A review of the potential neurological adverse events of COVID-19 vaccines

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Received: 17 March 2022 / Accepted: 27 October 2022 / Published online: 16 November 2022 © The Author(s) under exclusive licence to Belgian Neurological Society 2022

Abstract

Despite the advantages of getting access to the coronavirus disease 2019 (COVID-19) vaccines, their potential ability to induce severe adverse events (AEs) has been a significant concern. Neurological complications are significant among the various adverse events following immunization (AEFI) due to their likely durability and debilitating sequelae. Neurological AEs following COVID-19 vaccination can either exacerbate or induce new-onset neuro-immunologic diseases, such as myasthenia gravis (MG) and Guillain–Barre syndrome (GBS). The more severe spectrum of AEs post-COVID19 vaccines has included seizures, reactivation of the varicella-zoster virus, strokes, GBS, Bell’s palsy, transverse myelitis (TM), and acute disseminated encephalomyelitis (ADEM). Here, we discuss each of these neurological adverse effects separately.

Keywords COVID-19 · Vaccine · Adverse event · Neurologic · SARS-CoV-2

Introduction

Despite the advantages of getting access to the coronavirus disease 2019 (COVID-19) vaccines, their potential ability to induce severe adverse events (AEs) has been a significant concern. Neurological complications are significant among the various adverse events following immunization (AEFI) due to their likely durability and debilitating sequelae [1, 2]. Neurological AEs following COVID-19 vaccination can either exacerbate or induce new-onset neuro-immunologic diseases, such as myasthenia gravis (MG), and Guillain–Barre syndrome (GBS) [3–5]. In addition, after vaccination, hypercoagulability and a pro-thrombotic state may further increase cerebrovascular events [6, 7]. The Centers for Disease Control (CDC) Vaccine Adverse Event Reporting System (VAERS) has announced several neurological complications following COVID-19 vaccines [8]. The most common neurological symptoms following COVID-19 vaccines have included headache, anosmia, dysgeusia, myalgia, paresthesia, weakness, and dizziness [9]. Several rare side effects, including tremor, diplopia, tinnitus, dysphonia, delirium, and syncope, have also been observed.
that are significant to note [10, 11]. The more severe spectrum of AEs post-COVID19 vaccines has included seizures, reactivation of the varicella-zoster virus, strokes, GBS, Bell’s palsy, transverse myelitis (TM), and acute disseminated encephalomyelitis (ADEM). Here, we discuss each of these neurological adverse effects separately.

Bells palsy

Bell’s palsy (BP), known as idiopathic facial paralysis, is an acute unilateral peripheral facial nerve palsy [12]. This condition is, in fact, an idiopathic facial palsy of spontaneous origin, although a causal association with the herpes simplex virus has been considered [13]. However, in the current pandemic, studies revealed abundant cases of BP following SARS-CoV-2 infection [14–16]. Several vaccines, including influenza, hepatitis B, and meningococcal conjugate vaccines, have been associated with BP [17–19]. With the development of COVID-19 vaccines, significant concerns have arisen about their potential to trigger the onset of Bell’s palsy. Despite being less prevalent than expected, this complication has still been abundantly reported following these vaccines [12, 20, 21]. Nonetheless, the US Food and Drug Administration (FDA) announced that the frequency of Bell’s palsy cases following vaccination is not more unusual than in the general population [22]. Despite the inability to confirm the causal relationship between the vaccines and this complication, the timing of onset following vaccination can suggest the association. Confirmation would need to be studied in larger populations [23]. This reaction could be either immune-mediated or induced by viral reactivation [24], but the latter does not seem valid for COVID-19 vaccines since no live attenuated COVID-19 vaccine platform has yet been introduced.

The immune-mediated mechanism for this complication is thought to be through host molecules’ mimicry of the vaccine’s antigens or by eliciting a type I interferons response [25, 26]. The timing of BP onset in relationship to vaccination is unclear, although most of the cases have occurred in an average 4-week interval after vaccination [27]. Moreover, there has been a case of sequential contralateral facial nerve palsies following each dose of COVID-19 vaccines reported recently [27]. Up to now, BP has been reported following various COVID-19 vaccine types, including Pfizer-BioNTech, Janssen, CoronaVac, Moderna, and Oxford-AstraZeneca vaccines [12, 23, 28–30]. Nonetheless, the risk of developing facial nerve palsy has been estimated to be higher with mRNA vaccines than with other vaccine platforms; this fact can help us decide the choice of COVID-19 vaccine in individuals with a history of BP [31]. It is vital to note that most cases of BP, regardless of etiology, are self-limiting and subside within a few months [32]. However, antiviral agents and steroids are frequently tried as a treatment and hasten recovery [32].

Guillain–Barré Syndrome

Guillain–Barré Syndrome (GBS) is defined as an inflammatory ascending polyradiculoneuropathy. The underlying triggers for this neurological disorder include infections and vaccines on an autoimmune basis [33] (Fig. 1). The introduction of COVID vaccines has arisen the concerns of developing GBS following vaccination [34] since GBS had been previously observed in individuals who received the meningococcal, tetanus-toxoid, human papillomavirus (HPV), and most prominently, the influenza vaccines [35–39]. This complication has been reported following Pfizer-BioNTech, Johnson & Johnson, and ChAdOx1 nCoV-19 COVID-19 vaccines [1, 40–42]. Moreover, one case of isolated bilateral facial plegia with paresthesias (BFP), an uncommon variant of GBS, has been reported following the Janssen COVID-19 vaccination [43]. It is believed that vaccine-induced immune responses may trigger autoimmune reactions, resulting in autoantibody production against myelin, resulting in GBS [40]. The diagnosis of vaccine-induced GBS is the same as that of other causes, through clinical and paraclinical findings such as cerebrospinal fluid (CSF) analysis and electromyography and nerve conduction velocity (EMG/NCV) studies, in addition to considering the temporal relationship between the event and vaccination [44]. Intravenous immune globulin (IVIg) (0.4 g per kg body weight every day for 5 days) and plasma exchange (200–250 ml plasma kg body weight in 5 sessions) can be considered as efficient treatments for GBS [45].

Transverse myelitis

Transverse myelitis (TM) is a condition where spinal cord segments may become inflamed, resulting in significant motor, autonomic and sensory deficits. [46]. Since the beginning of the current pandemic, several cases of TM have been reported in SARS-CoV-2-infected patients [47, 48]. Apart from infections as a cause of TM, vaccines are of great importance in the evolution of this neurological condition [49]. TM following vaccination had previously been observed with various vaccines, including tetanus, measles–mumps–rubella, influenza (H1N1), hepatitis B, polio, and Japanese B encephalitis vaccines [50–54]. This neurological complication has also been reported following COVID-19 vaccination with viral vector-based and mRNA-based COVID-19 vaccines. However, their association has not been confirmed in a number of trials [2, 55–57]. Moreover, a rare subtype of TM, known as longitudinally extensive transverse myelitis (LETM), has been reported following COVID-19 vaccination [58]. The pathophysiology of TM
in the settings of SARS-CoV-2 infection is thought to be either via direct viral neuro-invasion or immune-mediated, while the mechanism by which COVID-19 vaccines might trigger TM may be immune and inflammatory reactions [59, 60]. The diagnosis is made by typical clinical evidence of bilateral sensory, motor, or autonomic dysfunction with an established spinal cord defect origin in magnetic resonance imaging (MRI) [61]. Unfortunately, TM is a neurological condition with unfavorable outcomes [62]. Although there is insufficient evidence, high-dose IV methylprednisolone (1 g per day for 3–7 days) has to be started immediately for all TM cases to improve neurological function and accelerate recovery [63, 64]. In a case report study, a COVID-19 patient with acute TM treated with high-dose IV methylprednisolone (1 g daily for 3 days) showed improved neurological symptoms immediately after receiving IV corticosteroid therapy [65].

**Cerebrovascular events**

Since the beginning of the COVID-19 pandemic, a significant increase in stroke rates was observed, later discovered to be due to SARS-CoV-2 infection [66–68]. Although not as common as SARS-CoV-2 infection, COVID-19 vaccination is also suspected to increase the risk of cerebrovascular events [69]. It is unknown whether the cerebrovascular events, including ischemic/hemorrhagic strokes and cerebral venous sinus thrombosis, are related to COVID-19 vaccination. If they are related, it also remains unclear how the vaccines may contribute—by causing arterial hypertension,
worsening thrombocytopenia, or exacerbating a hypercoagulable state [70, 71]. Previously, a stroke took place following vaccination with various other vaccines, including diphtheria, measles–mumps–rubella, and influenza vaccines [72–74]. The probability and reports of systemic thrombotic thrombocytopenic events following COVID-19 vaccination have caused a great deal of concern and hesitancy worldwide [71]. The Oxford-AstraZeneca (ChAdOx1 nCoV-19) vaccine had been the most notorious for this complication that many countries suspended its use [75]. However, thrombotic events have not been uncommon following the Johnson & Johnson COVID-19 vaccine [76, 77]. Cerebrovascular events, including hemorrhagic and ischemic strokes, from venous and arterial etiologies and an increased thrombotic and embolic risk, have been noted [78–81]. There have been reports of thrombosis in the cortical veins, transverse sinus, sigmoid sinus, inferior sagittal sinus, the vein of Galen, and the straight sinus that have all presented with intracranial hemorrhage (ICH) and subarachnoid hemorrhage (SAH), shortly after COVID-19 vaccination [80–83].

