Medical imaging and the new coronavirus: facing a disruptive threat

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ABSTRACT: In December 2019, a novel coronavirus was identified in Wuhan (China), from a cluster of patients with unexplained pneumonia and termed SARS-CoV-2, responsible for Coronavirus Disease (COVID)-19. Medical imaging modalities play an important role in the management of COVID-19 infection. Consequently, it is necessary to identify strategies and procedures for infection control in the medical imaging department. This document aims to present the standard operating procedures (SOPs) of radiology (RD) and nuclear medicine (NM) units and to provide information about the potential contribution of the medical imaging modalities in the present COVID-19 scenario. Chest Computed Tomography (CT) is considered the prime imaging tool for COVID-19 diagnosis and follow-up. Chest X-ray (CXR), with less accuracy, seems to be an important tool, in particular where mobility is an issue. Likewise, first reports have been published on the specific potential value of ^{18}F-FDG PET (fluorodeoxyglucose) (positron emission tomography) imaging, predominantly related to incidental findings with ground-glass opacities and matched FDG uptake.

Keywords: COVID-19; Radiology; Nuclear medicine; Chest X-ray; Chest CT; PET-CT 18F-FDG

Imagem médica e o novo coronavírus: enfrentar uma ameaça inesperada

RESUMO: Em dezembro de 2019, um novo coronavírus foi identificado em Wuhan (China), a partir de um grupo de pacientes com pneumonia inexplicada, sendo denominado por SARS-CoV-2 e responsável pela doença do Coronavírus (COVID)-19. As modalidades de imagem médica desempenham um papel importante no diagnóstico e tratamento da infeção por COVID-19. Consequentemente, é necessário identificar estratégias e procedimentos de controlo nos vários departamentos. Este documento tem como objetivo apresentar os procedimentos operacionais padrão (POPs) a adotar pelas unidades de radiologia (RD) e medicina nuclear (MN) e fornecer informação sobre o potencial contributo das modalidades de imagem médica no cenário atual da COVID-19. A tomografia computadorizada (TC) do tórax é considerada a principal ferramenta de imagem para o diagnóstico e acompanhamento do COVID-19. A radiografia de tórax parece ser uma ferramenta importante, principalmente quando a mobilidade é um problema. Da mesma forma, as primeiras publicações sobre o potencial valor da ^{18}F-FDG PET (fluorodesoxiglicose) (tomografia por emissão de positrões) sugerem que está maioritariamente associado a achados acidentais de opacidades em vidro despolido com correspondente captação de FDG.

Palavras-chave: COVID-19; Radiologia; Medicina nuclear; Radiografia do tórax; TC do tórax; PET-CT 18F-FDG

Introduction

At the end of 2019, a novel coronavirus was isolated from a cluster of patients presenting with viral unexplained pneumonia in Wuhan (China) and termed SARS-CoV-2 (severe acute respiratory syndrome coronavirus), responsible for Coronavirus Disease (COVID-19)[1].

The rapid increase in the number of people infected worldwide led the World Health Organization (WHO) to recognize COVID-19 as a global pandemic on March 11, 2020[2].

SARS-CoV-2 is located in the β-cyclotron coronavirus genus and its cell entry is supposedly mediated by angiotensin-converting enzyme 2 (ACE2) receptor[3]. This mechanism is connected to the SARS-CoV-2 highly contagious pattern, whose route of transmission is mainly via respiratory droplets and contact transmission, resulting in varying degrees of lower respiratory tract symptoms[4].

Medical imaging modalities play an important role in the management of COVID-19 infection. Chest X-ray (CXR) and CT have been highly reported in the screening, diagnosis, and prognosis of the disease[5-7]an outbreak of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2. Likewise, first reports have been published on the specific potential value of ^{18}F-FDG PET (fluorodeoxyglucose) (positron emission tomography) imaging[8], particularly related to incidental findings[9-11].

Since an adequate treatment or vaccine is still being sought, and also due to the asymptomatic incubation period of this virus, it is necessary to establish frontline radiology (RD) departments that could act rapidly and accurately. Also, concerning the elective nuclear medicine (NM) imaging and therapy procedures, it cannot be excluded that infected or suspected COVID-19 patients will be referred to NM departments, such that special prevention and specific protection measures are essential.

Accordingly, in order to handle the potential risk and to be methodically prepared, this document aims to:

1. Identify operational strategies and procedures reported in the literature for infection control in RD and NM departments.
2. Provide the most suitable information about the potential contribution of the medical imaging modalities at the present COVID-19 scenario.

