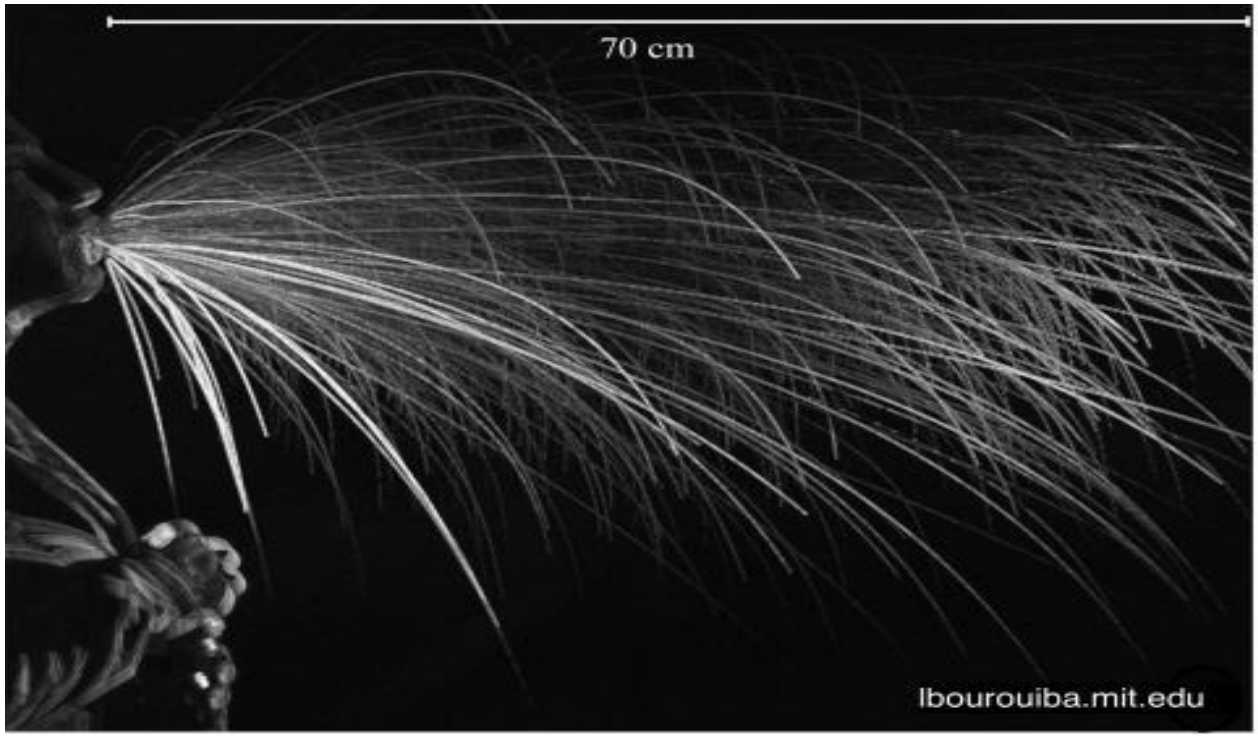
COVID-19 and Neurological Disease

Shibani S. Mukerji MD, PhD
Assistant Professor of Neurology
Associate Director of the Neuro-Infectious Diseases Unit



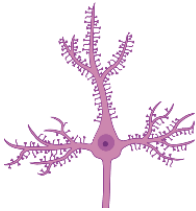
Disclosures

- Research Grant: James S. McDonnell Foundation
- Stock (Investment Account): Gilead
- Research Grant: NIMH

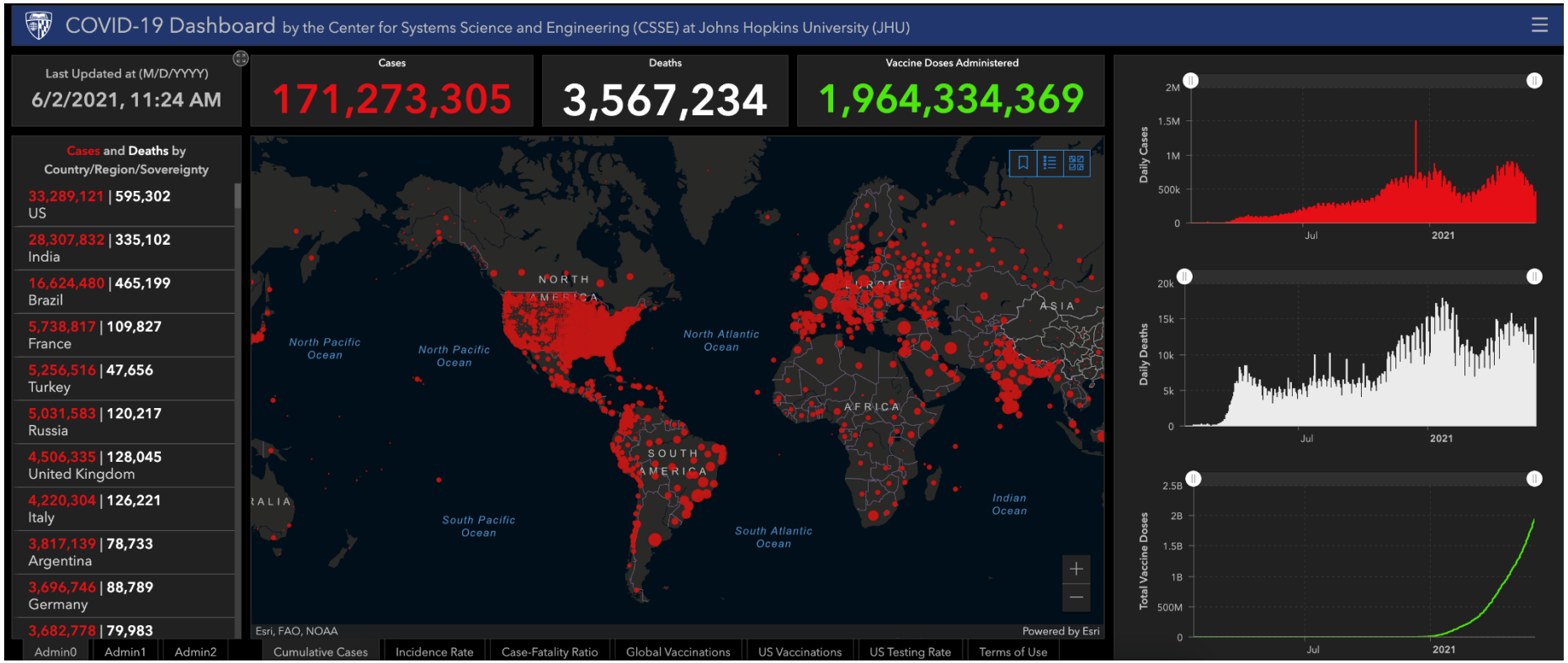
SARS-CoV-2
~0.1 um

HIV
~0.1 um

Worldwide COVID-19 Cases >171 million
Deaths Related to COVID-19 > 3.5 million
Vaccine Doses Administered > 1.9 billion

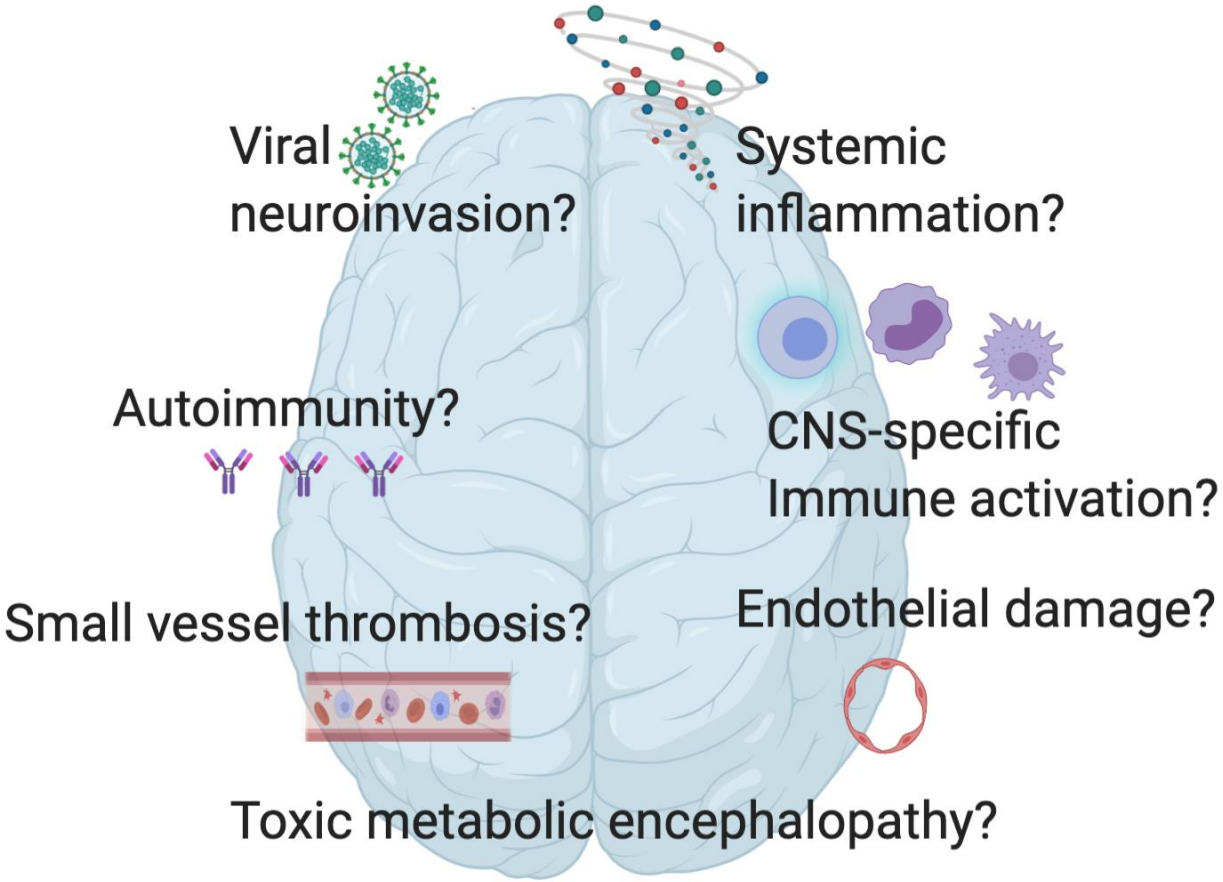


Diameter of neuron cell body ~20um



https://coronavirus.jhu.edu/map.html; Data as of June 2 2021

Critical Knowledge Gaps and Areas of Active Scientific Investigation Underlying Neurological Symptoms in COVID-19



Farhadian, Seilhean, and Spudich, Current Opinion in Neurology, 2021

What are common neurological symptoms in hospitalized COVID-19?

