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Management of infection control and radiological protection in diagnostic radiology examination of COVID-19 cases

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ABSTRACT

Since the COVID-19 outbreak, diagnostic imaging has been providing valuable radiological support for disease diagnosis and prognosis prediction. Radiological staff, especially radiographers working on the front line in the battle against the COVID-19 outbreak. They are in direct contact with the patients, bearing the responsibility and pressure of both the infection prevention and control and the radiation protection. A number of relevant professionals and experts reached a consensus, which clarifies the detailed implementing rules with respective to infection control and protection of the radiation workers, disinfection of diagnostic radiology equipment and workplace, and radiological protection. The aim is to further normalize the clinical procedures of radiological staff, reduce the infection risk, especially the radiation risk to medics and patients.

Since later December 2019, the outbreak of novel coronavirus pneumonia (COVID-19), which was first reported in Wuhan city of Hubei province, has spread rapidly across China. By January 25, 2020, all but Tibet of provinces, municipalities and regions on the Chinese mainland have announced to launch Level-I public health emergency response. Radiographers in hospitals at all levels are among those on the forefront of provinces, municipalities and regions on the Chinese mainland have announced to launch Level-I public health emergency response. Radiographers in hospitals at all levels are among those on the forefront.

The first to sixth versions of the Diagnosis and Treatment Program of the COVID-19 Cases issued by the National Health Commission clearly defined the important role of medical imaging in the diagnosis of suspected cases and clinically diagnosed cases.2 Computed tomography (CT) and digital radiography (DR) are two important imaging modalities for clinical screening, diagnosis and disease assessment of patients infected with COVID-19. For the most critically ill patients or hospitals without equipped CT scanner, the digital radiography is used to the diagnosis and prognosis prediction of the disease. Clinical practice has found that CT scanning has indispensable advantages for early diagnosis of COVID-19 cases. In the preliminary screening, diagnosis and evaluation of the disease, almost all patients need one or more diagnostic imaging examinations, so the infection prevention and control and radiation protection for patients and radiographers should attract attention. With the rapid spread of the epidemic, the demand of patients for diagnostic examination is increasing rapidly. Thus, large numbers of CT and DR equipment need to be added in medical institutions. Especially in Wuhan city and other districts of Hubei province where the epidemic situation is severe, dozens of temporary hospitals have been built, and then some novel devices like vehicle-mounted and in-cabin CT equipment have emerged. Therefore, it is necessary to formulate the radiation protection requirements for these venues to ensure the quick, safe and effective use of them.

For the purpose, this document is formed after discussions by the experts in many fields such as radiological technology, diagnostic...
radiology, radiation medicine and protection, and occupational health and disinfection.

1. Infection control and prevention requirements for radiological staff

1.1. Basic requirements

Radiographers are among the frontline medics at high risks due to their direct and close contact with patients during their work. They must meet the following requirements:

- Raising their awareness of self-protection and receive focused training from medical institutions.
- Being proficient in the knowledge, methods and skills in the battle against COVID-19 complying with the requirements for infection control and prevention formulated by the related hospitals for the workers of radiology departments, especially radiographers.
- Being familiar with the requirements for level of infection control and prevention at different posts, the related types of protective articles and their uses, and the requirements and methods for disinfection of personnel, equipment and places.3
- Being familiar with their respective teams’ members and tasks in containing the current epidemic, familiar with the contingency plan for emergencies and the workflow of imaging examinations for fever, suspected and confirmed patients.
- Being familiar with the infection control zones divided in the workplace where they are in, work in the defined zones in strict accordance with the requirements, and not illegally cross or confuse the zone boundaries in effort to reduce the risk of cross infection.
- Being familiar with the normalized procedures and relevant requirements for using, wearing and undressing the protective suits and supplies, while insisting on the "seven-step hand-washing method" and strictly implementing hand hygiene operation.4
- Instructing patients to wear disposable surgical mask and other protective suits and supplies during examinations, preceded by unaffected imaging process and image quality,
- Reasonably arranging the examinations for patients to reduce their waiting time in diagnostic examination location and minimize their overlapping and intersection in imaging room or waiting area.
- Avoiding close face-to-face communication with the patients as much as possible, and keep a distance of more than 1 m away from the patient except for positioning.