How to be prepared

COVID-19 is an unfolding situation and health care providers worldwide are adapting their standard operating procedures (SOPs) to minimize risks of exposure[4]. The WHO has published the *COVID-19: operational guidance for maintaining essential health services during an outbreak*[12] which includes six main processes that can be extrapolated to NM and RD facilities. Following the typical patient's 'journey' through the NM or RD department[4,13], the main recommendations can be summarized as follows:

1. General control principles for COVID-19 protection.
2. Protection of healthcare professionals.
3. Adapting clinical practice workflow (effective patient flow).

Whilst there are similarities in how RD departments can exercise caution, there are also pertinent differences regarding the setting of the NM units. In fact, the majority of NM scans and therapies tend to be outpatient, thus some patients may already have been screened for COVID-19 before being booked for scans[14]. Next, a comprehensive evaluation of the principal aspects of RD and NM practice is given.

General control principles for COVID-19 protection

Establish simplified purpose-designed governance and coordination mechanisms between Healthcare Administrations and clinical departments is encouraged to be adopted[4,13]:

- Designation of a COVID-19 Incident Management Team;
- Screening (standardized questionnaire) for COVID-19 prior to patient examinations, at the time of scheduling, hospital entrances, and front desks;
- Rapid isolation of patients with suspicion of COVID-19;
- Reallocation of human, financial and material resources, with a rotating team plan;
- Rescheduling non-urgent scans and therapies;
- Specific training in identifying COVID-19 symptoms, hygiene procedures, handling COVID-19 patients, disinfection procedures, and use of personal protective equipment (PPE), for all staff;
- Implementation of cleaning and disinfecting procedures for equipment and accessories;
- Restricted travel for staff for all domestic and international work-related activities;
- Promoting the use of telehealth for staff meetings.

Protection of healthcare professionals

In addition to the general procedures, all healthcare personnel should be aware of the following topics[3-4,13]:

- Record symptoms and temperature at the start of the shift;
- Maintain strict hand hygiene;
- Maintaining at least 1-meter distance in all interactions when possible, avoiding crowding at the workplace;
- Wear the medical uniform, cap, and mask as PPE, and if available, also for patients, as per local policies and standards;
- For the healthcare professional who injects the radiopharmaceuticals or contrast media to the patients with a confirmed or suspected diagnosis of COVID-19, safety goggles or faces shield, isolation gown, disposable latex gloves, and shoe covers are needed – detailed information can be found on the work of Assadi *et al*[3];
- Training in local scenario infection control recommendations.

Adapting clinical practice workflow (effective patient flow)

I. Nuclear Medicine

During the outbreak of COVID-19, NM departments should continue their operation by adopting flexible procedures[13] and must address the considerations described in Figure 1. Hence as advocated by the American College of Nuclear Medicine (ACNM)[15], with temporarily changes in routine clinical practice, such as:

