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Review Article

Clinical Imaging Procedures and Guidelines during COVID-19 Pandemic

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Abstract

COVID-19 is a global pandemic that has affected almost all the world countries and spread quickly among people. Therefore, the World Health Organization (WHO) and governments have implemented strict safety protocols to stop the spread of the virus and to control the infection range. The Radiology department plays a vital role in confirming or following up with COVID-19 cases. Accordingly, guidelines and regulations were implemented to ensure staff and patients' safety and to overcome the high demand for the imaging procedures.

The purpose of this review is to highlight and address the current imaging procedures, including health and infection control guidelines applied in the radiology department. Therefore, most recent relevant articles from different databases were reviewed and summarized.

Precautionary measures including portable X-ray equipment to restrict transporting infected patients to radiology departments, utilization of personal protective equipment (PPE) and disposable gowns, and disinfecting CT, MRI gantry and ultrasound probes should be strictly implemented by radiology department personnel. During US imaging, US examiner might be at risk of getting infected due to close contact with the patient and prolonged examination time, especially with point-of-care and portable US. Regarding the radiology staff, temporal and physical team segregation strategy can be an effective way in managing radiology department workload. Therefore, maintaining the mental and physical health of staff play a critical role to implement proper health care procedures to the COVID-19 patients.

Keywords: COVID-19; Precautions; Guidelines; Radiology; CT; MRI

Introduction

Corona-viruses are groups of viruses that can affect humans and animals. The first group (229E, NL63, OC43, and KHU1) can lead to slight to moderate respiratory infections such as influenza. A severe respiratory infection can occur by the second group of the coronaviruses, including SARS-CoV and MERS-CoV. The last one on the viruses' chain is COVID-19 [1,2]. The rapid increase of the COVID-19 cases globally led to considerable changes in different life aspects. Among them, the health care system. During the pandemic, health care facilities should follow strict COVID-19 infection control policies and guidelines to sustain a sterilized environment to operate the work [3].

With the worsening of the COVID-19 cases worldwide, people's anxiety and fears from the virus infection increased as well. Since COVID-19 and Flu are respiratory system diseases, people start to confuse COVID-19 characteristics and symptoms with a Flu condition. However, each of them is caused by a different virus type. The spread of COVID-19 between people is faster than a Flu virus, but coronavirus symptoms require a longer time than Flu symptoms to be recognized or appear. There are some similarities and differences between the symptoms of both diseases. Common symptoms of both diseases may include chills, shortness of breath, headache, runny nose, and more. On the other hand, COVID-19 patient could experience some other symptoms such as losing smell or taste senses [4,5].

COVID-19 is a global pandemic that has affected almost all the world countries, and it was spread quickly among people. Therefore, WHO and governments have implemented severe safety protocols to stop the spread of the virus and to control the infection range [3]. Moreover, CDC (The United States Centers for Disease Control and Prevention) applied prevention techniques to stop the spread of viruses. The spread of the virus can be managed by increasing the awareness of people around the world to comply with the safety guidelines [24].

Nowadays, all hospitals require imaging modalities as the primary diagnostic method. Computed Tomography (CT) is a promising imaging modality for most respiratory system diseases, including COVID-19 and Flu. In Flu cases using CT scan, axial CT images can depict the lung's consolidation and pleural thickening while COVID-19 cases using CT scan show crazy-paving sign and focal consolidation [6].

As a response to the pandemic, radiology departments announced particular policies to handle the crisis safely in order to control the spread of the virus and to apply precautions to control the department's exams. Therefore, the infection control during the COVID-19 procedure was modified to be more applicable to the current situation.

Different areas within radiology department including X-ray imaging, CT scan, magnetic resonance imaging (MRI) and ultrasound imaging (US) applied various guidelines and procedures to control patient and staff infection during COVID-19 imaging. General X-ray and CT are the most frequent imaging modalities used for COVID-19 diagnosis and follow up. Therefore, radiology staff work in close contact with patients for positioning or bedside imaging need to strictly apply prevention and control measures. There are different gaps in the literature regarding the best safety practices within the radiology department were identified. These include the type of mask that should be used for staff safety, utilization of portable X-ray and US to reduce disease infection, staff workload and examination procedures for CT and MRI scan. Accordingly, this review aims to discuss the implemented updated COVID-19 imaging guidelines, regulations and precautions to ensure the staff and patients' safety and to overcome the high demand for the imaging procedures.

WHO and general COVID-19 guidelines

WHO intends to guide the public about COVID-19 in national and subnational levels and to update the global strategies to respond to COVID-19 pandemic. Therefore, a study was conducted to provide a short term forecast and prediction of final epidemic size. At the beginning of the epidemic in China, there was a rapid spread of the disease. After the implementation of extreme quarantine measures, the growth rate seems to be decreased. However, the model was unable to characterize the second wave dynamics of construction. This model can provide a prediction of the estimated outbreak and help countries to prepare for the pandemic [42]. Also, it can provide an insight in to the current situation, severity of the disease and symptoms in order to slow down the transmission of the disease by implementing preventive measures like rapid identification, testing and treating the patients with severe COVID-19 symptoms and implementation of isolation protocols. Moreover, implementing coordination and planning, contact tracing, providing clinical care and essential healthcare services to reduce mortality and adapt strategies based on risk and vulnerability are some of the national strategies outlined by WHO [41].

