INTRODUCTION

The increasing number of people getting vaccinated against SARS-CoV-2 worldwide has resulted in a wide range of postvaccination neurological complications being observed. In India, 80% of vaccinations for treating COVID-19 involve the Covishield (ChAdOx1-S/nCoV-19, Astra-Zeneca) vaccine, followed by the Covaxin (an inactivated SARS-CoV-2 antigen) vaccine. The government of India subsequently approved the Sputnik vaccine and the Johnson & Johnson vaccine, but they have been administered only sparsely. As at October 27, 2021, around 1.0 billion people had been vaccinated in India. There have been anecdotal case reports of COVID-19 vaccine complications in the form of Guillain-Barre syndrome (GBS), vaccine-induced prothrombotic immune thrombocytopenia (VIPIT), and cerebral venous thrombosis (CVT) around the world. A recent article reported a single series of seven cases of GBS in India (Covishield or Covaxin) during the study period and their temporal relationship with vaccination.

METHODS

This ambispective multicenter hospital-based cohort study covered the period from March to October 2021. The study included all cases suspected of having neurological complications following COVID-19 vaccination.

RESULTS

We report a spectrum of serious postvaccination neurological complications comprising primary central nervous system demyelination (4 cases), cerebral venous thrombosis (3 cases), Guillain-Barre syndrome (2 cases), vaccine-induced prothrombotic immune thrombocytopenia syndrome (2 cases), cranial nerve palsies (2 cases), primary cerebral hemorrhage (1 case), vestibular neuronitis (1 case), chronic inflammatory demyelinating polyneuropathy (1 case), generalized myasthenia (1 case), and seizures (1 case).

CONCLUSIONS

Although the benefits of vaccination far outweigh its risks, clinicians must be aware of possible serious adverse events associated with COVID-19 vaccinations.

KEYWORDS

coronavirus vaccine; neurologic disease; acute inflammatory demyelinating polyradiculoneuropathy; chronic inflammatory demyelinating polyradiculoneuropathy; cerebrovascular disorders.
METHODS

This ambispective multicenter hospital-based cohort study was performed from March to October 2021 in the departments of neurology at Apollo Hospitals (Bangalore), India. All patients who had presented to Apollo Hospitals, Bangalore with neurological adverse events following immunization with any of the available COVID-19 vaccines in India during the study period were recruited into the study.

A case comprised any patient with symptoms or signs suggestive of a neurological illness with the onset of symptoms at 1 to 30 days after immunization with any of the available COVID-19 vaccine in India and with no other possible etiology. Approximately 1.04 billion COVID-19 vaccine doses were administered in India during the study period.

The inclusion criteria for patients were as follows: 1) history suggestive of neurological illness following immunization with any of the available COVID-19 vaccines (Covishield, Covaxin, or Sputnik) in India during the study period that was attributable to the vaccine and 2) informed consent provided by the patient or their surrogates. The exclusion criteria for patients were as follows: 1) reverse-transcriptase polymerase chain reaction (RT-PCR) for SARS-CoV-2 positivity and chest computed tomography (CT) scan suggestive of COVID-19; 2) other plausible causes of the neurological illness other than COVID-19 immunization; and 3) no informed consent provided.

All subjects fulfilling the inclusion and exclusion criteria were recruited from the neurological services of Apollo Hospitals, Bangalore and evaluated as follows:

1) Clinical evaluation: detailed history-taking regarding the clinical symptoms including the age at onset, their relationship with vaccination, progression, duration, and other relevant details were recorded.
2) Laboratory evaluation: RT-PCR for SARS-CoV-2 positivity and chest CT to rule out COVID-19 were performed. COVID-19 antibody titer levels were assessed. Other relevant biochemical tests as a part of the etiological workup were performed.
3) Imaging studies: relevant imaging studies such as magnetic resonance imaging (MRI) were performed based on the suspected clinical condition and its relevance in helping to make a diagnosis.
4) Treatment history: the treatments that the patient received for the said neurological adverse events were documented during the course of the illness.
5) Data analysis: the collected data were entered into a pre-designed pro forma and incorporated into a Microsoft Excel spreadsheet for analysis.

