

Review Article

Reopening the country: Recommendations for nuclear medicine departments

ABSTRACT

The best practices for nuclear medicine departments to operate safely during the COVID-19 pandemic have been debated in the literature recently. However, as many governments have started to ease restrictions in activity due to COVID-19, a set of guidelines is needed to resume routine patient care throughout the world. The nonessential or elective procedures which were previously postponed or canceled during the COVID-19 pandemic will gradually restart in the following weeks despite the continued risks. In this paper, we aim to review some of the most effective general precautions to restart the regular nuclear medicine operations safely.

Keywords: COVID-19, nosocomial transmission, nuclear medicine, patient safety, positron emission tomography-computed tomography, precautions, reopening, SARS-CoV-2, ventilation/perfusion scintigraphy

INTRODUCTION

Since December 2019, a novel coronavirus respiratory disease (COVID-19), which was first reported in Wuhan (China), has raised global public health concern. Since early February 2020, COVID-19 has been declared a public health emergency by the World Health Organization, with the number of confirmed cases continually rising worldwide. As of June 29, 2020, over 10 million COVID-19 cases with >500,000 deaths have been recorded in >200 countries and territories.^[1] The majority of patients present with fever and cough and mostly represent bilateral multifocal pulmonary lesions.^[2] COVID-19 is assumed to be transmitted-via respiratory droplets during unprotected close contact with infected patients, and possibly through contaminated surfaces in health-care settings.^[3]

The current unexpected surge of COVID-19 patients poses a significant threat to international health-care services, including nuclear medicine departments. As in other eras of practice, nuclear medicine centers are dealing with the great risk of acquiring and transmitting infection due to close contact with patients and long hours spent within departments during the uptake phase. Furthermore, due

to preexisting medical conditions such as cancer and cardiopulmonary disease, nuclear medicine patients are among the most vulnerable groups during the ongoing pandemic. Hence, nuclear medicine physicians are preparing to adopt a new norm for their operations as they plan for the future. Vigorous policies need to be put in place to support patients with COVID-19 while maintaining standard services for other patients. Moreover, to deliver high-quality care for

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our patients, the health of our workforce should be made high priority under these regulations.

Several articles have debated the best practices for nuclear medicine departments to operate as safely as possible during the unfolding COVID-19 pandemic.^[4-13] Implementation of a robust COVID-19 screening plan for staff and patients, cleaning and disinfection protocols for medical equipment, appropriate use of personal protective equipment (PPE), social distancing, and hygiene measures are among the most important strategies during the ongoing crisis. However, as many governments have started to ease restrictions inactivity due to COVID-19, a set of guidelines is needed to resume routine patient care throughout the world. The nonessential or elective procedures which were previously postponed or canceled during the COVID-19 pandemic will gradually restart in the following weeks despite the continued risks.^[13] Hence, strong safety measures must be imposed to protect both staff and patients in the department. This paper will review some of the most effective general strategies to restart the daily nuclear medicine operations safely, as shown in Tables 1 and 2.

GENERAL CONSIDERATIONS

The following recommendations are preferred to remain in place until the risk is halted (A-E):

A. Before arrival (making appointments/consultation)

To minimize unnecessary movement and congregation of patients within nuclear medicine care facilities, teleconsultation before attending the center is still paramount, until situation changes. Patients should be asked to come alone, if possible, to minimize overcrowding in the workplace or at reception desks. Exceptions can be made in certain situations for those who may need additional help.

Nonurgent imaging or procedures (level 3) should be deferred only in known/suspected COVID-19 patients until considered noncontagious.