Regarding disease severity and transmission, current evidence suggests that asymptomatic and pre symptomatic patients are all capable of transmitting the virus with the incubation period ranges between 6 to 14 days. It was noted that patients older than 65 years were more prone to the severity of COVID-19 disease and men were highly susceptible to succumb to the disease. Thus, men are 2.4 times more prone than women irrespective of age and

susceptibility [35]. In order to allocate the medical resources effectively, patient's age, gender, time interval from illness onset to diagnosis are important parameters to be analyzed. It was noted that a minimum of 19 days of hospital stay was required for patients who were below the age of 45, while patients who were above the age of 45 stayed a bit longer; 21 days [39]. However, the hospitalization duration of patients can increase due to delirium stage. Therefore, these patients end up staying longer than the patients who do not have delirium and required increased assistance from health care professionals, and are at higher risk of nosocomial infections. Hence, it is necessary to detect the occurrence of delirium at early stages, prevent, manage and include early mobility and exercises. The main factors that may contribute to the onset of delirium include inadequate pain management, overuse of sedatives, restraints, social isolation, immobility and sleep disruption [33].

For protection purposes, protective masks can prevent splashes of biological fluids and droplets. The Advantages of using masks include reduced spread of droplets and contributing to the stopping of spread of the virus. On the other hand, disadvantages may include headaches, skin irritation, rashes, worsening acne, breathing difficulties, waste management issues and disposal problems [30]. Various studies have been conducted regarding the importance of masks in preventing transmission of infection. One of the studies conducted light scattering experiment using laser to illuminate droplets and counted them and also identified the saliva droplets that flew in to the air by the individuals who did not wear masks. By this research, it is clear that asymptomatic and pre-symptomatic individuals who do not wear masks in public can contribute to the transmission of COVID-19 and spread the infection. Accordingly, there are different types of masks intended for specific purposes. N95 masks are recommended by the WHO for health care professionals which have the ability to filter 95% of particles as small as 0.3microns whereas homemade cloth masks which can be used by general public restricts viral particles during coughing and has 50 to 100% of efficacy of surgical masks. Therefore, by looking at the statistics, wearing masks in public prevents transmission of COVID-19 infection by people who are not showing any symptoms and are not aware that they could be carrier of the disease. Hence, wearing masks in public could be the new norm after the pandemic [37]. Additionally, WHO recommends the use of contact and droplet precautions for Healthcare workers (HCWs), protection from aerosols in procedures where there is a chance of being exposed, a risk assessment tool for HCWs who is exposed to infected patients, and also psycho-social support, adequate staffing levels and clinical rotations to prevent burn-out amongst HCWs [40].

Radiology and COVID-19 guidelines

The American College of Radiology (ACR) acknowledges the fact that radiological practices have been severely affected due the emergence and spread of the pandemic. It aims to provide general guidance to re-engage the non-emergent radiological examinations. As an accurate risk-benefit analysis of postponing radiological examination is not possible due to various reasons; specific outcome based risk of COVID-19 and outcome based risk of postponing imaging must be considered. Hence, the decision making relies on the combined approach of both referring physician and radiologist. It should outline guidelines to follow for safely performing non urgent radiological examinations. This can be used as a valuable tool to refer in other hospitals while resuming routine radiology care during COVID-19 pandemic [29].

Among these guidelines, there are different methods to reduce transmission of infection in radiology department. These include transmission based precautions by using PPE (gloves, masks, positive pressure isolation suites) and precautions introduced by CDC (Centers for Disease Control) which are combination of standard precautions and body substance fluid isolation practices, contact precautions and airborne precautions [36]. Additionally, precautionary measures to be followed by radiology department personnel include using portable X-ray equipment to restrict transporting infected patients to radiology departments, utilization of PPE, disposable gowns and disinfecting CT and MRI gantry, ultrasound probes, keyboards and mouse at the workstations after every contact with suspected patients [32].

Furthermore, health professionals need to apply standard rules to minimize the spread of the COVID-19 virus. For example, one bedspread to be used per person and wiping off the exam equipment with 2000 mg/L chlorine containing disinfectant or 75% ethanol and avoiding disinfecting the medical equipment room with spray to protect equipment from damage [18].

