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COVID-19 Management

Diagnostic Imaging in the Age of COVID-19

In a disease surrounded by unknowns, patients' imaging is shedding a light on the course of COVID-19.

Radiology in the age of COVID-19

During this relative respite that the COVID-19 offers us after the purportedly first peak of the pandemic, we can reflect on how this tiny virus changed our lives. For the healthcare system, the adaptation to the pandemic is being particularly tough. Here we will focus on how COVID-19 is changing radiology teams' everyday life.

In just a few months scientists learned a lot about this disease whose clinical spectrum ranges from the absence of symptoms to death. Experts realised that SARS-cov-2 virus' deadly power is enhanced by the large percentage of asymptomatic and pre-symptomatic carriers of this high infective virus. We are still learning how to protect ourselves from the infection, and there are still many unknowns. Finding an effective treatment will take time, and vaccine candidates are still in their early stages of trials regarding effectiveness and safety. On the other hand, experts believe that the pandemic will remain for a couple of years, or perhaps forever, maybe SARS-cov-2 becoming one more seasonal virus. Many of us long for the hypothesis that the virus may lose aggressiveness over time.

From the diagnostic point of view, things have progressed very quickly, considering that the disease has been known for just six months. Thanks to the Chinese scientists, the molecular structure of SARS-Cov-2 was soon available, allowing the early design a reverse transcriptase polymerase chain reaction (RT-PCR) for the diagnosis of infection in nasopharyngeal swabs. But the sensitivity of these RT-PCR tests is reported as low as 60-70%, in part because their results depend on the moment on which the samples are taken at the progression of the disease. Subsequently, various serologic tests for anti-SARS-Cov-2 antibodies have been added to the market, but they are not especially useful as diagnosis tests at the beginning of the disease. In Wuhan, given the RT-PCR false negatives particularly early in disease time course, the scarcity of tests at the peak of the pandemic, and the frequent delay in obtaining the results, doctors soon considered the use of imaging as an adjunctive diagnostic tool for screening of COVID-19.

As COVID-19 manifests predominantly as a pneumonia-like respiratory process, the radiology techniques most involved in its diagnosis and follow-up are those of chest imaging, mainly chest X-rays and chest CT. The Emergency and Chest divisions of the radiology departments are the most involved, but at the peak of the pandemic the COVID-19 cases outshone the rest, and almost every member of hospitals' Radiology teams participate sometimes not only in its radiological diagnosis but collaborating in other hospital areas.

Chest radiography (CXR) can be insensitive for detection of early or mild disease but is useful in triaging patients and monitoring care in those with radiographically detectable pneumonia (Wong 2020). We soon learned from Wuhan's experience: to decrease the likelihood of intrahospital infection, specific circuits for suspected or confirmed COVID-19 patients' requiring radiological studies must be perfectly differentiated at the hospitals. Radiographs must be carried out with portable equipment, which allows limiting the displacement of patients through the hospital. Radiology technicians are the ones who approach patients with their portable equipment wherever they are: in the emergency department, in the hospital ward or at the ICU. Safeguard of radiology workers with personal protective equipment (PPE) was seen to be essential: now, in addition to the lead apron, radiographers must wear a mask, a waterproof apron, face shields, etc.

CT findings in COVID-19 pneumonia demonstrate a temporal evolution typical of organising pneumonia as a response to acute lung injury. The hallmarks of COVID-19 infection on imaging at the beginning of the disease are bilateral and peripheral ground glass opacities with lower lobe predominance. Four to 14 days after symptom onset there is a greater lung involvement with consolidation, and "reverse halo sign" and "crazy paving" signs are useful findings because they are not usual in other viral pneumonias. Bilateral lung involvement was observed in 28% of early patients, 76% of intermediate patients, and 88% of late patients (Guan 2020). CT findings correlate with the severity of the disease (Yu 2020) and could help make treatment decisions for patients in the ICU (Gattinoni 2020). To facilitate communication with requesting physicians, a radiological reporting system (COVID-RADS) has been created (Salehi et al. 2020).