1.2. Levels for infection prevention and control during diagnostic examination

General protection

It is suitable for workers who are far away from patients such diagnostic room, post-processing room and information management room. This requires to wear disposable protective cap, disposable medical surgical masks and working clothes, while paying attention to hand hygiene.

Level I protection

It is suitable for workers who work with review triage, registry, film delivery, ordinary X-ray examination for non-fever patients. They should wear disposable protective cap, disposable medical surgical masks (N95 type or higher level medical protective masks while in contact with patients having epidemiological history), working clothes (added isolation gown when in contact with patients experiencing epidemiological history), disposable latex gloves if necessary, meanwhile strictly implementing hand hygiene.

Level II protection

It is applicable for close-range operators who carry out diagnostic examination of suspected or confirmed patients admitted in the fever, infection, respiratory clinics, isolation wards, special radiological rooms and other sites. They should wear disposable working cap, N95 or higher level medical protective face masks, goggles/protective screen, disposable latex gloves, medical protective clothing (added wear isolation gown when in isolation ward), disposable shoe covers and boot covers, plus strict implementation of hand hygiene.

Level III protection

It is suitable for close-range operators who carry out X-ray examination for suspected or confirmed severe patients under the condition of long-term exposure to high concentration aerosol in the relatively closed environment. On the basis of second-level protection, wear protective screen, goggles or comprehensive respiratory protector or positive pressure headgear, and strictly implement hand hygiene.

The determination of infection prevention and control level shall be dependent upon the type of patients contacted and the degree of risk exposed to patients instead of only being limited to the specific workplaces mentioned above.

1.3. Workers in conventional X-ray examination room

The workers here should be subject to Level I protection, wearing disposable gloves. Even N95 face masks and protective suits are needed in the case of carrying out examinations of the patients with epidemiological history or suspected patients.

They should provide instructive guidance on the patients, such as breath holding and other related training, by using the intercom system in the examination room as much as possible on the premise of ensuring the protection of patients.

They should immediately inform the diagnostic physician of the suspected case that has found during examination for further confirmation. Suspected case should be reported upward according to the relevant procedure and meanwhile the disinfection must be conducted for the floor, equipment and air within the X-ray room. The technologists should replace their protective suits, and implement the hand hygiene procedure.

1.4. Workers in dedicated diagnostic examination room

When two radiographers co-work in a diagnostic X-ray examination room, the one who is responsible for positioning will subject to Level II protection because of her or his direct contact with the patient in an infection area. However, another one working on the operator’s console can follow the Level I protection for her- or him-self, depending on actual situation: if the examination room is dedicated to screening fever patients, she or he can perform the Level I protection; but when the room is purposely-set for suspected and confirmed patients, she or he must implement Level II protection. Can a radiographer be subject to Level III protection, only when he has to directly contact with suspected or confirmed critically ill patients due to handling the patient’s neck and chest at short distance.

Nurses working with patients should be subject to Level II protection when they come into close contact with the patient in need of being injected with contrast agent for diagnostic other purposes. When they have to directly contact with suspected or confirmed critically ill patients for purpose of handling the patient’s neck and chest at short distance, Level III protection is prerequisite.

Suspected or confirmed patients must be accompanied by specially-designated person observing the relevant plans and requirements provided for by the hospital where they are in, when they are going for diagnostic examination in a dedicated X-ray room through dedicated channel.

In case of critically ill patients, the imaging bed shall be paved with the disposable waterproof quarantine sheet, which shall be replaced once for each patient. Quick-drying disinfectant for hand hygiene should be
used immediately after touching the patient.

Instructive guidance should be provided on the patients, involving breath holding and other related training, by using the intercom system in the X-ray room as much as possible on the premise of ensuring the protection of patients.