However, we should take into account that individuals with risk factors of thromboembolic events, such as pregnancy, postpartum state, oral contraceptives use, surgery, trauma, immobilization, malignancies, and thrombophilic genetic or autoimmune conditions including anti-thrombin, protein C, and protein S deficiency, factor V Leiden mutation, antiphospholipid antibodies, and hyperhomocysteinemia, are more prone to vaccine-induced cerebrovascular complications [84–87]. It is important to note that anti-CXCL4 antibodies are responsible for most cases of vaccine-induced immune thrombotic thrombocytopenia (VITT); this is similar to what happens with heparin-induced thrombocytopenia (HIT) [71, 88]. Depending on which vessel is involved, clinical manifestations may range from a simple headache, nausea, vomiting, and diplopia to focal neurologic signs, altered consciousness, and coma. The diagnosis of cerebrovascular AEs is generally made with comprehensive imaging, including brain computed tomography (CT), venogram, angiography, and MRI [89]. Management of cerebrovascular events following vaccination is generally the same as with any other cause, with the goal being assessment and management of risk factors and secondary stroke prevention. Heparin and platelet transfusions should be avoided until VITT has been excluded [90, 91]. In cases of systemic thrombotic thrombocytopenic events, IVIg, high-dose glucocorticoids, and plasmapheresis are recommended when indicated to restore platelet counts and address the autoimmune phenomenon [79, 92].

**Encephalopathy**

Acute encephalopathy has been attributed to various etiologies, including toxins, infections, and vaccines. One of the most prevalent neurological sequelae of COVID-19 has been encephalopathy which presents with cognitive impairment, altered consciousness, and even seizures [93–96]. However, the condition has been observed much less frequently following COVID-19 vaccination [94, 97–100]. In the past, several cases of encephalopathy had been reported after various vaccines, including hepatitis B, rabies, pertussis, measles, influenza, and HPV vaccines [101–107]. The pathophysiologic mechanism for vaccine-induced acute disseminated encephalomyelitis (ADEM) seems to be the inflammatory cascade or the cytokine storm triggered by the production of spike protein from translated mRNA in the vaccines [108, 109]. The diagnosis of ADEM in the settings of COVID-19 vaccination is similar to that of other causes and is accomplished through clinical and cerebrospinal fluid (CSF) findings and imaging modalities such as brain MRI. The treatment consists of corticosteroids and sometimes IVIg and plasmapheresis [110]. Fortunately, ADEM has a favorable outcome if conservative support is satisfactory [111].

**New-onset seizures**

The pathophysiologic mechanisms of seizures during a SARS-CoV-2 infection differ significantly from those following COVID-19 vaccination. In the former, specific antibiotic therapies, cerebral hypoxemia, acute renal failure, and electrolyte impairment can be the underlying reasons [112–114]. The latter can happen in the settings of vaccine-induced encephalopathy or venous occlusion [97]. Before the current pandemic, HPV and H1N1 vaccinations had been related to functional (non-epileptic) seizures, which were believed to be psychogenic attacks [115, 116]. The association of febrile seizure with the measles–mumps–rubella–varicella vaccine has long been well established [117]. It is unknown whether non-motor seizures are related to COVID-19 vaccines or only a coincidence [118]. Patients with a known history of epilepsy or prior history of seizures may have a decreased threshold in the post-vaccine period due to the symptoms and illness. Rare attacks have included new-onset refractory status epilepticus that require further assessment and follow-up [119]. The diagnosis is based on clinical history, physical examinations, brain imaging (CT scan and MRI), electroencephalography, and serum prolactin level measurement. There are a variety of antiepileptic drugs (Table 1) that can be administered as first-line monotherapy in adults with epilepsy [120].

**Varicella-zoster virus reactivation**

Since the beginning of the COVID-19 pandemic, several cases of herpes zoster have been reported in SARS-CoV-2 infected patients, even in immunocompetent individuals.
The potential mechanism for this event is suggested to be COVID-19-induced lymphopenia and CD4+ T cell dysfunction [123]. Nonetheless, immunomodulation, immune dysregulation, and attenuated alloreactivity are believed to be the underlying pathophysiology for vaccine-induced herpes zoster reactivation [124, 125]. Herpes zoster reactivation was previously reported following yellow fever, influenza, hepatitis A, and rabies vaccines [126, 127]. Up to the present time, this neurological complication has been reported following various COVID-19 vaccines, including mRNA-based (Pfizer-BioNTech, Moderna), viral vector (Oxford ChAdOx1-S or AZD1222), and inactivated vaccines (COVAXIN) [125, 128–133]. Moreover, a case of varicella-zoster virus-induced small vessel vasculitis following the first dose of the Pfizer-BioNTech COVID-19 vaccine has been reported [134]. It should be noted that in all suspected cases of vaccine-induced herpes zoster reactivation, a de novo SARS-CoV-2 infection should be ruled out. The diagnosis is made with clinical manifestations (dermatomal rash, pain, paresthesia, dysesthesia, allodynia, pruritus), IF test for VZV antigen, and PCR test for VZV DNA. acyclovir, valacyclovir, and famciclovir (guanosine analogs) are recommended for VZV treatment [135].

### Table 1 Summary of the proposed diagnosis and management of neurological adverse events following COVID-19 vaccination

