

On-line Table: MR imaging brain findings reported in patients with COVID-19

Articles	No. of Patients with Brain MR Imaging	Location	Type of Study and Clinical Features of Patients with COVID-19	Average Age and Sex	Findings
Kandemirli ⁶	27	Turkey	Retrospective study examining COVID-19 ICU patients with neurologic symptoms. 19 patients intubated, 8 noninvasive ventilator support.	63 years old (range 34–87) 21 males 6 females	-12/27 patients with acute findings: -10 patients with cortical FLAIR signal abnormality; 3 of which with subcortical and deep white matter signal abnormality, 7 with cortical restricted diffusion, 5 with subtle leptomeningeal enhancement, and 3 cases with punctate cortical blooming. -1 patient with dural venous sinus thrombosis. -1 patient with acute infarct in the right middle cerebral artery territory. -15 patients: no acute findings 27 patients in total: 11 COVID-19 patients included in the study: -4 patients with diffuse white matter abnormality, interpreted as leukoencephalopathy, -1 patient with parenchymal microhemorrhages on susceptibility-weighted imaging -6 with a combination of white matter abnormality and microhemorrhages -Leukoencephalopathy described as “T2 hyperintensities that were symmetric and confluent, demonstrated mild restricted diffusion, and involved bilateral and deep and subcortical white matter.” -Microhemorrhages predominately reported in juxtacortical white matter, and the corpus callosum. 16 COVID-19 patients excluded from the study: -11 with acute or subacute infarcts (include 3 with microhemorrhagic transformation) -4 with parenchymal hemorrhages -1 with thalamic expansile T2 hyperintensity -1 with thalamic expansive T2 hyperintensity Acute MRI brain findings/diagnoses: -1 Acute ischemic infarct -1 Cranial nerve enhancement (Miller-Fisher syndrome). -1 PRES -1 acute encephalopathy -2 non-specific encephalopathy -1 hypoxic-ischemic encephalopathy -2 exacerbation of demyelinating disease -8 patients with leptomeningeal enhancement -11 patients with bilateral frontotemporal hypoperfusion -2 patients with small acute infarcts -1 patient subacute infarct
Radmanesh ⁷	27	New York	Retrospective study of 11 COVID-19 ICU patients with depressed mental status and specific MRI findings. All were intubated mean duration 27 days.	53 years old (range 38–64) 9 males, 2 females	
Mahammedi ⁸	20	Italy	Retrospective study evaluating neuroimaging in hospitalized COVID-19 patients with acute neurological symptoms.	Not available for patients with MRI brain exams	
Helms ¹	13	France	Observational series of COVID-19 patients with ARDS. MRI brain scans performed for unexplained encephalopathy.	Not available for patients with brain MR imaging	

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Helm ⁹	France	10	Prospective cohort study evaluating 150 patients with COVID-19 ARDS. Primary end-point was to compare thrombotic events in patients with COVID-19 ARDS from non-COVID-19 ARDS.	Not available for patients with MRI brain exams	10 patients with brain MRI examinations -2 patients with left cerebellar ischemic stroke: one acute and one likely pre-existing to COVID-19 infection -1 patient had bilateral multiple periventricular ischemic lesions -1 patient with acute intraparenchymal hematoma and multiple recent ischemic lesions
Dogan ²⁴	Turkey	6	Case series reporting plasmapheresis in 6 COVID-19 patients with meningoencephalitis.	49 y/o male 59 y/o male 22 y/o male	-Patient 1: Cortical FLAIR hyperintensity and leptomeningeal enhancement. -Patient 2: Cortical and white matter FLAIR hyperintensity. Subarachnoid hemorrhage. -Patient 6: Findings consistent meningoencephalitis, not further specified.
Tunç ²⁵	Turkey	4	Case series 4 patients with acute ischemic strokes. None were ventilated.	45 y/o female 67 y/o female 72 y/o male 77 y/o male	-3 patients had normal MRI brain exams -right MCA acute infarcts -left lentikulostriate acute infarcts -left MCA acute infarcts -right pontine infarct -Left PICA acute infarct. Subsequent bilateral PCA acute infarcts. -acute corpus striatum infarct -acute infarcts in right thalamus, left pons, right occipital lobe, right cerebellum
Beyrouti ²⁶	United Kingdom	3	Case series 6 patients with acute ischemic strokes.	64 y/o male 61 y/o male, 73 y/o male.	-Left PICA acute infarct. Subsequent bilateral PCA acute infarcts. -acute corpus striatum infarct -acute infarcts in right thalamus, left pons, right occipital lobe, right cerebellum
Nicholson ¹⁶	Toronto, Canada	2	Case series of 4 patients, MRI brain obtained in 2. Both patients with MRI were on ECMO therapy.	57 y/o male 62 y/o male	Patient 1: -petechial parenchymal hemorrhages on SWI, with some small parenchymal hematomas. -diffuse extensive parenchymal susceptibility SWI abnormality, possibly correlating to a venular distribution and predominantly in a sub-cortical pattern. -few scattered multifocal cortical infarcts. Patient 2: -multifocal 'blooming' in the subarachnoid and subpial spaces along the cortex in a gyriform pattern. -extensive abnormal SWI signal tracking along small cortical veins -mild FLAIR hyperintensity in some cortical regions. -T2 hyperintensity in subcortical white matter, with callosal involvement. -trace intraventricular hemorrhage.