Radiographers, on the operator’s console, should have the remote CT scans on COVID-19 cases to be conducted by making the best of the intelligent positioning system and the bed-lifting system on the premise of ensuring the protection of patients and meeting imaging requirements. After the CT scans are completed, patients should be first allowed to be off from the bed, followed by completing the relevant post-processing, so as to reduce the patient’s stay in the examination room.

1.5. Radiographers in fever, infection and respiratory clinics

Radiographers working in such clinics should be strictly subject to Level II protection, with the double-layer gloves being worn and the quick-drying disinfectant used immediately for cleaning their hands after contacting patients each time.

They should gather patient information, prescribed imaging parameters and adjust tube position as well as other relevant operations prior to the mobile DR imaging, alongside with instructing the patient’s cooperation for the positioning for the purpose of completing the smooth examination.

In the case of the imaging room with fixed DR and CT equipment on site, they should follow such protection requirements as being provided for in “Workers in dedicated diagnostic examination room” (Section 1.4).

1.6. Radiographers in quarantine wards

Radiographers working in quarantine wards should be strictly subject to Level II protection, with the double-layer gloves worn and disposable isolation gown added. When having to directly contact with suspected or severe confirmed patients for purpose of handling the patient’s neck and chest at short range, they must be subject to Level III protection.

They should gather patient information, pre-set imaging parameters and adjust tube position as well as other relevant operations prior to the mobile DR imaging, meanwhile directing the patients who are able to move to act following the positioning requirements and asking the nursing workers to assist the patients who cannot move in positioning, so as to complete the smooth examination.

In the case of the imaging room with fixed DR and CT equipment, they should be follow such protection requirements as being provided for in “Workers in dedicated diagnostic examination room” (Section 1.4).

Radiographers working in the quarantine ward should be full-time medics who must work and live in the quarantine venues designated specially in a hospital. After having worked for some consecutive days, such as 14 days, they have to be placed under quarantine for another 14 days. They are permitted to return to normal work and life only no abnormality is found after the end of quarantine period of time.

1.7. Workers in registry, film pick-up office and other workplaces

Workers in these workplaces should be subject to Level I protection. However, when the efforts to fight the infection need to be intensified due to complicated variety of patients and degraded working environment, they should wear protective suits, goggles, and/or protective face screen.

Radiologists should be subject to the General protection. However when they have accessed to the relevant venues or come into contact with patients, the necessary protection levels they would be subject to will vary depending on the actual conditions encountered.

2. Requirements for disinfection of diagnostic equipment and examination room

2.1. Basic requirements

Fever, infection and respiratory clinics; dedicated X-ray room of radiology department; and quarantine wards, are all the key areas which need to be brought under the control and disinfection during diagnostic X-ray examination.

Dedicated mobile and/or fixed DR/CT equipment and purposely-set diagnostic examination room should be provided for the suspected patients treated in fever, infection and respiratory clinics and the confirmed patients in quarantine wards. Or, dedicated CT scan room and fixed DR room should be set as necessary in the department of radiology.

The newly-built infection departments and/or fever clinics should be equipped with dedicated fixed DR room whereas those with good condition should have special-purpose CT scanning room as priority. The layout of these facilities should be arranged in terms of “three subareas and two channels”, i.e. infected, semi-infected and clean subareas, patient channel and medical worker channel. Concurrently, consideration should be taken of the rapid transition between epidemic and non-epidemic functions in design of these facilities for the purpose of higher utilization efficiency.

As required for infection prevention and control, the dedicated X-ray room in a hospital should be definitely divided into infected, semi-infected and clean subareas. If possible, a buffer belt should be available between semi-infected and clean subareas with strict disinfection measures implemented.

Suspected and confirmed patients are required to move forward, with accompany of designated person, to the dedicated diagnostic X-ray room via special route and area and not permitted to radiology department by themselves for any purpose. Suspected patients are not allowed to be examined along with confirmed patients.