JAMA Neurology | Original Investigation

Neurologic Manifestations of Hospitalized Patients With Coronavirus Disease 2019 in Wuhan, China

Ling Mao; Huijuan Jin; Mengdie Wang; Yu Hu; Shengcai Chen; Quanwei He; Jiang Chang; Candong Hong; Yifan Zhou; David Wang; Xiaoping Miao; Yanan Li, MD, PhD; Bo Hu, MD, PhD

Table 1. Clinical Characteristics of Patients With COVID-19

Characteristic	No. (%) Total (N = 214)	Severe (n = 88)	Nonsevere (n = 126)	*P* value[a]
Nervous system symptoms				
Any	78 (36.4)	40 (45.5)	38 (30.2)	.02
CNS	53 (24.8)	27 (30.7)	26 (20.6)	.09
Dizziness	36 (16.8)	17 (19.3)	19 (15.1)	.42
Headache	28 (13.1)	15 (17.0)	13 (10.3)	.15
Impaired consciousness	16 (7.5)	13 (14.8)	3 (2.4)	<.001
Acute cerebrovascular disease	6 (2.8)	5 (5.7)	1 (0.8)	.03
Ataxia	1 (0.5)	1 (1.1)	0	NA
Seizure	1 (0.5)	1 (1.1)	0	NA
PNS	19 (8.9)	7 (8.0)	12 (9.5)	.69
Impairment				
Taste	12 (5.6)	3 (3.4)	9 (7.1)	.24
Smell	11 (5.1)	3 (3.4)	8 (6.3)	.34
Vision	3 (1.4)	2 (2.3)	1 (0.8)	.37
Nerve pain	5 (2.3)	4 (4.5)	1 (0.8)	.07
Skeletal muscle injury	23 (10.7)	17 (19.3)	6 (4.8)	<.001

Published online Apr 10, 2020
Cited by >3400 articles

Original Investigation | Neurology

May 11, 2021

Global Incidence of Neurological Manifestations Among Patients Hospitalized With COVID-19—A Report for the GCS-NeuroCOVID Consortium and the ENERGY Consortium

Sherry H.-Y. Chou, MD, MSc[1,2]; Ettore Beghi, MD[3]; Raimund Helbok, MD[4]; et al

» Author Affiliations | Article Information

JAMA Netw Open. 2021;4(5):e2112131. doi:10.1001/jamanetworkopen.2021.12131

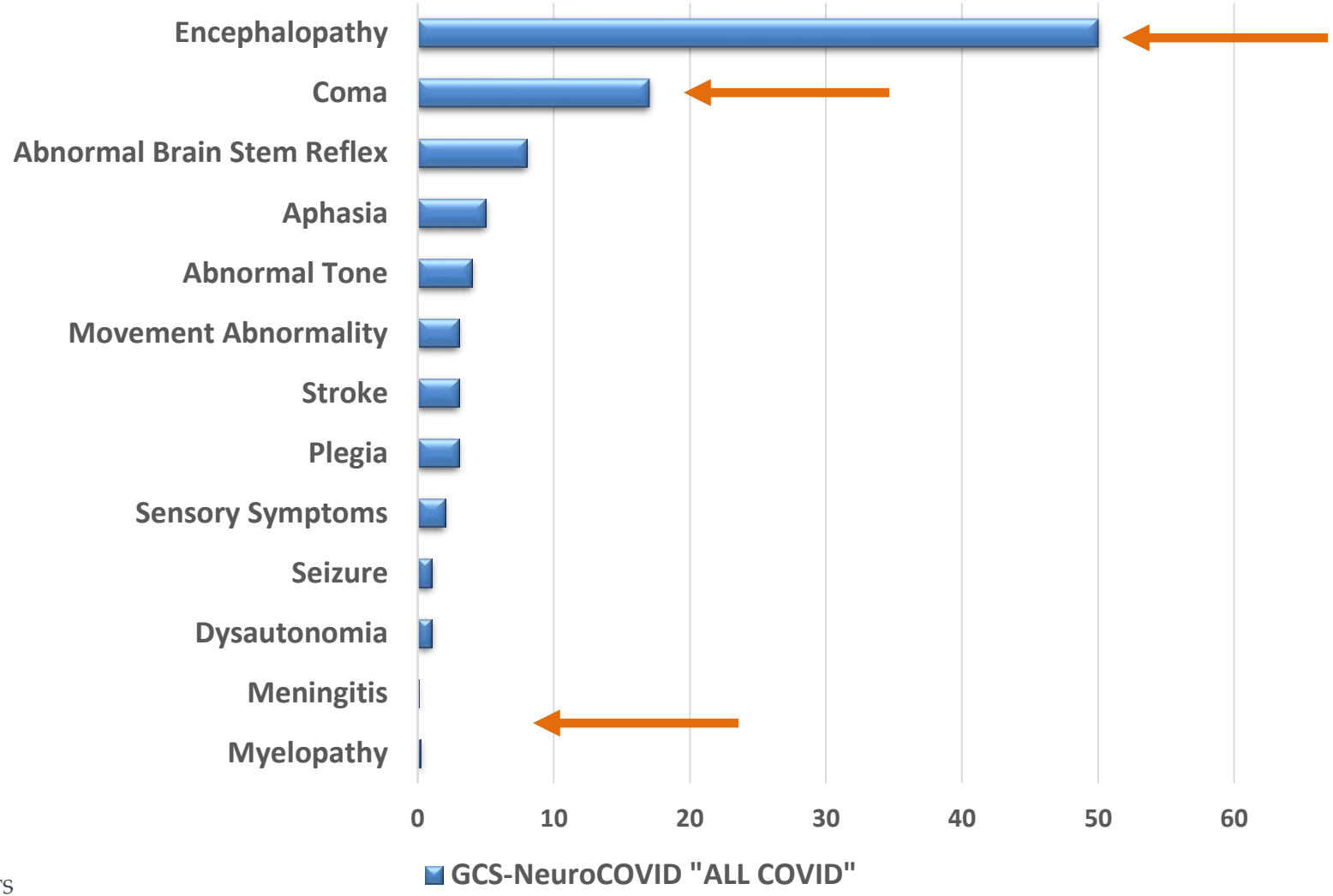
Table 2. Neurologic Manifestations in Study Population, Stratified by Cohort[a]

Manifestation	Patients, No./total No. (%)		
		GCS-NeuroCOVID Cohort	
	EAN ENERGY Registry (n = 214)	COVID-19 neurological (n = 475)	All COVID-19 (n = 3055)
Neurological manifestations			
Any neurological manifestation[b]	169/214 (79)	475/475 (100)	2439/3054 (80)
Clinically captured signs or syndromes[c]	151/169 (89)	385/475 (81)	1628/3055 (53)
Self-reported neurological symptoms			
Headache	56/204 (27)	164/475 (35)	1165/3053 (38)
Anosmia or ageusia	46/199 (23)	91/449 (20)	840/3052 (28)
Syncope	4/212 (2)	58/475 (12)	152/3054 (5)

- Case ascertainment by a trained neurologist
- Consecutive patients with or without neurological manifestations over 3mo.
- Cases collected did not require a neurologist

Moro E et al, *Eur J Neurol* 2020
Beghi E *et al*, *Eur J Neurol* 2021
Frontera J *et al*, *Neurocrit Care* 2020
McNett N *et al*, *Neurocrit Care* 2020

Acute encephalopathy (delirium) remains the most reported neurological sign, while meningitis, encephalitis and myelopathy are rare

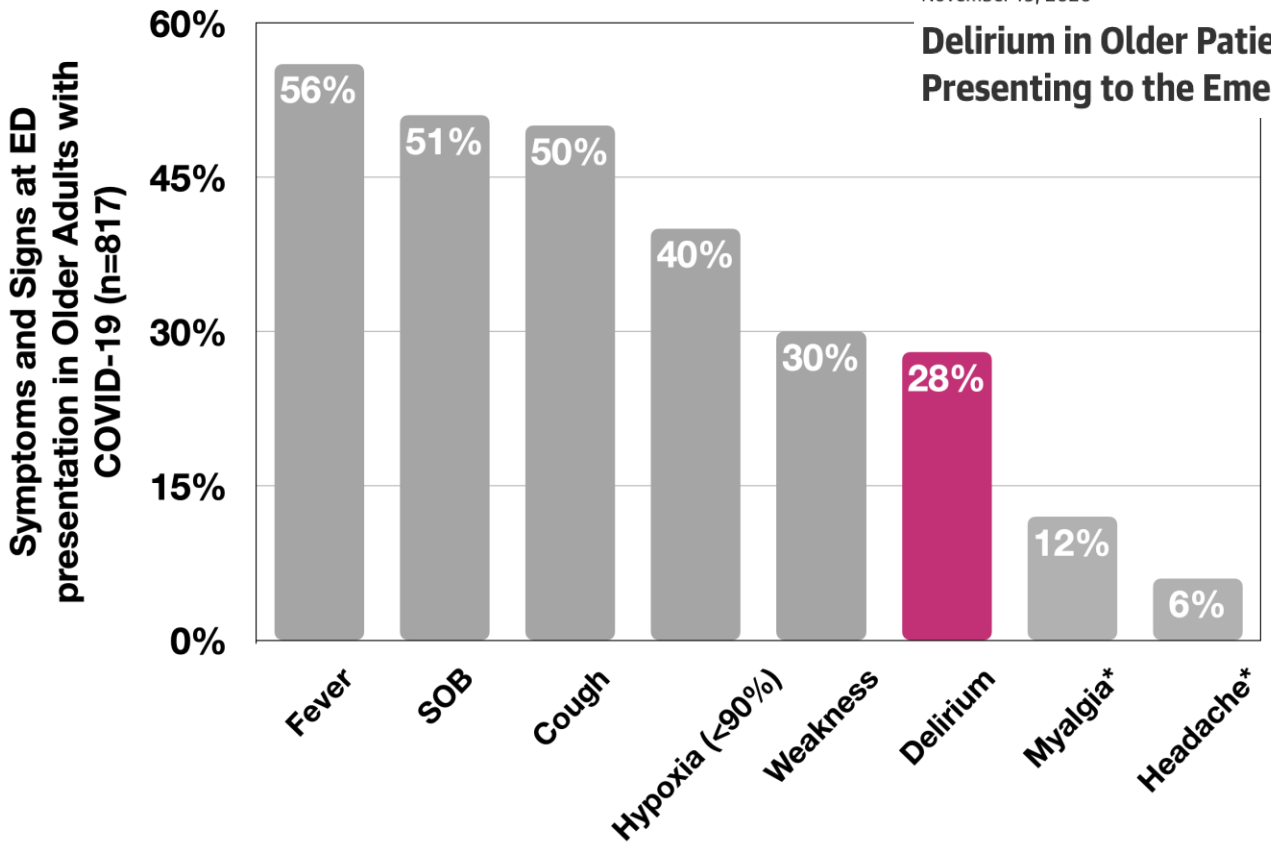


What is the hospital course for people with neurological disease and acute COVID-19?