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Francheschi ²⁷		2	Case series 2 patients with altered mental status. -1 patient required ventilation.	48 y/o male 67 y/o female	Hemorrhagic posterior reversible encephalopathy syndrome: Patient 1: -Edema in parieto-occipital regions with subacute blood products. -diffuse petechial hemorrhages through the corpus callosum. -small right occipital infarct Patient 2: -Edema in parieto-occipital regions -posterior infarcts -superimposed hemorrhages Confluent regions of restricted diffusion within subcortical and deep hemispheric white matter, with microhemorrhages. Diffusion and FLAIR hyperintensity in the right mesial temporal lobe/hippocampus.
Cavalcanti ²⁸	New York	1	Case Series in COVID-19 patients with cerebral venous thrombosis	28 y/o male	
Moriguchi ²⁹	Japan	1	Case report Meningitis/encephalitis presenting with seizures and impaired consciousness. Patient was intubated.	24 y/o male	
Sachs ³⁰	North Carolina	1	Case report Intubated ICU patient.	59 y/o male	-diffuse, confluent, posterior predominant white matter T2/FLAIR hyperintensity -scattered micro-hemorrhage predominantly in the corpus callosum. -posterior circulation hyperperfusion on ASL. MRI exams day 1 and 9 post admission were normal
Pilotto ³¹	Italy	1	Case report Encephalitis with severe alteration of consciousness, EEG with generalized slowing.	60 y/o male	
Poyiadji ³²	Detroit	1	Case report Altered mental status.	50's female	Acute hemorrhagic necrotizing encephalopathy: -hemorrhagic, rim enhancing lesions in the thalami, medial temporal lobes, and subinsular regions T2 hyperintensity in the right inferior cerebellar peduncle, extending into the upper spinal cord
Wong ³³	United Kingdom	1	Case report COVID-19 pneumonia with multiple neurological deficits.	40 y/o male	

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Zanin ³⁴	Italy	1	Case report Intubated patient with COVID-19 pneumonia and seizures.	54 y/o female	-multiple T2 hyperintense, nonenhancing periventricular white matter lesions, with pattern suggestive of demyelination -T2 hyperintense lesions at the bulbo-meullary junction and cervicothoracic spinal cord -lesions were new from prior MRI brain exams PRES-like syndrome: -bilateral occipital and frontal cortical white matter, corpus callosum splenium T2/FLAIR hyperintensities and restricted diffusion. -Imaging findings resolved on follow-up MRI two weeks later
Kaya ³⁵	Turkey	1	Case report COVID-19 pneumonia requiring non-invasive mechanical ventilator support; altered consciousness, acute vision loss.	38 y/o male	Edema and enlargement of bilateral olfactory bulbs. Follow-up MRI demonstrated resolution Deep cerebral vein hemorrhagic venous infarction: -occluded internal cerebral veins and vein of Galen (on CT venogram) -deep right hemispheric vasogenic edema with regions of hemorrhage. Acute infarct left medial temporal lobe
Laurendon ³⁶	France	1	Case report Anosmia and dysgeusia	27 y/o male	
Chougar ³⁷	France	1	Case report Altered mental status, status epilepticus, mild respiratory symptoms	72 y/o male	
Avula ³⁸	New York	1	Case report Shortness of breath, right arm weakness	88 y/o female	
Piloti ³⁹	Italy	1	Case Report Cough with anosmia	25 y/o female	Cortical signal abnormality in the right gyrus rectus, and hyperintensity in the olfactory bulbs. Follow-up MRI brain 28 days later was normal.

Note:—ECOM indicates extracorporeal membrane oxygenation; ICU, intensive care unit; PCA, posterior cerebral artery; ASL, arterial spin-labeling; EEG, electroencephalography; ARDS, Acute Respiratory Distress Syndrome.