If no dedicated X-ray room to be used, diagnostic examination must be conducted within specified time on a batch-to-batch basis in an ascending order of risk from ordinary outpatient, high-risk fever outpatient to the suspected and confirmed patients in quarantine wards, concurrently accompanied with strict disinfection measures.

In diagnostic X-ray room and operator’s room, the plans, methods and procedures concerning infection control and disinfection of individuals, equipment and workplaces should be posted on the appropriate positions, including the requirements for infection control and prevention subareas divided in the workplace.7

As much network transmission of electronic application forms, digital images and diagnostic reports as possible should be used to reduce the direct contact with patients and infectant.

2.2. Disinfection methods for diagnostic examination room

Wipe disinfection

It is intended to disinfect material surface using 75% ethanol or 500 mg/L chlorine-containing disinfectant, except chlorhexidine, the same below, and to wipe floor using 500 mg/L chlorine-containing disinfectant. Material surface or floor, where infectant have been found and identified to be the infectious sources to the suspected or confirmed cases, should be wiped using 1,000 mg/L chlorine-containing disinfectant after such infectant is cleared.7

Ultraviolet disinfection

It is used for disinfection of air indoors. Ultraviolet light lamps installed should be not less than 1.5 W/m² in quantity and not less than 70 μW/cm² in intensity. The area to be disinfected is limited to the area covered by the ultraviolet light.

Spray disinfection

It is used for indoor air disinfection by atomizing or spraying or
fumigating with 400–600 mg/L chlorine dioxide, or 5,000 mg/L per-acetic acid or 1,000 mg/L chlorine-containing disinfectant.

**Immersion disinfection**

It is mainly used for the disinfection of goggles through being immersed in 500 mg/L chlorine-containing disinfectant or 75% ethanol for more than 30 min.

After the end of diagnostic examination, site-specific terminal disinfection needs to be carried out by following the below methods. The first is to use electric aerosol sprayer to spray disinfectant within the examination room at horizontal direction, at 1 m above the ground, from inside to outside, in an used quantity of 30 mL/m², and under the not-less-than 30 min closed condition. The second is since to apply the wipe disinfection methods to the apparatus and devices, especially the places with which patients and medical workers could come into contact amid examination. The third is to, after wiping, carry out the second spray disinfection under the 30 min closed condition and then open for ventilation for the next use in examination.

Both the disinfection methods for diagnostic equipment and the disinfectants permitted by manufacturer should be used by reference to the instructions recommended by its manufacturers, especially for use in CT imaging room. If permitted, the spray disinfection can be conducted with prescribed amount as recommended by the manufacturer after turning off power. Re-start of equipment can begin after disinfectant disappearing in air through opened door and window for ventilation.

The machines, devices or equipment, for which peroxide-like disinfectants are forbidden by the manufacturer to carry out terminal disinfection, should be exposed to ultraviolet light for 30 consecutive minutes. After the end of ultraviolet light exposure, the wipe disinfection method can be introduced to the equipment surface and indoor environment. After the end of wipe disinfection, ultraviolet light exposure should continue for another 30 consecutive minutes for the next use in examination.

2.3. Disinfection of conventional diagnostic X-ray examination room

**Equipment disinfection**

This should be done by using the wipe disinfection method whenever infectant is found or when suspected patient are treated. Infectant visible to the naked eye, if any, can be firstly cleared using disposable water-absorption materials, such as gauze dipped with 500 mg/L chlorine-containing disinfectant, and then wiped for disinfection.

**Facility disinfection**

This is to use the wipe disinfection method to clean internal and external door handles, radiation shielding articles, console panels, console screens, keyboards and mice in the room at least twice a day.

**Floor disinfection**

This is to clean floor through wet wipe disinfection normally at least once a day, but moment by moment whenever infectant is found. The conventional disinfection should be conducted after the visible infectant completely cleared.

**Air disinfection**

This can be achieved by increasing ventilation frequency and keeping good ventilation. Indoor air should be exposed to ultraviolet light for 30 min each time, at least twice a day, followed by ventilation through opened door and window. In the case of suspected patient the terminal disinfection measures should be implemented.

