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# Clinical and radiological characteristics and 1-year self-reported outcomes from patients with encephalitis and coronavirus disease 2019

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## Abstract

**Introduction** Severe acute respiratory syndrome coronavirus infection is responsible for multisystemic disease and has high transmissibility. It culminated in a pandemic, challenging scientific knowledge and care capacity. Neurological symptoms are highly prevalent, and cases of encephalitis have been described, in both peri- and postinfectious periods. However, pathogenesis and prognosis are unclear. Thus, we aim to describe the clinical findings in cases of encephalitis in patients infected with severe acute respiratory syndrome coronavirus, together with a 1-year follow-up of self-perception of recovery and remaining neuropsychiatric symptoms.

**Methods** This is a retrospective observational study in which patients with cerebrospinal fluid collection and a recent diagnosis of severe acute respiratory syndrome coronavirus infection were screened for encephalitis through analysis of medical records. We describe their clinical and paraclinical findings using descriptive statistics, together with their long-term outcome, through a self-assessment questionnaire.

**Results** Among the 135 patients screened, 11 patients were included. Most of them were admitted for neurological symptoms (73%), and in 63% of cases, those symptoms occurred within the first 7 days of systemic symptoms. Most patients had minor pulmonary involvement assessed on chest computed tomography. On cerebrospinal fluid analysis, the most relevant finding was hyperproteinorrachia. Three patients (27%) had positive changes on magnetic resonance studies. In the outcome analysis, most patients (77%) reported gait difficulties and 66% reported memory and concentration problems.

**Conclusion** Encephalitis associated with severe acute respiratory syndrome coronavirus 2 infection is rare but responsible for chronic sequelae in cognitive and motor aspects. The pathophysiology seems to be associated with both the immune-mediated and inflammatory processes, and the low frequency of paraclinical findings demands a high clinical suspicion.

**Keywords** Encephalitis, COVID-19, SARS-CoV-2, Neuroinflammatory diseases

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## Introduction

The coronavirus disease 2019 (COVID-19) pandemic challenged medicine and science to understand it and develop efficient care in a rapid response. At first, it was considered mainly a respiratory disease, but its multi-organ involvement became clear posteriorly, including the central nervous system. The infective pathophysiology of COVID-19 can be divided into three stages. In the early infection phase (stage 1), viral RNA replicates in the lungs, causing mild symptoms such as fever and cough, with a generally favorable prognosis. The pulmonary phase (stage 2) involves continued viral replication and inflammation, potentially leading to viral pneumonia and hypoxia, requiring hospitalization. In the hyperinflammation phase (stage 3), about 30% of patients experience a severe immune response, known as a "cytokine storm," characterized by elevated inflammatory markers and widespread inflammation, which can result in acute respiratory distress syndrome (ARDS), vascular permeability, and potentially fatal complications such as shock and cardiopulmonary collapse [1]. Neurological symptoms commonly seen in COVID-19 patients throughout those stages are headache, encephalopathy, and loss of taste and smell, but a few cases of encephalitis have been described [2]; a meta-analysis found a total of 138 cases published [3]. According to the World Health Organization, up to one-third of patients experienced some neurological manifestation, and the risk of delirium and confusion potentially increased in patients older than 60 years [4]. However, encephalitis seems to be a rare complication, with a pooled prevalence of 0.3% [4]. There are multiple potential mechanisms of neuroinvasion such as transsynaptic transfer across infected neurons, entry via the olfactory nerve, infection of vascular endothelium, or leukocyte migration across the blood–brain barrier (BBB) [5]. Furthermore, immune and inflammatory mechanisms might be involved in encephalitis physiopathology. A population study reported the relationship between immune-mediated encephalomyelitis triggered by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection, but without association with vaccination [6].

In this study, we aim to provide a detailed characterization of encephalitis related to COVID-19 by specifically examining its clinical presentation, electroencephalogram (EEG) findings, and magnetic resonance imaging (MRI) results. Additionally, we evaluated patient recovery using an online self-perception and quality-of-life questionnaire.

## Methods

This is an observational and longitudinal study with retrospective analysis. Data were collected in the setting of a multicentric, hospital-based study. This is part of a project entitled the ISARIC/WHO Clinical Characterization Protocol for Severe Emerging Infections: Coronavirus. It was approved by the National Ethics and Research Committee, by the Instituto D'Or de Pesquisa e Ensino (CONEP-CAAE 29496920.8.0000.5262, 19 March, 2020), with an individual patient consent waiver.