Regarding radiology resident safety, applying COVID-19 safety measures on the radiology resident and fellow trainees during their training program has led to several changes such as decreased need for onsite work as most of the radiologist are allowed to work

remotely, trainees are redeployed in areas other than radiology on voluntary basis to internal medicine wards and ICUs to manage the workload of patients requiring hospitalization. The advantage of these measures is that the trainees can help fellow colleagues during this pandemic and work as a team. However, reduced number of training hours as they get to work 1 week and off for 1 week, traditional trainee- faculty member work station training has been stopped as a mean of social distancing measure, in person teaching conferences has been replaced by virtual conferences and teaching methods, research has been suspended due to laboratory closure and restricted participant visits are limitations of the applied safety measures. Additionally, postponing core examinations will lead to delay in completion of clinical scheduling and graduation which will impact the start time for fellows and incoming radiology residents. Therefore, the impact of COVID-19 has not just affected the educational aspects, it has also significantly increased psychological distress due to the pandemic and financial burden to trainees with medical school debt [26].

CT scan and COVID-19 guidelines

CT scan of the chest can be used as a supplementary tool to help in identifying the lesions. it was concluded that by keeping RT PCR test as gold standard for reference, CT chest imaging for patients with COVID-19 has a sensitivity of 99% and hence it can be used as a tool for diagnosing patients with COVID-19. However, in children it is only 66% sensitive [34].

The specificity of CT cannot be accurately measured as it does not test a singular feature pertaining to the disease when compared to laboratory tests. Features indicative of COVID- 19 pneumonia can be found in large number of other conditions. Therefore, various national and international bodies like CDC and ACR do not recommend the use of CT as a tool to detect COVID-19. Instead, it should be used to evaluate and diagnose the complications arising from COVID-19 infection [38]. It was observed that abnormal chest imaging findings were noted, including transient areas of sub segmental consolidation with bilateral ground-glass opacities being predominant later in the course of the disease. The representation of pathology closely resembled the features of MERS and SARS. However, the overall findings are highly nonspecific and they overlap with the symptoms of influenza H1N1 or atypical pneumonia. Therefore, it should be correlated with history of contact with COVID-19 patient or recent history of travel to an eastern Asian country.

Special CT imaging procedures for COVID-19 patients were implemented to keep the standard workflow in department [7]. One of the modifications applies to the department design. The radiology department includes four areas, and each area contains different conditions. The first area is the contaminated area, which belongs to the confirmed COVID-19 patients. This area contains two rooms; one for CT exams and the other for the Digital Radiology exams. It has additional entrance to the fever area (semi-contaminated) as some patients with fever might only be suspected COVID-19 patients, which represents the second area. The third area is the buffer area specified mainly to staff preparing for exams. The fourth area is the clean area that contains reception, offices, and examination rooms. Everyone in the department, including the staff and patient, must wear a surgical mask all the time. Also, gloves, gown cuff, and eye protection, including both goggles and, face shields, are recommended. On the other hand, in the presence of suspected or confirmed COVID-19 cases, radiographers must replace the surgical mask with an N95 mask and wear disposable double gloves [7,8].

Additionally, CT exam for a suspected COVID-19 patient requires transporting patients to the radiology department. In this case, more than one radiographer should be handling the case. Two of them will contact the patient through moving and positioning. Hence, they must be adequately protected by following the infection control rules. Before positioning the patient, a disposable sheet should be placed above the machine table. The next step after the exam is to clean the room and prepare for the next patient [16].

A study has described unique CT technology that can be conducted for COVID-19 patients named uVision CT. This particular procedure demonstrated effectiveness in disinfection and protection processes during the procedure. This technology can identify patients' body surfaces and set proper centers to include interesting exam areas. In this way, radiographers can communicate with patients through devices, and no need to closely contact their patients. This procedure ensures the safety of staff and patients as well [16].

X-ray imaging and COVID-19 guidelines

X-ray is the most used modality in the radiology department, especially during the pandemic. A study reported that portable chest X-ray is the most procedure performed for ICU COVID-19

patients [11]. On the other hand, another study showed that using new analysis techniques of the convolutional neural network can classify COVID-19 patients accurately [10]. Therefore, different countries such as China, Spain, and Italy have considered X-ray imaging as potential screening tools besides the RT-PCR for screening and administration of different patients' conditions. Accordingly, a chest X-ray (CXR) is needed using the portable X-ray unit that can be carried into the patients' rooms to minimize the interaction with patients in the imaging department [10,11].

To perform an X-ray exam for suspected patients, staff should apply infection control rules before, during, and after the exam. A portable machine can perform X-ray exams to avoid moving patients from one place over another to reduce the risk of spreading the infection. Therefore, portable X-ray machines are allocated for the isolation units, and disposable covers are provided for the imaging detectors. The examination room must be prepared with all the necessary equipment [3].

US imaging and COVID-19 guidelines

COVID-19 in pregnancy needs a framework that can be followed by the maternity centers managing pregnant patients during pandemic and ensuring safety of the patient and health care workers. Physiological susceptibility of cardiovascular system and immune system is elaborated by mentioning different types of infections and risks they are prone to. Probability of pregnant patient to acquire these pathology is higher as they are considered as vulnerable group [28]. The ultrasound (US) scan plays a vital role in the current pandemic especially for pregnancy examinations. The whole process requires the radiology department staff's cooperation to manage imaging the patients by applying the COVID-19 safety strategies in the radiology department [13].