2.4. Disinfection of dedicated diagnostic examination room

**Equipment disinfection**

This is conducted through wipe disinfection at least 3 times a day, with emphasis on the areas where patients could contact with beds, detectors and gantry, but moment by moment whenever infectant is found. Infectant visible to the naked eye, if any, can be firstly cleared using disposable water-absorption materials, subsequently followed by the routine disinfection. The infectant attributable to suspected or confirmed COVID-19 cases should be cleared cautiously by using gauze dipped with 5,000 mg/L chlorine-containing disinfectant, except chlorhexidine; if with a large amount, the infectant should be first covered fully with the water-absorbent-containing disinfectant powder or bleaching powder, or otherwise, after such a full cover, pouring 5,000 mg/L chlorine-containing disinfectant upon the water-absorbent waiting 30 min for further cleaning. During the cleaning process, the contact with infectant should be avoided, with the cleared infectant being treated as if medical wastes.

**Facility disinfection**

It is intended to clean, through wipe disinfection, internal and external door handles, radiation shielding articles, console panels, console screens, keyboards and mice in the room, at least 3 times a day.

**Floor disinfection**

It is intended to use wet wipe disinfection to clean floor, normally at least 3 times a day, but moment by moment whenever infectant is found. The routine disinfection should be conducted after the visible infectant completely cleared.

**Air disinfection**

It is intended to use the disinfecting devices with air-circulation function for lasting disinfection under the condition of diagnostic examination equipment operation. However, in the case of non-operation condition, spray disinfection (by reference to manufacturer’s recommendations) or ultraviolet irradiation is needed for 30 consecutive minutes, at least 3 times a day, followed by good ventilation by the aid of increased ventilation frequency.

The above-mentioned disinfection measures apply to the diagnostic X-ray rooms solely dedicated to the suspected and confirmed patients. For those solely dedicated to screening fever patient, the above disinfection measures also apply here routinely. However, in the case of suspected cases, the terminal disinfection above described should be implemented immediately.

For diagnostic X-ray room commonly used by conventional, fever and infected outpatients, along with suspected and confirmed patients admitted in quarantine wards, the diagnostic examination must be conducted within defined period of time on a batch-to-batch basis in an ascending order of patients’ infection severity. When conventional and/or fever outpatients are diagnosed as suspected cases, or otherwise after the suspected and confirmed patients completed their examinations, terminal disinfection measures should be activated at once.

Both X-ray room and operator’s console room must be equipped with separate, rather than central, air conditioners.

The disinfection measures mentioned above also apply to not only the disinfection of vehicle-mounted CT scanners but also the CT equipment room in makeshift hospitals.

2.5. Disinfection of diagnostic X-ray equipment in fever, infection and respiratory clinics

After the examination by mobile DR equipment is completed, the wipe disinfection can be applied to the equipment surface, especially for the areas where patient could be involved with, including detectors and radiation shielding articles, or necessary confinement and isolation should be implemented in advance by using disposable plastic bags. If suspected case is found the wipe disinfection should be applied to the surface of the whole equipment.

For the separately built diagnostic X-ray rooms, the disinfection measures designed for the dedicated diagnostic X-ray examination room should be applied. If suspected case is found, the terminal disinfection
should be implemented at once.9

When the mobile DR equipment needs to be moved out of the fever or other clinics for use, the entire surface of the equipment needs to receive the wipe and disinfection and then be exposed to ultraviolet light for more than 30 min before use.

2.6. Disinfection of diagnostic X-ray examination equipment in quarantine wards

Amid moving the mobile DR equipment out, the areas where patient could be involved with, including detector and radiation shielding articles, should be confined and isolated in advance by using disposable plastic bags, or otherwise, receive the wipe disinfection after examination.

For separately-structured X-ray rooms, the disinfection measures designed for dedicated diagnostic X-ray examination room should be applied.