Patients were retrospectively screened by applying the following criteria: (1) being admitted into one of seven participating hospitals in Rio de Janeiro between May 2020 and January 2021 with confirmed active infection with SARS-CoV-2 or recently confirmed infection (in the last 3 months from the lumbar puncture) and (2) presenting neurological symptoms that required a lumbar puncture. The assistant team defined the eligible patients prior to a lumbar puncture. From this list, patients who met the criteria for encephalitis were selected [6, 7].

The case definition included any person aged 18 years or older who presented with diagnostic criteria for encephalitis [7], specifically the development of an altered mental status (defined as decreased or altered level of consciousness, lethargy, or personality changes) lasting $\geq$ 24 hours and the presence of two or more of the following encephalitis minor criteria [7]: (i) generalized or partial seizures not fully attributable to preexisting epilepsy, (ii) new onset of focal neurologic findings, (iii) cerebrospinal fluid (CSF) white blood cell count $\geq$ 5/cubic $mm^3$, (iv) abnormality of brain parenchyma on neuroimaging suggestive of encephalitis that was either new from prior studies or appeared acute in onset, (v) abnormality on electroencephalography consistent with encephalitis and not attributable to another cause, and (vi) documented fever $\geq$ 38 °C (100.4°F) within the 72 hours before or after presentation.

The exclusion criteria were the following: patients with metabolic disorders that could explain the altered mental status, such as significant electrolyte disturbances, decompensated liver or kidney insufficiency, central nervous system lesions (such as strokes or tumors), or those with undefined diagnoses or insufficient data.

Patients were classified into possible encephalitis, with two minor criteria points, and probable encephalitis, with three or more minor criteria points. The classification between the postinfectious period and the parainfectious period was defined by a cutoff of 7 days from the first systemic symptom.

The selection of patients was made through a retrospective medical record analysis. Demographic information and laboratory findings were extracted by the research team, while clinical characteristics and image

findings were analyzed and discussed between neurologists and radiologists from the central research team. Acute ischemic lesions and hemorrhages on MRI that could justify symptoms were listed as exclusion criteria. Some patients consented to participate voluntarily in a follow-up study, carried out through a self-applied internet questionnaire. Questions regarding neurological and psychiatric symptoms, as well as functional recovery after COVID-19, were included in this study (Table 1).

Electroencephalographic findings were collected through medical records, and different techniques and machines were used in each hospital. Therefore, descriptions were limited in encephalopathic patterns, epileptic discharges, and no abnormal findings.

Laboratory confirmation of SARS-CoV-2 infection was carried out using real-time reverse transcription-polymerase chain reaction (RT–PCR) on throat swabs and nasopharyngeal specimens in all patients. In all patients, routine blood examinations included complete blood count, coagulation profile, and serum biochemical tests, including renal and liver function.

Statistical analysis was descriptive, with measures of central tendency, using Microsoft Excel, 2018.

## Results

From 135 patients with recent COVID-19 diagnosis and lumbar puncture analysis, a total of 18 patients were selected. Seven were excluded for incomplete information in medical records or unclear diagnoses. Eleven cases of encephalitis (six male, mean age 59.8 years old, ranging from 43 to 83 years old) were identified, seven of them with possible encephalitis and four with probable encephalitis. The frequency of each encephalitic characteristic finding is summarized in Fig. 1. Regarding the four postinfectious cases, there was a mean of 28.5 days from COVID-19 symptoms to the decision for lumbar puncture.

Eight patients (73%) were admitted owing to neurological symptoms, but all patients presented systemic symptoms (for example, respiratory, diarrhea, or myalgia). Ten patients (90%) were admitted into intensive care unit (ICU), and four patients (36%) required mechanical ventilation, three of them owing

**Table 1** Questions used in the self-assessment questionnaire on recovery after coronavirus disease 2019

| Question | Answer |
|---|---|
| Do you feel fully recovered from COVID-19? | Agree/Disagree |
| Do you still present some of the following symptoms: | |
| Headache | Yes/No |
| Loss of taste | Yes/No |
| Cannot move or control your movements | Yes/No |
| Loss of touch perception in a part of your body | Yes/No |
| Tingling sensation | Yes/No |
| Seizures | Yes/No |
| Tremor | Yes/No |
| Mental confusion/lack of concentration | Yes/No |
| Problems swallowing or chewing | Yes/No |
| Problems to talk or communicate | Yes/No |
| Sleeping problems | Yes/No |
| Weakness in the arms/legs | Yes/No |
| Pain or ache? | I don't have pain/I have mild/moderate/severe pain |
| Anxiety / depression | I'm not/I'm a little/I'm extremely |
| We would like to know how good or bad your health is today.• This scale is numbered from 0 to 100.• 100 means the best health you can imagine. 0 means the worst health you can imagine | 0–100 |
| Do you have trouble walking or climbing steps? | Yes/No |
| Do you have trouble remembering or concentrating? | Yes/No |
| Do you have difficulty communicating, for example, understanding or being understood? | Yes/No |
| Do you have a problem with: | |
| Mobility | Yes/No |
| Self-care | Yes/No |
| Daily activities | Yes/No |