Ethical clearance was received from the Institutional Ethics Committee (AHB-BMR-010/06-21). Informed consent was received from all of the participants.

RESULTS

The details of the index cases are described below; the remaining cases are presented in Table 1.

Cerebral venous thrombosis

Three patients had presented with CVT postvaccination. The index case is described here and the other two cases (cases 2 and 3) are presented in Table 1.

Case 1: A 60-year-old male was admitted with a 3-day history of two headache episodes associated with primary generalized seizures; which had never occurred previously. He had received Covishield (first dose) 4 weeks prior to the onset of symptoms. Brain MRI showed nonhemorrhagic infarcts. Magnetic resonance venography showed extensive thrombosis of the superior sagittal sinus (Fig. 1A-D). His Thrombocheck profile for other known causes of CVT was negative. He was treated with intravenous heparin with antiedema measures, which were subsequently overlapped with oral anticoagulants. He made a full recovery.

Guillain-Barre syndrome

Two patients had presented with acute inflammatory demyelinating polyneuropathy following vaccination. The index case is described here and the other case (case 5) is presented in Table 1.

Case 4: A 70-year-old male presented with progressive weakness and paresthesia of all four limbs that first appeared 15 days after the first dose of Covishield. RT-PCR for SARS-CoV-2 was negative at admission. He had areflexic quadripareisis with facial palsy associated with bilateral lower motor neurons, along with autonomic dysfunction. Nerve conduction studies (NCS) showed demyelinating sensorimotor neuropathy of all four limbs with albumin-cytological dissociation in cerebrospinal fluid (CSF) analysis. He was treated with intravenous immunoglobulin (IVIG) at a daily dose of 2 g/kg for 5 days. His serum vasculitis and paraneoplastic workup was negative. His condition improved, and at the last follow-up he was ambulant with support.

Chronic inflammatory demyelinating polyneuropathy

Case 6: A 30-year-old male presented with a history of progressive quadripareisis with facial weakness that he first noticed 15 days after the first dose of Covishield. He was treated elsewhere with IVIG at 2 g/kg, after which there was initial
| Case no. | Age (yr)/sex | Vaccine type/dose number | Time from vaccination to symptom onset | Symptoms | Signs | Investigations | Final diagnosis | Treatment | Clinical course and outcome | Follow-up |
|---------|--------------|--------------------------|----------------------------------------|----------|--------|---------------|----------------|-----------|-----------------------------|-----------|
| 1       | 60/M         | Covishield/first dose    | 28 days                                | Headache after 3 days GTCS (2 episodes) | Altered sensorium Left hemiparesis | Brain MRI: nonhemorrhagic infarcts in parasagittal, right peri-Rolandic cortex, and posterior aspect of left superior frontal sulcus (Fig. 1A-D) MRV: extensive thrombosis of superior sagittal sinus, torcula, right transverse-sigmoid sinus, and upper 1 cm of right IJV (Fig. 1A-D) Thrombocheck profile: negative | CVT | Anticoagulants Antiepileptics | Hospital stay for 8 days | Improved | Seizure-free No deficits |
| 2       | 30/M         | Covaxin/first dose       | 24 days                                | Headache after 3 days Loss of consciousness after 1 day | Neck stiffness No focal deficits | Brain MRI: edema MRV: acute thrombosis of right transverse sigmoid sinus and upper 4 cm of right IJV (Fig. 1E and G) Thrombocheck profile: negative | CVT | Anticoagulants Antiepileptics | Hospital stay for 5 days | Improved | Headache-free No deficits |
| 3       | 37/M         | Covishield/first dose    | 14 days                                | Headache after 3 days GTCS (2 episodes) | Neck stiffness No focal deficits | Brain MRI: nonhemorrhagic infarcts in left frontal lobe MRV: thrombosis of superior sagittal sinus, torcula, and left frontal cortical vein Thrombocheck profile: negative | CVT | Anticoagulants Antiepileptics | Hospital stay for 11 days | Improved | Seizure-free No deficits |
| 4       | 70/M         | Covishield/first dose    | 15 days                                | Progressive weakness of lower limbs followed by upper limbs after 3 days Paresthesias of all four limbs after 3 days | Quadripareis Generalized areflexia Bilateral LMN facial palsy Autonomic dysfunction | NCS: demyelinating sensorimotor neuropathy CSF: albumin-cytological dissociation Serum vasculitis and paraneoplastic workup: normal | GBS | IVIG at 2g/kg for 5 days | Hospital stay for 21 days | Improved | Walks with support |
| 5       | 54/F         | Covishield/first dose    | 20 days                                | Progressive weakness of lower limbs followed by upper limbs after 21 days Paresthesias of all four limbs after 21 days | Quadripareis Generalized areflexia Bilateral LMN facial palsy | NCS: axonal sensorimotor neuropathy CSF: albumin-cytological dissociation Spine MRI: normal | GBS | IVIG at 2g/kg for 5 days | Hospital stay for 8 days | Improved | Wheelchair-bound Walks with support |
### Table 1. Summary of cases of neurological complications following COVID-19 vaccination (continued)