Chinese studies in February reported higher sensitivity of

chest CT compared to RT-PCR (98% vs. 71%) for COVID-19 screening, but these results should be interpreted cautiously mainly due to pre-test probabilities: chest CT is more sensible as a screening test at the peak of the COVID-19 pandemic (Fang 2020).

There are various caveats of CT as a screening tool for COVID-19. First, to prevent additional infections and deaths, reducing false negatives is particularly important, and chest CT can miss COVID-19 cases, because chest CT is normal in more than half of patients imaged 0-2 days after symptom onset (Bernheim 2020). We know that after the Diamond Princess Cruise passengers' experience: only two-fifths of PCR positive people had lung opacities at CT. Cases missed at CT screening could infect others (Inui 2020).

Second, there are also CT false positive diagnoses, since CT findings are not specific, mainly because they overlap with those of other viral pneumonias, including influenza. Nevertheless, the probability of misidentifying them as COVID-19 is much lower outside of flu season, and especially in the context of this pandemic, false positive are not very problematic: the recommendation is simply to self-isolate, this being useful also for flu patients.

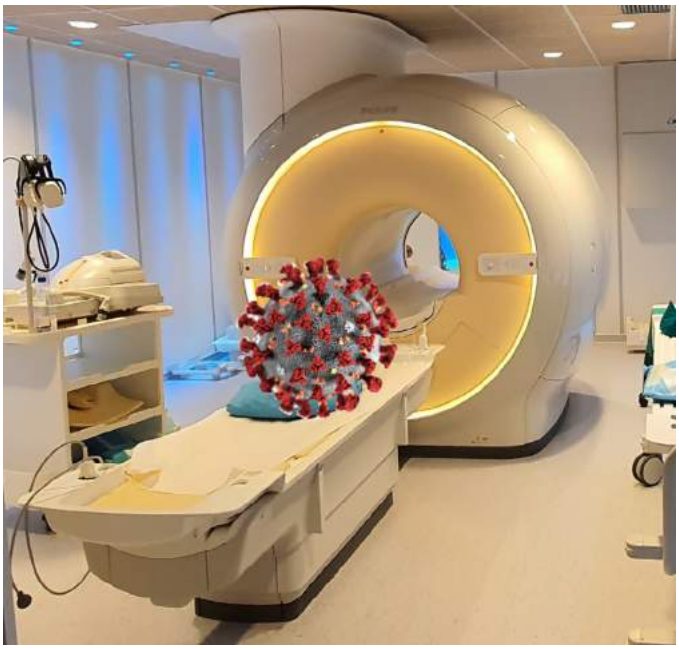
Apart from sensitivity and specificity issues, there are also practical considerations regarding Sars-Cov-2 contamination risk from scanners to other patients. There is a need to disinfect the CT room after studying a COVID-19 patient. But CT scanning is safer for health care workers than obtaining samples with nasopharyngeal swabs, often triggering explosive coughing and virus spreading (Huang 2020).

The main advantage of CT is its ubiquity, but although there are many CT machines their usage for monitoring COVID-19 patients during and after their disease is already overloading CTs. There is a high incidence of subclinical CT findings in SARS-cov-2 infected cases, showing mainly ground-glass opacities. If the entire infected population were monitored by CT, radiology and pneumology departments would be overwhelmed. In the next months and years radiology teams will be involved also in the control of the pulmonary sequelae of COVID-19 patients, one of the more worrisome being lung fibrosis. Available equipment and staff will be not sufficient.

Considering all these factors most radiology societies led by the American College of radiology (ACR), advise against chest imaging for initial COVID-19 screening and diagnosis.