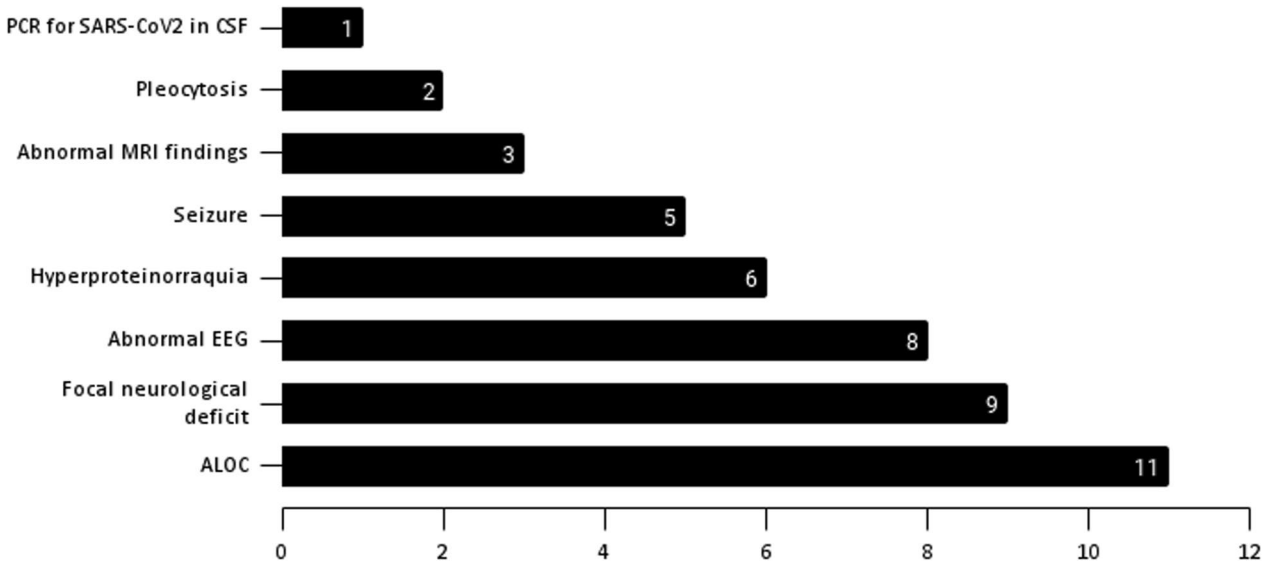


**Fig. 1** Encephalitis criteria findings, $n = 11$

to neurological symptoms (seizures or coma). Only one patient died, secondary to systemic complications (for example, sepsis). The average length of hospitalization was 33 days. On chest computed tomography (CT), the extent of pulmonary infiltration was 50% in one patient, 25–50% in two patients, and less than 25% in five patients, while two patients had no alterations and only one did not have this examination performed.

Comorbidities were a common finding (54%): systemic arterial hypertension (36%), diabetes mellitus (27%), and obesity (36%). None of the patients had a prior neurological diagnosis.

The most common neurological findings were seizures, hyperreflexia, and language disturbance, all summarized in Fig. 2.

Pleocytosis was found in only two patients (18%), with one patient showing 25 cells and the other showing 212 cells, while high opening pressures were found in four patients (36%), ranging from 4 $cmH_20$ to 50 $cmH_20$ in the entire cohort. Six (54%) patients showed hyperproteinorrachia 29–100 mg/dL, with a global mean of 46 mg/dL.