When the mobile DR equipment needs to be moved out of the fever or other clinics for use, the entire surface of the equipment needs to receive the wipe disinfection and then be exposed to ultraviolet light for more than 30 min before use.

2.7. Disinfection of registry, film pick-up offices, and other workplaces

Facility disinfection

It is intended to clean, through wipe disinfection, the desktop of workplace, the window and windowsill that patients could potentially contract with, door handles, keyboards and mice, self-service printers for radiographs and diagnostic reports alike, at least twice a day. Paper application forms must be intercepted at the registry to be disposed of in a safe manner, without transition permitted to the downstream workplaces.

Floor disinfection

It is intended to use wet wipe disinfection to clean floor normally at least 3 times a day, but moment by moment whenever infectant is found.10

3. Radiological protection requirements during diagnostic X-ray examination

Since the radiography is indispensable for diagnosis of COVID-19 cases and prediction of prognosis, almost all suspected patients have to undergo diagnostic examination in clinical practice, with many frequently having experienced repeatedly CT examinations in a short time period. Most recently, a large number of CT equipment have been installed at hospitals in Wuhan city, and many radiographers have also come from all over the country to provide support. However, although such examinations are necessary, the justification of practices, one of the three principles of radiological protection, should be taken into consideration in epidemic prevention and control.

Walter Ian Lipkin, a virus biologist with Columbia University who is praised as the “virus hunter” by the international medical community, said in an interview after his visit to China that he disapprove of massive screening with CT equipment because of the potential risks of radiation.11 Radiological protection is also one of the important matters worthy of attention in the fight against the coronavirus epidemic.

3.1. Basic requirements

Only in the case where patients could have been reasonably diagnosed with virus infection based on their epidemic contact history and physical signs, can diagnostic X-ray examinations be justified. Diagnostic X-ray examination should not be applied to screening normal populations without history of contact and changes in physical signs. A diagnostic X-ray examination, if unable to provide necessary support to the decisions for diagnosis and treatment, will be unnecessary.

During diagnostic X-ray examinations, especially CT scanning, it is necessary to make sure the shielding protection of patients, especially for sensitive populations like children and women of childbearing age under the relevant national laws, regulations and standards. On the premise of ensuring image quality, attention should be paid to optimizing imaging parameters and minimizing the radiation doses to sensitive populations.

The cumulative dose received by the patients who have undergone repeated diagnostic examinations, especially CT scanning, in a short time period should be recorded to evaluate the justification of further examinations.

Radiation workers can go to their posts only after receiving radiation protection training, meanwhile wearing personal dosimeters for external radiation exposure monitoring.

For a diagnostic room newly installed with X-ray equipment, full consideration should be taken of the protection and safety of the workers in adjacent rooms, including upstairs and downstairs, and the surrounding workplaces. Meanwhile the workplace protection monitoring should be carried out to ensure qualified protection of facilities and equipment, which should be in consistent with the relevant National Standards GBZ130-2013.12 At the same time, the radiological equipment should be subject to performance acceptance test, which can be put into use only after passing the test.

Under both the notice issued by the General Office of the Ministry of Ecology and Environment on February 1, 2020 and that by the National Health Commission on February 6 in the same year, the newly added diagnostic imaging equipment is exempt, amid the battle against epidemic, from a combination of environmental impact assessment, radiation safety licensing, as well as the those required for the diagnostic radiology and radiotherapy technology and the medical radiation institutions. However, after the epidemic is contained, theses processes must be additionally completed in line with the relevant regulations.13,14

3.2. Radiological protection requirements for mobile DR equipment

When using mobile DR equipment for examination in an area, like fever clinic, where no dedicated diagnostic examination room is built, the persons around such an area should be informed to go away as far as possible. Additionally, there should be no other persons in the main direction of radiation beam.

When using mobile DR equipment for X-ray examination in a quarantine ward, protection measures should be taken for the patients in the adjacent beds within 2 m of the DR equipment, while irradiation beam should not be directed towards other patients.