| Neurological adverse event | Diagnosis | Management |
|----------------------------|-----------|------------|
| Bell’s palsy               | History and physical examination: Rapid-onset (less than 72 h) unilateral paralysis of the facial nerve (weakness or complete loss of movement) with no defined reason | Oral corticosteroids (prednisolone) and antiviral agents (acyclovir and valacyclovir) |
| Guillain–Barré Syndrome   | Clinical and paraclinical findings such as cerebrospinal fluid (CSF) analysis and electromyography and nerve conduction velocity (EMG/NCV) studies, in addition to considering the temporal relationship between the event and vaccination | IVIg (0.4 g per kg body weight every day for 5 days) and plasma exchange (200–250 mL plasma per kg body weight in 5 sessions) are similarly efficient remedies for GBS |
| Transverse myelitis        | Typical clinical evidence of bilateral sensory, motor, or autonomic dysfunction with an established spinal cord defect origin in magnetic resonance imaging (MRI) | High-dose IV methylprednisolone (1 g daily for 3–7 days) |
| Cerebrovascular events    | Brain computed tomography (CT), venogram, angiography, and MRI | IVIg |
| Encephalopathy            | Clinical and cerebrospinal fluid (CSF) findings and imaging modalities such as brain MRI | Corticosteroids and sometimes IVIg and plasmapheresis |
| New-onset seizures        | Clinical history, physical examinations, brain imaging (CT scan and MRI), electroencephalography, and serum prolactin level measurement | Narrow-spectrum drugs (focal seizure) Carbamazepine, Eslicarbazepine Gabapentin, Lacosamide, Oxcarbazepine, Phenytoin, Broad-spectrum drugs (focal and almost all generalized seizures) Lamotrigine, Levetiracetam, Topiramate, Valproate, Zonisamide |
| Myasthenia gravis exacerbation | Suspected through compatible signs and symptoms of fatigable muscle weakness and confirmed by EMG studies, pharmacologic testing, and serum Ab assay | Pyridostigmine (30 mg 3–4 times a day, then can be increased to 60 mg 4 times a day) Oral prednisone (0.75–1 mg per kg daily) Azathioprine, Cyclosporine, Tacrolimus, Rituximab |
| Varicella-zoster virus reactivation | Clinical manifestations (dermatomal rash, pain, paresthesia, dysesthesia, allodynia, pruritus), IF test for VZV antigen, PCR test for VZV DNA | Acyclovir (800 mg orally 5 times a day for 7–10 days) Valacyclovir (1 g orally 3 times a day for 7 days) Famciclovir (500 mg orally 3 times a day for 7 days) |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|-----------|----------------------|----------------|---------|------------------------|-----------|-----------|---------------------------------------------------------------|
| 1           | Afshar et al. [144]/2021 | Bell’s palsy | F/64 | Iran | Left side facial nerve palsy | History and physical examination, brain CT scan and MRI, pulmonary CT scan, RT-PCR for SARS-CoV-2, and anti-SARS-CoV-2 IgM test | Lopinavir/ritonavir (Kaletra) + dexamethasone | Associated with COVID-19 infection |
| 2           | Dahl et al. [145]/2021 | Bell’s palsy | M/37 | Norway | Right side facial nerve palsy | History and physical examination, cerebral CT scan, spinal fluid examination, spinal fluid PCR, anti-SARS-CoV-2 IgG antibodies test | – | Associated with COVID-19 infection |
| 3           | Bastola et al. [146]/2021 | Bell’s palsy | M/48 | India | Left side facial nerve palsy | History and physical examination, chest HRCT and PCR for SARS-CoV-2 | Prednisolone | Associated with COVID-19 infection |
| 4           | Al-Mashdali et al. [147]/2021 | Bell’s palsy | M/21 | Qatar | Right side facial nerve palsy | History and physical examination, chest CT scan and RT-PCR for SARS-CoV-2 | Prednisolone and eye lubricant | Associated with COVID-19 infection |
| 5           | Hasibi et al. [148]/2021 | Bell’s palsy | M/52 | Iran | Right side facial nerve palsy | History and physical examination, RT-PCR for SARS-CoV-2 and spiral chest CT scan | Prednisolone and favipiravir Then: remdesivir and IV dexamethasone | Associated with COVID-19 infection |
| 6           | Ferreira et al. [149]/2022 | Bell’s palsy | M/11 | Portugal | Right side peripheral facial paralysis | History and physical examination, PCR for SARS-CoV-2, cranial CT, and MRI | Prednisolone | Associated with COVID-19 infection |
| 7           | Iacono et al. [150]/2022 | Bell’s palsy | M/5 | Italy | Right side facial nerve palsy | History and physical examination, brain MRI and serological tests for SARS-CoV-2 | Prednisolone and eye lubricant | Associated with COVID-19 infection |
| Case number | Reference | Neurological disorder     | Sex/Age (years) | Country | Clinical manifestation                                                                 | Diagnosis                                                                 | Treatment                                                                 | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|------------|-----------|--------------------------|-----------------|---------|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------|
| 8          | Kaplan[151]/2021 | Bell’s palsy            | F/48            | USA     | Left side facial nerve palsy                                                           | History and physical examination, PCR for SARS-CoV-2 and chest CT scan | Prednisone, valacyclovir, and doxycycline (the doxycycline was discontinued after Lyme disease titers became negative) | Associated with COVID-19 infection                             |
| 9          | Szewczyk et al. [152]/2021 | Bilateral facial nerve palsy | M/70            | Poland  | Bilateral facial nerve palsy                                                           | History and physical examination, brain CT scan and MRI and serological tests for SARS-CoV-2 | Intravenous immunoglobulins (IVIg)                                     | Associated with COVID-19 infection                             |
| 10         | Kumar et al. [153]/2021 | Bell’s palsy            | F/28            | India   | Right side lower motor neuron facial nerve palsy                                       | History and physical examination, RT-PCR for SARS-CoV-2                    | Prednisone and valacyclovir                                             | Associated with COVID-19 infection                             |
| 11         | Neo et al. [154]/2021 | Bell’s palsy            | M/25            | Singapore | Left side facial weakness/palsy                                                         | History and physical examination, RT-PCR for SARS-CoV-2, and serological tests for SARS-CoV-2 | Oral corticosteroids, valacyclovir, and eye care advice                | Associated with COVID-19 infection                             |
| 12         | Neo et al. [154]/2021 | Bell’s palsy            | M/34            | Singapore | Right side facial weakness                                                            | History and physical examination, RT-PCR for SARS-CoV-2, and serological tests for SARS-CoV-2 | Oral corticosteroids, valacyclovir, and eye care advice                | Associated with COVID-19 infection                             |
| 13         | Khaja et al. [155]/2020 | Guillain-Barré Syndrome and Bell’s Palsy | M,44           | USA     | Bilateral facial weakness                                                             | History and physical examination, RT-PCR for SARS-CoV-2, serological tests for SARS-CoV-2, and brain MRI | IVIg                                                            | Associated with COVID-19 infection                             |
| Case number | Reference          | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment                                                                 | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|-------------------|-----------------------|-----------------|---------|------------------------|-----------|---------------------------------------------------------------------------|----------------------------------------------------------------------------|
| 14          | Theophanous et al. [156]/2021 | Bell's palsy          | M/6             | USA     | Right side facial nerve palsy | History and physical examination, RT-PCR for SARS-CoV-2 | IV acyclovir and IVIg infusion (because of agammaglobulinemia) Then discharged with prednisolone and acyclovir | Associated with COVID-19 infection |
| 15          | Wan et al. [157]/2020 | Bell's palsy          | F/65            | China   | Left side facial nerve palsy | History and physical examination, RT-PCR for SARS-CoV-2, and brain MRI | Arbidol and ribavirin | Associated with COVID-19 infection |
| 16          | Bohania et al. [158]/2021 | Bell's palsy          | F/18            | –       | Right side facial nerve palsy | History and physical examination, COVID-19 antigen testing | Steroids, eye taping during sleep, and methylcellulose eye drops | Associated with COVID-19 infection |
| 17          | Burrows et al. [159]/2021 | Bell's palsy          | M/61            | UK      | Right side lower motor neuron facial palsy | History and physical examination and head CT scan | Prednisolone | Associated with COVID-19 vaccination (Pfizer-BioN-Tech) |
| 18          | Cellina et al. [160]/2022 | Bell's palsy          | F/35            | Italy   | Left side facial nerve palsy | History and physical examination and brain MRI | Prednisone | Associated with COVID-19 vaccination (Moderna) |
| 19          | Iftikhar et al. [12]/2021 | Bell's palsy          | M/36            | Qatar   | Left side facial nerve palsy + left upper limb numbness and weakness | History and physical examination, brain CT scan, and MRI | Prednisolone and eye lubricant | Associated with COVID-19 vaccination (Moderna) |
| 20          | Mussatto et al. [161]/2022 | Bell's palsy          | M/60            | USA     | Left side facial nerve palsy | History and physical examination | Prednisone and valacyclovir | Associated with COVID-19 vaccination (Pfizer-BioN-Tech) |
| 21          | Repajic et al. [28]/2021  | Bell's palsy          | F/57            | USA     | Left side facial nerve palsy | History and physical examination | Prednisone and an antiviral agent | Associated with COVID-19 vaccination (Pfizer-BioN-Tech) |
| Case number | Reference                | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|--------------------------|-----------------------|-----------------|---------|------------------------|-----------|-----------|---------------------------------------------------------------|
| 22          | Yu et al. [162]/2021     | Bell’s palsy          | F/36            | China   | Right side facial nerve palsy | History and physical examination, serological tests for SARS-CoV-2, and brain CT scan | Prednisone and artificial tear | Associated with COVID-19 vaccination (Sinovac Life Sciences inactivated COVID-19 vaccine) |
| 23          | Mason et al. [163]/2021  | Bell’s palsy          | F/35            | USA     | Bilateral facial nerve palsy | History and physical examination, brain MRI and CT angiography | Methylprednisolone (IV) and acyclovir | Associated with COVID-19 vaccination (Moderna) |
| 24          | Mirmosayyeb et al. [164]/2022 | Bell’s palsy          | F/27            | Iran    | Left side facial nerve palsy | History and physical examination and brain MRI | Prednisone and valacyclovir | Associated with COVID-19 vaccination (Russian Sputnik V) |
| 25          | Mirmosayyeb et al. [164]/2022 | Bell’s palsy          | M/58            | Iran    | Left side facial nerve palsy | History and physical examination | Prednisone and valacyclovir | Associated with COVID-19 vaccination (Russian Sputnik V) |
| 26          | Pothiawala[165]/2021     | Bell’s palsy          | M/46            | Singapore | Right side facial nerve palsy | History and physical examination | Prednisone and acyclovir | Associated with COVID-19 vaccination (Moderna) |
| 27          | Kundi et al. [166]/2022  | Bell’s palsy          | F/66            | USA     | Right side facial nerve palsy | History and physical examination and brain CT | Prednisone, acyclovir, meclizine, and ondansetron | Associated with COVID-19 vaccination (Ad26.COV2.S vaccine) |
| 28          | Nishizawa et al. [167]/2021 | Bell’s palsy          | F/62            | Japan   | Right side facial nerve palsy | History and physical examination, head CT and brain MRI | – | Associated with COVID-19 vaccination (Ad26.COV2.S vaccine) |
| 29          | Colella et al. [20]/2021 | Bell’s palsy          | M/37            | Italy   | Left side facial nerve palsy | History and physical examination | Prednisone and artificial tear | Associated with COVID-19 vaccination (Pfizer-BioNTech) |
| 30          | Martin-Villares et al. [168]/2022 | Bell’s palsy          | F/34            | Spain   | Right side facial nerve palsy | History and physical examination and brain MRI | – | Associated with COVID-19 vaccination (Moderna) |
Table 2 (continued)

| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|-----------|-----------------------|----------------|---------|------------------------|-----------|-----------|-----------------------------------------------------------------|
| 31          | Scheidl et al. [169]/2020 | Guillain-Barré Syndrome | F/54 | Germany | Acute, proximally pronounced, moderate, symmetric paraparesis, areflexia, numbness, and tingling of all extremities | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis and EMG and NCV studies) | IVIg (0.4 g per kg body weight every day for 5 days) | Associated with COVID-19 infection |
| 32          | Bueso et al. [170]/2021 | Guillain-Barré Syndrome | F/60 | USA | Symmetrical weakness of both the lower and upper extremities | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis) | IVIg (0.4 g per kg body weight every day for 5 days) + enoxaparin 30 mg twice a day | Associated with COVID-19 infection |
| 33          | Sedaghat and Karimi [171]/2020 | Guillain-Barré Syndrome | M/65 | Iran | Acute progressive weakness of distal lower extremities, quadriplegia, and bilateral facial paresis | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis and EMG and NCV studies) | IVIg (0.4 g per kg body weight every day for 5 days) | Associated with COVID-19 infection |
| 34          | Agosti et al. [172]/2021 | Guillain-Barré Syndrome | M/68 | Italy | Acute progressive symmetric ascending flaccid tetraparesis, bifacial nerve palsy, and muscular weakness | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis and NCV studies) | IVIg (0.4 g per kg body weight every day for 5 days) | Associated with COVID-19 infection |
| 35          | Paybast et al. [173]/2020 | Guillain-Barré Syndrome | M/38 | Iran | Acute symmetric progressive ascending paresthesia of both lower and upper extremities and bilateral facial droop | Clinical and paraclinical findings (such as CSF analysis and EMG and NCV studies) | Therapeutic plasma exchange for 5 sessions | Associated with COVID-19 infection |
| 36          | Paybast et al. [173]/2020 | Guillain-Barré Syndrome | F/14 | Iran | Progressive ascending quadriparesis and mild lower limb weakness | Clinical and paraclinical findings (such as CSF analysis) | IVIg (20 g daily for 5 d) | Associated with COVID-19 infection |
Table 2 (continued)