This exam can be safe for pregnancy tests and also be operated by a portable machine. After performing the exam, the room should be cleaned very well, and sonographers should wash their hands before and after leaving the room. However, US examiner might be at risk of getting infected due to close contact with the patient and prolonged examination time, especially with point-of-care and portable US [12].

MRI imaging and COVID-19 guidelines

MRI examination of COVID-19 infection-control regulations cover five aspects as requirements for the MRI scan including MRI room design, pre-admission, preparation of medical staff and patients and finally disinfection after MRI examination [14]. MRI for suspected COVID-19 patients, requires help from the infection control team to move a patient in and out of the department safely. After performing the MRI exam, the room should be cleaned by expert staff in dealing with high magnetic field areas. As a result, High Efficiency Particulate Air (HEPA) filter should be used to exchange the air before the next patient. By following these steps, the room will be decontaminated and ready for the subsequent examination [15].

Interventional radiology and COVID-19 guidelines

For interventional procedures, fixed and essential contact surfaces within the room should be covered with a clean sterile cover. Moreover, Careful hand hygiene, the correct wearing of protective equipment, N95 or FFP2 masks and eye protection, gowns, gloves, aprons, and shoe covers are recommended, and used personal protective equipment (PPE) must be collected in dedicated disposal bags [7,17]. Additionally, in order to reduce intra institutional spread of SARS COV-2 and COVID-19, some procedures need to be followed in interventional radiology department during the COVID-19 pandemic including segregation of patients and decentralization of services in response to nosocomial transmission of infection, mandatory RT PCR testing for all patients and health care workers to identify infected patients and staffs, designating separate routes for isolated patients so that they do not use the conventional routes, limiting the presence of number of staffs who are not directly involved in the procedures and eliminating non-essential equipment from the room and training staffs adequately to follow the guidelines listed by the WHO for using PPE and N95 masks. By following such rigorous guidelines, there was no cross infection documented in their hospital. However, it did increase the cost of the equipment and the procedure time [25].

Moreover, there is a high incidence and severity of complications associated with patients undergoing surgery who were unknown to be carriers of the disease, or were infected after the procedure. The most logical and simple way to handle this is by cancelling all elective procedures unless deemed urgent, maintaining social distancing, carrying out immunoglobulin M and immunoglobulin G in the first appointment, and a second test must be repeated after 7 days, in addition to a PCR test and isolating patient for 7 days before the surgery [27]. Accordingly, coordination between staff,

handling patients, preparation of staff and interventional suite before the arrival of patients and after finishing the procedure, and improving the facility ventilation systems are crucial steps [25].

Staff workload and COVID-19 guidelines

A study has indicated that the medical staff are considered the frontline of fighting COVID-19 and focused on following the safety protocols in the X-ray department as they examine COVID-19 suspected patients. Also, they have to examine other patients daily with other different diseases [18]. Likewise, a study has discussed the dynamic department process and the management role for supporting the radiology staff to achieve sufficient capacity during such crisis [19]. Besides, radiographers, nurses, and other staff in the radiology department must demonstrate an acceptable knowledge level about applying protection control methods during the procedures [7,19].

Radiographers who work with COVID-19 patients may face a lot of stress and pressure. Therefore, re-scheduling duty timing and providing longer break time are suggested to ensure readiness to continue the duty. COVID-19 affects the workflow in radiology departments; for example, for the patients' waiting area, the pandemic decreases the waiting area capacity to comply with the patient's social distancing. The frequency of the examinations is also reduced and the working hours are extended to cover the work overload. However, applying longer working hours will facilitate the room's cleaning and preparation procedures for the next patient. For COVID-19 suspected patient's imaging, two radiographers must conduct the procedure. The First radiographer has to comply with safety measures and apply the procedure. The preparation includes double gloves, gown cuff, and N95 mask with a face shield, positioning the patient and cleaning the equipment after scanning. The second radiographer has to conduct the scanning in the control console room [8,9].

Therefore, hospitals may have to increase the number of workers and train them. Accordingly, some hospitals follow segregation strategy by forming a team with different skills, including radiologists, radiographers, and nurses. Team segregation is divided into temporal and physical strategies. For temporal segregation, sometimes anyone from the staff can have the infection without any symptoms, which will lead to spreading the virus between the staff during the incubation period of COVD-19 (14 days). Therefore, an exchange occurs at the end of the 2nd week period between the team groups. One group is working for two weeks cautiously, and the other group is self-quarantined at home. However, this strategy faces many problems since hospitals cannot tolerate too many quarantine staffs. The other issue is working at this level of risk for 14 consecutive days may be mentally and physically overwhelming for the staff. On the other hand, physical segregation is to split staff between hospitals and to complete their work in the selected hospital to avoid viral transition across hospitals. Furthermore, staff like radiologists can have the ability to control their workstation remotely from their homes, unlike radiographers and nurses who are required to be present in person [8]. Additionally, hospitals worldwide facing COVID-19 have increased the number of portable machines in every emergency department (ER) since the beginning of the outbreak and equipped with outdoor tents ready to deal with infected patients to control disease transmission [7,8].

