Challenges in Neuroimaging in COVID-19 Pandemia

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INTRODUCTION

Since the first case of infection was reported in December 2019, in Wuhan, China, SARS CoV 2 has spread all over the world, and was declared as a pandemic on the 11th of March by the WHO. The reported mortality rate is between 0.3 and 1% in the general population, rising to 14% in hospitalized cases (1). Even though Covid-19 infection causes a predominantly respiratory disease, its explosive eruption worldwide has affected all medical specialties.

Health care systems and workers have had to react rapidly. Each region and hospital has adapted differently depending on their specific characteristics, the prevalence of the infection and the recommendations of governments and preventative medical services. The practice of Neuroradiology, along with Radiology departments, have not escaped the effects and have had to face up to the new circumstances (2). Some works (articles, webinars and guidelines) have appeared giving recommendations and sharing their experience to face the challenge that the Covid-19 pandemic implies for the Neuroradiology. In this article, we present and discuss these recommendations in the different phases of the pandemic.

BEFORE THE PEAK OF THE PANDEMIC

In the early stages of the pandemic, crisis committees, connected with the local, regional and state public institutions, were created to establish new guidelines and protocols for each center (3–7). A general practice adopted in Radiology and Neuroradiology, was the creation of departmental coordination groups (typically comprising a radiologist/neuroradiologist, a radiographer and a secretary), to work in conjunction with these committees (8–10). In addition, general measures were implemented to limit the exposure of healthcare workers and patients for early viral detection. Securing the supply of medical material and personal protective equipment (PPE) was also a priority (6).

As the rapid and explosive spread of the Covid-19 infection required a rapid response, this coordination and reorganization of Radiology departments, a common strategy followed in hospitals, was, in our opinion, key to achieving this. The supply of PPE for staff, another critical point during the early stages of the pandemic, was a great challenge, due to the high worldwide demand (11).

THE PEAK OF THE PANDEMIC

In this phase various measures have been recommended.

One of these is the strict selection of neuroimaging tests. Although each center has had to set their own criteria depending on their particular idiosyncrasies, there have been some general recommendations (4, 5, 12, 13). In the case of critical examinations, where the neuroimaging could impact the immediate management of patients, the recommendation has been to perform the test despite the pandemic situation, subject to a risk/benefit analysis. In the case of non-critical
neuroradiological examinations, the recommendation has been
to postpone them and establish levels of priority (13–16). In some
cases, examinations could even be canceled (15).

In this phase, the increased pressure on hospitals due to
the number of Covid patients, with the consequent lack of
material and human resources, and the need for social distancing,
have made it impossible to carry out the usual volume of
examinations. For this reason, even if there have been no
specific recommendations on which particular neuroradiological
examinations to maintain, we believe that the prioritization of
tests during the peak of the pandemic has been key to ensure
that the most critical patients received an optimal radiological
diagnosis. The establishment of different priority levels in the
elective tests has been essential for their orderly rescheduling.
To give an objective view of the impact, neuroradiological
examinations during the pandemic peak decreased by almost
50% (17, 18). We think it has also been important, as emphasized
in some articles, the need of a fluid communication between
neurologists, neurosurgeons and other clinicians, to highlight any
special situations arising in particular cases.

Special mention should be made of patients with acute
stroke, who present a particular challenge for neuroradiology
departments, due to the existing relationship reported between
patients with severe coronavirus infection and cerebrovascular
stroke disease (19). As these patients usually undergo a brain
CT and angio-CT scan, some studies have recommended the
incorporation of a chest CT to rule out the possible existence
of a concomitant pneumonia due to Covid-19, which would
require isolation of the patient (20, 21). It seems a sensible
recommendation when the prevalence of the infection in the
population is high.