| Case number | Reference          | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation                  | Diagnosis                                                                 | Treatment                        | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|--------------------|-----------------------|-----------------|---------|-----------------------------------------|----------------------------------------------------------------------------|----------------------------------|---------------------------------------------------------------|
| 37          | Dufour et al. [174]/2021 | Guillain-Barré Syndrome | F/36            | USA     | Progressive ascending weakness          | RT-PCR for SARS-CoV-2, history and physical examinations                  | IVIg (0.4 g per kg body weight every day for 5 days) | Associated with COVID-19 infection                            |
| 38          | Toscano et al. [175]/2020 | Guillain-Barré Syndrome | –               | Italy   | Flaccid areflexic tetraplegia evolving to facial weakness, upper-limb paresthesia | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis and head and spine MRI) | 2 IVIg cycles | Associated with COVID-19 infection                            |
| 39          | Toscano et al. [175]/2020 | Guillain-Barré Syndrome | –               | Italy   | Facial diplegia and generalized areflexia evolving to paresthesia of lower limbs with ataxia | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis and head and spine MRI) | IVIg | Associated with COVID-19 infection                            |
| 40          | Toscano et al. [175]/2020 | Guillain-Barré Syndrome | –               | Italy   | Flaccid tetraparesis and facial weakness evolving to areflexia | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis and head and spine MRI) | 2 IVIg cycles | Associated with COVID-19 infection                            |
| 41          | Toscano et al. [175]/2020 | Guillain-Barré Syndrome | –               | Italy   | Flaccid areflexic tetraparesis and ataxia | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis and head and spine MRI) | IVIg | Associated with COVID-19 infection                            |
| 42          | Toscano et al. [175]/2020 | Guillain-Barré Syndrome | –               | Italy   | Facial weakness, flaccid areflexic paraplegia | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis and head and spine MRI) | IVIg and plasma exchange | Associated with COVID-19 infection                            |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|-----------|-----------------------|----------------|--------|------------------------|-----------|-----------|---------------------------------------------------------------|
| 43          | El Otmani et al. [176]/2020 | A subtype of GBS: Acute Motor and Sensory Axonal Neuropathy (AMSAN) | F/70 | Morocco | Bilateral weakness and paresthesia in all four extremities | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis and EMG and NCV studies) | IVIg (2 g/kg for 5 days), Hydroxychloroquine (600 mg/day), and Azithromycin (500 mg on the first day, then 250 mg/day) | Associated with COVID-19 infection |
| 44          | Khan et al. [177]/2021 | Guillain-Barré Syndrome | M/27 | India | Myalgia, weakness of the lower limb (then it involved the upper limb), and generalized hypotonia | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis and NCV studies) | IVIg (0.4 g per kg body weight every day for 5 days) | Associated with COVID-19 infection |
| 45          | Khan et al. [177]/2021 | Guillain-Barré Syndrome | F/35 | India | Paresthesia in both lower limbs followed by mild weakness | COVID-19 testing (she was positive for COVID-19), clinical and paraclinical findings (such as CSF analysis and NCV studies) | Managed as a case of COVID-19 (Supportive) | Associated with COVID-19 infection |
| 46          | Khan et al. [177]/2021 | Guillain-Barré Syndrome | F/40 | India | Lower-limb paresthesia is associated with weakness rapidly progressing from lower to upper limbs, respiratory muscles weakness | Clinical and paraclinical findings (such as CSF analysis and NCV studies) | IVIg (0.4 g per kg body weight every day for 5 days) | Associated with COVID-19 infection |
| 47          | Khan et al. [177]/2021 | Guillain-Barré Syndrome | F/48 | India | Paresthesia in both lower limbs and weakness | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis and NCV studies) | IVIg (0.4 g per kg body weight every day for 5 days) | Associated with COVID-19 infection |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|-----------|----------------------|----------------|---------|-----------------------|-----------|-----------|---------------------------------------------------------------|
| 48          | Khan et al. [177]/2021 | Guillain-Barré Syndrome | M/50 | India | Paresthesia in both lower limbs (then it involved upper limbs) and weakness | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis) | IVIg (0.4 g per kg body weight every day for 5 days) | Associated with COVID-19 infection |
| 49          | Su et al. [178]/2020 | Guillain-Barré Syndrome with dysautonomia | M/72 | USA | Symmetric paresthesias and ascending appendicular weakness | SARS-CoV-2 PCR, clinical and paraclinical findings (such as CSF analysis and EMG and NCV studies) | IVIg (2 g/kg between days 3 and 6) | Associated with COVID-19 infection |
| 50          | Darvishi et al. [179]/2021 | Guillain-Barré Syndrome | M/56 | Iran | Subacute progressive lower limbs weakness, paresthesia, and pain (then it progressed to severe, flaccid paraparesis) | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis) | IVIg (0.5 g/kg/d for 5 days) | Associated with COVID-19 infection |
| 51          | Zhao et al. [180]/2020 | Guillain-Barré Syndrome | F/61 | China | Symmetric weakness and areflexia in both lower limbs | RT-PCR for SARS-CoV-2, clinical and paraclinical findings (such as CSF analysis and NCV studies) | IVIg | Associated with COVID-19 infection |
| 52          | Mackenzie et al. [181]/2021 | Guillain-Barré Syndrome | F/39 | Colombia | Progressive generalized weakness of lower limbs | SARS-CoV-2 PCR, clinical and paraclinical findings (such as CSF analysis and EMG and NCV studies) | Supportive care, enoxaparin, losartan, meperidine IV for muscle pain, hydroxychloroquine, and dexamethasone | Associated with COVID-19 infection |
| Case number | Reference                  | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation                                                                                           | Diagnosis                                                                 | Treatment                                                                 | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|----------------------------|-----------------------|-----------------|---------|-----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------------|
| 53          | Mostel et al. [182]/2021   | Guillain-Barré Syndrome | F/69            | USA     | Progressive motor weakness and sensation loss in extremities, numbness and paresthesia in the right hand and leg, numbness and paresthesia in the left limb | SARS-CoV-2 antibodies, clinical and paraclinical findings (such as EMG studies) | IVIg (2 g/kg for 5 days)                                                   | Associated with COVID-19 infection                                    |
| 54          | Farzi et al. [183]/2020    | Guillain-Barré Syndrome | M/41            | Iran    | Ascending paresthesia and paralysis                                                                                | SARS-CoV-2 PCR, clinical and paraclinical findings (such as EMG and NCV studies) | IVIg (0.4 g per kg body weight every day for 5 days)                      | Associated with COVID-19 infection                                    |
| 55          | Nejad et al. [184]/2021    | Guillain-Barré Syndrome | M/70            | Iran    | Symmetric weakness and areflexia in both lower limbs                                                              | SARS-CoV-2 PCR, clinical and paraclinical findings (such as CSF analysis) | IVIg                                                                      | Associated with COVID-19 infection                                    |
| 56          | McKean et al. [185]/2021   | Guillain-Barré Syndrome | M/48            | Malta   | Bilateral facial weakness, ascending paraesthesia, and bilateral progressive lower limb weakness                   | Clinical and paraclinical findings (such as CSF analysis and NCV studies), brain CT and MRI | IVIg (2 g/kg for 5 days)                                                   | Associated with COVID-19 vaccination (Oxford/AstraZeneca)              |
| 57          | Hasan et al. [186]/2021    | Guillain-Barré Syndrome | F/62            | UK      | Paraesthesia and progressive weakness of both lower limbs                                                        | Clinical and paraclinical findings (such as CSF analysis and NCV studies), brain CT and MRI | IVIg (2 g/kg for 5 days)                                                   | Associated with COVID-19 vaccination (Oxford/AstraZeneca)              |
| 58          | Allen et al. [187]/2021    | Guillain–Barré Syndrome | M/54            | UK      | Bilateral facial weakness and distal dysesthesia in hands and feet                                               | Clinical and paraclinical findings (such as CSF analysis and NCV studies), brain MRI | Oral prednisolone (60mg for 5 days)                                      | Associated with COVID-19 vaccination (Oxford/AstraZeneca)              |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|-----------|-----------------------|----------------|---------|-----------------------|-----------|-----------|---------------------------------------------------------------|
| 59          | Allen et al. [187]/2021 | Guillain–Barré Syndrome | M/20 | UK | Bilateral facial weakness and distal dysesthesia in feet | Clinical and paraclinical findings (such as CSF analysis and NCV studies), brain MRI | Oral prednisolone (60 mg for 5 days) | Associated with COVID-19 vaccination (Oxford/AstraZeneca) |
| 60          | Allen et al. [187]/2021 | Guillain–Barré Syndrome | M/57 | UK | Dysarthria and facial weakness, distal dysesthesia in feet, and proximal leg weakness | Clinical and paraclinical findings (such as CSF analysis and NCV studies), and brain MRI | IVIg | Associated with COVID-19 vaccination (Oxford/AstraZeneca) |
| 61          | Allen et al. [187]/2021 | Guillain–Barré Syndrome | M/55 | UK | Bilateral thigh paresthesia, bilateral facial weakness | Clinical and paraclinical findings (such as CSF analysis) and brain MRI | No treatment | Associated with COVID-19 vaccination (Oxford/AstraZeneca) |
| 62          | Min et al. [188]/2021 | Sensory Guillain–Barré Syndrome | M/58 | Republic of Korea | Severe paresthesia on both feet, mild hypoesthesia in vibration, temperature, and pain on both feet | SARS-CoV-2 PCR, Clinical and paraclinical findings (such as CSF analysis, NCV studies, and skin biopsy), and MRI | – | Associated with COVID-19 vaccination (Oxford/AstraZeneca) |
| 63          | Min et al. [188]/2021 | Sensory Guillain–Barré Syndrome | F/37 | Republic of Korea | Paresthesia in both lower limbs | SARS-CoV-2 PCR, Clinical and paraclinical findings (such as CSF analysis, NCV studies, and skin biopsy), and MRI | – | Associated with COVID-19 vaccination (Oxford/AstraZeneca) |
| 64          | Scendoni et al. [189]/2021 | Guillain–Barré Syndrome | F/82 | Italy | Progressively worsening of walking, weakness, lack of sensitivity in both lower limbs, and areflexia | Clinical and paraclinical findings (such as CSF analysis and EMG and NCV studies) | IVIg (0.4 g per kg body weight every day for 5 days) | Associated with COVID-19 vaccination (Pfizer-BioNTech) |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|-----------|----------------------|----------------|---------|----------------------|-----------|-----------|---------------------------------------------------------------|
| 65          | Maramattom et al. [190]/2021 | Guillain–Barré Syndrome | F/43 | India | Areflexic quadriparesis, facial diplegia, and respiratory failure | Clinical and para-clinical findings (such as CSF analysis and NCV studies) | IVIg | Associated with COVID-19 vaccination (Oxford/AstraZeneca) |
| 66          | Maramattom et al. [190]/2021 | Guillain–Barré Syndrome | F/67 | India | Distal paraesthesia in all the extremities, bilateral facial weakness, dysphagia, and increasing limb weakness | – | IVIg and plasmapheresis | Associated with COVID-19 vaccination (Oxford/AstraZeneca) |
| 67          | Maramattom et al. [190]/2021 | Guillain–Barré Syndrome | F/53 | India | Bilateral lower limb numbness and weakness, right-sided facial and tongue numbness (then it progressed to bilateral lower motor neuron facial palsy and Areflexic flaccid quadriplegia) | – | Mechanical ventilation | Associated with COVID-19 vaccination (Oxford/AstraZeneca) |
| 68          | Introna et al. [191]/2021 | Guillain–Barré Syndrome | M/62 | Italy | Absent deep tendon reflexes, severe bilateral optic disk edema, progressively worsening sensory ataxia and ascending quadripareisis | Clinical and para-clinical findings (such as CSF analysis and EMG and NCV studies), brain CT and MRI | IVIg (2 g/kg for 5 days) | Associated with COVID-19 vaccination (Oxford/AstraZeneca) |
| 69          | Razok et al. [192]/2021 | Guillain–Barré Syndrome | M/73 | Qatar | Progressive bilateral lower limb weakness | Clinical and para-clinical findings (such as CSF analysis and EMG and NCV studies), brain CT and MRI | IVIg (0.4 g per kg body weight every day for 5 days) | Associated with COVID-19 vaccination (Pfizer-BioNTech) |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with |
|-------------|-----------|----------------------|----------------|---------|-----------------------|-----------|-----------|-----------------|
| 70          | Rao et al. [193]/2021 | Guillain-Barré Syndrome | F/42 | USA | Progressive ascending weakness and paresthesias | Clinical and para-clinical findings (such as CSF analysis and NCV studies), brain and cervical MRI | IVIg (total of 2 g/kg in four divided doses) | SARS-CoV-2 infection vs post-COVID-19 vaccination |
| 71          | Moreno-Escobar et al. [194] | Transverse myelitis | M/41 | – | Bilateral paresthesia in upper and lower limbs, along with urinary and fecal retention | Serological study and CSF analysis, imaging studies | IV methylprednisolone | COVID-19 infection |
| 72          | Qazi et al. [195]/2021 | Transverse myelitis | F/35 | Pakistan | Abrupt bilateral lower limb weakness, paresthesia, and urinary retention | Serological study and CSF analysis, imaging studies | IV methylprednisolone (1 g/day for 7 days) | COVID-19 infection |
| 73          | Chow et al. [196]/2020 | Transverse myelitis | M/60 | Australia | Bilateral lower limb weakness, urinary retention, and constipation | Serological study and CSF analysis, imaging studies | IV methylprednisolone (1 g/day for 3 days) | COVID-19 infection |
