoft Excel 2016 (Microsoft, Redmond, WA, USA). The data were gathered through completed online surveys and then transported manually to Microsoft Excel 2016, as we received more than one response in some hospitals. Before performing the analysis, whole variables were reviewed for the accuracy of data entry and missing values. Short-answer questions were also examined using content analysis. First, the role of CT in diagnosing COVID-19 was analyzed for the included hospitals (33 hospitals). Second, the safety of CT staff from being infected with coronavirus was analyzed for the total 42 participants. Third, the performance of CT radiologists (13 in total) was analyzed.

Results

The main goal of this study was to investigate the importance of CT in diagnosing COVID-19 and the safety of the CT staff from being infected with coronavirus in Saudi Arabia. The study covered all the regions of Saudi Arabia, except for Northern Borders and Najran. An online questionnaire with 42 responses representing 33 hospitals was administered to examine the goals. The number of participants and the number of hospitals are given in Figure 1.

The Role of Chest CT in Diagnosing COVID-19 in Saudi Arabia

An online questionnaire, including 42 responses from 33 hospitals, was used. Among them, 22 (61%) were isolation hospitals, whereas the rest were not. Additionally, only 6 hospitals had not received any positive COVID-19 cases (82%). X-ray is the first imaging modality for the majority
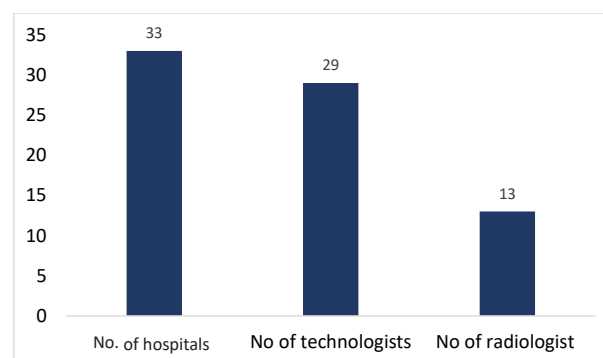
Figure 1. Number of Participants (Radiologists and Technologists) and Hospitals.

of these hospitals (94%). In addition, these hospitals had received 3049 positive COVID-19 cases and completed 275 chest CT examinations for these cases (9% underwent CT examinations), and two hospitals (6%) had performed follow-up chest CT examinations (Figure 2). None of the hospitals did more than 3 chest CT examinations a day. Moreover, there is no standard chest CT protocol for all of these hospitals, and the used protocols are shown in Figure 3. Thirteen hospitals (40%) specified using a CT scanner only for positive and suspected COVID-19 cases. However, 25 (60%) participants recommended using chest CT examination for COVID-19.

The Safety of CT Staff from the Infection
A set of questions in the questionnaire was about the safety of CT staff from the virus and their level of awareness of the disease. Thirty-six (86%) participants followed the prepared plan of radiology departments for COVID-19, which has been formulated by the Ministry of Health in Saudi Arabia, whereas 6 (14%) of them did not follow the plan. In addition, 31 (94%) radiology departments that participated in this questionnaire provided PPE, such as gloves, masks, and sanitizers, and only 2 (6%) radiology departments did not provide them. Twenty-eight participants (66.6%) thought N95 masks can prevent the entry of the virus in the body through breathing, while 10 of them thought surgical masks can do that, and 4 believed that cloth masks are enough. Further, 25 (59.5%) of the participants said 2 m is a safe distance to stay away from others, whereas 17 (40.5%) of them believe 1 m is safe. Moreover, 37 (88%) participants expressed they could not tell if someone has COVID-19 because not everyone with COVID-19 has symptoms; 3 (7%) of them reported that they can tell just by knowing where a person comes from and their race and ethnicity, and 2 (5%) of them said it is obvious in the sense that a person with COVID-19 coughs a lot. Moreover, only 6 (18%) radiology departments had staff infected with the virus, whereas 27 hospitals did not

have COVID-19 cases among the CT staff.

Artificial Intelligence
The CT radiologists who participated in the survey agreed that ground-glass opacity appearance is the most common feature in CT for COVID-19. In addition, there is no hospital which adopted an artificial intelligence (AI) system that can help interpret CT images of COVID-19 in radiology departments.

Discussion
The results from 33 hospitals in Saudi Arabia showed that the role of CT in managing patients with COVID-19 was limited to only about 9% of the 3049 patients who underwent chest CT. In addition, the CT technologists were exposed to infection with coronavirus in six (18%) radiology departments, whereas in the other 27 departments (82%) (Figure 1), the CT technologists and radiologists were not exposed to the infection with the virus. In addition, both the CT technologists and radiologists showed a high level of awareness, as they followed the prepared plan of radiology departments for COVID-19, which has been implemented by the General Directorate of Radiology and Applied Services in the Ministry of Health in Saudi Arabia, and knew how the virus can be transmitted. AI systems were not provided in the included hospitals to improve the radiologists' decision-making process in diagnosing COVID-19.