Strategies to maintain COVID-19 guidelines

There are several strategies can help hospitals to control COVID-19 pandemic. Firstly, by conducting awareness sessions about infection prevention techniques such as social distancing, handwashing, and sanitizing methods, and reviewing the practice protocols for decontaminating imaging rooms after dealing with COVID-19 patients [19]. Secondly, when dealing with COVID-19 patients, staff need to have PPE, surgical cap, gloves, N95 mask, medical protective clothing, goggles, and face shield readily available. A special infection control procedure must be performed on the equipment as well [7]. Thirdly, reducing staff traffic and gathering in all departments is recommended. Fourthly, staff stress relief can play an essential role in the quality of work by encouraging staff to have adequate sleep and rest [20].

Maintaining the mental and physical health of staff play a critical role to implement proper health care procedure to the COVID-19 patients. Their family concerns and fears about viral transmission require more attention by enhancing the service's and preventing infection. The working environment can be improved by including room for staff supplied with food, beds, and furniture to rest in a quiet place. Likewise, using calling applications to communicate with their families, such as Teams software, is helpful. Therefore, there is a significant demand on the radiology services that requires appropriate preparedness rules and guidelines to overcome a large number of COVID-19 cases and to ensure the safety of the staff [21-23].

Additionally, physical activities play an important role in reducing the symptoms of depression, stress and improved concentration. Regular physical activities can result in better cardiovascular health, increased immunity and endurance and strengthening respiratory muscles. WHO recommends some simple home based exercises that can be followed during the lockdown which can be easily followed to keep ourselves active. Performing household chores also results in energy expenditure. Importance of regular interruptions from prolonged sitting time is encouraged in order to regulate metabolic health [31]. The included articles are summarized in table 1.

Author name and article number in the references list	Study title	Country	Study type	Study aims	Data type	Key findings
Alvin MD., *et al*. [26]	The Impact of COVID-19 on Radiology Trainees.	USA	Report study	Solutions for the radiology employee and trainee to face the pandemic.	Guidelines	This report may proactively assess the impact of the current pandemic on residents and trainees. All radiology trainees to stay informed and compliant with measures to contain COVID-19 without complacency or panic.
An P., *et al*. [18]	Management strategy of novel coronavirus (COVID-19) pneumonia in the radiology department: a Chinese experience.	China	Communication study	Aspects of CT acquisition process, protection level, equipment management.	Guidelines	It is necessary to determine practical, efficient and feasible prevention and control measures to prevent and control the spread of COVID-19 in the radiology departments. To complete the radiology examination safely and diagnose COVID-19 pneumonia patients with high efficiency and quality.
Ierardi AM., *et al*. [25]	How to handle a COVID-19 Patient in the Angiographic Suite.	Italy	Report study	The precautions to control the spread of COVID-19 within the healthcare facility.	Guidelines	Control measures are to minimize intra-institutional spread of SARS-CoV-2 and COVID-19. Pre-, intra- and post-procedural approaches for IR workflow described in the setting of an IR unit highly exposed to COVID-19.
Ashari MA., *et al*. [3]	Strategies for radiology departments in handling the COVID-19 pandemic.	Malaysia	Report Study	Strategies to improve preparedness, and response towards the pandemic in the radiology department	Guidelines	To form a centralized task force at the department level to construct policies and strategies in liaison with institutional and international guidelines. Rational and proper usage of personal protective equipment, especially by frontline staff, reduces the risk of nosocomial spread. Proactive human resource management is crucial to ensure services continue at optimal capacity.