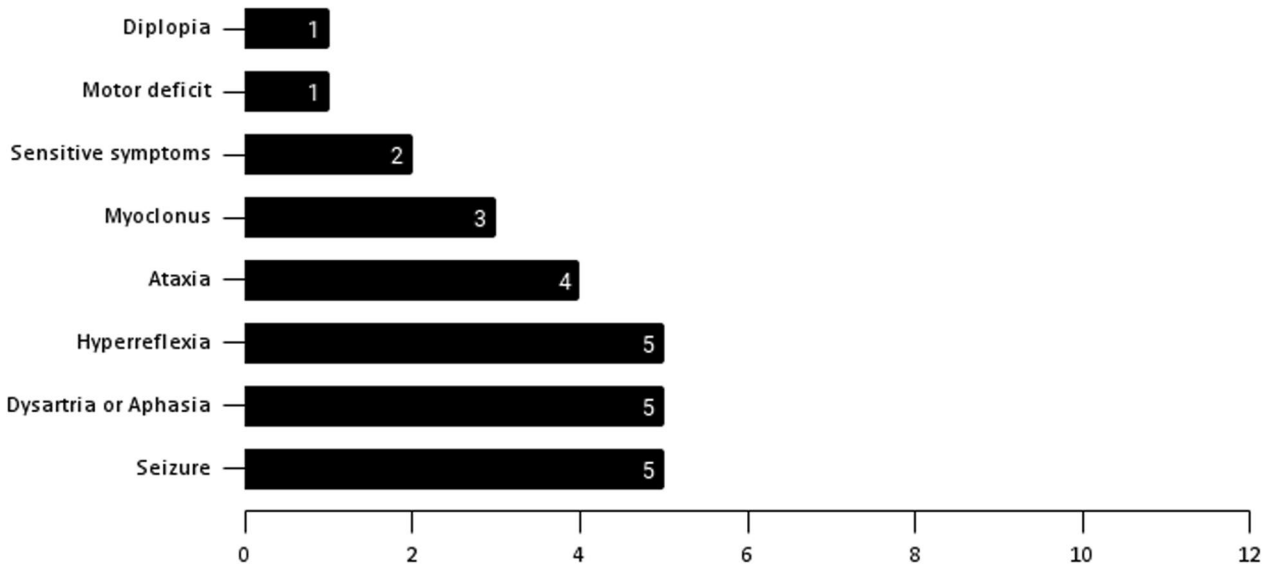


**Fig. 2** Frequency of reported neurological symptoms and signs, $n = 11$

Three (42%) of seven patients had high lactate levels. All patients presented normal glucose on cerebrospinal fluid (CSF) analysis. CSF screening for bacteria and virus infection was negative in all patients. Nine patients underwent CSF RT-PCR for SARS-CoV-2, and only one case was positive. The clinical and radiological characteristics of this patient were reported in detail elsewhere [8].

Two patients did not have an MRI performed. Both were hospitalized in a temporary field hospital built only for the COVID-19 pandemic, where MRI was not available. They all had typical clinical and CSF findings, but no relevant findings on the brain CT. Of nine patients with brain MRI, three (33%) presented with abnormal findings, as per dural enhancement, lesions suggestive of acute demyelinating encephalomyelitis (ADEM) with contrast enhancement, and focal white matter lesion characteristic of a demyelination process. Figure 3 shows two images findings from cases 4 and 6, as defined in Table 2.

EEG showed an encephalopathic pattern in two patients (18%). Three patients had both encephalopathy patterns and epileptic discharges (17%), while two patients had normal results (18%). Four patients had no EEG available (36%).

Treatment for neurological syndrome included methylprednisolone pulse therapy (three patients) and intravenous immunoglobulin (two patients), with no other specific treatment included, except for antipsychotics and antiepileptic drugs.

Some more defined clinical phenotypes were found (Table 2). Patient 1 can be defined as having new-onset refractory status epilepticus (NORSE), patient 6 had a diagnosis of an ADEM-like syndrome, and patients 2 and 8 had an association between encephalopathy and myoclonus.

Nine of ten surviving patients answered the follow-up self-applied questionnaire, with a mean of 377 days after discharge, ranging from 116 days to 492 days. Figure 4 summarizes the most important findings.

## Discussion

In this retrospective, multicenter study, we identified 11 patients who met the established criteria for encephalitis [7, 8], selected from a cohort of 135 patients with COVID-19 and a clinical indication for lumbar puncture. Our findings regarding encephalitis manifestation are confirmatory [2, 9]; each patient had a unique clinical presentation, mostly with no relevant MRI findings and only subtle pleocytosis and hyperproteinorrachia, which challenges diagnosis and requires high clinical awareness. In our subsequent 1-year longitudinal assessment, most patients documented sleep patterns, memory retention, concentration, and mobility disruptions, accounting for a long-term change in quality of life.

Until January 2021, a total of 187,339 cases were confirmed in the City of Rio de Janeiro (data from e-SUS). During our study, no COVID-19 vaccine scheme was available and the main variants in Rio de Janeiro were B.1.1.33 and P.2 (Zeta). Most patients were admitted because of neurological symptoms and most had mild to moderate pulmonary disease. In these hospital protocols, patients with neurological symptoms are often admitted to intensive care units, regardless of their systemic condition. Eight patients were hospitalized for their neurological symptoms. Previous data [2] suggest that encephalitis may not be associated with a more severe systemic condition, so much so that, among the patients selected in this present study, while ten were admitted to intensive care, only four required mechanical ventilation, mainly for decreased level of consciousness or convulsive status.