All frontline personnel should receive the proper education on COVID-19 symptoms to detect the patients with suspected infection early. All employees must be aware of

Table 1: A suggested approach for reopening nuclear medicine operations, based on the level of their urgency, in patients without SARS-CoV-2 infection

Level of urgency	Time interval	Recommended precautions
Level 0	Emergent: Needing an immediate test	<p>V/P scintigraphy (only if clinically indicated)</p> <p>All suspected cases should undergo portable X-ray imaging initially. If lung opacification is present, the patient should be referred for CTPA. Only if CTPA is contraindicated, V/P scintigraphy is obtained^[14]</p> <p>In case of a normal perfusion scintigraphy, PTE is ruled out, and no ventilation scintigraphy is needed</p> <p>All the personnel should follow the recommended PPE for COVID-19 pneumonia, including an N95 respirator or higher, medical mask, apron, gown, gloves and eye protection with Googles^[15]</p> <p>Create a negative airway pressure in the procedure room relative to the hallway if possible^[9,12]</p> <p>After cleaning: Use intensified disinfectant protocols (e.g., 70% isopropyl alcohol, chlorine-based products...) for the scanner, the procedure equipment, the procedure room surfaces, and the viewing station^[3,16]</p> <p>All other emergent investigations (e.g., MPS in recent ACS or preoperative evaluation, GI bleeding, Meckel)</p> <p>Consider discussion with referring provider</p> <p>Perform the test as scheduled, with extra-precautions and minimum staff</p> <p>Use proper PPE including surgical mask and gloves</p> <p>Acquisition protocols should as per routine</p> <p>Follow intensified disinfectant protocols at all levels</p>
Level 1	Urgent: <4 weeks	<p>Only schedule for indications which change the treatment plan in the immediate future, or hold a clear short-term benefit. Consider discussion with referring provider, for a precise decision-making</p> <p>Examples: FDG-PET for staging or therapy response assessment, 68Ga-PSMA for staging, 177Lu-DOTATATE, 68Ga-DOTATATE for staging and therapy decision, oncologic bone scans</p> <p>Generally, the high-risk cancers or other rapidly progressive medical conditions reside in this category</p>
Level 2	Semi-urgent: 4-8 weeks	<p>For indications that require follow-up in a certain time frame, but do not meet the definition of urgent</p> <p>Examples: 68Ga or FDG PET/CT follow-up, MPS for stable angina or SOB</p> <p>Each patient needs to be assessed on an individual basis</p>
Level 3	Nonurgent: >8 weeks	<p>For low priority tests, including elective procedures, and routine follow-up evaluations, especially in stable chronic conditions</p> <p>Examples: Nononcologic bone scan, DAT scintigraphy, gastric emptying, bowel transit, dacrosintigraphy, salivary gland scintigraphy</p>

CT: Computed tomography; V/P: Ventilation/perfusion; CTPA: CT pulmonary angiogram; MPS: Myocardial perfusion scintigraphy; ACS: Acute coronary syndrome; GI: Gastrointestinal; SOB: Shortness of breath; FDG: Fluorodesoxyglucose

Table 2: Proposed disciplines for nuclear medicine services in SARS-CoV-2 patients

SARS-CoV-2 positive patients
They should attend the department only under threatening circumstances, including level 1 and probably level 2
For SARS-CoV-2-positive patients, after discussion with their referring clinicians, nuclear medicine tests should be performed under intensified disinfect protocols
Schedule the patient as the last case of the morning or afternoon session
If possible, set a dedicated camera for symptomatic/confirmed patients with COVID-19 infection
The patient should be transferred immediately into the scan room and not left waiting anywhere
Additional PPE should be followed by all personnel (particularly in ventilation studies)
Two technologists are desired, one to attend the patient with full PPE, and the other to operate the scanner
Thorough disinfection of all imaging equipment and surfaces is mandatory (with separate cleaning equipment) ^[3]
To ensure proper ventilation and adequate air circulation of the imaging room, a time delay should be considered before the next patient (recommended at least 60 min; follow national/institutional guidelines) ^[17-19]
For SARS-CoV-2 patients at level 3 and 4, the procedure should be postponed and rebooked, even if the patient has attended the center ^[9]
On the detection of CT findings associated with COVID-19 pneumonia in asymptomatic patients who have undergone hybrid PET-CT or SPECT-CT imaging
Take a brief directed clinical and contact history from the patient, to exclude other differential diagnosis
Inform the referring physician immediately, for appropriate management per local guidelines
Thorough disinfection of all imaging equipment and surfaces is mandatory (with separate cleaning equipment) ^[3]
To ensure proper ventilation and adequate air circulation of the imaging room, a time delay should be considered before the next patient (recommended at least 60 min; follow national/institutional guidelines) ^[17-19]