The length of the cable connecting the exposure switch should be not less than 3 m, or otherwise, a remote control/delayed exposure switch has to be equipped.

Exposure field must be adjusted strictly to focus on specific part of patient’s body, allowing the radiation beam to be limited within the range defined by clinical procedures and to ensure to match the image detector. Doing so can not only reduce the radiation dose to the examined and the surrounding workers, but also greatly reduce the scattered radiation and improve the image contrast.

Critically ill patients with COVID-19 show serious lung exudation as a whole, with high tissue density and very low contrast. Especially for obese patients, the tube voltage should be adjusted up, for example, to 65–70 kV and tube current up to 10–15 mAs. For children, the suitable radiography conditions should be chosen based on their age and body shape, for example, 55 kV, 1–2 mAs for children aged 3–5 years.

3.3. Radiological protection requirements for fixed DR equipment

The exposure field should be strictly controlled, using high voltage of above 100 kV and automatic exposure mode for radiography, to allow facilitated discovery of early patchy exudation in COVID-19 cases. For children patients, automatic exposure mode is recommended for
radiography with lower voltage of about 80 kV, for example.

3.4. Radiological protection requirements for fixed CT equipment

For the purpose of radiation protection, the shielding of a CT equipment room should be designed as required by the National Standards GBZ130-2013. Shielding thickness should be not less than 2.5 mm Pb equivalent owing to the heavy workload of CT scanning during the coronavirus epidemic. The CT scanning should be conducted within strictly-controlled scope, meanwhile urging patients to hold breath to the full extent practicable. For patients with short breath holding time, scanning should be carried out in the order from foot to head.

COVID-19 patients are required to undergo repeatedly chest CT scanning in a short period of time. The first scanning can be performed at routine dose by using the automatic tube voltage, or manually selecting voltage low to 100 kV, and tube current modulation technology. For the patients undergoing repeated examinations, it is recommended to use low dose scanning technology so as to increase the level of image noise level or iterative reconstruction algorithm. Radiation dose should be kept as low as reasonably achievable, for example, effective dose below 1 mSv, without compromising image quality required.

3.5. Vehicle-mounted and in-cabin CT equipment

For the purpose of the battle against the COVID-19 epidemic, novel special CT imaging devices, like vehicle-mounted and in-cabin CT scanners, have emerged in response to clinical needs. Under the National Standards the Notice of the General Office of the National Health Commission on Providing Service Assurance for Safety Regulation of Radiological Procedures in Containing the COVID-19 (GBWZJ-2020-110), the qualified radiological technology service institutions should be entrusted to test the newly added radiological equipment for diagnosis and treatment, in order to make sure that the venues where diagnostic and treatment equipment to be placed to meet the requirements of the national relevant regulations, standards and specifications concerning radiological protection and safety and radiological procedures.

The newly-added radiological equipment for diagnosis and treatment, that are intended for continued use after the coronavirus is contained, should be licensed by the relevant regulatory authorities responsible medical uses of nuclear technology under the national relevant laws and regulations.

The radiation protection for vehicle-mounted CT equipment should be performed by the reference to the National Standards Radiological Protection Requirements for Vehicle-mounted Medical X-ray Diagnosis System (GBZ 264–2015).

The parameters required for CT imaging have the similarities with those for fixed CT equipment. With account taken of their smaller size along with special building materials and structures, the requirements for radiation protection shielding of the in-cabin CT room or vehicle-mounted CT room should be slightly higher than for fixed CT room, including the roof and floor, which are not ignored. The limit value imposed on radiation leak from the diagnostic equipment room should be in consistent with the requirements of National Standards GBZ130-2013.

In conclusion, this document presents a detailed description of the disinfection measures and protective materials prone to getting fusible in diagnostic imaging amid the COVID-19 epidemic providing the frontline radiographers with the guidance and suggestions on how to use them in clinical practices. At the same time, specific requirements and solutions are provided to the problems worthy of attention in radiological protection, with suggestions provided on the reasonable arrangement of diagnostic X-ray examinations.

Declaration of competing interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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