| Case no. | Age (yr)/sex | Vaccine type/ dose number | Time from vaccination to symptom onset | Symptoms | Signs | Investigations | Final diagnosis | Treatment | Clinical course and outcome | Follow-up |
|----------|---------------|---------------------------|----------------------------------------|----------|-------|---------------|-----------------|-----------|----------------------------|-----------|
| 6        | 30/M          | Covishield/ first dose    | 15 days                                | Progressive quadriparesis after 5 days | Quadriparesis | MRI: enhancement of cauda equina, bilateral trigeminal nerves, and meatal segment of facial nerves (Fig. 2D-F) | CIDP     | IVIG at 1 g/kg for 3 months previously | Hospital stay for 8 days | Improved | Wheelchair-bound |
|          |               |                           |                                        | Facial weakness after 3 days | Generalized areflexia | NCS: sensorimotor demyelinating neuropathy with conduction block |           | Methyl prednisolone for 5 days at 1 g/day |                      |         |
|          |               |                           |                                        | Truncal ataxia | Right LMN facial palsy | MMEP: abnormal |                       |         |                                      |         |
|          |               |                           |                                        | Bilateral poor finger–nose coordination | Impaired posterior column sensation bilaterally | Left sural nerve biopsy: inflammatory demyelinating neuropathy |                       |         |                                      |         |
|          |               |                           |                                        | Bilateral mute plantar response | Impaired posterior column sensation bilaterally | CSF: albumin-cytological dissociation |                       |         |                                      |         |
|          |               |                           |                                        |  | | |                       |         |                                      |         |
| 7        | 20/F          | Covishield/ first dose    | 16 days                                | Fever with malaise after 10 days | Left hemiparesis | Brain MRI: tumefactive demyelination in right temporoparietal region (Fig. 2A-C) | CNS tumefactive demyelination | Methyl prednisolone at 1 g/day for 5 days followed by oral steroids | Hospital stay for 7 days | Improved | Ambulant |
|          |               |                           |                                        | Difficulty walking after 10 days | Left extensor plantar response | LP-CSF: normal (glucose, 63 mg/dL; protein, 65 mg/dL; cell count, 2 cells/mm$^3$) |                       |         |                                      |         |
|          |               |                           |                                        | Paresthesias of left upper and lower limb after 5 days | Gait imbalance | Serum NMO-MOG: negative |                       |         |                                      |         |
|          |               |                           |                                        |  | | |                       |         |                                      |         |
| 8        | 21/F          | Covishield/ first dose    | 21 days                                | Numbness after 2 days Weakness of right upper and right lower limbs after 2 days | Right-side hemiparesis | MRI: demyelinating lesion in left medulla and pons | CNS tumefactive demyelination | Methyl prednisolone at 1 g/day for 5 days followed by oral steroids | Hospital stay for 6 days | Improved | Ambulant |