Backer JA., *et al*. [2]	Incubation period of 2019 novel coronavirus (2019-nCoV) infections among travelers from Wuhan, China, 20–28 January 2020.	Netherlands	Analytical study	Distribution of incubation periods estimated for travelers from Wuhan with confirmed 2019-nCoV infection in the early outbreak phase	The data used for this analysis has been translated from Chinese sources such as provincial center of disease control.	Incubation period distribution is required to determine the appropriate duration of quarantine. Knowledge of the incubation period helps to assess the effectiveness of entry screening and contact tracing. 88 confirmed cases gave an estimated incubation period for Coronavirus, which helps in identifying the virus and the appropriate quarantine durations.
Cárdenas Camarena L., *et al*. [27]	Elective Surgery during SARs-Cov-2/COVID-19 Pandemic safety protocols with literature review.	Mexico	Literature review	Reduce the effect of infection of SARs-Cov-2/COVID-19 in hospitals.	Reviewed 105 articles and 60 selected for analysis.	Although RT-PCR and Ab tests indicated for COVID-19 diagnosis, there will always be a 10% chance that those might not detect an actual infected patient. Avoid including patients with comorbidities that could worsen the COVID-19 infection. Implementation of prevention and control strict measures in each health care facility where surgeries are scheduled.
CDC [24]	Things to know about the COVID-19 pandemic.	USA	CDC guidelines	COVID-19 information and prevention protocols	Public information from CDC	Comply with precautions to prevent the spread of the virus.
Chaudhry FB., *et al*. [21]	COVID-19: Frontline experience at a tertiary care hospital in UK.	UK	Report study	Understand the huge effort of the frontline in the hospital during the COVID-19 breakout in the UK.	Frontline experience	To support the medical frontline due to the massive stress and efforts during the crises. Psychological impact of the pandemic on staff and suggested strategies.
Cozzi D., *et al*. [11]	Chest X-ray in new Coronavirus Disease 2019(COVID-19) infection: finding and correlation with clinical outcome	Italy	Clinical retrospective study	Chest radiological features of COVID-19 and correlate with the clinical result.	CXRs of patients with clinical–epidemiological suspect of COVID-19 infection. 482 patients were fulfilling the criteria.	CXR in COVID-19 patients shows either patchy or diffuse reticular nodular opacities or consolidation. Portable X-ray machine is very useful, inexpensive and radiographs can be taken to the patient's bedside, reducing radiology department's exposure to infection and minimizing the risk of cross-infection.
Dashraath P., *et al*. [28]	Coronavirus disease 2019(COVID-19) pandemic and pregnancy.	Singapore	Literature review	The clinical features of pregnant women with COVID-19, and a pragmatic and integrated framework that addresses the obstetric complexities of managing this disease in pregnancy.	A review of COVID-19 in pregnancy. Details of Data not mentioned	The role of the equipment protection and protocols decreases the spread of COVID-19. Antiviral therapy and vaccine development, including the novel use of chloroquine in the management of COVID-19. Special precautions are required to minimize cross-infection of healthcare providers while performing procedures.

Davenport MS., *et al*. [29]	ACR Statement on safe resumption of Routine radiology care during the coronavirus disease 2019 (COVID-19) pandemic.	USA	Report Study	Radiology protocols during COVID-19 in the US.	Guidelines	Guidelines and routine procedures are applied for COVID-19 care in Radiology. Strategy for the safe resumption of routine radiology care during the COVID-19 pandemic.
Ding J., *et al*. [9]	Prevention and control measure in radiology department for COVID-19	China	Report Study	Guidelines control measures, and prevention of the spread of COVID-19 in Radiology Department.	Guidelines	**T**he novel coronavirus spreads rapidly through droplet and contact transmission. Radiologists and technologists were possibly infected by patients. Prevention and control measures in radiology department for COVID-19 are important.
Ertl Wagner BB., *et al*. [22]	Preparedness for the COVID-19 pandemic in a tertiary pediatric radiology department.	Canada	Analytical study	The importance of preparation for the radiology departments to cope with the changes with COVID-19.	Guidelines	To evaluate the current situation and cope with challenges. Description and analysis of current processes as basis for discussion for pediatric radiology departments.
Gogna A., *et al*. [12]	Diagnostic Ultrasound Services During Coronavirus Disease (COVID-19) Pandemic.	Singapore	Report study	The protocols that increase the quality of Ultrasound department services during the outbreak of COVID-19	Guidelines	The Ultrasound service providers should comply with the strategies of COVID-19 prevention as they are frontline fighters. Diagnostic US protocol for effective service provision, staff protection, and business continuity planning
Goh Y., *et al*. [8]	Operational strategies to prevent coronavirus disease 2019(COVID-19) spread in radiology: Experience from a Singapore Radiology Department after severe acute respiratory syndrome	Singapore	Report study	Operational guidelines and strategies to limit the spread of COVID-19 among staff and patients.	Guidelines	Adequate portable imaging capabilities, work force demands, and PPE stock. Strict infection control practices, heightened levels of hygiene, and rigorous cleaning. Staff segregations to reduce disease spread.