Of course, there is a role of chest CT in COVID-19 patients with complications, cases of diagnostic uncertainty, and critical illness. Most clinical guidelines recommend chest CT when alternate diagnosis is suspected or when COVID-19 testing is unavailable or highly restricted.

However, the Fleischner Society (Rubin et al. 2020) considers that there is a role for imaging in COVID-19 diagnosis, particularly at the peak of the pandemic. In some circumstances the ideal diagnostic approach would involve both swab PCR tests and a chest CT to ensure the highest



sensitivity, to miss the fewest cases possible. For COVID-19 screening complementary to RT-PCR, a sub millisievert low-dose with no intravenous contrast CT technique is enough (Dangis 2020).

According to the Fleischner Society statement "The Role of Imaging in Patient Management during the COVID-19 Pandemic," imaging is indicated in hospitalised patients with moderate to severe symptoms consistent with COVID-19 despite a negative COVID-19 test result if pre-test probability is high. Chest CT scans for screening or diagnosis of COVID-19 would not be beneficial in a low-prevalence region due to high rate of false-positives (Kim et al. 2020).

As a chest CT can show COVID-19 changes even in asymptomatic people, depending on prevalence of the disease, we can expect incidental detection of COVID-19 pneumonia on any CT examination (Pozzessere et al. 2020). It is crucial to review chest images immediately after the CT images acquisition to quickly detect features suggestive of COVID-19 pneumonia, whatever the indication of the CT examination. Radiology departments must be prepared since COVID-19 pneumonia is associated with potential virus transmission.

Artificial Intelligence (AI) and COVID-19 Imaging

Many teams worldwide are developing AI systems based on the imaging signature of COVID-19 (Kundu 2020). There are studies about deep learning-based triage of COVID-19 cases from chest CXR, but there is more interest in AI studies on chest CT, mainly to differentiate COVID-19 pneumonia from other causes of pneumonia.

There is an international common goal to build data repositories to fuel COVID-19 AI, such as those of the RSNA and the European EUSOMII. Chest imaging with the help of AI could help not only in diagnosis but in risk stratification

and in monitoring the response to treatment. In an ideal world, AI models could personalise drug choice along the course of COVID-19 and could be even useful to develop new COVID-19 drugs.

Automated segmentation and quantification of infection from chest CT regions give rise to quantitative scores (Belfiore 2020), such as a "corona score," which may provide new radiomic biomarkers with potential clinical utility to assess progression over time in hospitalised patients.

Despite the high hopes placed on artificial intelligence, there is not still evidence for clinical utility of AI models for COVID-19 imaging. The Royal Australian and New Zealand College of Radiologists (RANZCR) has released a position statement urging caution with this unproven technology: "Given that CT is not always recommended for diagnosis of COVID-19, an untested and unvalidated radiology AI diagnostic assistance system is of questionable value."

COVID-19: Imaging of a Multisystemic Disease

COVID-19 is not a purely pulmonary process, but a multisystemic disease, probably through a prothrombotic mechanism. A variety of extrapulmonary manifestations have been reported, including in the gastrointestinal tract, brain, heart, kidneys or muscles. Imaging addresses the array of potential complications during COVID-19 recovery. The work-out of most of these pathologies need imaging, including abdominal CT, ultrasound (US) MRI and PET-CT (Manna 2020).

Abdominal pain is an atypical and nonspecific presenting symptom of COVID-19. Emergency radiologists need to be aware patients may present with abdominal complaints and look at the lung bases for findings of COVID-19 (Siegel 2020). Bowel abnormalities and cholestasis are common on abdominal imaging of inpatients with COVID-19 (Bhayana 2020)

COVID-19 has been reported in association with a variety of brain imaging findings such as ischaemic infarct, diffuse leukoencephalopathy and microhaemorrhages (Radmanesh 2020).

Recently, the pathophysiological substrate of two of the typical clinical symptoms associated with COVID-19, has been described thanks to MRI: myalgia, revealed as myositis signs at musculoskeletal MRI (Beydon 2020), and anosmia, seen as a MRI signal alteration at the posterior gyrus rectus at a brain MRI study (Politi 2020).