In terms of patient protection, the first step has been to detect
potential cases in patients coming for a neuroradiological test.
To this end screening questionnaires (3–5, 9) have been carried
out, often even conducted by telephone before the arrival of
the patient, followed by PCR tests if necessary and available.
Specific circuits have been established within Neuroradiology
departments to avoid contact between infected and uninfected
patients. “Clean” radiological equipment has been kept for
uninfected patients and “dirty” for infected patients (5, 13, 22–
25). Social distancing has been enforced in waiting rooms and
masks made mandatory for all patients (5, 13, 26). Cleaning,
disinfection and air purification frequency have also been
increased (5, 13, 22–25).

These are reasonable measures which are recommended in
guidelines and have been adopted generally in hospitals and
imaging centers. We think it is important that each hospital
establishes their own protocols, as these recommendations
can be carried out in different ways according to particular
characteristics. For example, in relation to air purification, some
of the recommended measures have been the use of a high-
efficiency particulate air (HEPA) filter, ultraviolet irradiation or
simply lengthening the time between two patients. The choice as
to which to use is a decision that depends on multiple factors.
In relation to the use of masks or other medical devices, such
as ventilators, in Neuroradiology departments, we think it is
important to highlight that they need to be compatible with the
MRI environment, for both safety and image quality reasons.
In the case of CT examinations, they must not contain metallic
elements which could distort the image (26–29).

In terms of healthcare staff protection, education about
security measures, the provision of PPE and the establishment of
physical barriers, such as plastic screens and equipment covers,
have been some of the more extensively adopted precautionary
measures (5, 13, 14). Tele-neuroradiology has been another
widely adopted practice to reduce the exposure of departmental
staff, with the use of “Picture Archiving and Communication
System” PACS. Where telematic work has not been possible,
the establishment of groups, working different hours or days,
has been an extensively used option, along with the use of
individual workstations and maintaining social distancing in
the work-space (7, 26, 29). In order to maintain clinical and
educational communication, the use of phone calls (instead of
personal interactions) and teleconference applications for virtual
sessions has been widespread, especially for essential clinical care
meetings (30). These applications allow communication from
workstations or even phones, and also screen sharing to show
neuro-radiological images (25).

Probably one of the most specific challenge for
Neuroradiology, related to the staff protection, has been the
rapid deployment of Home PACS Workstations and the
expansion of teleradiology (31–33).

AFTER THE PEAK OF THE PANDEMIA

Once the peak of the pandemic has passed, the most emphasized
recommendation for Radiology departments has been to recover
activity in a tiered manner (13–15, 34–36). The postponed
examinations should be re-scheduled following the degrees of
priority established during the peak of the pandemic (13–15). The
new petitions generated by the recovery of activity in hospitals
also need to be taken into account. We think that all these
common measures to recover radiological activity, have to be
adapted to each situation, as the prevalence of the pandemic
and the resources of health care systems could be very variable.
In this regard we found the work of Madhuripan et a. (17)
interesting, which related the radiology volume recovery after
the pandemia to different variants, such as regional pandemic
severity, the lifting of government restrictions, patient Covid-
19 infection concern, management during the pandemic peak,
impact of the economic recession and Radiology practice profile.

General measures to avoid the transmission of Covid-19
have still been recommended in this phase and are likely to be
necessary for some time (35). For example, the obligatory use
of masks and enforcing of social distancing in the hospital, the
use of PPE for health workers and the increased disinfection
and ventilation of imaging suites. As a result of these measures,
Radiology departments still need to allow for longer times
between patient examinations. Many hospitals have responded to
this by increasing the hours of radiological assistance, extending
the activity of the MRI and CT scans during the night and
weekend shifts (34, 35). We think this may be necessary to re-
schedule all the postponed activity, but hospital management
must take into account that it may mean hiring more staff or agreeing new shifts with workers.

The continued use of tele-radiology, at least partially, is still recommended at this stage (13, 34, 35). This has been one of the most widespread measures adopted in neuroradiology and has generally been implemented successfully (31–33). After these experiences and in line with other articles (37), we believe that for neuroradiologists, the coronavirus pandemic may contribute to the permanent establishment of tele-neuroradiology, or at least to a mixed model with part of the time physically present and part of the time reporting remotely.