Our main clinical findings align with other encephalitis cohorts. In Italy, the ENCOVID study described 25 cases of encephalitis and confirmed SARS-COV2 infection [2]. Their most relevant findings were that patients presented moderate respiratory COVID-19 syndrome, with aphasia/dysarthria being the most common symptom. Seizures were reported in a third of cases, but status epilepticus was a rare phenomenon, and CSF analysis showed mild pleocytosis and hyperproteinorrachia. Most cases presented with a normal MRI, with three cases of ADEM and two cases of limbic encephalitis, both with incidence after systemic COVID-19 syndrome. In a meningoencephalitis review, including a total of 54 cases, a myriad of clinical presentations were seen and corroborated a tendency of an innocent MRI and a CSF with high protein levels and mild pleocytosis [2, 10].

An unsolved issue in encephalitis associated with a viral infection is to define whether its etiology is driven by the virus or an autoimmune mechanism. The low detection rate of the virus in CSF and several reports of steroid respondent encephalopathy/encephalitis support an immune-mediated mechanism. Besides, a neuropathological study with 43 post mortem patients found inflammatory changes most pronounced in the brainstem and cerebellum, and in 79% of patients, the virus protein could be detected, although not related to the severity of neuropathological changes [11]. In six patients with encephalopathy/encephalitis, an unusual pattern of marked CSF inflammation was described, measured by the biomarkers neopterin and β2M but without the typical responses of CSF pleocytosis, BBB disruption, or intrathecal IgG production seen in many other CNS infections [12]. Eleven patients with neurological symptoms not explained by metabolic or structural abnormalities, mostly myoclonia and seizures, presented