Ultrasound (US) plays an important role in the pandemic, especially at the ICU, where patients sometimes need abdominal US studies due to liver function changes. Upper and lower extremity vascular US is useful in patients with suspected deep vein thrombosis (DVT).

Point-of-care (POC) hand-held US devices are increasingly being used due to its low cost and high availability. POC chest US can have a role, but it is a very operator dependent for lung disease. It has been proposed to use it in emergency settings as a COVID-19 screening technique at the peak of the pandemic. POC echocardiography might have utility in haemodynamically unstable patients.

Imaging, including coronary CT, is crucial in the diagnosis and follow-up of COVID-19-associated Kawasaki-like disease in children and adolescents (Verdoni 2020).

Virtual autopsies can help reveal at least part of the mysteries surrounding COVID-19. Post-mortem CT (PMCT) high incidence of thromboembolic events supports an important role of SARS-Cov-2-induced coagulopathy (Wichmann 2020).

COVID-19 Radiology Educational Issues

Every cloud has a silver lining, and never before has there been so much interdisciplinary collaboration. Never had knowledge been shared in such a rapid way, with great international collaboration, initiated in China. Most medical journals shared their articles on COVID-19 in open access. Webinars also proliferated in hospitals and medical societies. Imaging databases to share COVID -19 cases have been created as teaching repositories, such as that of the British Society of Thoracic Imaging (BSTI). Free online courses have been created about COVID-19 imaging, such as that of Institut de Diagnòstic per la Imatge in Spain.

The radiology societies are offering free access to services related with COVID-19 imaging such as the European Society of Radiology ESR, the ACR, the Sociedad Española de Radiología SERAM, Canadian Association of Radiologists CAR or the American Roentgen Ray Society (ARRS), for example.

The cancellation of radiology congresses is another educational and academic consequence of the pandemic. The 2020 edition of the European Congress of Radiology (ECR) in Vienna, was one of the first European medical congresses postponed due to safety concerns regarding COVID-19. Many congresses such as ECR 2020 or the RSNA 2020 are going to be virtual, online-only, and others have been rescheduled to 2021.

Radiology residents' training is among the many challenges that radiology faces during this pandemic due to the requirements of social distance with staff radiologists. Simulated daily worklists and teaching files can be useful in diagnostic radiology. Conferences can be done remotely.

The Radiology "New Normality"

There are many unknown-known and maybe even more unknown-unknown about COVID-19. The prospect of new waves of the pandemic as long as the fact there is no proper vaccine means that our way of working will change, we do not know for how long, perhaps forever. One can speak of a COVID-19 age in Radiology.

During the peak of the pandemic, the organisation of the radiology departments changed, prioritising the patients with COVID-19, and deferring the follow-up of all non-urgent pathologies, including the oncological, in order to avoid

SARS-cov-2 infection of those patients, who must be now our priority (Mazzone 2020).

On the other hand, the significant decrease of outpatient imaging volumes during the peak had significant economic consequences in private practices.

We are now trying to come back to "the new normality" but due to the measures established to contain the pandemic, such as the need to maintain a social distance or the need for extreme hygiene and disinfection, it is necessary to space the imaging consultations to allow fewer people in the waiting room and for cleaning-up. This implies an increase of the waiting lists and further economic costs for the private radiology centres. At the same time, we must be prepared for a second or even successive waves of COVID-19, the magnitude of which is unknown.

Hospitals must improve patient flow. The COVID-19 patients independent hospital circuit is only theoretical, as the theorical "COVID-free" areas, due to the high percentage of asymptomatic among the infected people and the false negatives of diagnostic techniques. Organising the movement of patients in the hospital faces architectonic problems, especially in smaller and older hospitals. As swab screening, performed as an out-of-hospital operation, radiology equipment at the entrance or outside of the hospital, or in isolated places must be preferred. At the pandemic peak, in some hospitals, mobile CT units were installed outside hospitals, reports being made by radiologists using teleradiology.