Delirium is a common presenting symptom in COVID-19, underreported in hospitalized settings and associated with poor outcomes

Original Investigation | Emergency Medicine
November 19, 2020

Delirium in Older Patients With COVID-19 Presenting to the Emergency Department



In the 226 patients with **delirium**, 37% lacked typical symptoms of fever or shortness of breath.

Kennedy M et al *JAMA Network Open 2020*

* Next most frequent neurological symptom

Delirium is a common presenting symptom in COVID-19, underreported in hospitalized settings and associated with mortality and rehab needs

Frequent neurologic manifestations and encephalopathy-associated morbidity in Covid-19 patients

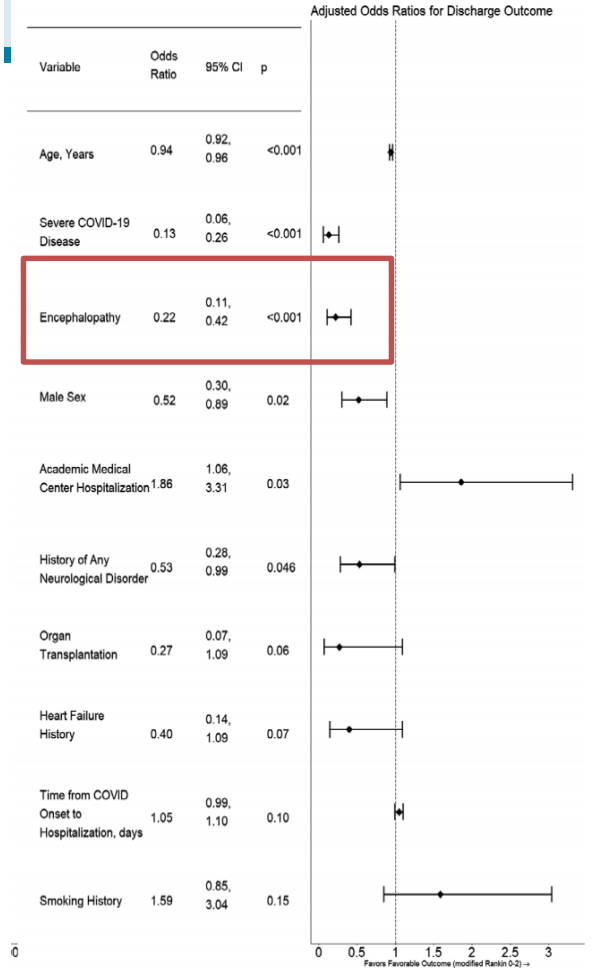
Eric M. Liotta[a], Ayush Batra[a], Jeffrey R. Clark, Nathan A. Shlobin, Steven C. Hoffman, Zachary S. Orban & Igor J. Koralnik

Ken & Ruth Davee Department of Neurology, Northwestern University Feinberg School of Medicine, Chicago, Illinois

Table 1. Patient characteristics by presence of neurologic manifestations and encephalopathy.

	Overall	No Neurologic Manifestation	Any Neurologic Manifestation	*P*	No Encephalopathy	Encephalopathy	*P*
n	509	90	419		347	162	
Age, years (mean (SD))	58.51 (16.93)	62.98 (18.97)	57.53 (16.31)	0.005	55.22 (16.10)	65.51 (16.54)	<0.001
Male, *n* (%)	281 (55.2)	50 (55.6)	231 (55.1)	1	180 (51.9)	101 (62.3)	0.034
Female, *n* (%)	228 (44.8)	40 (44.4)	188 (44.9)		167 (48.1)	61 (37.7)	
Patient outcomes							
Hospital length of stay, days (median [IQR])	7.00 [3.24, 13.00]	5.00 [2.00, 8.00]	8.00 [4.00, 14.00]	<0.001	5.00 [3.00, 8.00]	17.00 [11.00, 25.00]	<0.001
Modified Rankin Scale Score at Hospital Discharge, *n*(%)				0.093			<0.001
0 to 2: Looks after own affairs without assistance	362 (71.1)	63 (70.0)	299 (71.4)		310 (89.3)	52 (32.1)	
3: Ambulates unassisted, needs some help with own affairs	47 (9.2)	5 (5.6)	42 (10.0)		18 (5.2)	29 (17.9)	
4 to 5: Unable to ambulate unassisted, needs assistance with own bodily care	57 (11.2)	9 (10.0)	48 (11.5)		8 (2.3)	49 (30.2)	
6: dead	43 (8.4)	13 (14.4)	30 (7.2)		11 (3.2)	32 (19.8)	
30-day mortality, *n* (%)	46 (9.1)	13 (14.4)	33 (7.9)	0.079	11 (3.2)	35 (21.7)	<0.001

Modified Slide Courtesy of Dr. Sherry Chou, UPMC



In a hospitalized COVID-19 dataset of 1985 patients, a natural language processing tool identified 1117 (57%) patients who did not have a delirium ICD code but had other indicators suggesting a patient experienced delirium (e.g., medications related to delirium, restraints; verified by manual review). This highlights the low sensitivity of delirium ICD codes relative to manual chart review. *unpublished data (Ge, Westover)

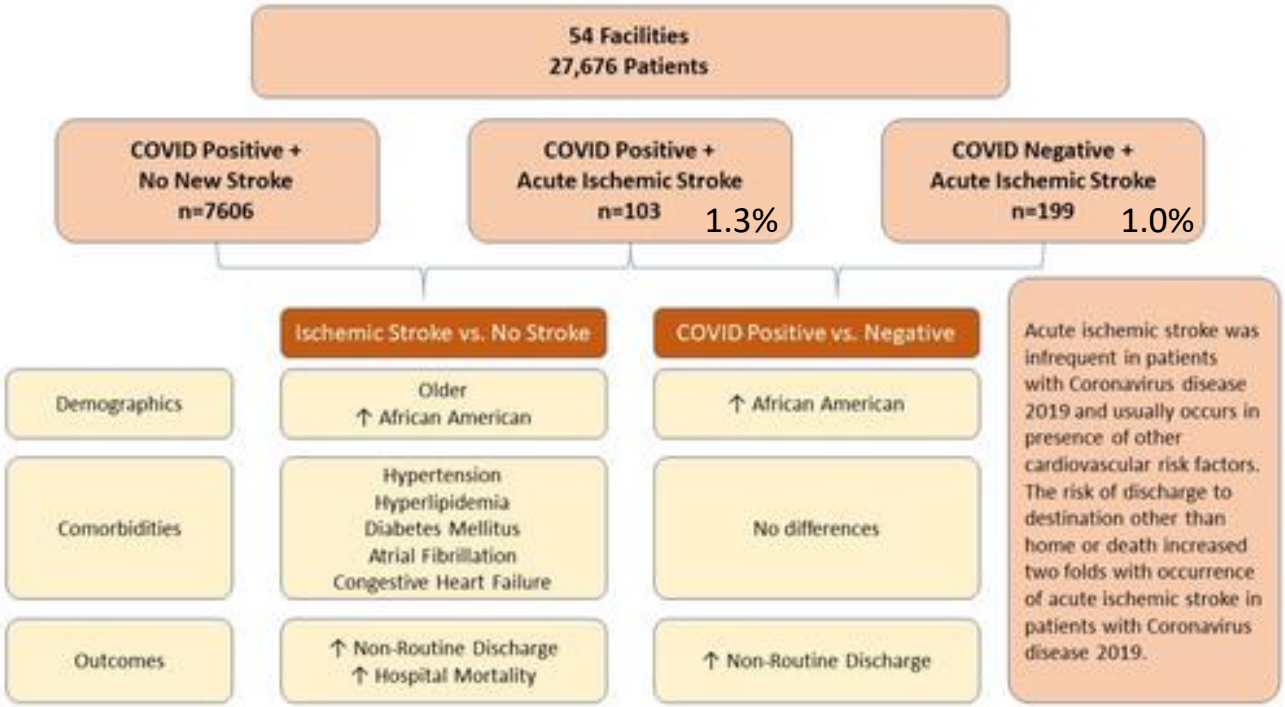
Acute ischemic stroke is infrequent in COVID-19, but when present is associated with negative outcomes

Acute Ischemic Stroke and COVID-19

An Analysis of 27 676 Patients

Adnan I. Qureshi, William I. Baskett, Wei Huang, Daniel Shyu, Danny Myers, Murugesan Raju, Iryna Lobanova ✉, M. Fareed K. Suri, S. Hasan Naqvi, Brandi R. French, Farhan Siddiq, Camilo R. Gomez, Chi-Ren Shyu

Originally published 4 Feb 2021 | https://doi.org/10.1161/STROKEAHA.120.031786 | Stroke. 2021;52:905–912



COVID + Stroke were more likely to have cerebral edema, intracerebral hemorrhage or MI compared to those without Stroke.