Huang Z., *et al*. [7]	The Battle against Coronavirus Disease 2019 (COVID-19): Emergency Management and infection Control in Radiology Department.	China	Report Study	Strategy, emergency management and infection control procedure for radiology	Guidelines	Reconfiguration of the Radiology department. Equipment disinfection procedures. The prevention strategies resulted in none of the radiology staff infected by COVID-19 infection.
Khan SH., *et al*. [10]	Coronavirus Disease Analysis using Chest X-ray Images and Novel Deep Convolutional Neural Network.	Pakistan	Analytical study	The role of Chest X-ray to diagnose COVID-19 in order to control the outbreak of the virus.	Images collected from Pakistan Higher Education.	The analysis model provides additional help in patient classification.
WHO [30]	Rational use of personal protective equipment for coronavirus disease 2019 (COVID-19)	World Health Organization	WHO guidance report.	Information about PPE	Public article for PPE	Preventive measures for COVID-19. Optimizing the availability of PPE. Responders must be trained on the use of PPE.
Jakobsson J., *et al*. [31]	Physical Activity During the Coronavirus (COVID-19) Pandemic: Prevention of a Decline in Metabolic and Immunological Functions	Sweden and Norway	Review study	Prevention methods for the Immune system.	Selected articles were reviewed.	To follow the prevention methods to avoid infection and complications of COVID-19. Interrupt prolonged sitting time and reduce sedentariness. Muscle-strengthening and cardiovascular exercises.
Kooraki S., *et al*. [32]	Coronavirus (COVID-19) Outbreak: What the Department of Radiology should know.	USA	Review study	Discuss the epidemiology and the imaging results of the symptoms of coronavirus.	Selected articles were reviewed.	The radiology department should follow the prevention procedures to stop the virus's spread. Precautions and safety measures for radiology department personnel to manage patients.
LaHue SC., *et al*. [33]	Collaborative Delirium Prevention in the Age of COVID-19.	USA	Report study	How to ensure the health of a patient with delirium during COVID-19.	Guidelines	Recommendations for minimizing the risk and duration of delirium in all patients during the COVID-19 pandemic. Integrate technology into the workflow to reduce the isolation felt between patients and family members.

Liang Y., *et al*. [20]	Screening for Chinese medical staff mental health by SDS and SAS during the outbreak of COVID-19	China	Clinical study	Assessing the mental health of frontline staff.	SDS and SAS raw scores of 23 doctors and 36 nurses from COVID-19 associated departments (38 participants) and others (21 participants).	Adequate resting for medical staff can relieve the stress. Essential for medical staff to keep physical and psychological health during our struggle of COVID-19. SDS and SAS were simple tools to monitoring the self-mental health.
Lv M., *et al*. [34]	Chest computed Tomography for the diagnosis of patients with Coronavirus Disease 2019: A rapid Review and Meta-Analysis	China	Review Study	Role of CT for the diagnosis and the main imaging manifestations of patients with COVID-19.	103 studies with a total of 5,673 participants were eligible for inclusion.	The meta- analysis review illustrates the effectiveness of chest CT to diagnose COVID-19 cases. The sensitivity of chest CT scan in COVID-19 is 99% Common imaging manifestation of patients infected with SARS-CoV-2 was GGO with bilateral peripheral distribution.
Jin JM., *et al*. [35]	Gender differences in patients with COVID-19: focus on severity and mortality	China	Clinical Study.	To compare the severity and mortality between male and female patients with COVID-19 or SARS.	43 hospitalized patients, 37 cases of patients who died of COVID-19 and 1,019 patients who survived in China, and data of 524 patients with SARS, including 139 deaths, from Beijing in early 2003.	Coronavirus is a large family of viruses that cause illnesses ranging from the common cold to severe pneumonia, such as SARS, and Middle East Respiratory Syndrome (MERS) Men with COVID-19 are at higher risk of death than women. Gender is a risk factor for higher severity and mortality in patients with COVID-19, independent of age and susceptibility.
Saudi MOH [15]	Radiology Department preparedness plan for COVID-19.	Saudi Arabia	Policies and procedures	List of the policies and professional radiological services.	Guidelines	The radiologist should follow the policies when investigating COVID-19 known/suspected patients to prevent the virus spread.

Mirza SK., *et al*. [36]	Microbiology for radiologists: How to minimize infection transmission in the radiology department.	USA	Report Study	Ways of transmission of infection-to prevent spread to the radiology staff.	Guidelines	Routes of Disease Transmission. Transmission based precautions. Safe handling of specimens.
Basha MM., *et al*. [19]	Radiology department preparedness for COVID-19: Radiology Scientific expert reviews panel.	USA	Report study	Priorities for COVID-19 preparedness in different hospitals.	Guidelines	To achieve sufficient capacity for continued operation during a health care emergency of unprecedented proportions. To support the care of patients with COVID-19. To maintain radiologic diagnostic and interventional support for the entirety of the hospital and health system.
Pan W., *et al*. [23]	Mental state of central sterile supply department staff during COVID-19.	China	Survey study	Lists the factors that affect the general mental health during the COVID-19 crises in China.	423 CSSD staff members from 35 Secondary A or above hospitals in Sichuan Province, China. 423 questionnaires were distributed, and 423 valid questionnaires were returned.	Factors for resilience, perceived stress, and anxiety for CSSD staff. The medical staff was under massive stress during the COVID-19, which required mental health attention. CSSD staff was at risk of being infected with the novel coronavirus through occupational exposure
Qu J., *et al*. [16]	Infection control for CT equipment and Radiographers' personal protection during the coronavirus Disease (COVID-19) Outbreak in China.	China	Report study	Investigate the infection prevention and control management of CT	Guidelines	Modifications to the CT examination process, including disinfection protocol to enhance the overall imaging. Disinfection of CT Examination rooms. Personal protection of radiographers.
Rab S., *et al*. [37]	Face masks are new normal after COVID-19 pandemic.	India	Letter to the Editor	Highlight the importance of wearing masks in different countries	Guidelines	Wearing masks will be expected after the COVID-19 pandemic. Medical or homemade masks for general public use and N95 masks for health care professionals are suggested by WHO. Mask-wearing in a public place seems one of the most effective ways to stop the spread of the virus when compliance is high.