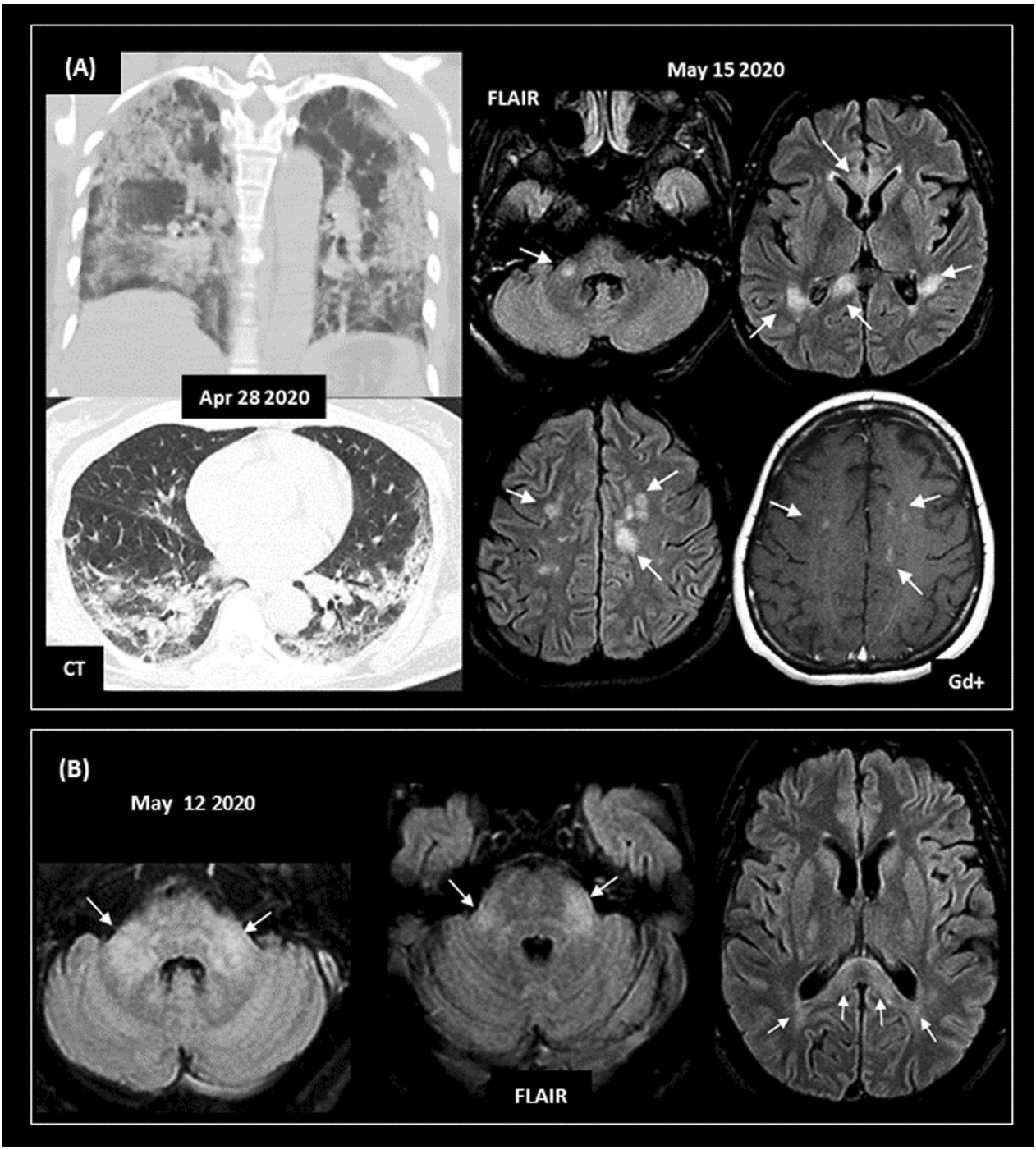


**Fig. 3** Imaging findings from illustrative cases of coronavirus disease 2019 patients presenting with neurological symptoms. **A** Case 6: 50-year-old female. Extensive coronavirus disease 2019 pneumonia and acute demyelinating brain lesions, with some enhancing spots. **B** Case 4: 65-year-old male. Coronavirus disease 2019 encephalitis with positive severe acute respiratory syndrome coronavirus 2 quantitative reverse transcription polymerase chain reaction in the cerebrospinal fluid screening. No signs of viral pneumonia on the computed tomography scan were depicted (not shown). CT, computed tomography; TOF, time-of-flight arterial angiographic magnetic resonance sequence. FLAIR, fluid-attenuated inversion recovery magnetic resonance sequence. Gd+, gadolinium venous contrast T1 weighted magnetic resonance sequence. Both figures have been publish previously by this group study [8, 14]

**Table 2** Resume of patients' main characteristics, diagnosis, and follow-up

| ID | Sex/age in years/ethnicity | Days from the first symptom to cerebrospinal fluid analysis | Neurological presentation | Cerebrospinal fluid findings | Magnetic resonance imaging findings | Electroencephalogram | Diagnosis | Neurologic management | Follow-up |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Male/51/White | 6 | Agitation and change in behavior, followed by super refractory status epilepticus | No relevant findings | Only CT. No relevant findings | Epileptiform discharges followed by encephalopathic pattern | Possible—NORSE | AED and IVMP | Feels 85% recovered, fatigue, and difficulty climbing stairs |
| 2 | Female/83/prefer not to say | 4 | Disorientation, somnolence, fever, myoclonus, and ataxia | Protein 59 mg/L | Diffuse dural enhancement | No relevant findings | Probable—encephalopathy and myoclonus | AED and prednisone | Feels 53% recovered, moderate difficulty walking and concentrating |
| 3 | Man/73/white | 2 | Disorientation, somnolence, fever, and aphasia | Cells 25 $mm^3$, 71% lymphocytes, protein 100 mg/L, Gli 81 mg/dl, Lac 21 mg/dL | No relevant findings | Encephalopathic pattern and epileptiform discharges | Probable—viral encephalitis | IVIG | Feels 70% recovered, fatigue, problems with sleep, mild difficulties with walking, concentration, and memory |
| 4 | Man/65/white | 4 | Drowsiness, diplopia, ataxia, urinary retention progressing to coma | Cells 212 $mm^3$, 46% lymphocytes, protein 86 mg/L, Gli 57 mg/dl, Lac 32 mg/dL. RT-PCR positive SARS-CoV-2 | Sparse FLAIR hyperintense in white matter in both hemispheres, corpus callosum, and cerebellar peduncles | No relevant findings | Probable | AP | Feels 85% recovered, fatigue, dysautonomia, mild difficulties climbing stairs, concentration and memory |
| 5 | Man/48/mixed | 38 | Disorientation, attention and awareness deficits, and paraparesis and clonus | No relevant findings | No relevant findings | No relevant findings | Possible | IVMP, AP, and AED | Despite reporting being 100% recovered, he mentions paresthesia in the left lower limb and problems sleeping |
| 6 | Woman/50/prefer not to say | 7 | Somnolence, dysarthria, ataxia, and paraparesis | Protein 57 mg/L, Lac 17 mg/dL | Widespread supra- and infratentorial white matter lesions, some with contrast enhancement, with corpus callosum involvement | Not available | Probable ADEM | IVMP, AP and AED | Feels 50% recovered, with changes in sensitivity, communication, concentration, and balance. Dependent on assistance for instrumental activities of daily living |