1. Reschedule and postpone outpatients whenever possible;

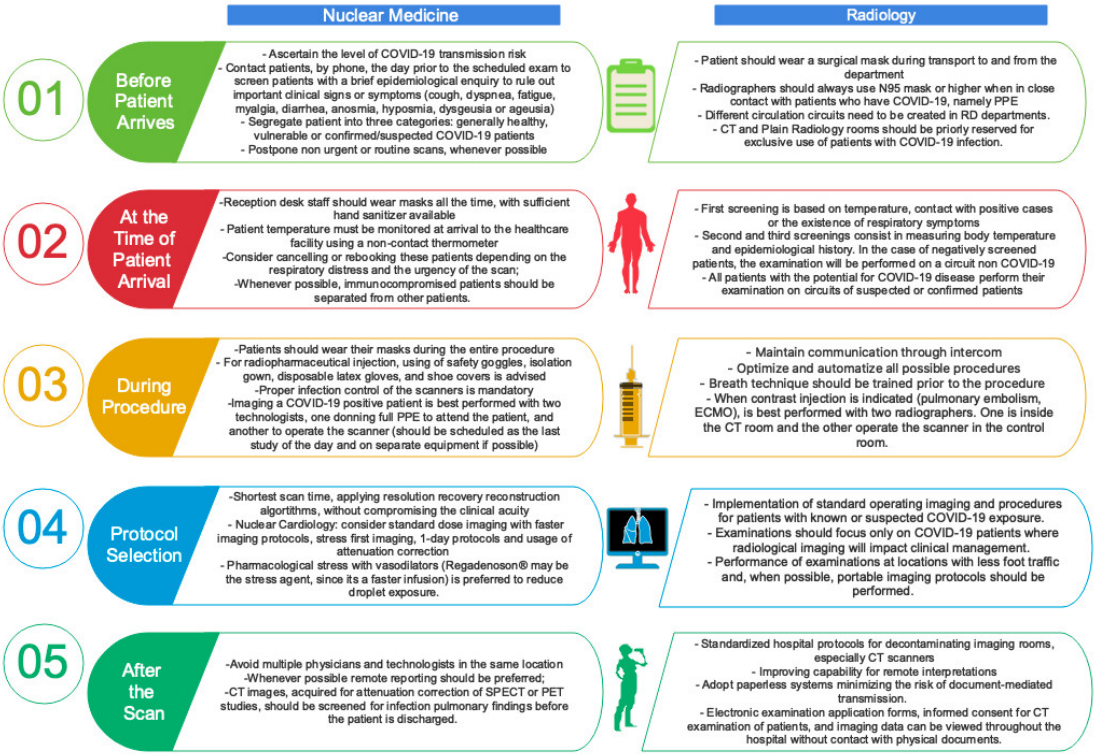

Figure 1. NM and RD departments workflow.

2. Convert the V/Q scan into perfusion only, combined with SPECT-CT if available;
3. Optimize scan protocols to reduce frequency and time of patient visit (shorter image scan time, avoid unnecessary multi-day images, and perform 1-day myocardial perfusion protocol);
4. Whenever possible the clinical staff must organize the workflow in order to meet the 'one person to end' policy;
5. Oncological therapeutic decision meetings should be done online;
6. Split the NM manpower staff into two different teams – an onsite and an offsite team, ideally in a 14-day rotation period.

Additionally, a joint information statement was published[16], addressing the practice of nuclear cardiology in the pandemic setting. Accordingly, only scans with the potential to change therapeutic management within the next few weeks, and an impact on short-term prognosis should be performed. In this sense, these authors recommend a three-category triage based on whether the scan would change patient management:

a. In the near term – *Priority 1* – perform as scheduled;
b. In the intermediate term – *Priority 2* – postpone by 2-4 months;
c. In the long-term – *Priority 3* – postpone by > 4 months.

This situation clearly requires clinical judgment for rebooking NM tests. Moreover, shortages of radiotracers or molybdenum-technetium generators can impact patient workflow such that a list of all possible suppliers should be permanently updated. It is essential to ensure the uninterrupted operation of cyclotrons to guarantee the provision of PET services to oncologic patients. Also, it should be noted that, at the time of this paper submission, the COVID-19 pandemic is in transition. In fact, a 'new normal' over an inconstant period might force the NM community to adopt progressively 'new SOPs', as stated by Huang *et al* (2020)[17]. Consequently, these authors proposed a stepwise reopening schedule for NMs departments to gearing up back to normality in accordance with the local Public Health Guidance.

II. Radiology

All PPE tends to be scarce during outbreaks, thus protection levels can be set out accordingly with the risk levels of occupational exposure as a function of the patient workflow. Thus, radiology departments are proposed as a level 3 protection department[18] (*cf.* Figure 1), addressing appropriate PPE and specific accessories, as referred on point number 2, namely *Protection of Healthcare Professionals*.

To limit the transportation of patients with COVID-19, whenever possible, portable radiographic equipment should be used. Available portable X-ray equipment should be allocated to exclusive wards for COVID-19 patients and intensive care units, ensuring the reservation of portable X-ray equipment for examining patients not COVID-19. When limited portable equipment is available, their management involves allocating one to COVID-19 patients and another to non-COVID-19 patients or perform all the exams first on patients with the confirmed disease after.

All patients who undergo radiological examinations should be subjected to a triple screening as demonstrated in Figure 1. Accordingly, the priorities for the Radiology department adoption to pandemic scenarios should be as stated in Figure 1[18], as an essential key to guarantee strategic planning and inclusion of all radiology staff.

Medical imaging modalities

At present, the diagnostic strategy is based on the combination of the history of exposure, clinical characteristics, RT-PCR, followed by imaging tests[19]. In this section, we systematically review the chest imaging manifestation of COVID-19 with the description of the commonly used acquisition protocols and imaging key findings of Chest X-ray (CXR), CT, and PET-CT ^{18}F-FDG.