| 74          | Sarma et al. [197]/2020 | Transverse myelitis | F/28 | USA | Lower back pain, bilateral symmetric upper and lower extremity numbness, and urinary retention | Serological study and CSF analysis, imaging studies | Prednisolone and plasma exchange | COVID-19 infection |
| 75          | Ahmad et al. [198]/2021 | Transverse myelitis | F/34 | Iraq | Progressive intermittent leg pain, paresthesia, and weakness on both sides | Serological study and CSF analysis, imaging studies | IV methylprednisolone (500 mg 1 × 1 for 5 days) | COVID-19 infection |
| 76          | Nejad Biglari et al. [199]/2021 | Transverse myelitis | F/11 | Iran | Acute paresis in the lower limbs, urinary and fecal retention | Serological study and CSF analysis, imaging studies | IVlg (0.4 g per kg body weight every day for 5 days) + pulse of methylprednisolone 30 mg/ Kg for 3 days | COVID-19 infection |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|-----------|----------------------|----------------|---------|-----------------------|-----------|-----------|---------------------------------------------------------------|
| 77          | Palahuta et al. [200]/2021 | Transverse myelitis | M/23 | Ukraine | Acute-onset non-compressive myelitis with bilateral paresthesia | Serological study and CSF analysis, imaging studies | IV methylprednisolone (1 g/day for 5 days) | Associated with COVID-19 infection |
| 78          | Lingas [201]/2022 | Transverse myelitis | M/70 | USA | Numbness on both lower limbs | Serological study and CSF analysis, imaging studies | IV methylprednisolone (high dose), IVIg, ceftriaxone, ampicillin, and acyclovir | Associated with COVID-19 infection |
| 79          | Prete [202]/2022 | Transverse myelitis | F/43 | USA | Progressive numbness and tingling in lower limbs and complete quadriplegia | Serological study and CSF analysis, imaging studies | Long-term steroid regimen and plasmapheresis | Associated with COVID-19 infection |
| 80          | Shahali [203]/2021 | Transverse myelitis | M/63 | Iran | Weakness and immobility in lower extremities, constipation, and urinary retention | Serological study and CSF analysis, imaging studies | IV methylprednisolone (1 g/day for 3 days) | Associated with COVID-19 infection |
| 81          | Hsiao et al. [204]/2021 | Transverse myelitis | M/41 | Taiwan | Progressive paresis below T4, lower-limb weakness | Serological study and CSF analysis, imaging studies | IV methylprednisolone (1000 mg/day for 5 days) | Associated with COVID-19 vaccination (Oxford/Astra-Zeneca) |
| 82          | Tan et al. [205]/2021 | Transverse myelitis | F/25 | Malaysia | Bilateral lower-limb weakness and impaired walking | Serological study and CSF analysis, imaging studies | IV methylprednisolone (1000 mg/day for 5 days) | Associated with COVID-19 vaccination (Oxford/Astra-Zeneca) |
| 83          | Notghi et al. [206]/2021 | Transverse myelitis | M/58 | UK | Progressive numbness in lower limbs, allodynia up to chest level, genital dysaesthesia, and an episode of urinary incontinence | Serological study and CSF analysis, imaging studies | IV methylprednisolone (1 g/day for 5 days) | Associated with COVID-19 vaccination (Oxford/Astra-Zeneca) |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|-----------|-----------------------|-----------------|---------|------------------------|-----------|-----------|---------------------------------------------------------------|
| 84          | Pagenkopf et al. [58]/2021 | Transverse myelitis | M/45 | Germany | Acute flaccid tetraparesis (especially in the lower limbs) and urinary retention | Serological study and CSF analysis, imaging studies | IV methylprednisolone (1 g/day for 5 days) | Associated with COVID-19 vaccination (Oxford/AstraZeneca) |
| 85          | Eom et al. [207]/2022 | Transverse myelitis | M/81 | Republic of Korea | Bilateral hand weakness and numbness | Serological study and CSF analysis, imaging studies | IV methylprednisolone (1 g/day for 5 days) | Associated with COVID-19 vaccination (Pfizer-BioNTech) |
| 86          | Eom et al. [207]/2022 | Transverse myelitis | F/23 | Republic of Korea | Bilateral paresthesia and weakness in the lower limbs | Serological study and CSF analysis, imaging studies | IV methylprednisolone (1 g/day for 5 days) | Associated with COVID-19 vaccination (Pfizer-BioNTech) |
| 87          | Miyake et al. [208]/2022 | Transverse myelitis | M/75 | Japan | Total sensory loss below the umbilicus and complete paraparesis in both lower limbs | Serological study and CSF analysis, imaging studies | IV methylprednisolone (1 g/day for 3 days), then oral prednisolone (initial dose of 1 mg/kg/day) | Associated with COVID-19 vaccination (Pfizer-BioNTech) |
| 88          | Maroufi et al. [209]/2022 | Transverse myelitis | F/31 | Iran | Progressive lower limbs paraparesis and paresis, urinary retention, and fecal incontinence | Serological study and CSF analysis, imaging studies | IV methylprednisolone (1 g/day for 7 days); Then, oral prednisolone 50 mg daily | Associated with COVID-19 vaccination (Oxford/AstraZeneca) |
| 89          | Tahir et al. [210]/2021 | Transverse myelitis | F/44 | USA | Numbness and weakness in the lower extremities, urinary retention, and back pain | Serological study and CSF analysis, imaging studies | IV methylprednisolone and plasma exchange | Associated with COVID-19 vaccination (Johnson and Johnson COVID-19 vaccine) |
| 90          | Hirose et al. [211]/2021 | Transverse myelitis | M/70 | Japan | Progressive sensorimotor dysfunction of both lower limbs | Serological study and CSF analysis, imaging studies | IV methylprednisolone (1000 mg/day for 5 days); then oral prednisolone (30 mg/day with gradual tapering) | Associated with COVID-19 vaccination (Moderna) |
| Case number | Reference         | Neurological disorder                          | Sex/Age (years) | Country     | Clinical manifestation                                                                 | Diagnosis                                                                 | Treatment                                                                 | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|-------------------|-----------------------------------------------|-----------------|-------------|---------------------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------------------------------------------------------------|---------------------------------------------------------------------|
| 91          | Rajae et al. [212]/2021 | Cerebrovascular events (ischemic stroke)       | M/68            | Morocco     | Left hemiparesis with dysarthria and left facial paralysis                             | Serological study and imaging studies (brain CT scan and MRI)            | Thrombolysis                                                            | Associated with COVID-19 infection                                   |
| 92          | Avvantaggiato et al. [213]/2021 | Cerebrovascular events (ischemic stroke)       | F/29            | Italy       | Left hemiplegia, left-sided central facial palsy, dysarthria, facial drop, and complete paralysis of the ipsilateral upper and lower limbs | Serological study and imaging studies (brain CT scan and MRI)            | –                                                                        | Associated with COVID-19 infection                                   |
| 93          | Bigliardi et al. [214]/2020   | Cerebrovascular events (ischemic stroke)       | M/62            | Italy       | Left hemiplegia, left hemianopsia, and forced right deviation of gaze                  | Serological study and imaging studies (brain CT scan and chest CT angiography) | anticoagulant (LMWH)                                                   | Associated with COVID-19 infection                                   |
| 94          | Zhai et al. [215]/2020       | Cerebrovascular events (ischemic stroke)       | M/79            | China       | Right limb weakness and non-fluent speech                                              | Serological study and imaging studies (brain CT scan)                    | Clopidogrel (75 mg) and atorvastatin (20 mg)                             | Associated with COVID-19 infection                                   |
| 95          | Farooque et al. [216]/2020   | Cerebrovascular events (ischemic stroke)       | M/70            | Pakistan    | Right-sided weakness and sensory loss in both upper and lower limbs                    | Serological study and imaging studies (brain CT scan and MRI)            | Aspirin. (150 mg twice a day), LMWH (0.6 ml twice a day), and IV dexamethasone (1cc twice a day) | Associated with COVID-19 infection                                   |
| 96          | Owolabi et al. [217]/2021    | Cerebrovascular events (hemorrhagic stroke)    | M/59            | Saudi Arabia | Right-sided incoordination, weakness, facial deviation, and altered level of consciousness | Serological study and imaging studies (brain CT scan)                    | Hydroxychloroquine, dexamethasone, remdesivir, and antibiotics           | Associated with COVID-19 infection                                   |
| 97          | Owolabi et al. [217]/2021    | Cerebrovascular events (hemorrhagic stroke)    | M/51            | Saudi Arabia | Left-sided limb and facial weakness                                                   | Serological study and imaging studies (brain CT scan)                    | Hydroxychloroquine, dexamethasone, and antibiotics                      | Associated with COVID-19 infection                                   |
| 98          | Fraiman et al. [218]/2020    | Cerebrovascular events (hemorrhagic stroke)    | F/38            | Brazil      | Acute alteration in the level of consciousness                                        | Serological study and imaging studies (brain CT scan and MRI)            | –                                                                        | Associated with COVID-19 infection                                   |
| Case number | Reference          | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation                                                                 | Diagnosis                                                                                              | Treatment                                      | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|--------------------|-----------------------|-----------------|---------|----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|-------------------------------------------------|---------------------------------------------------------------|
| 99          | Flores et al. [219]/2020 | Cerebrovascular events (hemorrhagic stroke) | M/40           | USA     | Pinpoint, minimally reactive pupils, withdrawal to painful stimuli in the right side of the body, left hemiparesis | Serological study and imaging studies (brain CT scan and MRI)                                         | –                                              | Associated with COVID-19 infection                           |
| 100         | Dakay et al. [220]/2021 | Cerebrovascular events (cerebral venous sinus thrombosis) | M/17           | USA     | Left-sided headaches and occasional emesis                                              | Serological study and imaging studies (MRI brain with MR venography)                                 | Anticoagulation                                 | Associated with COVID-19 infection                           |
| 101         | Dakay et al. [220]/2021 | Cerebrovascular events (cerebral venous sinus thrombosis) | F/72           | USA     | Dyspnea and generalized weakness                                                       | Serological study and imaging studies (CT angiogram)                                                | –                                              | Associated with COVID-19 infection                           |
| 102         | Dakay et al. [220]/2021 | Cerebrovascular events (cerebral venous sinus thrombosis) | M/26           | USA     | Acute left-sided hemiparesis followed by severe headache, nausea, and dizziness        | Serological study and imaging studies (MRI brain with MR venography, brain CT scan, cerebral angiography, and CT angiogram) | –                                              | Associated with COVID-19 infection                           |
| 103         | Anipindi et al. [221]/2021 | Cerebrovascular events (cerebral venous sinus thrombosis) | M/66           | USA     | Severe headaches, palpitations, dizziness, and diaphoresis                              | Serological study and imaging studies (MRI and CT brain along with CT venogram)                     | Rivaroxaban 20 mg (6 months)                      | Associated with COVID-19 infection                           |
| 104         | Tu et al. [222]/2020   | Cerebrovascular events (cerebral venous sinus thrombosis) | M/ mid-thirties | Singapore | Generalized non-remitting headache                                                     | Serological study and imaging studies (MRI and CT brain along with CT venogram and MR venogram)     | Dabigatran                                     | Associated with COVID-19 infection                           |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with |
|-------------|-----------|-----------------------|----------------|---------|-----------------------|-----------|-----------|----------------|
| 105         | Tu et al. [222]/2020 | Cerebrovascular events (cerebral venous sinus thrombosis) | M/the late thirties | Singapore | First-onset seizure (generalized tonic-clonic convulsion) | Serological study and imaging studies (CT brain along with CT venogram) | IV heparin, IV levetiracetam, and cobalamin replacement | COVID-19 infection |
| 106         | Blauenfeldt et al. [78]/2021 | Cerebrovascular events (ischemic stroke) | F/60 | Denmark | Strong, persistent abdominal pain, headache | Serological study and imaging studies (CT brain) | Hemicraniectomy + postoperative dalteparin 5000 IU daily | COVID-19 vaccination (Oxford/Astra-Zeneca) |
| 107         | Elaidouni et al. [223]/2022 | Cerebrovascular events (ischemic stroke) | M/36 | Morocco | Numbness in left hemibody, headaches (24 h after the vaccine injection), | Serological study and imaging studies (CT brain, MRI brain, MRI angiography of supraaortic trunks) | Aspirin and Enoxaparin (100 U/ kg/12 h) | COVID-19 vaccination (Sinopharm) |
| 108         | Kenda et al. [224]/2021 | Cerebrovascular events (ischemic stroke) | F/51 | Slovenia | Acute-onset global aphasia, right-sided hemiplegia, and hemianopsia | Serological study and imaging studies (CT/MRI brain and CT angiography) | Mechanical thrombectomy + high-dose IVlg (1 g/kg for 2 consecutive days) | COVID-19 vaccination (Oxford/Astra-Zeneca) |
| 109         | Al-Mayhani et al. [225]/2021 | Cerebrovascular events (ischemic stroke) | F/35 | UK | Right temporal and periorbital headache | Serological study and imaging studies (CT brain and CT angiography) | Urgent decompressive hemicraniectomy, IVlg, plasmapheresis, and fondaparinux | COVID-19 vaccination (Oxford/Astra-Zeneca) |