**Table 2** (continued)

| ID | Sex/age in years/ethnicity | Days from the first symptom to cerebrospinal fluid analysis | Neurological presentation | Cerebrospinal fluid findings | Magnetic resonance imaging findings | Electroencephalogram | Diagnosis | Neurologic management | Follow-up |
|---|---|---|---|---|---|---|---|---|---|
| 7 | Woman/73/Black | 20 | Disorientation, somnolence, status epilepticus associated with myoclonus | No relevant findings | No relevant findings | Epileptiform discharge | Possible | AP and AED | Death |
| 8 | Man/68/Black | 2 | Disorientation and agitation, ataxia, and myoclonus | Only CT. No relevant findings | No relevant findings | No relevant findings | Possible—encephalopathy and myoclonus | AP | Feels 50% recovered, mental confusion and mild difficulty climbing stairs, concentration and memory |
| 9 | Woman/44/prefer not to say | 2 | Somnolence and disorientation, fever and paraparesis with urinary retention | No relevant findings | No relevant findings | Not available | Possible | Prednisone | Not available |
| 10 | Man/60/white | 2 | Somnolence, dysarthria, and ataxia | No relevant findings | No relevant findings | Not available | Possible | IVIG | Feels fully recovered |
| 11 | Woman/43/white | 4 | Disorientation, drowsiness, fever, and epileptic seizures | No relevant findings | No relevant findings | Epileptiform discharge | Possible | AED | She did not quantify how much she felt recovered, but reported depression and difficulties with concentration and mobility |

*AED* antiepileptic drugs, *IVIG* intravenous immunoglobulin, *AP* antipsychotics, *IVMP-* intravenous methylprednisolone, *CSF* cerebrospinal fluid, *NORSE* new-onset refractory status epilepticus, *Gli* glucose, *Lac* lactate, *CT* computed tomography, *ADEM* acute disseminated encephalomyelitis. *MRi* magnetic resonance image, *EEG* electroencephalogram. None of the patients had been vaccinated

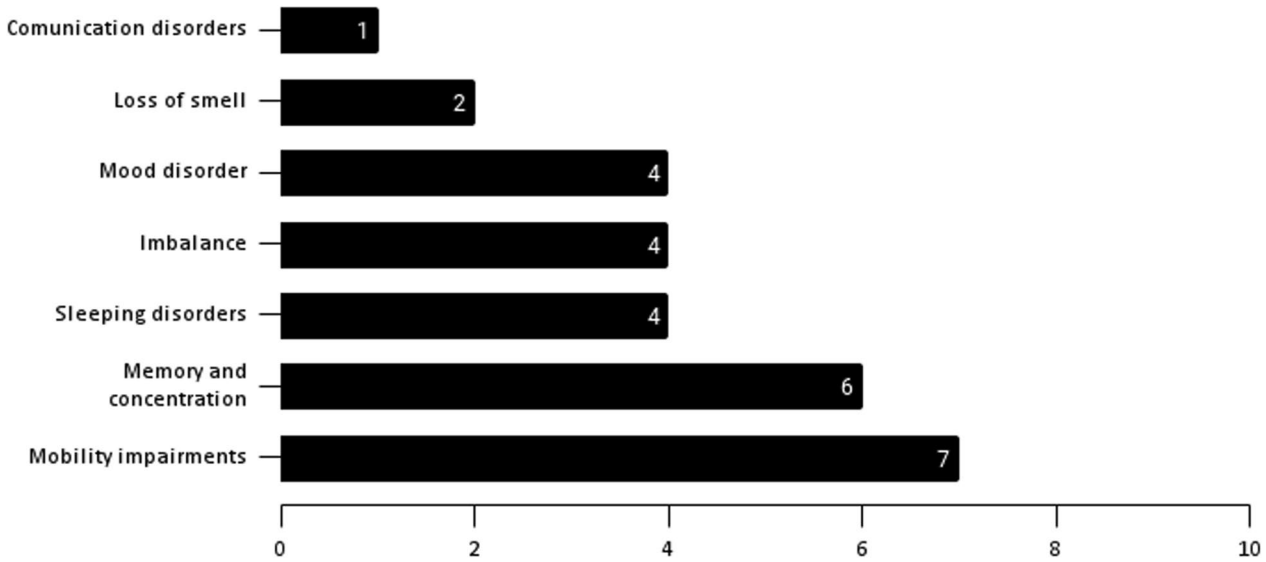


**Fig. 4** Symptoms reported through a follow-up questionnaire, $n = 9$

antineuronal and antiglial autoantibodies and specific immunofluorescence patterns. Four of the patients also presented high neurofilament levels [13]. Additionally, neuroinflammatory biomarkers, including interleukin-6 and CSF tumor necrosis factor, have been shown to correlate with disease severity and neuroimaging alterations in COVID-19 neurological complications [4].