Chest X-ray (CXR)

Radiographers are invariably the first practitioner to see the diagnostic image and can play a vital role in identifying possible COVID-19 patients by performing a preliminary clinical evaluation (PCE) and triage[20]. PCE is already a recognized competency for radiographers in many regions of the world[20]. Thus, rapid radiographer's PCE and triage will facilitate prompt CXR reporting, aid patient diagnosis, and management decisions in a timely way[20]. Artificial Intelligence (AI) can also play an important future role since AI supported systems will facilitate the triage process and optimizes patient pathways and outcomes.

Portable CXR will likely be the primary imaging modality used in COVID-19 diagnosis and management[21], assuming an important role in the minimization of the transmission risk associated with patient transfer[20]. It is recommended the usage of wireless digital radiology (DR) portable detector technologies, allowing the radiographer to have less contact time with the patient, fewer exposure errors and fewer retakes, better image quality, and rapid image sharing through the PACS system[22]. The detector should be protected with triple layers of polythene sheets at the intensive care unit[22], marking, at least, one detector for exclusively for COVID-19 cases.

Portable X-ray equipment is designed for limited spaces movements allowing minimum possible contact with other surrounding objects (e.g. beds)[20,22]. Appropriate manipulation by skilled radiographers involves a minimum contact with the different components of the equipment namely to the x-ray tube, detector, and console[22]. The procedure to prepare the X-ray equipment is around 45 minutes, thus imaging of COVID patients should be done, preferentially, in locations where there is less foot traffic away from the stations of critically ill patients[22].

CXR shows an overall sensitivity of 69% but with lower sensitivity at early stages[19], since it may have subtle changes or be normal[23]. CXR characterization and signs of the most common abnormalities COVID-19[21,23] (*cf.* Figure 2) are:

1. Bilateral lower lobe consolidations and the presence of the multifocal air-space disease may be a significant clue to COVID-19;
2. The hazy pulmonary opacities on CXR can sometimes be diffuse making identification challenging in some instances;
3. High frequency of peripheral lung involvement, which tends to be multifocal, either patchy or confluent.

Chest CT

The major role of chest CT is to understand the extent and dynamic evolution of lung lesions induced by COVID-19[24].

The accurate diagnosis of viral pneumonia based on chest CT may indicate isolation and plays an important role in the management of patients with suspected COVID-19 infection. Early discussions suggested that CT should be the preferred modality for diagnosis of COVID-19[25].

Li *et al*[25] state that bilateral ground-glass opacities and consolidation were two main signs on CT images of COVID-19 lesions. The distribution of disease is predominantly peripheral (subpleural) and confined to the middle and lower lobes in the initial chest CT. When the disease advanced, consolidation and coalescing infiltrates pervaded the lungs and the upper lobes were affected, with CT showing 'white lungs'[25].

As stated by Huang *et al*[24] low-dose chest CT has been widely used in the screening of early lung cancer and it is well known that many early lung cancers are ground-glass opacities (GGO), so low-dose screening is also applicable for COVID-19.

Regarding the technique, Yang Q *et al*[26] recommend volume CT with a maximum acquisition slice thickness of 5mm (≥ 16 slices multi-detector CT) and a reconstruction slice thickness of 1.0 to 1.5mm. Multi-planar reformats (transverse, sagittal, and coronal planes) are beneficial for the early detection of lesions in patients with negative nucleic acid tests.

For the correct use of CT in COVID-19 patients some modifications are needed to be focused on strict disinfection of examination rooms, the arrangement of waiting areas, and efforts to increase radiographers' awareness of personal protection. Radiographer protection procedures for CT examination includes the topics previously discussed with the special caution that if the patient cannot get onto or off the examination table independently, the person accompanying the patient should assist the patient, rather than the radiographer[24]. To minimize the infection risk, by intercom, the radiographer trains the patient in the needed breathing techniques[24]. The radiographer should consider that most patients undergoing CT had difficulty to deep breathe, therefore, when reviewing CT examinations attention to differentiate GGO or consolidations from motion artifact. Some CT devices are now equipped with AI technology that enables radiographers to perform an examination without leaving the control room, complete with precise positioning and automatic scanning, reducing the risk of contagion between the staff and patients[26].