PPE: Personal protective equipment; CT: Computed tomography; PET: Positron emission tomography; SPECT: Single-photon emission computed tomography

the importance of the issue and be able to implement all safety measures properly.

B. At arrival

All patients and visitors should be screened at the time of entrance into imaging buildings and hospitals to detect those at risk for having COVID-19 infection early.^[9] This results in the rapid isolation of high-risk patients before entering the examination room.

Standardized questions should be asked at reception desks, to ensure that those who are at the highest risk of infection are rapidly identified and appropriately triaged. According to CDC criteria,^[20] fever and or symptoms of acute respiratory illness (e. g., cough, difficulty breathing) should be investigated. Diagnosis may also be guided by epidemiologic factors such as the occurrence of local

community transmission of COVID-19 infections. Recent history of travel abroad, especially to an endemic area and contact with confirmed positive cases, puts these patients at the highest risk. Furthermore, body temperature must be evaluated using electronic skin contact tools.^[9] When suspicious findings (e. g., dry cough or elevated temperature) arise in nonurgent settings, outpatients should be freely rescheduled to the following few days and recommended to contact their general practitioner to receive proper care.^[9]

Particularly when interacting with suspected or confirmed COVID-19 patients, frontline nuclear medicine staff should perform all precautionary measures, including PPE. Patients with respiratory symptoms should be advised to use medical masks for any activity in health care settings.^[15] Although, if available, using PPE for all patients (particularly the high-risk patients or high-risk areas) is advised due to concern for asymptomatic transmission of COVID-19.^[4,13]

C. Waiting rooms and uptake phase

To avoid intra-hospital transmission of COVID-19 infection, designated facilities with separate entrances and waiting areas within the department are recommended to prevent interactions between patients.^[21] In nuclear medicine departments, both the radiation safety issues and infection prevention must be taken into account.

All patients with confirmed or suspected COVID-19 who need urgent nuclear medicine imaging or procedure should wear medical face masks, and be placed in a single-person room or a separate area from others, with a dedicated bathroom and closed door.^[15]

D. Injection of radionuclide

All procedures must be performed under standard protective principles, including proper PPE with septic and antiseptic techniques, disinfection of the devices, hand hygiene before and after each procedure, and proper disposal of the waste. The precautions must be followed per local guidelines until the situation changes, or new guidelines be released.

E. Imaging acquisition (single-photon emission computed tomography [SPECT], positron emission tomography [PET])

Technologists should utilize appropriate disposable protective elements during the scan. Clean disposable cover sheets should be set between the imaging table and the

patient. Rapid imaging protocols have been proposed to limit exposure to potentially infected patients.^[17,22]

For suspected or confirmed cases, patient infection status should be highlighted by both the referring and consulting physicians to keep them separate from other patients. In this setting, high-risk patients should be brought immediately into the imaging room and not left in waiting areas for extended periods. These procedures must be undertaken with the minimal delay with assistance from the lowest possible number of staff to limit exposure.^[15]

SPECIAL CONSIDERATIONS

A. Ventilation/perfusion scintigraphy

Currently, it is widely believed that the SARS-CoV-2 virus spread through respiratory droplets. Thus, aerosolizing procedures should be considered as higher risk. Ventilation/perfusion (V/P) scintigraphy resides in this category for transmission risk of COVID-19 infection, due to potential exposure with aerosolized secretion.^[14] Contact with secreted respiratory droplets due to patients coughing or leakage from the delivery system^[23] poses an increased risk of infection to nuclear medicine staff. In addition, the overlapping symptoms of pulmonary thromboembolism and COVID-19 may further complicate risk stratification in this setting. Therefore, we should consider all V/P candidates with uncertain COVID-19 status as potentially positive and wear appropriate PPE. Given the likelihood of patients presenting with a dry cough, the test warrants extra PPE.