The main radiology societies such as the ACR (Davenport 2020) or the RSNA have established recommendations on how to return to the new radiological normality. Among the many ideas of the RSNA post to protect staff, performing the CXR through the window of COVID-19 patients' room is suggested.

In Spain, the Seram published a guide for radiology appointments during the COVID-19 pandemic, an attempt to prioritise the citation of the most serious cases. Hypothetically, this pandemic may be a starting point to end the overuse of imaging techniques.

Conclusion

Radiology organisations, at the centre of much of the COVID-19 patient's process, face multiple challenges. In the age of coronavirus, radiology needs to evolve, looking for new approaches to ensure safe patient imaging while keeping innovation as well as the teaching of the new generations of radiologists. COVID-19 infection prevention of healthcare workers and patients must be a priority. Waiting for a potential new infection wave, we must act adjusting to the local epidemic statistics. Availability of personal protective equipment (PPE) must be guaranteed.

In a disease surrounded by unknowns, COVID-19 patients imaging is shedding a light on the course of their illness. In this changing landscape of uncertainty, it is critical to strengthen teams of prepared and cohesive people, who can face COVID-19 risks with knowledge, technical resources, and adequate protection. ■

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Key Points

- Initially considered a purely pulmonary process, COVID-19 is a systemic disease that requires a comprehensive imaging approach, with involvement of all techniques and the study of all anatomical areas.
- There are discrepancies regarding the role of CT in diagnosis and screening of COVID-19.
- Radiology teams are in continuous adaptation to local COVID-19 epidemiological changes. COVID-19 infection prevention of healthcare workers and patients must be a priority.
- Many of the changes brought about by the COVID-19 crisis such as portable machines, equipment disinfection, teleradiology, and virtual conferences, for example, are here to stay.
- In this changing landscape of uncertainty, the most important thing it to strengthen teams of prepared and cohesive people, who can face COVID-19 risks with knowledge, technical resources, and adequate protection.

REFERENCES

Bhayana R, Som A, Li M (2020) Abdominal Imaging Findings in COVID-19: Preliminary Observations Radiology. In Press. Available from doi.org/10.1148/radiol.2020201908

Belfiore MP, Urraro F, Grassi R et al. (2020) Artificial intelligence to codify lung CT in COVID-19 patients. Radiol Med, 125(5):500-504. doi:10.1007/s11547-020-01195-x

Bernheim A, Mei X, Huang M et al. (2020) Chest CT Findings in Coronavirus Disease-19 (COVID-19): Relationship to Duration of Infection. Radiology, 295(3):200463. Available from doi:10.1148/radiol.2020200463

Beydon M, Chevalier K, Al Tabaa O et al. (2020) Myositis as a manifestation of SARS-CoV-2 [published online ahead of print, 2020 Apr 23]. Ann Rheum Dis. Available from doi:10.1136/annrheumdis-2020-217573

Dangis A, Gieraerts C, De Bruecker Y et al. (2020) Accuracy and reproducibility of low-dose submillisievert chest CT for the diagnosis of COVID-19. Radiology. Available from doi.org/10.1148/ryct.2020200196

Davenport MS, Bruno MA, Iyer RS et al. (2020) ACR Statement on Safe Resumption of Routine Radiology Care During the Coronavirus Disease 2019 (COVID-19) Pandemic [published online ahead of print, 2020 May 6]. J Am Coll Radiol, S1546-1440(20)30510-X. Available from doi:10.1016/j.jacr.2020.05.001ACR

Fang Y, Zhang H, Xie J et al. (2020) Sensitivity of Chest CT for COVID-19: Comparison to RT-PCR Radiology. Available from doi.org/10.1148/radiol.2020200432

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