Despite low prevalence of clinical seizures, electrographic abnormalities are common in COVID-19 and associated with poor outcomes

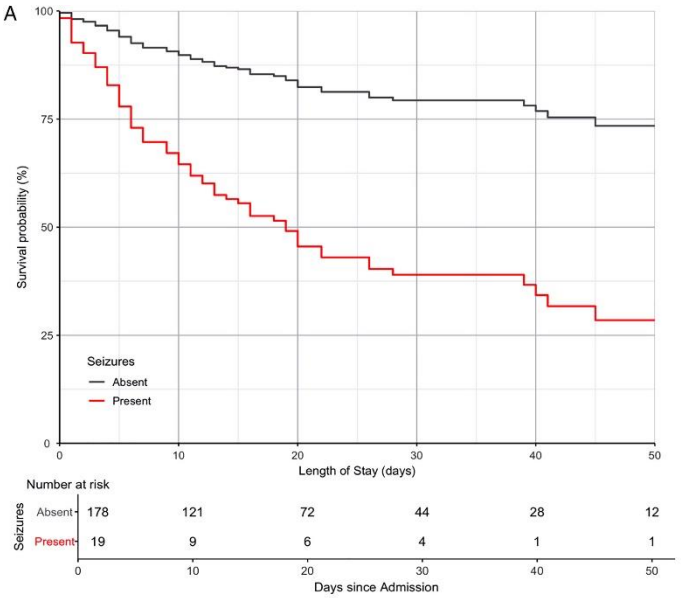
Electroencephalographic Abnormalities are Common in COVID-19 and are Associated with Outcomes

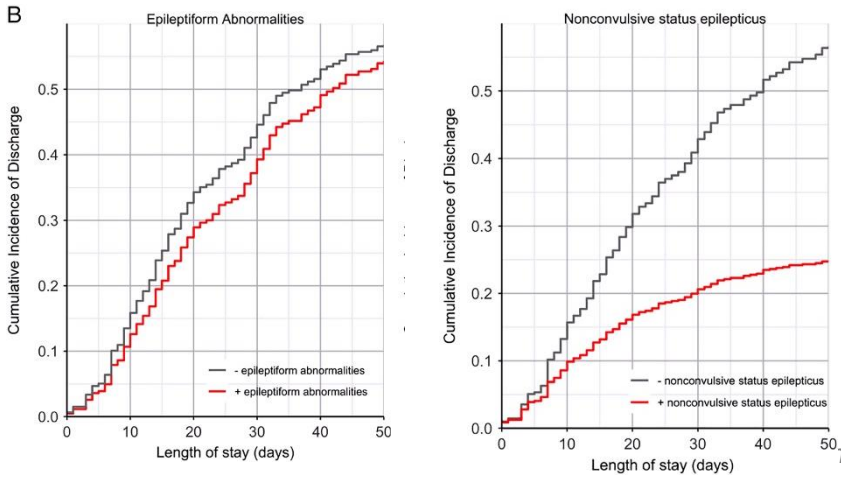
Lu Lin MD, PhD, Abrar Al-Faraj MD, Neishay Ayub MD, Pablo Bravo MD, Sudeshna Das PhD, Lorenzo Ferlini MD, Ioannis Karakis MD, PhD, Jong Woo Lee MD, PhD, Shibani S. Mukerji MD, PhD, Christopher R. Newey DO, MS, Jay Pathmanathan MD, Myriam Abdennadher MD, Charles Casassa MD, Nicolas Gaspard MD, PhD, Daniel M. Goldenholz MD, PhD, Emily J. Gilmore MD, Jin Jing PhD, Jennifer A. Kim MD, PhD, Eyal Y. Kimchi MD, PhD, Harshad S. Ladha MD, Steven Tobochnik MD, Sahar Zafar MD, Lawrence J. Hirsch MD, M. Brandon Westover MD, PhD, Mouhsin M. Shafi MD, PhD ... See fewer authors

TABLE 1. Characteristics of Evaluated Cohort

Characteristic	All Patients (n = 197)
Age, yr	65 (57–73)
Male sex, n (%)	118 (59.9)
Past medical history	
Prior epilepsy, n (%)	32 (16.2)
Prior CNS disorders, including epilepsy, n (%)	67 (34.0)

EEG Finding	Variable	Odds Ratio	p	Prevalence of EEG Finding, n/Total n (%)	
Epileptiform abnormalities	Old intracranial lesion on imaging	2.34	0.03	Yes	23/35 (65.7)
				No	73/162 (45.1)
	Maximal CRP during hospital course	1.48	0.01	–	–
	Time from admission to first positive COVID test	1.46	<0.05	–	–





MASSACHUSETTS GENERAL HOSPITAL
NEUROSCIENCE

Summary

- Multiple studies estimate that neurological symptoms or clinical findings will occur in most patients hospitalized with COVID-19’
- The most common neurological sign in acute, hospitalized COVID-19 is delirium or encephalopathy
- The presence of neurological signs like delirium, stroke or seizures are associated with worse outcomes during the acute period (long-term / post-hospital sequelae remain to be defined)

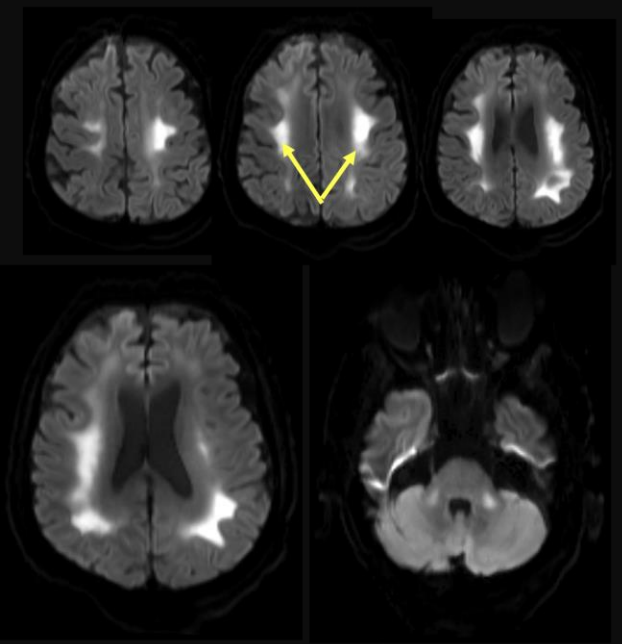
Take Away

- Low threshold for investigating neurological symptoms or signs in people hospitalized with COVID-19 and if present, anticipate increased rehab needs

What are neuroradiographic findings in acute COVID-19?

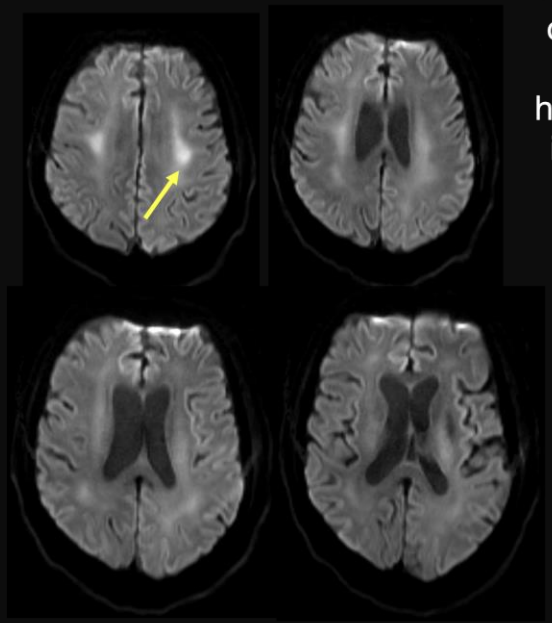
Diffuse, confluent, symmetric white matter involvement is more commonly reported in people with severe COVID-19 than mild COVID-19 disease

Case 1



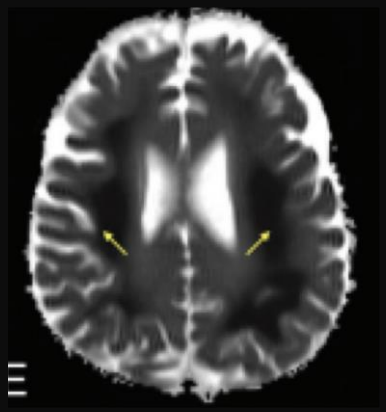
Hypoxemic respiratory failure secondary to COVID-19 with septic shock

Case 2



Prolonged intubation, renal failure requiring CVVH, transaminitis, GI bleeding. Lower extremity weakness on exam but alert following commands

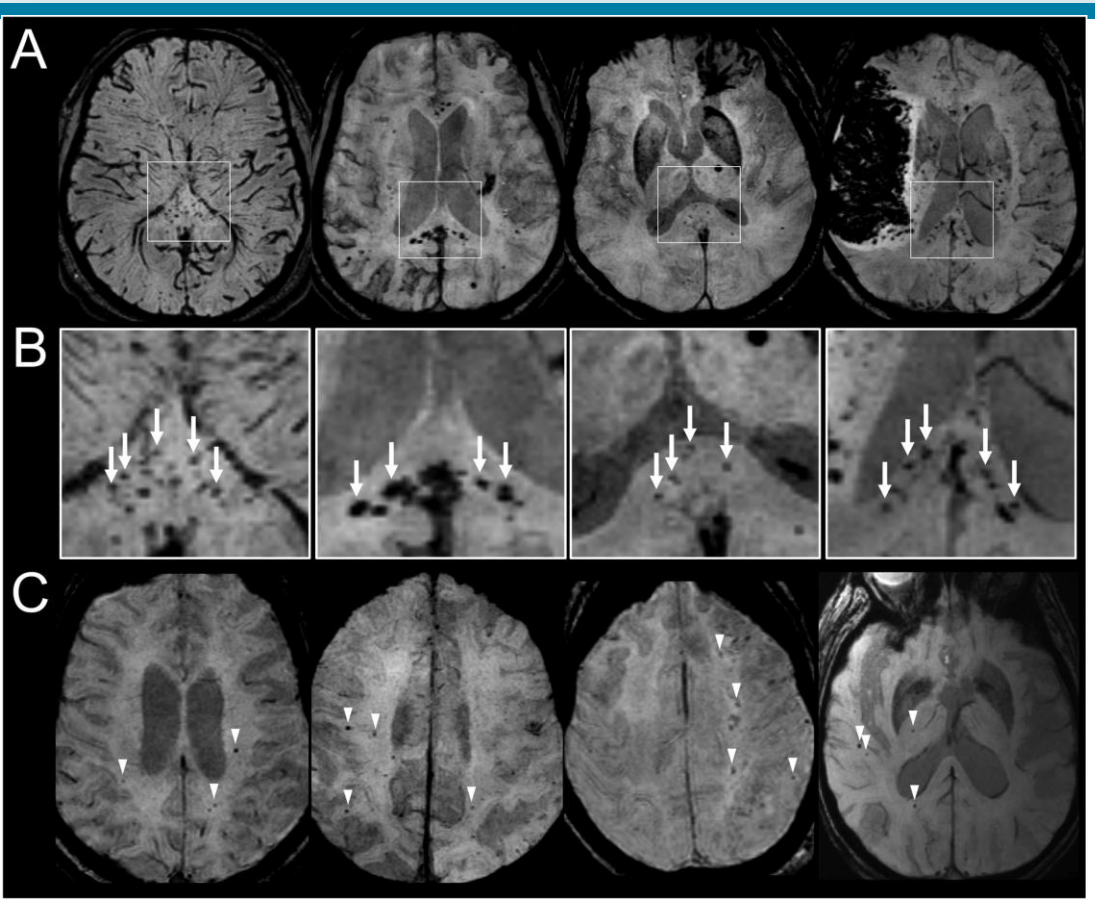
Among those with leukoencephalopathy + diffusion restriction vs diffusion restriction alone, patients were more obese, lower hemoglobin levels and had a trend towards increased frequency of acute renal failure