| 110         | Al-Mayhani et al. [225]/2021 | Cerebrovascular events (ischemic stroke) | F/37 | UK | Diffused headache, left visual field loss, confusion, and left arm weakness | Serological study and imaging studies (diffusion-weighted MRI and CT angiography) | IVlg, IV methylprednisolone, plasmapheresis, and fondaparinux | COVID-19 vaccination (Oxford/Astra-Zeneca) |
| 111         | de Mélo Silva et al. [226]/2021 | Cerebrovascular events (hemorrhagic stroke) | F/57 | Brazil | Acute-onset sweating and paleness, followed by left-sided hemiparesis, vomiting, and somnolence | Serological study and imaging studies (CT brain) | Hematoma drainage, external ventricular drain, and decompressive craniectomy | COVID-19 vaccination (Oxford/Astra-Zeneca) |
| Case number | Reference          | Neurological disorder                  | Sex/Age (years) | Country     | Clinical manifestation                                                                 | Diagnosis                                                                 | Treatment                                                                 | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|--------------------|----------------------------------------|----------------|-------------|----------------------------------------------------------------------------------------|---------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------------------------------------------|
| 112         | Takeyama et al.    | Cerebrovascular events (hemorrhagic stroke) | F/48           | Japan       | Gradually progressing left-sided hemiparesis                                             | Serological study and imaging studies (CT/MRI brain and CT angiography) | Right frontotemporal craniotomy                                          | Associated with COVID-19 vaccination (Pfizer-BioNTech)              |
| 113         | Dias et al.        | Cerebrovascular events (cerebral venous sinus thrombosis) | F/47           | Portugal    | The sudden left-sided motor deficit, papilledema, left visual extinction, right gaze deviation, and left hemiparesis | Serological study and imaging studies (MRI brain, MRI venography) | Acetazolamide and enoxaparin 60 mg twice a day (later changed to warfarin) | Associated with COVID-19 vaccination (Pfizer-BioNTech)              |
| 114         | Dias et al.        | Cerebrovascular events (cerebral venous sinus thrombosis) | F/67           | Portugal    | Sudden right-sided lower limb tonic movements, motor deficit, loss of consciousness, and headache | Serological study and imaging studies (MRI brain) and Electroencephalography | Levetiracetam (500 mg twice a day) and enoxaparin (80 mg twice a day); then switched to dabigatran (150 mg twice a day) | Associated with COVID-19 vaccination (Pfizer-BioNTech)              |
| 115         | Zakaria et al.     | Cerebrovascular events (cerebral venous sinus thrombosis) | M/49           | Malaysia    | A new-onset headache and giddiness                                                        | Serological study and imaging studies (CT brain and CT cerebral venogram) | Subcutaneous Clexane (1 mg/kg twice a day) and clopidogrel (75 mg)       | Associated with COVID-19 vaccination (Pfizer-BioNTech)              |
| 116         | D'Agostino et al.  | Cerebrovascular events (cerebral venous sinus thrombosis) | F/54           | Italy       | Left-sided signs                                                                         | Serological study and imaging studies (CT/MRI brain and CT/MRI angiography) | –                                                                        | Associated with COVID-19 vaccination (Oxford/AstraZeneca)          |
| 117         | Atta et al.        | Cerebrovascular events (cerebral venous sinus thrombosis) | F/48           | UK          | Right-sided headache,                                                                    | Serological study and imaging studies (CT cerebral venogram)             | Fondaparinux (7.5 mg), IVIg (1 g/kg) and dexamethasone (20 mg/day)       | Associated with COVID-19 vaccination (Oxford/AstraZeneca)          |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|-----------|----------------------|----------------|---------|-----------------------|-----------|-----------|-----------------------------------------------------------|
| 118         | Delorme et al. [232]/2020 | Encephalopathy | M/72 | France | Acute psychomotor agitation, cognitive and behavioral frontal lobe syndrome, upper limbs myoclonus, and cerebellar ataxia | CSF analysis, electroencephalogram (EEG), brain MRI, and brain FDG-PET/CT imaging | IVIg (2 g/kg) | Associated with COVID-19 infection |
| 119         | Delorme et al. [232]/2020 | Encephalopathy | F/66 | France | Acute cognitive impairment, psychomotor slowing, cognitive and behavioral frontal lobe syndrome, and severe apraxia | CSF analysis, EEG, brain MRI, and brain FDG-PET/CT imaging | IVIg; then, due to persisting severe cognitive impairment, IV pulse corticosteroids (2 mg/kg/day 3 days then 1 g/day 3 days) started | Associated with COVID-19 infection |
| 120         | Delorme et al. [232]/2020 | Encephalopathy | F/60 | France | Acute anxiety, depressed mood, akathisia, gait imbalance, psychomotor agitation, dysexecutive syndrome, and cerebellar ataxia | CSF analysis, EEG, brain MRI, and brain FDG-PET/CT imaging | Pulse corticosteroids (2 mg/kg/day 3 days) | Associated with COVID-19 infection |
| 122         | Delorme et al. [232]/2020 | Encephalopathy | M/69 | France | Generalized convulsive status epilepticus, fever, fatigue, anosmia, and ageusia | CSF analysis, EEG, brain MRI, and brain FDG-PET/CT imaging | Pulse corticosteroids (1 g/day 5 days) | Associated with COVID-19 infection |
| 123         | Lazraq et al. [233]/2021 | Encephalopathy | M/79 | Morocco | Mental confusion, sudden-onset dysarthria | The serological study, CSF analysis, EEG, brain CT, MRI, and MR angiography | Sodium valproate | Associated with COVID-19 infection |
| 124         | Goodloe et al. [234]/2021 | Encephalopathy | M/52 | USA | Altered mental status, fever, and severe agitation | The serological study, CSF analysis, EEG, brain CT, and MRI | Vancomycin, ceftriaxone, azithromycin, acyclovir, and clevidipine | Associated with COVID-19 infection |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with |
|-------------|-----------|----------------------|----------------|---------|-----------------------|-----------|-----------|----------------|
| 125         | Teimouri-Jervekani et al. [235]/2021 | Encephalopathy | M/53 | Iran | Severe headache and bizarre behavior | The serological study, brain CT and MRI | Hydroxychloroquine (200 mg twice a day for 5 days) | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
| 126         | Al-Mashdali et al. [236]/2021 | Encephalopathy | M/32 | Qatar | Acute confusion, disturbed memory, and auditory hallucination | The serological study, CSF analysis, EEG, and brain MRI | Methylprednisolone | Associated with COVID-19 vaccination (Moderna) |
| 127         | Liu et al. [237]/2021 | Encephalopathy | F/86 | USA | Acute confusion with visual hallucinations and left frontal headache | The serological study, CSF analysis, EEG, brain CT, and MRI | Lorazepam, fosphenytoin, and discharged with levetiracetam | Associated with COVID-19 vaccination (Moderna) |
| 128         | Liu et al. [237]/2021 | Encephalopathy | M/73 | USA | Cognitive deficits, hallucinations, and periods of unresponsiveness | The serological study, CSF analysis, EEG, brain CT, and MRI | Lorazepam and levetiracetam | Associated with COVID-19 vaccination (Moderna) |
| 129         | Baldelli et al. [108]/2021 | Encephalopathy | M/77 | Italy | Confusion, agitation, and delirium | The serological study, CSF analysis, EEG, brain CT, and MRI | Oral prednisone (50 mg per day) | Associated with COVID-19 vaccination (Oxford/AstraZeneca) |
| 130         | Bensaidane et al. [238]/2022 | Encephalopathy | M/56 | Canada | Altered mental status | The serological study, CSF analysis, EEG, brain CT angiography, and MRI | High-dose IV methylprednisolone (1 g/day for 7 days) | Associated with COVID-19 vaccination (Oxford/AstraZeneca) |
| 131         | Monti et al. [239]/2020 | New-onset seizures | M/50 | Italy | Acute onset of psychiatric symptoms (confabulations and delirious ideas), focal motor seizures, and impaired awareness | The serological study, CSF analysis, EEG, brain MRI, and total-body CT and PET | Diazepam, valproic acid, lacosamide, methylprednisolone, IVIg, plasma exchange | Associated with COVID-19 infection |
| 132         | Bhatta et al. [240]/2020 | New-onset seizures | M/11 | USA | Acute-onset seizure for 2 min | The serological study, EEG, and brain CT | Levetiracetam (500 mg twice a day) | Associated with COVID-19 infection |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|-----------|-----------------------|----------------|---------|------------------------|-----------|-----------|---------------------------------------------------------------|
| 133         | Park et al. [241]/2021 | New-onset seizures | F/45 | USA | Focal to bilateral tonic–clonic seizure, loss of consciousness, and urinary incontinence | The serological study, CSF analysis, EEG, brain MRI, and CT | Oxcarbazepine (600 mg twice a day); then lacosamide (200 mg twice a day) | Associated with COVID-19 infection |
| 134         | Dono et al. [242]/2021 | New-onset seizuresa | M/81 | Italy | Non-convulsive status epilepticus with coma | The serological study, CSF analysis, EEG, brain MRI, and CT | Lorazepam (4 mg two IV boluses), levetiracetam (2000 mg IV), methylprednisolone (1 g/daily IV for 5 days); then, oral prednisolone (60 mg/day for 10 days) and IVIg (160 g over 5 days) | Associated with COVID-19 infection |
| 135         | Cho et al. [243]/2022 | New-onset seizures | M/84 | Korea | Myoclonic seizures (Myoclonic status epilepticus) | The serological study, EEG, brain Diffusion-weighted MRI | Sedative medication: Midazolam Antiseizure medication: Lorazepam and Levetiracetam | Associated with COVID-19 infection |
| 136         | Cho et al. [243]/2022 | New-onset seizures | M/45 | Korea | Focal to bilateral tonic–clonic seizures (2 times) | Serological study and EEG | Sedative medication: Remifentanil and Dexmedetomidine Antiseizure medication: Lorazepam and Levetiracetam | Associated with COVID-19 infection |
| 137         | Cho et al. [243]/2022 | New-onset seizures | M/63 | Korea | Focal impaired aware seizures (several times) | Serological study and EEG | Sedative medication: Dexmedetomidine Antiseizure medication: Phenoobarbital, Levetiracetam, Topiramate, and Perampanel | Associated with COVID-19 infection |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with |
|-------------|-----------|----------------------|----------------|---------|-----------------------|-----------|-----------|----------------|
| 138         | Cho et al. [243]/2022 | New-onset seizures | M/72 | Korea | Myoclonic seizure, generalized tonic–clonic seizures (several times) | Serological study and EEG | Sedative medication: Remifentanil and Dexmedetomidine Antiseizure medication: Levetiracetam and Topiramate | SARS-CoV-2 infection vs post-COVID-19 vaccination |
| 139         | Cho et al. [243]/2022 | New-onset seizures | M/73 | Korea | Myoclonic seizures (several times) | Serological study and EEG | Sedative medication: Remifentanil and Propofol Antiseizure medication: Levetiracetam and Valproic acid | COVID-19 infection |
| 140         | Cho et al. [243]/2022 | New-onset seizures | F/39 | Korea | Generalized tonic–clonic seizures (3 times) | The serological study, EEG, brain CT | Sedative medication—Antiseizure medication: Levetiracetam | COVID-19 infection |
| 141         | Aladdin et al. [119]/2021 | New-onset seizures | F/42 | Saudi Arabia | Generalized tonic–clonic seizure | The serological study, CSF analysis, EEG, and brain MRI | Lorazepam, phenytoin, levetiracetam, and lamotrigine | COVID-19 vaccination (Oxford/AstraZeneca) |
| 142         | Bauman et al. [244] | New-onset seizures | M/56 | USA | New-onset refractory status epilepticus | The serological study, CSF analysis, EEG, and brain MRI | Corticosteroids, plasmapheresis, IV Ig, rituximab, midazolam, propofol, ketamine, levetiracetam, lamotrigine, phenobarbital, clonazepam, zonisamide, oxcarbazepine, and perampanel | COVID-19 vaccination (Pfizer-BioNTech) |
| 143         | Desai et al. [245]/2021 | Varicella-zoster virus reactivation | F/62 | India | Painful blisters and fluid-filled bubble-form rashes | Serological studies | Oral and topical Acyclovir | COVID-19 infection |
| Case number | Reference | Neurological disorder | Sex/Age (years) | Country | Clinical manifestation | Diagnosis | Treatment | Associated with SARS-CoV-2 infection vs post-COVID-19 vaccination |
|-------------|-----------|----------------------|----------------|---------|-----------------------|-----------|-----------|---------------------------------------------------------------|
| 144         | Saleh et al. [246]/2021 | Varicella-zoster virus reactivation | F/49 | Egypt | Unilateral fluid-filled vesicles and painful erythematous areas over the hard palate | Serological studies | Oral acyclovir, topical antiseptics, chlorhexidine, and paracetamol | Associated with COVID-19 infection |
| 145         | Saati et al. [122]/2020 | Varicella-zoster virus reactivation | M/57 | Saudi Arabia | Fluid-filled bubble-form rashes and vesicles with surrounding erythematous areas over the right nipple | Serological studies | Famiclovir | Associated with COVID-19 infection |
| 146         | Van Dam et al. [129]/2021 | Varicella-zoster virus reactivation | F/29 | The Netherlands | Painful multiple vesicles on the left side of the os coxae | Clinically diagnosed | – | Associated with COVID-19 vaccination (Pfizer-BioNTech) |
| 147         | Van Dam et al. [247]/2021 | Varicella-zoster virus reactivation | M/34 | The Netherlands | Swollen, painful inguinal lymph nodes and a rash on the right lower limb | Serological studies and PCR tests over vesical fluid for VZV | Valacyclovir | Associated with COVID-19 vaccination (Pfizer-BioNTech) |
| 148         | Rodríguez-Jiménez et al. [248]/2021 | Varicella-zoster virus reactivation | M/58 | Spain | Asymptomatic herpes-form umbilicated vesicles and lymphadenopathy in the cervical area | PCR | – | Associated with COVID-19 vaccination (Pfizer-BioNTech) |
| 149         | Rodríguez-Jiménez et al. [248]/2021 | Varicella-zoster virus reactivation | F/47 | Spain | Herpes-form umbilicated vesicles and dysesthesia | PCR | – | Associated with COVID-19 vaccination (Pfizer-BioNTech) |
| 150         | Rodríguez-Jiménez et al. [248]/2021 | Varicella-zoster virus reactivation | M/39 | Spain | Painful herpes-form umbilicated vesicles | – | – | Associated with COVID-19 vaccination (Pfizer-BioNTech) |
| 151         | Rodríguez-Jiménez et al. [248]/2021 | Varicella-zoster virus reactivation | F/56 | Spain | Herpes-form umbilicated vesicles | PCR | – | Associated with COVID-19 vaccination (Pfizer-BioNTech) |
Miscellaneous neurological adverse events