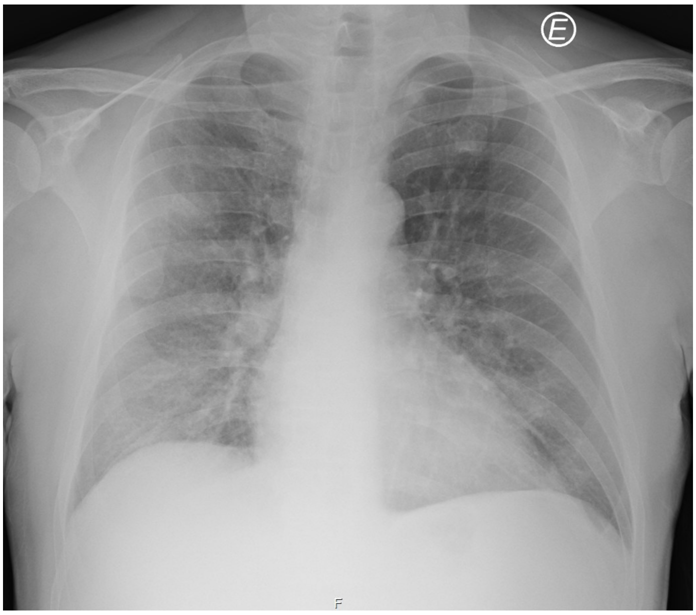

Figure 2. Radiological aspect of COVID-19 in chest X-ray.

After the exam, the radiographer browses the images to ensure that their quality meets the diagnostic requirements and then guides the patient to leave through the fever access area. The disposable sheets for patient examination are changed after each patient. In a PCE perspective, the following characterization strategy is proposed for chest CT[19]: distribution (peripheral, central, or both), involved lung lobes (right upper, middle, lower lobes, and left upper, lower lobes), number of lobes involved (one, two, three, four, or five), appearance (GGO), consolidation, or GGO with consolidation), specific signs ('crazy-paving' pattern, air bronchogram sign, architectural distortion, fibrous stripes, subpleural lines, vascular thickening, and nodules), and extrapulmonary manifestations (mediastinal enlarged lymph nodes and pleural effusion).

Related to findings and imaging patterns, different CT manifestations have been associated with the disease progression, based on the physiopathology of the acute lung injury induced by viral pneumonia[19]. In this review, the temporal stages proposed by Fatima *et al*[23] will be used and exemplified in Figure 3.

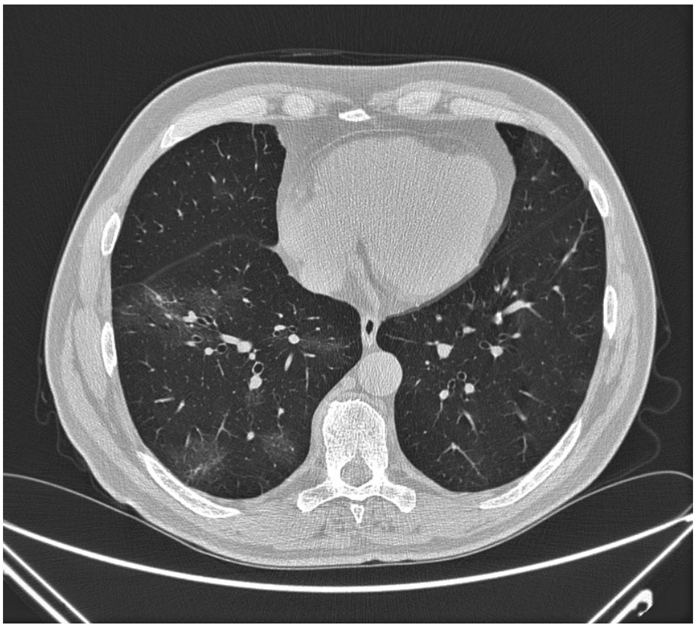

Figure 3. CT initial findings in COVID-19 positive patient.