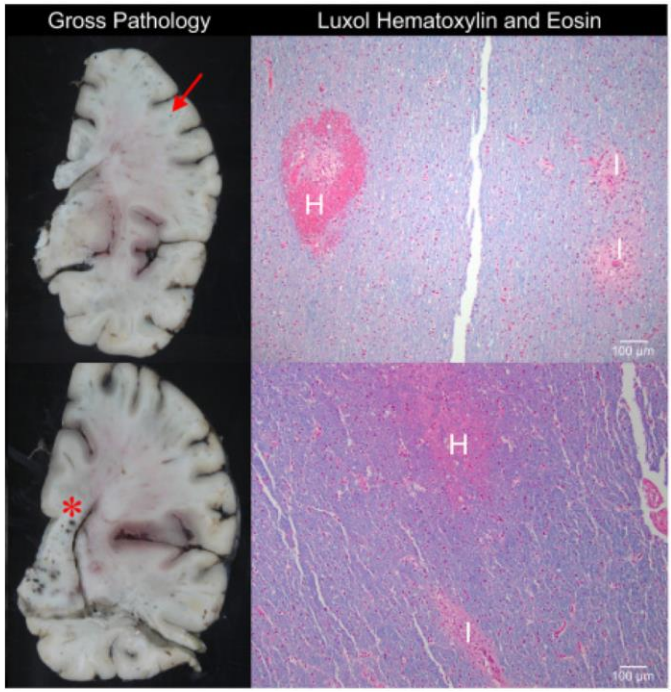


Slide Courtesy of Dr. Otto Rapalino, MGH

Rapalino O,. et al. AJNR Am J Neuroradiol. 2021

Microhemorrhages in Severe COVID-19





Conklin, John, et al. 2021

Radmanesh, Alireza, et al. *Radiology* 297.1 (2020); Agarwal, Shashank, et al. *Stroke* 51.9 (2020); Vattoth, Surjith, et al. *The Neuroradiology Journal* 33.5 (2020); Dixon, Luke, et al. *Stroke and Vascular Neurology* 5.4 (2020);Conklin, John, et al. *Journal of the neurological sciences* (2021)

What are cerebrospinal fluid findings in acute COVID-19?

CSF profile during acute COVID-19

Contents lists available at ScienceDirect

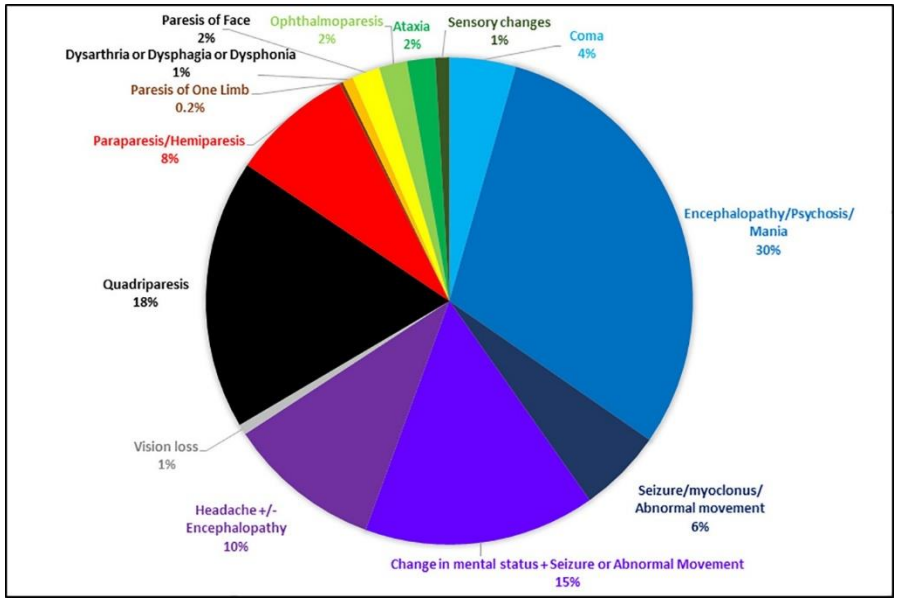
Journal of the Neurological Sciences

journal homepage: www.elsevier.com/locate/jns

Review Article

Cerebrospinal fluid in COVID-19: A systematic review of the literature

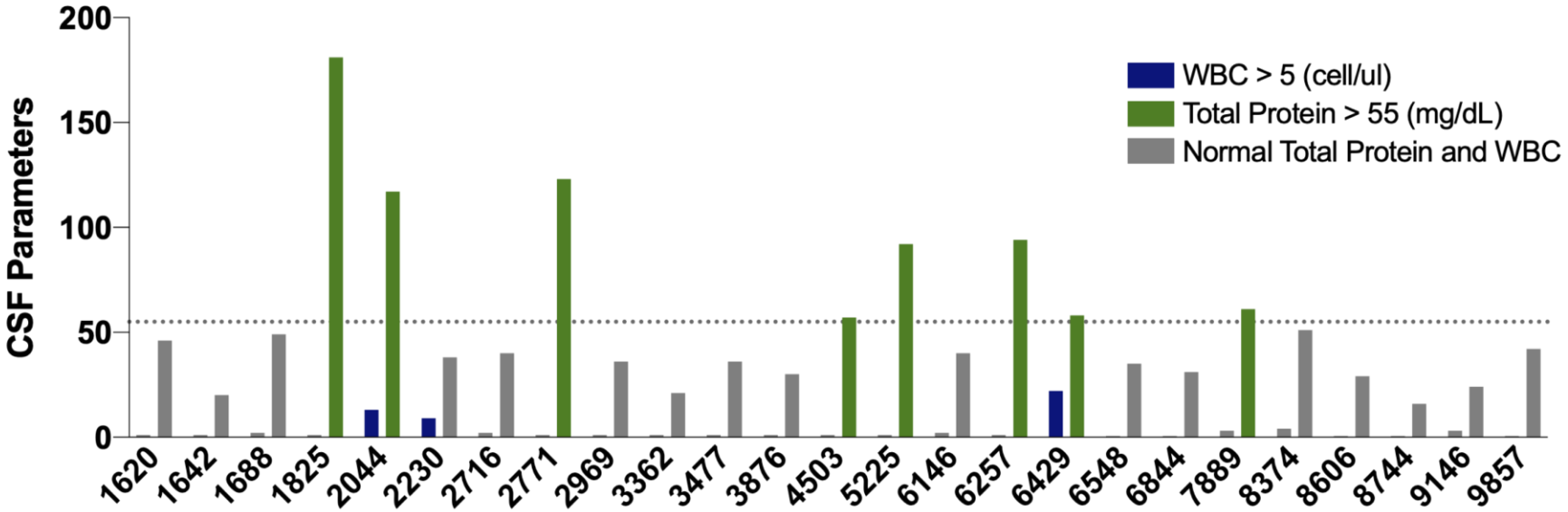
Ariane Lewis [a,b,*], Jennifer Frontera [a,b], Dimitris G. Placantonakis [b], Jennifer Lighter [c], Steven Galetta [a,d], Laura Balcer [a,d,e], Kara R. Melmed [a,b]



Meta-analysis of 430 patients with COVID-19 associated neurological symptoms

- CSF pleocytosis is uncommon during acute COVID-19 (~15%)
- SARS-CoV-2 RNA *rarely* found in CSF(~5%)
  - *note high CT values (low viral copy number)*
- Increased CSF protein in 40%
- CSF antibodies to SARS-CoV-2 frequent (~72%), but the source of these Ab not clear

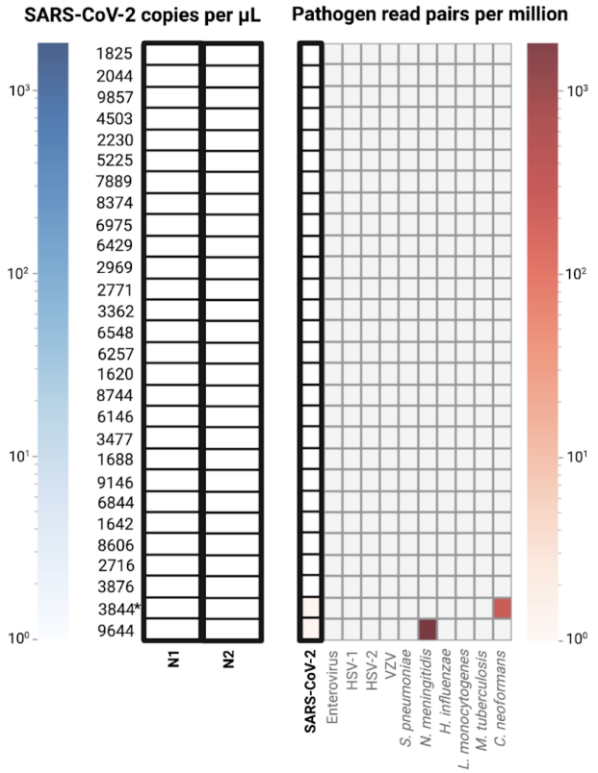
Viral and immune profiling in CSF rarely identifies viral RNA after acute COVID-19, but potentially compartmentalized immune responses