During the COVID-19 pandemic, many nuclear medicine centers have adjusted the V/P study in selected patients in favor of a nonventilation approach.^[24,25] It is suggested that patients with normal chest X-rays should initially undergo perfusion-only studies, and if the perfusion scintigraphy is normal, further ventilation study is not needed.^[14] On the other hand, if pulmonary opacities are found in X-ray, a ventilation study must be considered only if pulmonary computed tomography (CT) angiogram is contraindicated.

In these circumstances, ventilation scintigraphy must be performed in accordance with recommended safety guidelines. All staff must utilize appropriate PPE, guidelines, social distancing, hand hygiene, and proper use of adequate respiratory equipment, such as N-95 masks, gowns, aprons, and goggles.^[15] During ventilation scintigraphy, negative airway pressure is recommended in the procedure room.^[9,12] As with other imaging studies, medical equipment, including the gamma camera, and all surfaces of acquisition rooms should undergo thorough disinfection as recommended.^[3,16]

It should be noted that in the infected or suspicious patients with COVID-19, a ventilation scan must be avoided, as far as possible. Furthermore, a combination of low-dose CT and 99 mTc-MAA-SPECT lung perfusion study has been purposed recently to differentiate between embolism and pneumonia.^[26] Indeed, the CT component can exclude lung infiltration in the hypoperfusion regions and therefore gain valuable information in this regard.

B. Myocardial perfusion scintigraphy

As one of the most common imaging modalities in nuclear medicine centers, myocardial perfusion scintigraphy (MPS) necessitates a well-planned and rehearsed approach during the COVID-19 crisis. As far as possible, exercise stress testing should be avoided after a discussion with the referring clinicians on this change.^[17] Moreover, since MPS can be limited to the stress part in appropriately selected cases, including young patients with no previous history of coronary disease, a stress-first approach is desirable for these patients.^[27] To minimize time spent within the department, the 1-day protocol with the least amount of imaging time is preferred when possible.^[17,22] Finally, wait times for stress injection and scan time should be kept as short as possible without compromising the image quality.

Nevertheless, if the situation improves, these protocols could be eased gradually, based on national policies, and the patient's clinical situation.

C. Radioiodine treatment (RAI) in differentiated thyroid cancers (DTC)

Thyroid cancer does not appear to increase the risk for COVID-19 infection or its severe complications, as most of the patients with thyroid cancer do not receive immune-compromising treatments, unlike the other types of cancers.^[28] However, to optimally manage patients with thyroid cancers, the risk from COVID-19 infection and underlying cancer both must be taken into account.^[29] Even though the treatment itself does not increase the risk of COVID-19 infection, the radiation safety instructions would impede the care of these patients in case of further COVID-19 infection. As a result, radioiodine therapy for the majority of patients with low-risk DTC may have been deferred during the COVID-19 pandemic, as RAI is not expected to alter their prognosis.^[30]

Nevertheless, since restrictions against nonurgent procedures like RAI are gradually being lifted in many countries, patients who have had their treatment postponed may now be suitable for radioiodine administration. Administration of radioiodine

should be performed as an outpatient procedure, as much as possible, as per local agency regulations. It cannot be overemphasized that, for both low-risk and high-risk DTC groups, all standard safety measures must be fully applied to RAI in administration, monitoring, and posttherapy scanning.