Table 1. Chest CT findings and imaging patterns

Stage	***Findings*** (Fatima et al, 2020)	***Imaging Patterns*** (Fatima et al, 2020)
Ultra-early	(i) Prior to symptom onset. (ii) Throat swab positive, laboratory negative. (iii) Usually within 1-2 weeks of exposure.	(i) CT scan demonstrates bilateral, subpleural, multiple scattered ground glass opacities.
Early	(i) Patients present with symptoms (within 1-3 days of symptoms like fever, dry cough). (ii) on histopathology – there is congestion of alveolar capillaries resulting in alveolar and interlobular interstitial edema.	(i) CT shows multiple, bilateral ground glass opacities. Irregular, interlobular septa begin to develop.
Rapid progression	(i) This stage follows within 3-7 days of symptomatic presentation. (ii) There is an escalation in the hyperinflammatory response. Fibrous extensions that connect the alveoli begin to develop.	(i) CT findings include subpleural, posterior consolidations, dispersed air bronchograms along with superimposed irregular septa.
Consolidation	(i) Coincides with 2nd week of clinical symptoms. (ii) Vascular congestion diminishes, and fibrosis predominates.	(i) There is a decrease in size and density of consolidations.
Dissipation	(i) Occurs about 2-3 weeks after initial symptomatic presentation. (ii) There is more of a healing and repair response within the lungs.	(i) CT scans shows patchy consolidation, reticular opacities (strip-like opacities), bronchial and interlobular septal thickening.

Most CT imaging elements could overlap with other viral pneumonia, in particular with SARS and MERS, because of the similar pathogenesis resulting in diffuse interstitial and alveolar damage[19,27]. BSTI states that classic CT findings in COVID-19 are: peripheral GGO, crazy paving may be present and organizing pneumonia. Reported by Miao *et al*[27] lesions are mostly distributed bilaterally and close to the lower lungs or the pleura. The combinations of GGOs with bilateral pulmonary distribution and GGOs with pleural distribution could be useful in the identification and differential diagnosis of COVID-19[27].

Chest CT can also evaluate the time course of COVID-19 and assess the evolution of disease severity. With the evolution of the disease, different patterns can be observed as summarized in Table 1. Patients recovering from COVID-19 can be tracked with CT to assess for long-term or permanent lung damage, including fibrosis[26].

Many of the existing tools make possible the detection of subtle GGO, precisely segmentation of lesion region, calculate the lesion volume, volume rates of lesions to total/left/right lung, and each lung lobe. AI-assisted diagnostic systems for COVID-19 can be an essential tool, namely at classifying COVID-19 from other viral types of pneumonia and automatic follow-up and patient progression analysis.

AI systems can help the development of patient management strategies for timely, precise, and effective treatment decisions[26].

PET-CT ^{18}F-FDG

Positron emission tomography (PET) combined with computed tomography (CT) ^{18}F-labelled fluorodeoxyglucose (FDG) is essential for oncological practice[28].

Its noninvasive capacity to provide in vivo physiological information plays a key role in evaluating inflammatory and infectious lung diseases, including detection and estimation of the lung segments' involvement and monitoring progression and treatment responses[11,29].

In acute inflammation or infection of the chest, FDG uptake occurs primarily by activated neutrophils, the metabolism of which is heavily dependent on anaerobic glycolysis, requiring elevated uptake of glucose[28]. Also, as PET/CT uses absolute quantification models to estimate the radiopharmaceutical concentration throughout the lungs it allows the study of the behavior of inflammatory cells in their native microenvironment[28]. In the current COVID-19 pandemic, significant FDG uptake in patients with MERS-CoV infection which progressed to pneumonia has been observed by Das *et al*[30]. First reports are being published on the potential value of PETC-CT ^{18}F-FDG imaging in this situation[8].

For instance, Deng *et al*[11] recently revisited the work of Chefer *et al*.[31] and documented an increased FDG-avidity in mediastinal and axillary lymph nodes in a rhesus macaques model after MERS-CoV infection, while no changes on CT imaging or body temperature were revealed after 5 days of viral exposure. A correlation between FDG-uptake in lung-draining lymph nodes and monocyte count was remarkably observed, reporting that FDG-uptake in lymph nodes can precede fulminant viral replication, revealing the capability to detect subtle changes in host immune response to subclinical MERS-CoV infection. Analogously for COVID-19 management, these observations could suggest that ^{18}F-FDG-PET/CT imaging might play a role in the early stages of the disease when clinical symptoms are nonspecific and differential diagnosis is challenging[11].