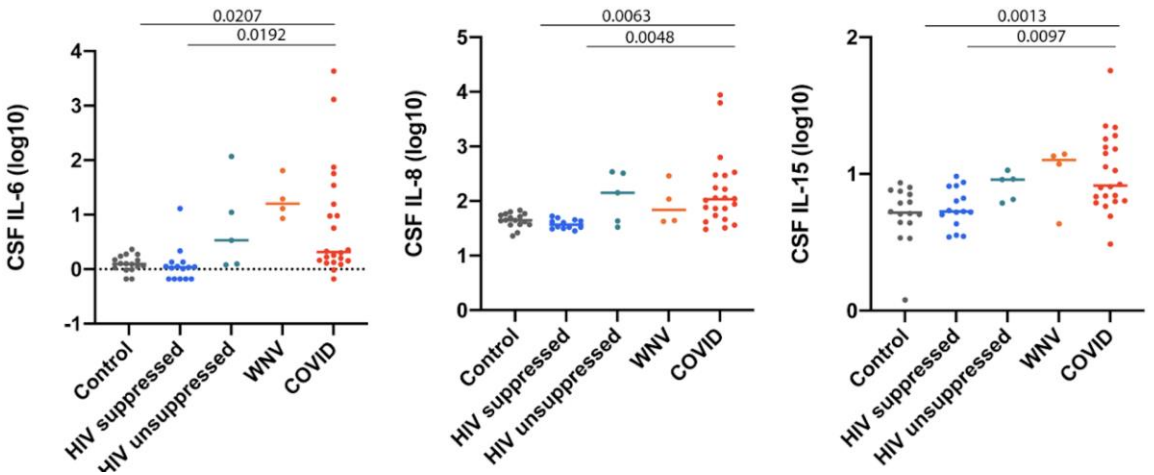


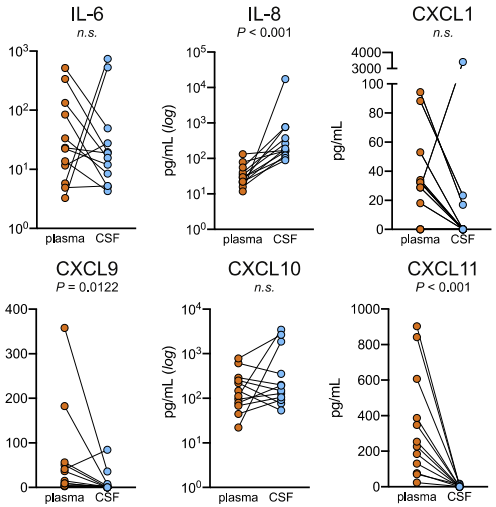
MASSACHUSETTS GENERAL HOSPITAL
NEUROSCIENCE

Katie Holroyd, MD
Erica Normandin, PhD

Viral and immune profiling in CSF rarely identifies viral RNA after acute COVID-19, but potentially compartmentalized immune responses







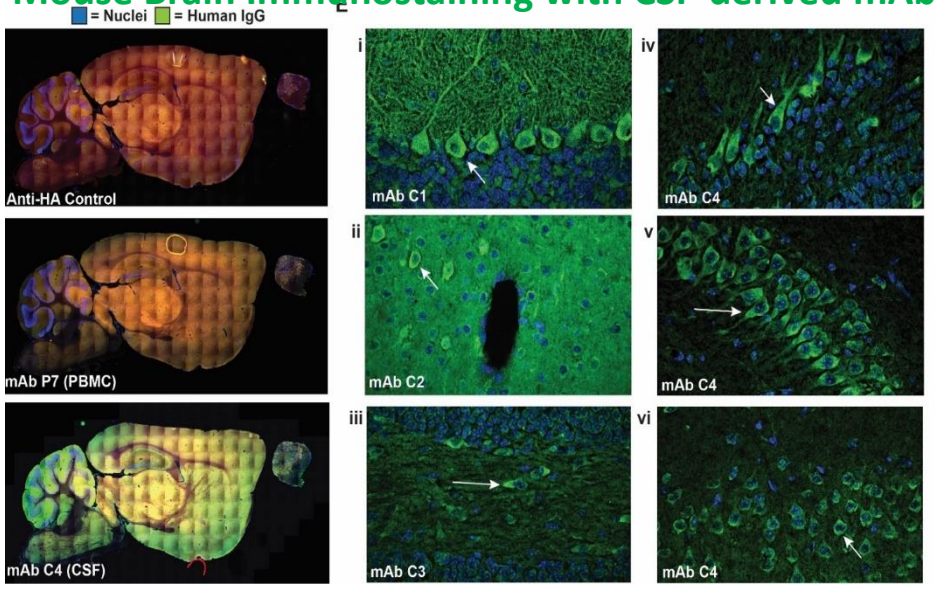
MASSACHUSETTS GENERAL HOSPITAL
NEUROSCIENCE

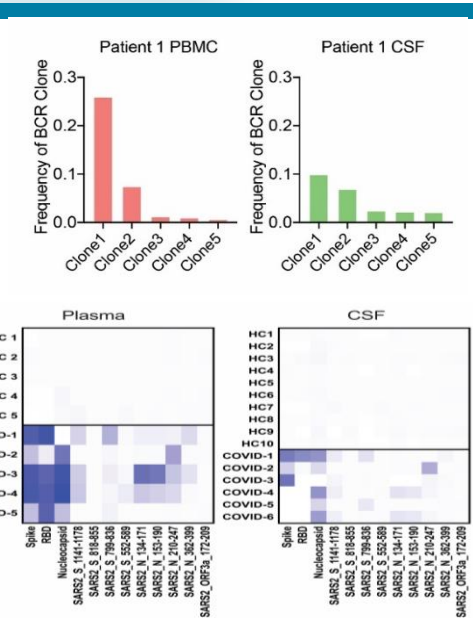
Katie Holroyd, MD
Erica Normandin, PhD

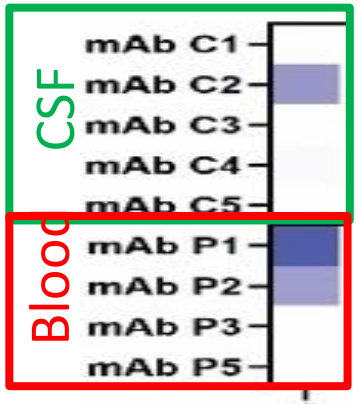
Song and Bartley et al, Cell Reports Medicine, In Press
Remsik et al Cancer Cell 2021

CSF-derived monoclonal antibodies or autoantibodies are present in the CSF of some COVID-19 patients with neurological symptoms

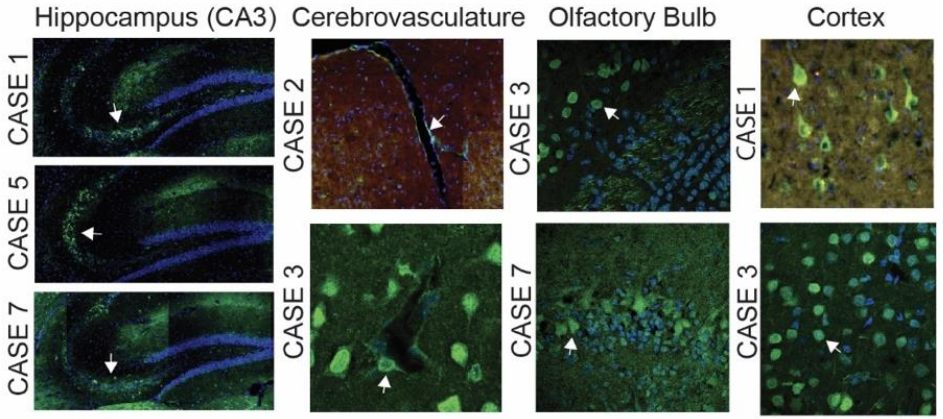
Mouse Brain Immunostaining with CSF-derived mAbs







Mouse Brain Immunostaining with COVID-19 CSF



Roy Jiang
Steve Kleinstein, PhD
Chris Bartley, MD PhD
Sam Pleasure, MD PhD
Michael Wilson, MD
Eric Song
Shelli Farihadian, MD

MASSACHUSETTS GENERAL HOSPITAL
NEUROSCIENCE

Modified Slide Courtesy of Dr. Shelli Farihadian, Yale

Summary

- In severe or critically ill patients, MRI brain findings may show white matter disease and microhemorrhages
- CSF in acute COVID-19 does not show inflammation in the spinal fluid in most cases and does not consistently show viral nucleic acid. Some people may have elevated CSF cytokines or antibodies (performed as part of research)

Take Away

- MRI brain imaging could be useful to understand sequelae in people with COVID-19, particularly those with severe or critical illness. The utility for mild disease remains to be defined.
- No guidelines currently recommend testing for SARS-CoV-2 RNA in CSF

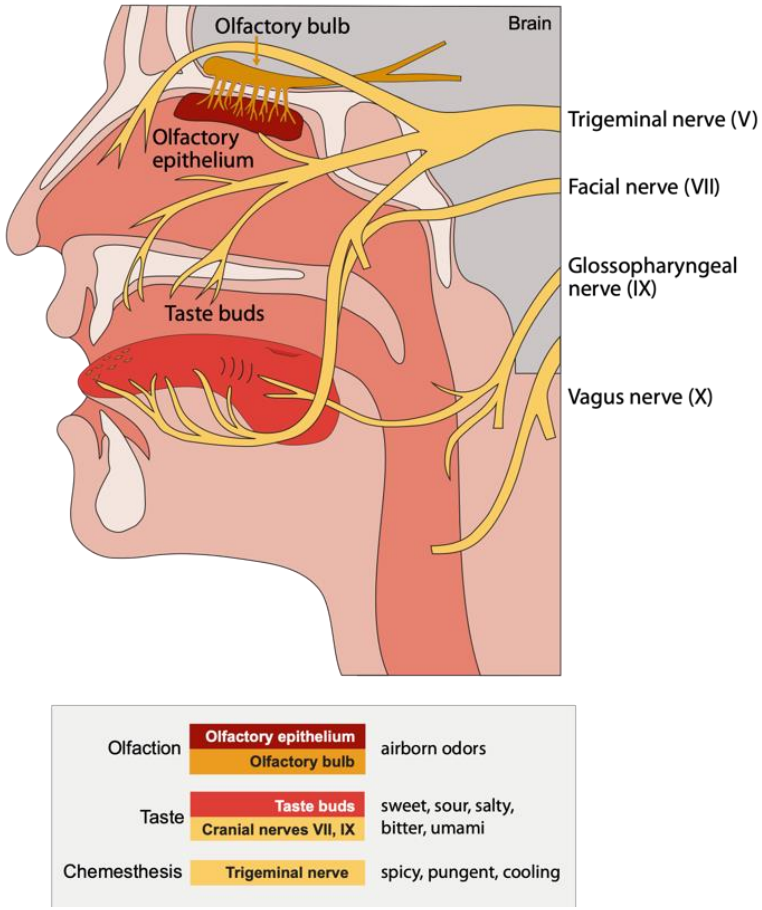
What are common neurological findings in non-hospitalized COVID-19?