Raptis CA., *et al*. [38]	Chest CT and coronavirus Disease (COVID-19): A Critical Review of the Literature to Date.	USA	Literature review	Examine studies to determine whether CT image can detect COVID-19 pneumonia.	Selected articles were reviewed.	CT can be utilized for the assessment of COVID-19 complications of pneumonia. Sensitivity of CT in detecting coronavirus Diseases pneumonia. Specificity of CT in detecting coronavirus Disease pneumonia.
Shen X., *et al*. 14]	Coronavirus disease 2019: MRI examination procedures and infection prevention and protection.	China	Clinical study	Examine strategies to prevent COVID-19 among medical staff and infected patients.	Data collected from cases and infection control experts.	MRI infection control procedures can minimize the infection risk. The infection prevention and protection are recommended for MRI scan, including layout requirements in the MRI room, preparation before admission, preparation of medical staff, preparation of patients, and terminal disinfection after an examination.
CDC [5]	Similarities and Differences between Flu and COVID-19 (2020).	USA	CDC Report	COVID-19 information and prevention protocols.	CDC public information.	Flu complications are higher for children than COVID-19 infection.
Society of Radiographers [13]	Obstetric ultrasound examination during the COVID-19 pandemic	UK	Joint statement/ report	Guidelines for Ultrasound practice during COVID-19.	Joint report of recommendations for the Ultrasound practice.	The recommendations and guidelines are important for the Ultrasound service providers.
CDC [1]	Coronaviruses Fact Sheet	USA	CDC Report	COVID-19 information and instructions.	Public information	Wash your hands often with soap and water for at least 20 seconds. Cover your nose and mouth with a tissue when you cough or sneeze and then throw the tissue in the trash. Stay home when you are sick, except when you need to get medical care. Avoid close contact (such as kissing, sharing cups, or sharing eating utensils) with people who are sick.
Wang Z., *et al*. [39]	Survival analysis of hospital length of stay of novel coronavirus (COVID-19) pneumonia patient in Sichuan, China.	China	Retrospective clinical cross-sectional study.	The required medical resources for the admitted COVID-19 cases in the hospital.	538 confirmed patients of COVID-19 infection in Sichuan Province from January to March 2020.	Resources play a vital role in clinical preparation to control the affected areas with COVID-19. Preparation control measures of COVID-19 should involve the allocation of sufficient medical resources.

WHO [40]	Coronavirus disease 2019 (COVID-19) Situation Report – 82	World Health Organization	WHO report	Report on the recent COVID-19 statistics.	WHO public report of COVID-19.	Cases statistics of different countries.
WHO [41]	COVID-19 strategy update.	World Health Organization	WHO report	Describe the COVID-19 update strategies in the world.	WHO public report.	COVID-19 invaded the world and affected the socioeconomic status.
Wu K., *et al*. 42]	Generalized logistic growth modeling of COVID-19 outbreak: comparing the dynamic in the 29 provinces in China and in the rest of the world.	Switzerland	Analytical study	Models to estimate the COVID-19 impact from china to other countries.	The data source is the national and provincial heath commission. For international data, the source is WHO.	Continuing containment measures will reduce the rapid growth of COVID-19 drastically. A strong correlation between the initial and total confirmed numbers of infected cases and travel index quantifying the mobility between provinces.
Yang Z., *et al*. [4]	Distinguishing COVID-19 from influenza pneumonia in the early stage through CT imaging and clinical features	China	Clinical study	Differentiate between COVID-19 and Influenza.	73 consecutive patients confirmed with severe acute respiratory syndrome.	The crazy paving is crucial for differentiation between the cases. The bronchial wall thickening was proved to be not significantly different between influenza and COVID-19 pneumonia. To evaluate the significant statistical difference of CT imaging and clinical features between COVID-19 and influenza pneumonia.
Yin Z., *et al*. [6]	A Comparison of Clinical and Chest CT Findings in Patients with Influenza A (H1N1) Virus Infection and Coronavirus Disease (COVID-19).	China	Clinical study	Compare (H1N1) pneumonia and (COVID-19) pneumonia.	Thirty patients with diagnosed influenza A (H1N1) virus infection (group A) and 30 patients with diagnosed COVID-19 (group B) were retrospectively enrolled.	Linear opacification, crazy-paving sign, vascular enlargement, pleural thickening, and pleural effusion, were more common in patients with COVID-19 pneumonia. Bronchiectasis and pleural effusion, which were more common in patients with influenza A (H1N1) pneumonia.

Table 1: Summary of the reviewed articles.

Conflict of Interest

This is to confirm that the authors and the institution have no financial or conflicts of interest.

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