|          |               |                           |                                        | Double vision after 2 days | Impaired posterior column sensation | LP-CSF: normal (glucose, 75 mg/dL; protein, 30 mg/dL; cell count, 2 cells/mm$^3$) |                       |         |                                      |         |
|          |               |                           |                                        |  | | |                       |         |                                      |         |
| 9        | 25/M          | Covishield/ first dose    | 15 days                                | Imbalance while walking after 3 days Slurring of speech after 3 days Intermittent double vision after 3 days | Nystagmus Cerebellar signs bilaterally Gait ataxia Positive Romberg sign | Brain MRI: normal in plain and contrast images | Acute cerebellitis | Methyl prednisolone at 1 g/day for 5 days followed by oral steroids | Hospital stay for 6 days | Improved | Ambulant |
|          |               |                           |                                        |  | | |                       |         |                                      |         |
| Case no. | Age (yr)/sex | Vaccine type/ dose number | Time from vaccination to symptom onset | Symptoms | Signs | Investigations | Final diagnosis | Treatment | Clinical course and outcome | Follow-up |
|----------|--------------|---------------------------|---------------------------------------|----------|-------|--------------|----------------|----------|-----------------------------|-----------|
| 10       | 31/M         | Covishield/ first dose    | 7 days                                | Imbalance while walking after 2 days | Cerebellar dysarthria, Nystagmus, Cerebellar signs bilaterally, Gait ataxia | Brain MRI: focal patchy discrete hyperintensities in bilateral cerebral hemispheres, dorsal brainstem, and cerebral peduncles, Spine MRI: hyperintensities in thoracic and lumbar regions, LP-CSF: pleocytosis with elevated protein (protein, 134 mg/dL; glucose, 63 mg/dL; cell count, 130 cells/mm³), CSF meningitis panel: negative, Serum vasculitis profile: negative, Serum NMO-MOG: negative, Serum ACE: normal, VEP: abnormal bilaterally | CNS demyelination | Methyl prednisolone at 1 g/day for 5 days followed by six cycles of LVPP, Followed by oral steroids | Hospital stay for 28 days | Improved |
| 11       | 79/M         | Covishield/ first dose    | 3 days                                | Fever after 2 days, Altered sensorium after 2 days | Altered sensorium, Right hemiparesis | Hemogram: severe thrombocytopenia, Initial brain MRI: normal, Hypofibrinogeneration, Elevated D-dimer, Bone marrow: normal, Repeat plain brain CT: multiple hemorrhages with bilateral SDH with intraventricular extension | VIPT syndrome | Platelet transfusion, Steroids, Mechanical ventilation, Inotropic support | Hospital stay for 15 days | Death |
| 12       | 19/F         | Covishield/ first dose    | 3 days                                | Headache after 5 days, Neck pain after 5 days, Vomiting after 3 days, Altered sensorium after 1 day | Altered sensorium, Aphasic, Right hemiparesis, Brisk lower limb reflexes, Right extensor plantar response | Brain MRI: large left parietal venous infarct, MRV: acute left transverse and sigmoid sinus thrombosis, CBC: severe thrombocytopenia, Anti-platelet-factor 4: weakly positive | VIPT syndrome | IVIG at 1 g/kg | Hospital stay for 13 days | Improved |
| 13       | 51/F         | Covishield/ second dose   | 2 days                                | Giddiness after 2 days, Imbalance while walking after 1 day, Vomiting after 1 day | Horizontal nystagmus, Impaired tandem walking | Brain MRI and MRA: normal, PTA: normal | Acute vestibular neuritis | Betahistine, Antiemetics | Hospital stay for 5 days | Symptom-free |