COVID-19 and the Loss of Smell
Added to CDC Guidelines in April 2020

- Patients with COVID-19 can present a sudden onset of anosmia without any other symptoms and can occur in the absence of nasal congestion *(Dawson et al CID 2021; Leichien et al Annals 2020*).
- Majority of people with anosmia were not hospitalized with acute COVID-19
- Before the onset of anosmia, often accompanied by dysguesia, other mild symptoms such as a dry cough and headache can also be present.

Characteristic	All Patients (n = 2013)
Median age (SD), *y*	39.50 (12.10)
Male sex	34.0
General symptoms	
Headache	70.1
Myalgia	61.8
Cough	58.4
Loss of appetite	47.5
Dyspnea	46.2
Diarrhea, abdominal pain	42.3
Fever (temperature >38 °C)	40.6
Arthralgia	39.0
Nausea, vomiting	18.7
Sticky mucus/phlegm	14.4
Chest pain	9.2

Leichien et al Annals of Internal Medicine 2020



Modified Slide Courtesy of Dr. Mark Albers, MGH

Headache and muscle pain are also on CDC guidelines for diagnostic testing

Smell Loss and Recovery in COVID-19

JIM Journal of Internal Medicine
Founded in 1863

Brief Report | Free Access

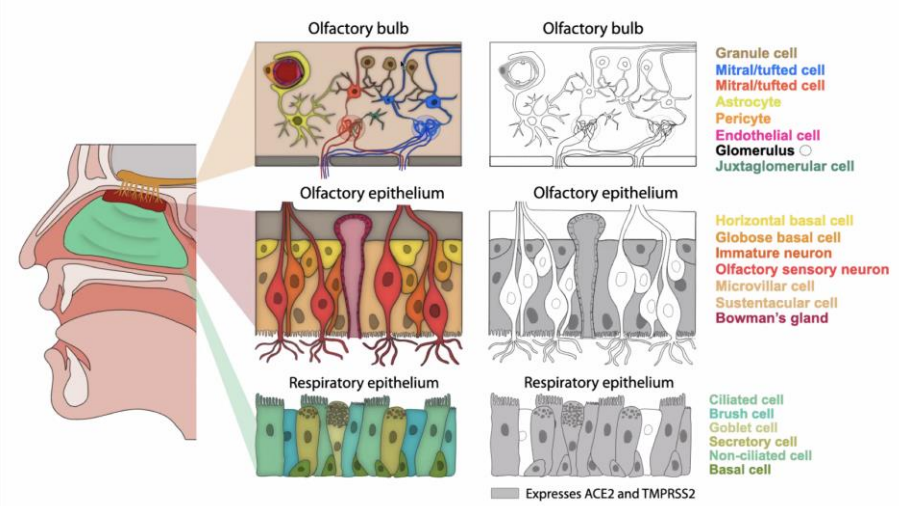
Prevalence and 6-month recovery of olfactory dysfunction: a multicentre study of 1363 COVID-19 patients

J. R. Lechien, C. M. Chiesa-Estomba, E. Beckers, V. Mustin, M. Ducarme, F. Journe, A. Marchant, L. Jouffe, M. R. Barillari, G. Cammaroto, M. P. Circiu, S. Hans, S. Saussez

Characteristics	All Patients (N = 1363)
Onset of smell dysfunction	N = 1339
Before the other symptoms	225 (16.8)
Concomitant with other symptoms	439 (32.8)
After the other symptoms	599 (44.7)
Did not remember/Missing data	76 (5.7)
Smell dysfunction duration	
1–4 days	157 (11.7)
5–8 days	213 (15.9)
9–14 days	172 (12.8)
15–30 days	186 (13.9)
31–45 days	152 (11.4)
45–60 days	131 (9.8)
Unresolved	328 (24.5)
Mean duration (Mean, SD, days)	21.6 ± 17.9

F/M, female/male; N, number; SD, standard deviation.

ACE2 and TMPRSS2 are expressed in support cells, not olfactory neurons



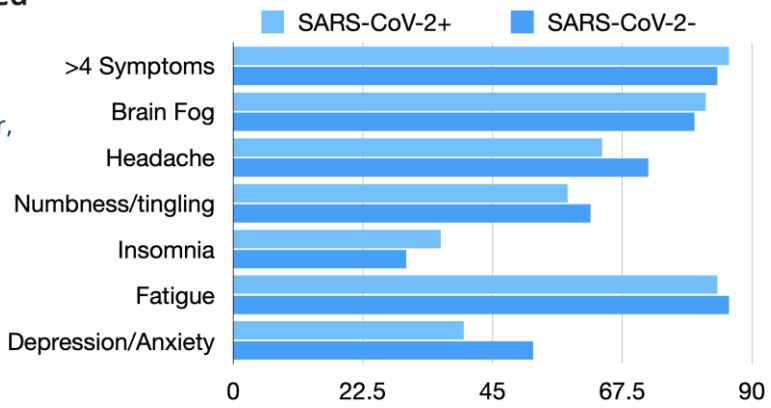
Cooper et al Neuron 2020
Brann et al Science Advances 2020.

About a third recover function in 1-14 days
About a third recover function in 15-60 days
At 6 months, 5% had residual smell dysfunction

Brain fog includes attention and working memory deficits and are common in people with persistent neurological symptoms after non-hospitalized COVID-19 infection

Persistent neurologic symptoms and cognitive dysfunction in non-hospitalized Covid-19 "long haulers"

Edith L. Graham, Jeffrey R. Clark, Zachary S. Orban, Patrick H. Lim, April L. Szymanski, Carolyn Taylor, Rebecca M. DiBiase, Dan Tong Jia, Roumen Balabanov, Sam U. Ho, Ayush Batra, Eric M. Liotta, Igor J. Koralnik ... See fewer authors



	Overall (n=100)	SARS-CoV-2+ (n=50)	SARS-CoV-2- (n=50)
Age	43.2 (11.3)	43.7 (11.8)	42.6 (10.8)
Female Sex	70 (70)	33 (66)	37 (74)
White Race	88 (88)	44 (88)	44 (88)
Latinx	12 (12)	6 (12)	6 (12)

Assessment Domain	SARS-CoV-2$^+$ T-score	*p*, against normative population median T-score of 50	SARS-CoV-2$^-$ T-score	*p*, against normative population median T-score of 50	*p*, between SARS-CoV-2 groups
PROMIS Quality of Life (median (IQR))					
Cognition	38 (30, 41)	<0.001	33 (31, 37.5)	<0.001	0.24
Fatigue	64 (55, 69)	<0.001	69 (61.25, 74)	<0.001	0.15
NIH Toolbox (median (IQR))					
Processing Speed	44.5 (35.5, 59)	0.28	41.5 (33, 53.75)	0.25	0.61
Attention	41.5 (37, 48.25)	<0.001	41.5 (38.5, 47)	0.15	0.64
Executive Function	45.5 (40, 60)	0.71	46.5 (28.75, 53.25)	0.22	0.49
Working Memory	43 (37.5, 48.75)	0.007	49.5 (42, 53.5)	0.53	0.19

Testing in Clinic:

- ANA > 1:160: 11/33 (1/3 had preexisiting immune mediated disease)
- Abnormal MRI brain: 9/48 (majority were nonspecific white matter changes)
- EEG: no abnormalities in 5 patients

No current FDA-approved therapies for cognitive impairment in COVID-19

Thank you

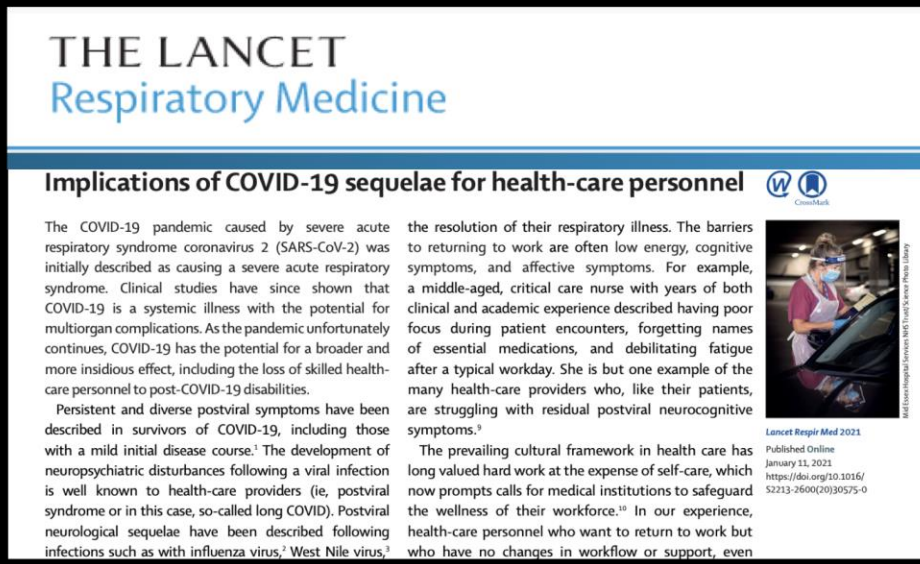
Keep In Touch

smukerji@partners.org

Website
https://www.massgeneral.org/neurology/research/mukerji-lab-neuroinfectious-diseases

@neuroIDdoc

Stay Safe



THE LANCET
Respiratory Medicine

Implications of COVID-19 sequelae for health-care personnel

The COVID-19 pandemic caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was initially described as causing a severe acute respiratory syndrome. Clinical studies have since shown that COVID-19 is a systemic illness with the potential for multiorgan complications. As the pandemic unfortunately continues, COVID-19 has the potential for a broader and more insidious effect, including the loss of skilled health-care personnel to post-COVID-19 disabilities.