D. Other therapeutic operations in nuclear medicine

The decision is determined on an individual basis, with consideration of each patient's clinical condition. Patients with malignancies should be considered vulnerable to infections due to their immunocompromised status. Therefore, postponing radionuclide therapy in these susceptible patients might be considered, such as ^{177}Lu -Dotatate for neuroendocrine tumors, or ^{177}Lu -PSMA for prostate cancers. However, when a delay in treatment would cause undue harm or suffering, treatment should be conducted under thorough precautions as per local policies. Administration of other agents such as radium-223 dichloride can be performed as an outpatient procedure in patients with no severe medical comorbidities.^[31]

UNSUSPECTED DIAGNOSIS OF ASYMPTOMATIC COVID-19 DISEASE BY NUCLEAR MEDICINE

Incidental detection of COVID-19 on PET-CT or SPECT-CT has been reported as several asymptomatic cases worldwide.^[32] This viral pneumonia should be placed among the differential considerations in patients with bilateral multifocal and increased fluorodesoxyglucose uptake. Similarly, the CT components of hybrid SPECT-CT images should be carefully reviewed for CT changes associated with COVID-19 infection. In the event of diagnosis such cases, this is the responsibility of the reading nuclear medicine physician or radiologist to inform the referring clinician immediately, not only to guide appropriate patient management but also about possible postexposure recommendations. On the early detection of COVID-19 findings in asymptomatic individuals, relevant contact tracing and appropriate patient's management should be followed according to the local guidelines.

KEEP PERSONNEL SAFE

Similar to the lockdown phase of the disease, reducing the number of staff per examination during procedures is still desirable to minimize exposure. Only the required staff for each procedure should be involved. Rotating staff schedules for onsite and offsite workstations may help facilitate this change.^[7,9] Albeit, as the lockdown begins easing to provide nonemergent health-care services, the staff should be prepared to deal with a surge of patients to nuclear

medicine facilities. Meanwhile, they must be flexible to cease nonurgent care in the event of a possible second wave of infection.^[13,33] Virtual meetings and video-conferencing tools have been preferred for meetings and educational purposes.^[34] As the pandemic curve continues to flatten in most countries, these activities could be resumed gradually.

The safety protection measures, such as social distancing or using PPE, need to be continued. Staff members must follow the local PPE guidance before dealing with patients, including proper use of face masks, gloves, gowns, and eye protection in certain situations. In addition, they must maintain strict hand hygiene and a minimum of 1-meter/six feet distance^[15,35] between all patients and staff in all possible interactions. They should also be trained in the proper indications of PPE use, how to properly wear and remove PPE in a manner that prevents self-contamination, and how to maintain and dispose of PPE.

Staff members and physicians who have suspicious symptoms or a history of recent contact with confirmed COVID-19 patients should be self-isolated, based on the relevant local regulations, until they are considered clear before being permitted to work. COVID-19 testing should be available as much as possible for all staff, especially those with persistent symptoms.^[9,13,36]

Deep cleaning of all suites, workstations, and department areas in use should be performed at the end of each day (all surfaces and floors) by trained members, following infection prevention guidelines.^[3] In patient areas with suspected or infected COVID-19 cases, the high-touched surfaces should be disinfected after each visit.^[3] The cleaner personnel should use specific PPE, including long-sleeved uniforms, medical mask, gowns and/or impermeable aprons, closed work shoes, rubber gloves, and eye protection.^[3]

If nuclear medicine operations are indicated for COVID-19 patients (as in immediate indications at level 0), a time delay should be considered before imaging next patient (at least 1 h, as per national public guidelines), to ensure proper ventilation and adequate air circulation of the imaging room.^[17-19] The equipment used for cleaning COVID-19 patients should be separated from others, and the disinfectant solutions should be discarded after each use in the sites of suspected or infected patients.

Once imaging is being performed or has been completed, tele-reporting options could still be utilized to ensure continuity of nuclear medicine services across different locations while maintaining staff segregation at the same time. In general, working remotely is recommended

whenever feasible.^[37] Furthermore, while reading, consider potential COVID-19-related findings (specifically at SPECT-CT or PET-CT procedures). Report such findings to the patient and the referring physicians immediately for proper decision.

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