**CONCLUSION**

The particular challenges for the practice of Neuroradiology during the Covid pandemic have been different during the distinct phases. In the early stage, the main challenge was the need for a rapid response. During the peak of the pandemic, the challenge was to maintain critical neurioimaging assistance, whilst preventing the spread of the infection amongst patients and healthcare workers. After the peak of the pandemic the challenge has been to recover neuroradiological activity while maintaining some Covid-19 measures, which seem likely to continue for a while. Some of the strategies with which Neuroradiology has faced the challenges of each phase have been general, and others more specific to the specialty. Broadly they have been quite consistent throughout the different articles and guidelines published.

After the peak of the Covid-19 pandemic we have to stay alert and know how to react on time to possible next waves, using what we have already learnt during these months. Neuroradiology assistance should be maintained taking into account the general care of the patients and the global health situation.

**AUTHOR CONTRIBUTIONS**

All authors contributed to the article and approved the submitted version.

**REFERENCES**

1. World Health Organization. *Report of the WHO-China Joint Mission on Coronavirus Disease 2019 COVID-19*. (2020). Available online at: https://www.who.int/docs/defaultsource/coronaviruse/who-china-joint-mission-on-covid-19-final-report.pdf

2. Mahajan A, Hirsch JA. Novel coronavirus: what neuroradiologists as citizens of the world need to know. *Am J Neuroradiol.* (2020) 41:552–4. doi: 10.3174/ajnr.A6526

3. Chen RC, Tan TT, Chan LP. Adapting to a new normal? 5 key operational principles for a radiology service facing the COVID-19 pandemic. *Eur Radiol.* (2020) 30:4964–7. doi: 10.1007/s00330-020-06862-1

4. Mossa-Basha M, Azadi J, Ko J, Klein J, Meltzer C, COVID-19 Task Force. RSNA COVID-19 Task Force: Best Practices for Radiology Departments during COVID-19. (2020). Available online at: https://www.rsna.org/-/media/Files/RSNA/Covid-19/RSNA-COVID-19-bestpractices.ashtx?la=en&hash=58700DDDEDB3E5A9C8EDE808B534B4ABB10291B7

5. Mossa-Basha M, Limnaa KF, Sahani DV. Radiology Department preparedness in the coronavirus disease 2019 (COVID-19) postshutdown environment. *J Am Coll Radiol.* (2020) 17:890–93. doi: 10.1016/j.jacr.2020.05.017

6. Wong ASK, Ooi CC, Leow MQH, Kiew YS, Yeo KCW, Tan SG, et al. Adapting lessons from SARS for the COVID-19 pandemic-perspectives from radiology nursing in Singapore. *J Radiol Nurs.* (2020) 39:164–7. doi: 10.1016/j.jradnu.2020.06.008

7. Myers L, Balakrishnan S, Reddy S, Gholamrezaeezad A. Coronavirus outbreak: is radiology ready? Mass casualty incident planning. *J Am Coll Radiol.* (2020) 17:724–9. doi: 10.1016/j.acra.2020.03.025

8. Schnall MD, Meltzer CC, Oteaga L, Soo Tan B, Mahoney MC, Mossa-Basha M, et al. Crisis leadership during COVID-19. *RSNA Webinar*. (2020). Available online at: https://www.youtube.com/watch?v=CIHRD55BU (accessed July 13, 2020).