Persistent and diverse postviral symptoms have been described in survivors of COVID-19, including those with a mild initial disease course.[1] The development of neuropsychiatric disturbances following a viral infection is well known to health-care providers (ie, postviral syndrome or in this case, so-called long COVID). Postviral neurological sequelae have been described following infections such as with influenza virus,[2] West Nile virus,[3] the resolution of their respiratory illness. The barriers to returning to work are often low energy, cognitive symptoms, and affective symptoms. For example, a middle-aged, critical care nurse with years of both clinical and academic experience described having poor focus during patient encounters, forgetting names of essential medications, and debilitating fatigue after a typical workday. She is but one example of the many health-care providers who, like their patients, are struggling with residual postviral neurocognitive symptoms.[9]

The prevailing cultural framework in health care has long valued hard work at the expense of self-care, which now prompts calls for medical institutions to safeguard the wellness of their workforce.[10] In our experience, health-care personnel who want to return to work but who have no changes in workflow or support, even

Lancet Respir Med 2021
Published Online
January 11, 2021
https://doi.org/10.1016/S2213-2600(20)30575-0

Slides not shown during the talk

Incidence of Neurological Manifestations with COVID-19 in Hospitalized Settings (March - October 2020)

Clinical Feature or Diagnosis	Mao et al.	Romero-Sánchez et al.	Pinna et al.	Karadaş et al.	Xiong et al.	Helms et al.	Benussi et al.	Paterson et al.	Chen et al.	Liotta et al.
COVID-19 (total # of patients)	214	841	650	239	917	58	56	43	274	509
COVID-19 with neurological manifestations (number (%) of	**78 (36.4)**	**483 (57.4)**	**50 (7.7)**	**83 (34.7)**	**39 (4.2)**	**49 (84.4)**	**56 (100)**	**43 (100)**	**78 (28.4)**	**319 (62.7)**
CNS Manifestations (Overall)	53 (67.9)	NR	NR	NR	NR	NR	NR	35 (81.4)	NR	
Dizziness	36 (46.1)	51 (10.5)	NR	16 (19.2)	NR	NR	NR	NR	21 (7.6)	151 (29.7)
Headache	28 (35.9)	119 (24.6)	12 (24)	64 (77.1)	2 (5.1)	NR	NR	NR	31 (11.3)	192 (37.7)
Impaired consciousness	**16 (20.5)**	**165 (34.1)**	**30 (60)**	**23 (27.7)**	**25 (64.1)**	**NR**	**NR**	**7 (16.2)**	**26 (9.5)**	**162 (31.8)**
Acute Stroke	**6 (7.7)**	**14 (2.9)**	**20 (40)**	**9 (10.8)**	**10 (25.6)**	**NR**	**43 (76.8)**	**8 (18.6)**	**NR**	**8 (1.6)**
Encephalitis	NR	1 (0.2)	NR	NR	0 (0.0)	NR	NR	12 (27.9)	NR	1 (0.2)
PNS Manifestations (Overall)	19 (24.3)	NR	NR	53 (22.1)	NR	NR	NR	8 (18.6)	NR	NR
Anosmia	11 (14.1)	41 (8.5)	3 (6)	18 (21.7)	NR	NR	NR	NR	NR	58 (11.4)
Dysautonomia	NR	21 (4.3)	6 (12)	NR	NR	NR	NR	NR	NR	16 (3.1)
AIDP	1 (0.2)	0 (0)	1 (1.2)	NR	NR	NR	NR	7 (16.2)	NR	0 (0)
Skeletal Muscle Manifestations (Overall)	23 (29.5)	253(52.3)	6 (12)	36 (43.3)	2 (5.1)	NR	NR	NR	NR	228 (44.8)

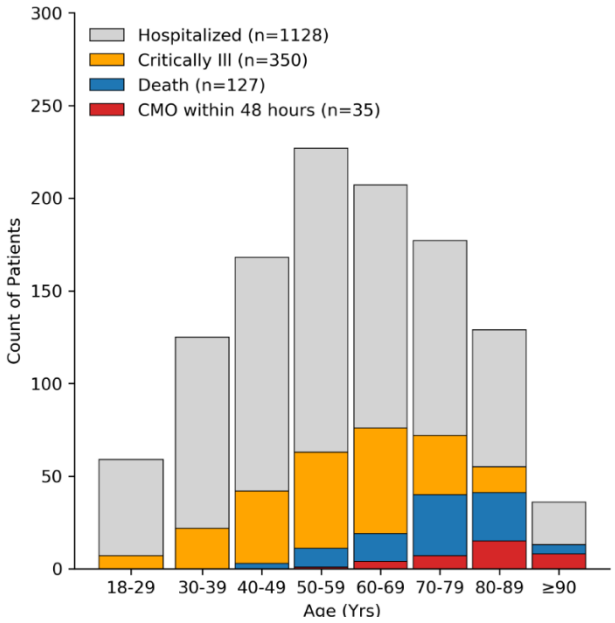
Pezzini, A. Lifting the mask on neurological manifestations of COVID-19. Nat Rev Neurol (2020)

Prolonged Intubation in Patients With Prior Cerebrovascular Disease and COVID-19

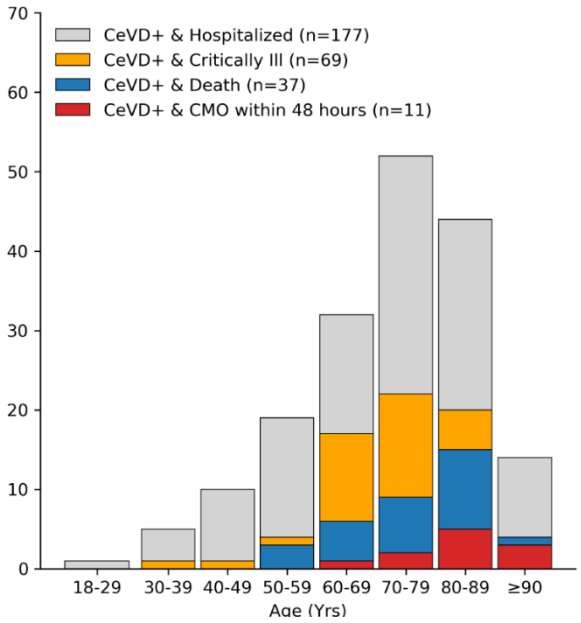
ORIGINAL RESEARCH article

Front. Neurol., 09 April 2021 | https://doi.org/10.3389/fneur.2021.642912

A



B



- History of ischemic stroke (10%)
- History of hemorrhagic stroke (2.0%)

- People with cerebrovascular disease were more likely to have tobacco use and higher burden of medical comorbidities

- Admission median D-dimer, troponin and PTT were higher in people with cerebrovascular disease than without ($p < 0.01$)

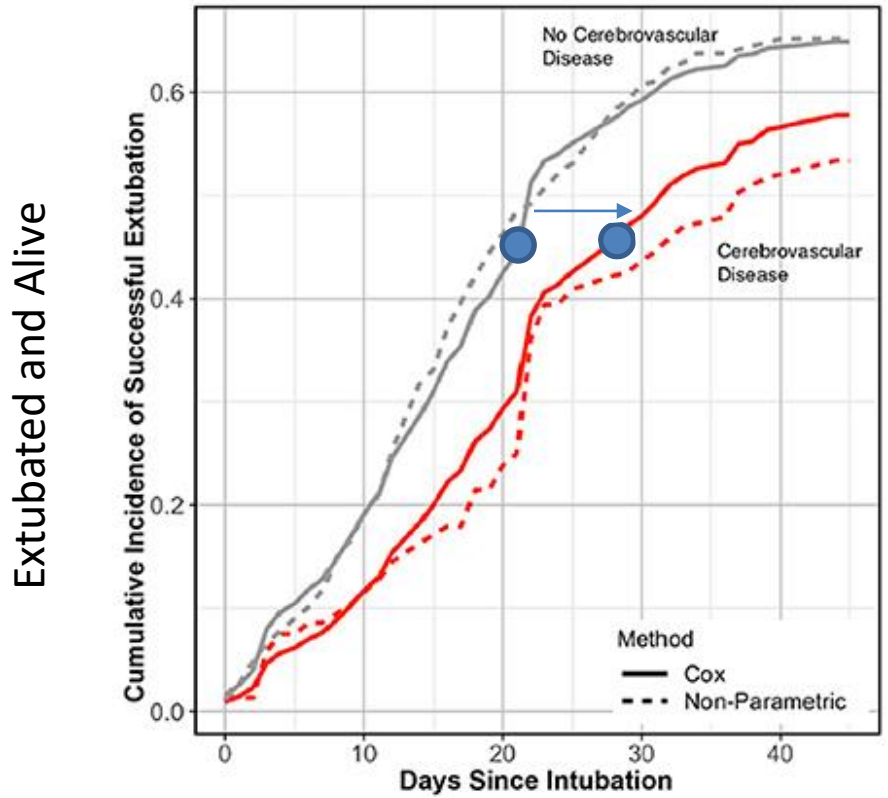
- **1.6 [1.1-2.36] aOR of critical illness or death in people with a history of cerebrovascular disease than without**

- *39/1128 (3.5%) people had a stroke after COVID-19 diagnosis of which 22/36 (56%) had a past history of cerebrovascular disease.*

Prolonged Intubation in Patients With Prior Cerebrovascular Disease and COVID-19

ORIGINAL RESEARCH article

Front. Neurol., 09 April 2021 | https://doi.org/10.3389/fneur.2021.642912



Number of patients intubated

Cerebrovascular Disease	49	36	23	13	5
No Cerebrovascular Disease	244	176	76	31	11

- Over a 45-day observation window, patients with cerebrovascular disease had a **longer intubation time compared to patients without cerebrovascular disease**

- ~4 days -5 days added time on mechanical ventilation