Further, several case reports have described autoimmune encephalitis with a time-associated SARS-COV-2 infection, with positive *N*-methyl-D-aspartate (NMDA) antibodies, in both adults and children [15–18]. Although exact mechanisms are not yet understood, it is probable that development of autoimmune encephalitis was triggered by SARS-CoV-2 infection in some patients.

Prognosticating encephalitis is a complicated task considering the diverse etiologies and each specific pathophysiology, with a high range of neurological and psychiatry sequelae, with no validated and universal measurement tool available [19]. For both infectious and autoimmune syndromes, the time to treatment initiation is crucial, while MRI and CSF abnormalities are not so clearly associated [20, 21]. In COVID-19 cases, where the mechanism is not so clearly defined and the level of suspicion is low, it is even harder to define prognosis.

COVID-19 patients with neurological symptoms presented worse 6-month functional outcomes and worse anxiety levels than patients without neurological symptoms [22]. Most long-term follow-ups were assessed by patient-reported outcome tools; however, one study evaluated patients with formal cognitive test after a mean time of 7 months (ranging from 1 month to 1 year) after COVID-19 diagnosis and found that hospitalized patients performed worse on global cognition, logical reasoning, and processes of verbal memory. Further, fatigue severity was associated with reduced performance on attention and psychomotor speed tasks [23].

In addition, among the specific group of patients with COVID-19, the term "long COVID" includes several symptoms, especially fatigue, cognitive dysfunction, and myalgia. It may be associated with chronic tissue damage, including viral persistence, inflammatory dysregulation, and autoimmune mechanisms [24]. There is evidence of frontoparietal hypometabolism on fluorodeoxyglucose positron emission tomography(FDG-PET) [24, 25] and impairment in memory and executive functions on neuropsychological tests [26].

Our patients referred to an important impact on their quality of life 1 year after diagnosis. Only two patients felt completely recovered from COVID-19. Although patients presented many symptoms at onset, most long-term complaints referred to mobility, cognitive, sleep, and mood disorders, aligning with the definition of "long COVID" and what is observed during recovery of other encephalitis etiologies. No patient presented any recurrent episode. The only fatality case was a patient complicated with pulmonary sepsis, acute kidney failure, and coagulation defects.

Our study has some shortcomings. Unfortunately, we could not provide a more sophisticated follow-up imaging study or more detailed inflammatory and antibody research. Further, selection bias may have occurred, since only patients with CSF evaluation were selected and a precise prevalence and incidence could not be calculated. However, strengths must be highlighted. All patients

presented a satisfactory elementary investigation. Also, although it is a small sample, it is one of the most significant cohorts of SARS-CoV-2-associated encephalitis and describes a long-term clinical follow-up of those patients.

## Conclusion

Encephalitis is a rare complication of SARS-CoV-2 infection. Although no definitive pathophysiology has been described, autoimmune and inflammatory mechanisms seem to be important components. The clinical presentation is diverse, and complementary studies (MRI and CSF) are often normal, which should lead to a high level of clinical suspicion. Beyond a year from onset, encephalitis continues to impact patients' quality of life, particularly in terms of mobility, cognitive function, and mood disorder. Further research is essential to uncover the underlying mechanisms and develop targeted interventions for long-term management.

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**Author contributions**
Nathane Rezende—conceptualization, investigation, resources, and writing original draft; Fernanda Barros-Aragao—resources and data curation and writing review; Talita Pinto—resources and writing review; Viviane Crelier—resources and writing review; Marcos Ravi Figueiredo and Carlos Otavio Brandao—resources; Andrea de Souz— formal analysis and writing review; Fernanda Tovar-Moll—supervision and visualization; Gabriel R. de Freitas—supervision and visualization, conceptualization, and writing review.

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**Data availability**
The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available owing to privacy or ethical restrictions.

## Declarations

**Ethics approval and consent to participate**
This study is part of a project entitled ISARIC/WHO Clinical Characterization Protocol for Severe Emerging Infections: Coronavirus. Approved by the National Ethics and Research Committee, by the Instituto D'Or de Pesquisa e Ensino (CONEP-CAAE 29496920.8.0000.5262, 19 March, 2020), with an individual patient consent waiver. All authors have read and consented to the publication of this manuscript.

**Consent for publication**
Written informed consent was obtained from the patients for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal, and in the instance of the patient who passed away, written informed consent was obtained from the patient's next-of-kin for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

**Competing interests**
None of the authors report relevant financial or nonfinancial competing interests.

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