



Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



Available online at  
**ScienceDirect**  
[www.sciencedirect.com](http://www.sciencedirect.com)

Elsevier Masson France  
**EM|consulte**  
[www.em-consulte.com](http://www.em-consulte.com)



## Editorial

# Brain imaging findings in COVID-19: What do we know so far?



The coronavirus disease 2019 (COVID-19) pandemic has been spreading rampantly throughout the world, with more than 2.8 million confirmed cases to date [1]. While at the initial stages, the focus has been on the typical respiratory symptoms with which patients present, which include fever, cough, and dyspnea; increasing evidence is revealing that it is essentially a multi-system disease. Physicians around the globe are noticing confirmed COVID-19 patients manifesting with neurological signs and symptoms – adding to the complexity in management of these patients.

The largest series published to date discussing the neurological manifestations of confirmed COVID-19 patients is by Hu et al. [2]. In their series of 214 patients, 78 (36.4%) had neurological manifestations. These include skeletal muscle injury, impaired consciousness, and acute cerebrovascular diseases. Interestingly, COVID-19 patients with more severe respiratory infections were associated with a higher prevalence of neurological manifestations (45.5%). Li et al. [3] postulated that due to the ability of certain groups of coronaviruses spreading via a synapse-connected route to the cardiorespiratory center from the mechanoreceptors and chemoreceptors in the lung and lower respiratory tract, it is theoretically possible that COVID-19 patients with more severe respiratory symptoms consequently display a higher prevalence of neurologic symptoms.

There is scarce published literature so far discussing the brain imaging findings of patients with confirmed COVID-19 infection. Filatov et al. [4] described an elderly male who came with headache and altered mental status, with brain computed tomography (CT) findings of an old posterior cerebral artery infarct. Magnetic resonance imaging (MRI) was not pursued. Zhang et al. [5] described a young patient with dysphagia, dysarthria, and encephalopathy, who was found to have imaging findings consistent with acute disseminated encephalomyelitis (ADEM) on CT and MRI. Griffith et al. [6] described brain MRI findings of acute hemorrhagic necrotizing encephalopathy (ANE) in a 50-year-old female presenting with altered mental status. Viguier et al. [7] encountered an elderly patient with severe respiratory symptoms, who came with an acute onset of aphasia and right-sided hemiparesis. The neurological exam was consistent with a left middle cerebral artery (MCA) syndrome, with a NIH stroke scale (NIHSS) of 10. Brain CT, CT angiography (CTA), and CT perfusion showed subtle cortical left frontal hypoattenuation and distal branch occlusion. CTA of the carotid arteries disclosed a large intraluminal floating thrombus in the left common carotid artery, presumably the source of the acute infarct. Diffusion weighted imaging (DWI) MRI, performed 2 days later confirmed multiple foci of acute ischemic strokes, with

no evidence of large vessel occlusion amenable for revascularization. Poillon et al. [8] encountered 2 patients who presented with headache and eye symptoms, with imaging evidence of cerebral venous thrombosis on CT and MRI. In both these patients, the postulation that COVID-19 infection possibly causes hyperactivation of inflammatory factors and damage to the coagulation system, leading to D-dimer and platelet abnormalities, may potentially play a significant role. The largest series of patients with neurologic symptoms and brain imaging findings published thus far is by Mezzani et al. [9]. In their series of 13 patients, imaging was pursued due to unexplained encephalopathy, revealing 8 with leptomeningeal enhancement (62%), 3 patients with evidence of ischemic stroke (23%) and 11 out of 11 patients (100%) with perfusion abnormalities, whom underwent perfusion imaging.

Hitherto, there are no typical brain imaging findings that may suggest COVID-19 infection. Due to its novelty, it is understandable that limited data is available in guiding physicians with regards to management. However, the evidence so far suggests a higher prevalence of neurologic symptoms in those patients with more severe respiratory symptoms – necessitating a higher degree of caution when dealing with this group of patients, so that prompt intervention may be instituted.

## Ethics statement

This article does not contain any studies involving human participants. Approval by an ethics committee was not applicable. The submission has not been published before.

## Funding

No funding was received for this manuscript.

## Disclosure of interest

The author declares that he has no competing interest.

## References

- [1]. *Coronavirus disease (COVID-19) Pandemic*. Geneva: World Health Organization; 2020 <https://www.who.int/emergencies/diseases/novel-coronavirus-2019>.
- [2]. Mao L, Jin H, Wang M, et al. Neurologic Manifestations of Hospitalized Patients With Coronavirus Disease 2019 in Wuhan, China. *JAMA Neurology*. 2020. <http://dx.doi.org/10.1001/jamaneurol.2020.1127>.
- [3]. Li YC, Bai WZ, Hashikawa T. The neuroinvasive potential of SARS-CoV2 may play a role in the respiratory failure of COVID-19 patients. *J Med Virol*. 2020;92:552–555.

- [4]. Filatov A, Sharma P, Hindi F, Espinosa PS. Neurological Complications of Coronavirus Disease (COVID-19): encephalopathy. *Cureus*. 2020;12(3): e7352.
- [5]. Zhang T, Rodricks MB, Hirsh E. COVID-19 Associated Acute Disseminated Encephalomyelitis – A Case Report. medRxiv. <https://doi.org/10.1101/2020.04.16.20068148>.
- [6]. Poyiadji N, Shahin G, Noujaim D, Stone M, Patel S, Griffith B. COVID-19-associated Acute Hemorrhagic Necrotizing Encephalopathy: CT and MRI Features. *Radiology*. 2020, <http://dx.doi.org/10.1148/radiol.2020201187>.
- [7]. Viguier A, Delamarre L, Duplantier J, Olivot JM, Bonneville F. Acute ischemic stroke complicating common carotid artery thrombosis during a severe COVID-19 infection. *Journal of neuroradiology*. 2020, <http://dx.doi.org/10.1016/j.neurad.2020.04.003>.
- [8]. Poillon G, Obadia M, Perrin M, Savatovsky J, Lecler A. Cerebral Venous Thrombosis associated with COVID-19 infection: causality or coincidence? *Journal of neuroradiology*. 2020, <http://dx.doi.org/10.1016/j.neurad.2020.05.003>.
- [9]. Helms J, Kremer S, Merdji H, et al. Neurologic Features in Severe SARS-CoV-2 Infection. *The New England journal of medicine*. 2020, <http://dx.doi.org/10.1056/NEJMc2008597>.

Mohamad Syafeeq Faez Md Noh <sup>a,b,\*</sup>

<sup>a</sup> Department of Imaging, Level 3, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia

<sup>b</sup> Department of Radiology, Universiti Putra Malaysia (UPM) Teaching Hospital, Persiaran MARDI-UPM, 43400 Serdang, Selangor, Malaysia

\* Correspondence to: Department of Imaging, Level 3, Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia.

E-mail address: [msf.mdnoh@gmail.com](mailto:msf.mdnoh@gmail.com)

Available online 19 May 2020