9. Iglesias B, Maiques JM, Martínez C, Rovira M, Valdés P. Radiology in the era of Covid-19 infection. *SERAM Webinars*. (2020). Available online at: https://seram.es/images/site/Futuro_Radiologia_COVID_SERAM_2.pdf

10. Tay KH, Ooi CC, Mahmood MIB, Aw LP, Chan LP, Ng DCE, et al. Reconfiguring the radiology leadership team for crisis management during the COVID-19 pandemic in a large tertiary hospital in Singapore. *Eur Radiol.* (2020) 11:1–7. doi: 10.1007/s00330-020-07116-w

11. Albano D, Bruno A, Bruno F, Calandri M, Caruso D, Clemente A, et al. Impact of coronavirus disease 2019 (COVID-19) emergency on Italian radiologists: a national survey. *Eur Radiol.* (2020) 30:6635–44. doi: 10.1007/s00330-020-07046-7

12. Davenport MS, Bruno MA, Iyer RS, Johnson AM, Herrera R, Nicola GN, et al. ACR statement on safe resumption of routine radiology care during the coronavirus disease 2019 (COVID-19) pandemic. *J Am Coll Radiol.* (2020) 17:839–44. doi: 10.1016/j.jacr.2020.05.001

13. Valdès P, Rovira A, Guerrero J, Morales A, Rovira M, Martínez C. The Radiology From the Onset of COVID-19 Infection. *SERAM Guidelines*. (2020). Available online at: https://seram.es/images/site/Futuro_Radiologia_COVID_SERAM_2.pdf

14. Prosch H, Ginsberg M, Odink AE. *Radiology Fighting COVID-19 | Maintaining Quality Imaging - Developing Guidelines and Protocols in Times of Crisis.* ESR Connect (2020). Available online at: https://vimeo.com/41429281

15. Valdès P, Rovira A, Guerrero J, Morales A, Rovira M, Martínez C. Proposals for the Citation of Radiology Studies in the post-COVID-19 era. *SERAM Guidelines*. (2020). Available online at: https://seram.es/index.php/informacion-coronavirus (accessed March 21, 2020).

16. Vagal A, Mahoney M, Allen B, Kapur S, Udusuen G, Wang L, et al. Rescheduling nonurgent care in radiology: implementation during the coronavirus disease 2019 (COVID-19) pandemic. *J Am Coll Radiol.* (2020) 17:882–9. doi: 10.1016/j.jacr.2020.05.010

17. Madhuripan N, Cheung HMC, Alicia Cheong LH, Jawahar A, Willis MH, Larson DB. Variables influencing radiology volume recovery during the next phase of the coronavirus disease 2019 (COVID-19) pandemic. *J Am Coll Radiol.* (2020) 17:855–64. doi: 10.1016/j.jacr.2020.05.026

18. Parkh KD, Ramaiya NH, Kikano EG, Tirumani SH, Pandya H, Stovicek B, et al. COVID-19 pandemic impact on decreased imaging utilization: a single institutional experience. *Acad Radiol.* (2020) 27:1204–13. doi: 10.1016/j.acra.2020.06.024

19. Goldberg MF, Goldberg MF, Cereijo R, Tayal AH. Cerebrovascular disease in COVID-19. *Am J Neuroradiol.* (2020) 41:1170–72. doi: 10.3174/ajnr.A6588

20. Qureshi AI, French BR, Siddiq F, Arora NA, Nattanmai P, Gomez CR. *COVID-19 screening with chest CT in acute stroke imaging: a clinical decision model.* *J Neuroimaging.* (2020) 30:617–24. doi: 10.1111/jon.12746

21. Rodríguez-Pardo J, Fuentes B, Alonso de Leciñana M, Campollo J, Calleja P. Proposals for the Citation of Radiology Studies in the post-COVID-19 era. *SERAM Guidelines*. (2020). Available online at: https://seram.es/index.php/informacion-coronavirus (accessed May 28, 2020).