Qin *et al*[10] reported a series of ^{18}F-FDG-PET/CT scans of four patients highly suspected for COVID-19 who were admitted to the Wuhan Union Hospital with lung GGOs and fever between January 13 and January 20, 2020, when the SARS-CoV-2 infectivity was unspecified. In this case series, all patients presented with peripheral GGOS and/or consolidative opacities in more than two lung lobes[10,29]. They reported a matched FDG uptake for all these lesions with a Maximum Standard Uptake Value (SUVmax) between 4.6 and 12.2, reflecting a significant inflammatory burden on COVID-19 similar to that elicited by the Middle East Respiratory Syndrome Coronavirus (MERS-CoV) since tumors presenting as GGOs are unlikely to be FDG-avid. Additionally, the authors observed that patients with higher FDG uptake in lung lesions take longer to heal and are positively correlated with the value of the erythrocyte sedimentation rate. It is important to note, that in three out of these four patients, SARS-CoV-2 nucleic acid testing was not performed and in one of these patients, RT-PCR for detection of SARS-CoV-2 was negative[29]. For instance, as the disease progresses, it may cause damage to the gastrointestinal tract, kidneys, heart, bone marrow, and other organs, such that FDG PET/CT may be more appropriate when viral infections are associated with other factors[11,32].

In this pandemic paroxysm crisis, incidental findings suggestive of COVID-19 on ^{18}F-FDG-PET/CT scans had been atypically reported[9], mostly associated with completely asymptomatic patients referred for other clinical indications. In fact, Albano *et al*[9] observed that within the 8-day period of March 16-24, 2020, 9% of the patients that underwent PET/CT for various malignancies showed unexpected signs of interstitial pneumonia on CT and elevated regional FDG-avidity. There was a significantly higher frequency of incidental pneumonia cases by PET/CT when compared to the homologous period. Lately, 5/7 patients had subsequent proof of COVID-19 by RT-PCR, confirming that nuclear medicine departments should be alerted accordingly. These preliminary results obtained by Albano *et al*[9] suggest that it might be possible to *accidentally* screen these patients (Figure 4), applying the standard procedures. Besides, the detailed standard acquisition and reconstruction protocol can be found in the paper published by these authors.

Moreover, Colandrea *et al*[33] in a pre-print not completed peer-reviewed paper described the cases of five oncological asymptomatic or paucisymptomatic patients but with