To understand the role that chest CT plays in managing patients with COVID-19 in Saudi Arabia, this study aimed at providing a discussion of this role. In addition, its pros and cons would help guide the competent authorities in developing strategic evidence-based plans on how to deal with such a pandemic in the future. In fact, there is a major conflict over the importance of CT as a diagnostic tool for COVID-19.

Currently, RT-PCR is important in Saudi Arabia to possibly diagnose a suspected infection and decrease further transmission both in the community and the environment, where the patients received medical care (Figure 3). The Ministry of Health has launched several initiatives to conduct an expanded examination to assess the prevalence of coronavirus in major cities with a high population density (7). However, RT-PCR is not devoid of challenges and limitations. Its efficacy depends on a sufficient collection of viral RNA that is usually collected from the nasopharyngeal swabs of the patients. This becomes a major challenge, as the amount of viral RNA varies drastically among patients over the course of the infection and even within a single person. This would alter the amount of viral RNA the reaction starts with, thereby raising the likelihood of a false-negative outcome. In addition, the efficacy of extracting the swabs varies among humans (individuals, as well as health workers). Therefore, increasing the amount of viral RNA led to the likelihood of variable RT-PCR results (8). Therefore, it is not clear whether CT should be used as a stand-alone
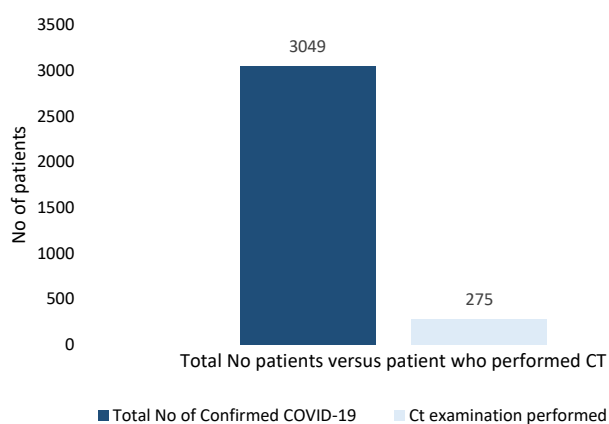
Figure 2. The Number of Computed Tomography (CT) Scans Performed on the Total Number of Patients with Coronavirus Disease (COVID-19).
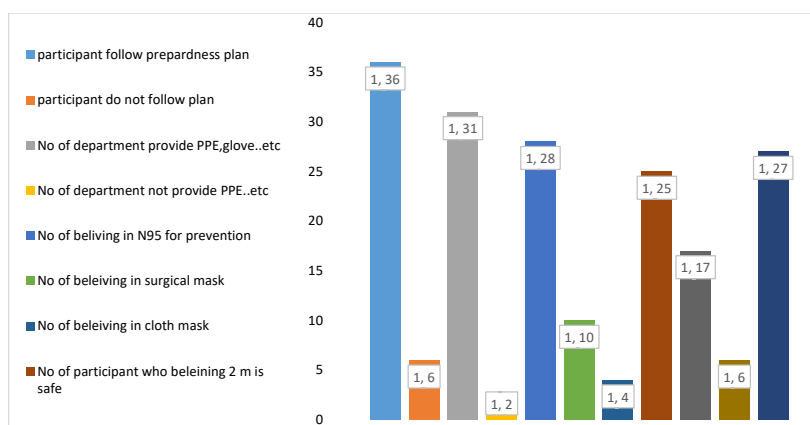
Figure 3. Safety among the Participants and Departments.

screening tool or as an adjunct to RT-PCR to exclude occult infection prior to any medical examination (8,9).

Some studies demonstrate that the role of CT in diagnosing COVID-19 is still undefined and unjustified (10). Rubin et al (6) reported that CT can be avoided because it does not provide any additional value addition to patients with COVID-19. Additionally, it does not reduce the risk of radiation exposure for patients and staff. In addition, Wang et al (10) explained that children are more sensitive to cancer induction via radiation; therefore, in COVID-19 positive or suspected children, CT should be avoided as much as possible. CT can cause procedure-induced transmission of infection, as the scanner can be infected by patients with COVID-19. Guan et al (11) mentioned that the first imaging modality for COVID-19 cases is X-ray; however, CXR has lower sensitivity than chest CT. Therefore, our outcomes in this study confirm their results, as CT does not add significant value for the diagnosis of COVID-19. However, other studies have proved that CT can play a significant role in diagnosing COVID-19. Tsou et al (12) recommended CT for the "screening, comprehensive evaluation, and follow-up" of COVID-19. In addition, CT has higher accuracy, sensitivity, and specificity than RT-PCR (11,12). Additionally, 60% of the participants who recommend chest CT agreed with studies that suggest chest CT for diagnosing COVID-19.