Apart from the aforementioned neurological side effects, some other AEs, including narcolepsy, small fiber neuropathy, neuroleptic malignant syndrome (NMS), and multiple sclerosis flare-ups, have been reported following COVID-19 vaccination, although their causal relationships are not confirmed [4, 136–139].

Relative risks of neurological adverse events in SARS-CoV-2 infection vs. post-COVID-19 vaccination

Many studies have reported various neurological disorders associated with COVID-19 infection and vaccines [80, 140–143]. However, given the shortage of comprehensive, prospective studies, it is still far too difficult to establish cause-effect relations between these factors. Therefore, future studies should determine the real risk of these adverse events following COVID-19 vaccination. Until then, it does not seem reasonable to limit vaccine administration. Nonetheless, considering the existing data, in this section, we have summarized some studies reporting cases of neurological adverse events associated with SARS-CoV-2 infection or vaccination (Table 2).

Conclusion

The present review can help healthcare workers and also the general population by emphasizing these points: any neurological symptom after COVID-19 vaccination can be potentially critical and needs to be cautiously evaluated; for any suspected adverse event following vaccination, we should initially exclude current or recent SARS-CoV-2 infection; and despite the current literature on serious complications imposed by COVID-19 vaccines, the benefits of vaccination outweigh the risks in ending the current pandemic since all of these complications can occur with the infection itself.

Acknowledgments

The authors would like to thank the clinical research development center of Imam Reza Hospital, Kermanshah University of Medical Sciences, for their kind support.

Authors' Contributions ZMA: Data collection and writing the manuscript. AS: Data collection and contributed substantial revisions to the manuscript’s content. AB: Data collection and writing the manuscript. AAK: Data collection and helped with manuscript writing. TTS: Contributed substantial revisions to the manuscript’s content. MATM: Data collection and helped with manuscript writing. ATP: Data collection and helped with manuscript writing. AM: Data collection and helped with manuscript writing. RH: Helped with manuscript writing and visualization. MB: Data collection, helped with manuscript writing, and contributed substantial revisions to the manuscript’s content. SE: Design of the research study and supervision.
Data Availability  The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declarations

Conflict of interest  Terence T. Sio reports that he provides strategic and scientific recommendations as a member of the Advisory Board and speaker for Novocure, Inc. and also as a member of the Advisory Board to Galera Therapeutics, which are not in any way associated with the content or disease site as presented in this manuscript. All other authors have no relevant financial interests to be declared.

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