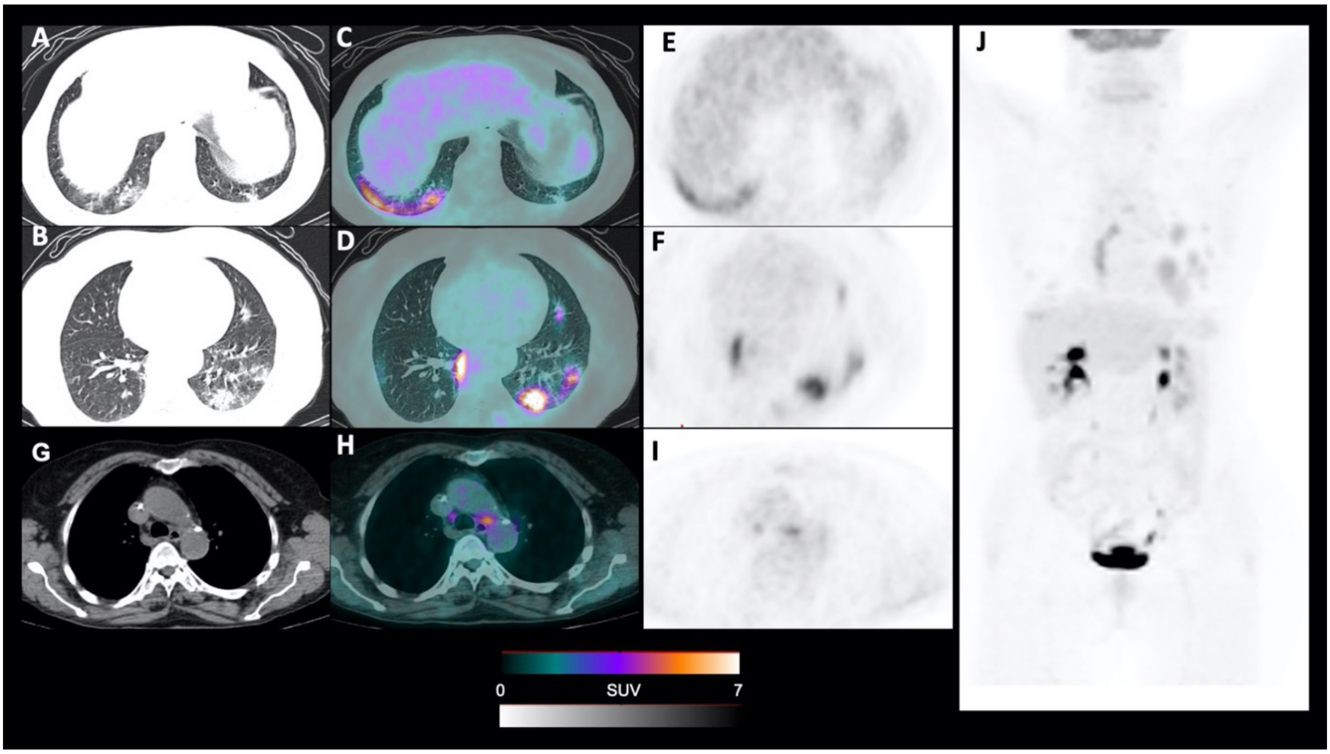

Figure 4. Example of an asymptomatic 65-year old woman with a history of ovarian cancer. Follow-up PET/CT was negative for ovarian malignancy but demonstrated interstitial pneumonia. Axial CT (**A,B**), PET/CT fused (**C,D**) and PET images (**E,F**) showing significant pneumonia with GOOS especially in the left lung (SUVmax 6.9) and FDG-avid mediastinal nodes (**G,H,I**). Maximum Intensity Projection (MIP) (**J**) confirming lung and nodal alterations. RT-PCR was performed immediately and confirmed COVID- 19. Reprinted with permission[9].

COVID–19 detected at PET/CT imaging. Firstly, this point should be considered as an important signal to implement strategies to safely handle both viral pathology and cancer. Secondly, as these patients probably represent the tip of the submerged part of the iceberg of COVID-19 infection, the NM units equipped with PET/CT scanners and trained staff may support the RD departments to earlier diagnose of these positive cases, identifying imaging finding patterns suggestive of COVID-19[8].

Complementing this incidental findings topic, Amini *et al*[34] reported a case of an 82-year-old man with a history of colon adenocarcinoma referred to 18F-FDG-PET/CT scan for recurrence evaluation. No hypermetabolic focus was detected in the pelvic or abdominal areas. However, a *foci* of moderate to severely increased FDG activity was identified in both lungs, with a corresponding SUVmax of 8.6, matching to the multiple peripheral bilateral pulmonary patchy GGO on CT. In this case, the patient did not have any specific symptoms to suggest a COVID-19 infection but four days later, SARS-CoV-2 lung infection was confirmed by RT-PCR.

Potentially, PET could be used in COVID-19 to evaluate changes in the FDG-uptake pattern elsewhere in the patient's body, especially as a whole-body readout technique to assess organ impairment. For instance, concomitant heart-brain inflammation could be observed using ^{18}F-GE180, targeting the mitochondrial translocator protein (TSPO)[29]. Additionally, it would be interesting to study the potential of ImmunoPET imaging to better understand the disease, especially to characterize which immune cell subsets are involved between the infectious and immune phases of COVID-19[8].

In this line, new technologies based on ultra-low-dose whole-body PET instrumentation, combined with deep neural network reconstruction methods[35] constitute a great opportunity to develop optimized PET protocols, allowing both shorter acquisition-time procedures and radiopharmaceutical uptake periods. Mainly to better characterize disease extension and prognosis, using a whole-body exploration[8].

Actually, the few ^{18}F-FDG-PET/CT images of COVID-19 patients published need to be properly characterized in larger patient cohorts before conclusions can be drawn. Nevertheless, FDG PET/CT is a sensitive method to detect and monitor inflammatory diseases and may add potential value to the challenge of diagnosing complications caused by viruses such as SARS-CoV-2[11]. It may also contribute to monitor treatment response monitoring and help to predict the recovery time[29], as patients with a higher SUVmax recover more slowly after the onset of symptoms[10].

^{18}F-FDG PET/CT cannot be routinely used in an emergency setting, however, this imaging modality might play a complementary diagnostic role in COVID-19 – especially at early stages when clinical symptoms are not specific and differential diagnosis is challenging[10,29].

Concluding remarks: a new reality

Among the doom and gloom of this crisis, NM and RD departments are rapidly adapting their workflow to new ways of operating and delivering care in the era of the COVID-19 pandemic, acting as key elements to prepare this new reality and to the new coming back.

CXR is an important tool, probably the first imaging modality used, in particular where mobility is an issue. However, Chest CT is considered an excellent imaging tool for COVID-19 diagnosis and follow-up.^{18}F-FDG PET/CT is also showing the particular potential that should be used carefully until clear and scientific evidence is available.

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