Most health authorities have devised plans for radiology departments to avoid the transmission of COVID-19 to staff and patients. The General Directorate of Radiology and Applied Services in the Ministry of Health in Saudi Arabia has issued a specific plan for COVID-19. This plan includes sections for each radiology department. In the section on CT, there are 17 points. For example, a scanner should be allocated for patients with COVID-19 if possible, COVID-19 cases must be highlighted, the staff must wear full PPE, patients with COVID-19 should wear surgical masks, and the scanning room should be disinfected after each patient. In addition, the Ministry of Health in Singapore has implemented a similar plan. The

sustainability of the functions of radiology departments over both long and medium periods is important, but a reduction of examinations is inescapable as the severity of the outbreak increases. Outpatient examinations might be cancelled if they are unnecessary. Personal protective equipment is essential to prevent the transmission of COVID-19 from patients to healthcare providers. Communication among technologists, radiologists, and other staff must be minimized, and radiology information systems must be used to share images and messages (10). Therefore, our results show a high level of awareness of the CT staff in Saudi Arabia, as 86% of the participants follow the plan. To our knowledge, no specific study has focused on infected radiology staff. However, Tsou et al (12) pointed out that there were about 3300 medical practitioners infected in China, and 20% of the healthcare providers in Italy have contracted the infection.

AI systems can help radiologists improve their performance in the diagnosis of COVID-19. Bai et al, (13) examined the performance of 6 radiologists, and they found improvements in their performance with AI. The accuracy, sensitivity, and specificity of the performance of these radiologists without AI were 85%, 79%, and 88%, respectively, whereas they were 90%, 88%, and 91%, respectively, with AI. Therefore, our outcomes show that radiologists are not able to take advantage of this new system as it is not provided in the hospitals.

As with the majority of studies, our study has certain limitations. Having many responders is always desirable. However, because of their heavy workloads, healthcare providers are less likely to participate in surveys. Our return rate of 42% (42/100; analysis rate of 42%) is only moderate and slightly lower than the return rates achieved in national surveys (14). Nevertheless, it is in line with the expected return rate for questionnaire surveys reported by Jepson et al (15). It is much harder to acquire a high response rate during such a pandemic. In addition, the survey was administered online with a 10-day time limit, which may have influenced the small rate of responses. There were some repeated responses to the same radiology

department from different participants. Some of their answers were different, but they did not affect the primary purpose of the questionnaire. We cannot claim that our data provide a comprehensive overview of the role that CT plays in the management of patients with COVID-19 in Saudi Arabia; however, they give interesting insights into the various practical aspects of its future use.

Conclusions

Healthcare providers around the world have been working relentlessly to curtail the spread of coronavirus. However, given that there is no prophylactic treatment available, breaking the chain of transmission through isolation of infected persons and social distancing remains the only option to prevent it. As such, there is a need for effective and reliable screening and testing methodologies to expedite the identification of infected persons. Although RT-PCR has provided an invaluable resource in the diagnosis of COVID-19, several diagnostic variables may limit its sensitivity. Given the superior diagnostic capabilities of imaging techniques such as CXR and CT, it is essential to explore the applicability of these methodologies in the identification of infected persons. Our results indicate that despite their high sensitivity, CT scans have played a limited role in the management of COVID-19 and may not be a practical approach to perform routine screening. However, over half of our respondents agreed that CT could add value to the diagnosis of COVID-19. Moreover, the technologists participated in this study showed a high level of awareness of the role of PPE in preventing exposure to the virus. These results suggest that although exposure to the virus is inevitable, the risk of infection due to non-adherence to PPE requirements is limited. In addition, although the technicians were knowledgeable about the diagnostic markers of COVID-19 in CT, we found low levels of the use of AI in imaging studies. These results suggest that although technicians and radiologists possess the requisite competencies to diagnose COVID-19, they could benefit from the integration of AI into imaging technology.

Recommendations

On the basis of the literature review and the results of this study, the authors recommendations are as follows: (1) in suspected cases, CT may well be applied where pathogenic tests are found to be negative more than once; (2) allocate a CT scanner to perform procedures for suspected patients and provide PPE for workers and patients; (3) precautionary steps should be taken to minimize the spread of a pandemic and ensure minimal radiation dose for both patients and healthcare providers; (4) choose a

specific protocol based on expert opinions and circulate it to all hospitals through the Ministry of Health; (5) use AI systems to assist radiologists in making an accurate diagnosis.

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