22. Sim WY, Chen RC, Aw LP, Abu Bakar R, Tan CC, Heng AL, et al. How to safely and sustainably reorganise a large general radiography...
service facing the COVID-19 pandemic. Radiography. (2020) 26:e303–11. doi: 10.1016/j.radi.2020.05.001
23. Ding J, Fu H, Liu Y, Gao J, Li Z, Zhao X, et al. Prevention and control measures in radiology department for COVID-19. Eur Radiol. (2020) 30:3603–8. doi: 10.1007/s00330-020-06850-5
24. Filippi CG, Gerevini S, Yao ZW, Shatzkes D, and Lim T. COVID-19 neuroimaging in real life: an international perspective from the WFNRS. In Webinar From The World Federation of Neuroradiological Societies. (2020). Available online at: https://www.youtube.com/watch?v=T2CJ1VID1RY&feature=youtu.be (accessed May 15, 2020).
25. Tay KH, Yee J, Rossi S. COVID-19 - radiology surge and second surge preparedness-part 1. RSNA Webinar. (2020). Available online at: https://www.youtube.com/watch?v=hXBdkjcg-4w&feature=youtu.be
26. Chen RC, Cheng LT, Liang Lim Jl, Gogna A, Ng DCE, Yi Teo LZ, et al. Touch me not: safe distancing in radiology during coronavirus disease 2019 (COVID-19). J Am Coll Radiol. (2020) 17:739–42. doi: 10.1016/j.jacr.2020.04.019
27. ACR. ACR Guidance on COVID-19 and MR Use. Available online at: https://www.acr.org/Clinical-Resources/Radiology-Safety/MR-Safety/COVID-19-and-MR-Use
28. Koorki S, Hosseiny M, Raman SS, Myers L, Gholamrezanezhad A. Coronavirus disease 2019 (COVID-19) precautions: what the MRI suite should know. J Am Coll Radiol. (2020) 17:830. doi: 10.1016/j.jacr.2020.05.018
29. Cheng LT, Heilbrun M, Sahani D. Radiology surge and second surge preparedness (Part 2). RSNA Webinar. (2020). Available online at: https://www.youtube.com/watch?v=1cHvvr9N_5w&feature=youtu.be (accessed June 22, 2020).
30. D’Anna G, D’Arco F, Van Goethem J. Virtual meetings: a temporary choice or an effective opportunity for the future? Neuroradiology. (2020) 62:769–70. doi: 10.1007/s00234-020-02461-5
31. Tridandapani S, Holl G, Canon CL. Rapid deployment of home PACS workstations to enable social distancing in the coronavirus disease (COVID-19) Era. Am J Roentgenol. (2020) 20:1–3. doi: 10.2214/AJR.20.23495
32. Dick EA, Raithatha A, Musker L, Redhead J, Mehta A, Amiras D. Remote reporting in the COVID-19 era: from pilot study to practice. Clin Radiol. (2020) 75:710.e5-8. doi: 10.1016/j.crad.2020.06.016
33. Martin-Nogueiro T, Lopez-Ortega R, Ros PR, Luna A. Teleworking beyond teleradiology: managing radiology departments during the COVID-19 outbreak. Eur Radiol. (2020) 2:1-4. doi: 10.1007/s00330-020-07205-w
34. Mossa-Basha M, Azadi J, Klein I, Menias C, Filippi C, Tan BS, et al. RSNA COVID-19 Task Force: Post-COVID Surge Preparedness. (2020). Available online at: https://www.rsna.org/-/media/Files/RSNA/covid-19/RSNA-COVID-19-PostSurgePreparedness.pdf (accessed May 06, 2020).
35. Azam SA, Myers L, Fields BKK, Demirjian NL, Patel D, Roberge E, et al. Coronavirus disease 2019 (COVID-19) pandemic: review of guidelines for resuming non-urgent imaging procedures in radiology during Phase II. Clin Imaging. (2020) 67:30–36. doi: 10.1016/j.clinimag.2020.05.032
36. Vagal A, Mahoney M, Anderson JL, Allen B, Hudepoh J, Chadalavada S, et al. Recover wisely from COVID-19: responsible resumption of nonurgent radiology services. Acad Radiol. (2020) 27:1343–52. doi: 10.1016/j.acra.2020.08.002
37. Moriaty AK, Friedberg E, Pyatt RS Jr., Everett C, McAdams C. What might your practice look like post-peak COVID-19? J Am Coll Radiol. (2020) 17:1053–5. doi: 10.1016/j.jacr.2020.06.009

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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