Table 3
Neurological Symptoms of COVID-19 [90]

| CNS = 24.8% | | PNS = 8.9% | | Skeletal muscle | |
|---|---|---|---|---|---|
| Dizziness | 16.80% | Smell impairment | 5.6% | Skeletal muscle injury | 10.7% |
| Headache | 13.1% | Taste impairment | 5.1% | | |
| Altered Consciousness | 7.5% | Nerve pain | 2.3% | | |
| Acute cerebrovascular disease | 2.8% | Vision impairment | 1.4% | | |
| Ataxia | 5.0% | | | | |
| Seizures | 5.0% | | | | |

CNS, central nervous system; PNS, peripheral nervous system.

conventional post-viral anosmia is linked to the immediate destruction of olfactory sensory neurons and can take several months for recovery [91].

A study has shown that the identification of non-neuronal cell types in the olfactory epithelium makes patients affected with SARS-CoV-2 highly vulnerable and cause anosmia [91].

Anosmia and ageusia are associated with COVID-19 [92, 107]. In a study of 417 European patients, 357 (85.6%) presented viral-associated olfactory dysfunction. 79.6% presented anosmia, while 20.4% presented hyposmia. Phantosmia and parosmia represented 12.6% and 32.4%, respectively. Most (65.4%) presented olfactory dysfunction after the onset of otorhinolaryngologic symptoms, 22.8% presented both at the same time, while only 11.8% before symptom onset. 63% of all were asymptomatic, but presented olfactory dysfunction persistence [92].

In a French study of 58 COVID-19 patients with ARDS, neurologic features were observed in 49 patients, including prominent agitation, confusion, and corticospinal tract signs [93]. COVID-19 positive patients with strokes have been reported worldwide, and numbers are increasing [94, 98–101]. The virus has not been detected in the cerebrospinal fluid, despite being positive on a COVID-19 nasal swab via RT-PCR. SARS-CoV-2's isolation in the cerebrospinal fluid may be dependent on the disease being systemic or not [102–105]. Further studies will be required to determine if the neurological symptoms are caused by the virus itself or indirectly by secondary, infectious, systemic inflammatory responses. Magnetic resonance imaging (MRI) in the early phase of infection in patients with anosmia, cerebrospinal fluid testing and pathology studies would be helpful to document objective radiological data [106].

While most neurological manifestations have been non-focal, some cases of severe and critical COVID-19 have been shown to present with strokes [93]. As per Mao et al., the rate of neurovascular events in their series was about 5.7% of which about 4.9% had ischemic strokes [88]. Most ischemic strokes in these case series were subcortical or distal emboli. Some cases were related to other risk factors like atrial fibrillation, diabetes, or hypertension. Other cases, coagulation pathway disorders directly associated with the viral inflammation or immunological response, like antiphospholipid antibodies or elevation of D-dimer and Fibrinogen, may have been responsible [93].

No specific correlation with COVID-19 associated strokes and age or pre-stroke severity of the disease has been found [94]. All the cases had a high neutrophil-lymphocyte ratio except for one. Almost half of the patients who were part of this cohort presented with large vessel occlusions. Eighty percent of those underwent a thrombectomy, most of them having poor outcomes, and this was typically secondary to non-neurological aspects of the disease such as ARDS or multiorgan failure [94]. COVID-19 related ischemic events can follow multiple etiopathogeneses. Hypertension, however, has not been independently associated with severity of COVID-19 [95]. Finally, paradoxical emboli from venous thromboembolism are yet another confounding cause of ischemic events in the brain [96, 97].

## DIAGNOSIS

Laboratory diagnostic methods have proven to be reliable in diagnosing COVID-19 and have been presented in tabular form in Table 4 [48, 108].

## TREATMENT

The primary treatment for COVID-19 is symptomatic, if mild. The universal treatment used in patients with moderate, severe, or critical presenta-