Table 1. Summary of cases of neurological complications following COVID-19 vaccination (continued)
Table 1. Summary of cases of neurological complications following COVID-19 vaccination (continued)

| Case no. | Age (yr)/ sex | Vaccine type/ dose number | Time from vaccination to symptom onset | Symptoms | Signs | Investigations | Final diagnosis | Treatment | Clinical course and outcome | Follow-up |
|----------|--------------|---------------------------|----------------------------------------|----------|-------|---------------|----------------|-----------|----------------------------|-----------|
| 14       | 72/F         | Covaxin/ second dose       | 7 days                                  | Giddiness after 2 days Headache after 1 day Vomiting after 1 day No known comorbidities | Left UMN facial palsy Neck stiffness Left spastic hemiparesis Normotensive | MRI: 2.5×1.6×0.5 cm³ intraparenchymal hematoma in right corona radiate and right caudate nucleus MRV and MRA: normal Hemogram: normal platelet count | Primary cerebral hemorrhage | Antiedema measures | Hospital stay for 3 days | Improved | Symptom-free Mild left hemiparesis |
| 15       | 55/M         | Covishield/ first dose     | 21 days                                 | Bilateral weakness of facial muscles after 1 day Difficulty speaking after 1 day | Bilateral LMN facial palsy | Brain MRI: enhancement of medial and labyrinthine segments of left seventh cranial nerve and left geniculate ganglion HbA1C: normal | Bilateral LMN facial palsy | Short course of oral steroids | OPD-based treatment | Improved | Mild bilateral facial palsy |
| 16       | 77/F         | Covaxin/ second dose       | 10 days                                 | Inability to move the right eye outward after 3 days | Right lateral rectus palsy | Brain MRI: normal HbA1C: normal | Right sixth cranial nerve palsy | Short course of oral steroids | OPD-based treatment | Improved | No deficits |
| 17       | 77/F         | Covishield/ second dose    | 3 days                                  | First episode of seizure (GTCS) | No neurological deficits | Brain MRI: incidental left CP-angle tumor EEG: normal | Late-onset seizures | Antiepileptics | OPD-based treatment | Improved | Seizure-free |
| 18       | 50/F         | Covishield/ first dose     | 7 days                                  | Drooping of both eyelids after 20 days Double vision after 20 days Difficulty chewing after 5 days Difficulty swallowing after 5 days | Bilateral ptosis Diplopia Dysarthria Fatiguability Diurnal fluctuation | Neostigmine test: positive RNS: decreased response HRCT: no evidence of thymoma Anti-acetylcholine-receptor antibody: positive | Myasthenia gravis | Steroids Pyridostigmine Mycophenolate mofetil | Hospital stay for 7 days | Improved | Symptom-free No deficits |

ACE, angiotensin-converting enzyme; AIDP, acute inflammatory demyelinating polyneuropathy; CBC, complete blood count; CIDP, chronic inflammatory demyelinating polyneuropathy; CP, cerebellopontine; CSF, cerebrospinal fluid; CT, computed tomography; CVT, cerebral venous thrombosis; EEG, electroencephalography; F, female; GBS, Guillain–Barre syndrome; GTCS, generalized tonic–clonic seizures; HRCT, high-resolution computed tomography; IJV, internal jugular vein; IVIG, intravenous immunoglobulin; LMN, lower motor neuron; LP, lumbar puncture; LVPP, large-volume plasmapheresis; M, male; MMEP, multimodal evoked potentials; MRA, magnetic resonance angiography; MRL, magnetic resonance imaging; MRV, magnetic resonance venography; NCS, nerve conduction studies; NMO-MOG, neuromyelitis optica, myelin oligodendrocyte glycoprotein; OCB, oligoclonal bands; OPD, outpatient department; PET, positron-emission tomography; PTA, pure tone audiometry; RNS, repetitive nerve stimulation; SDH, subdural hemorrhages; UMN, upper motor neuron; VEP, visual evoked potentials; VIPIT, vaccine-induced prothrombotic immune thrombocytopenia.
mild improvement, but the weakness worsened after 1 week and the patient became bedridden after 2 months. Chronic inflammatory demyelinating polyneuropathy (CIDP) was suspected due to the disease progression over 8–10 weeks despite receiving IVIG, and so the patient underwent MRI, which showed enhancement of the cauda equina, bilateral trigeminal nerves, and mental segment of facial nerves (Fig. 2D and E). NCS showed sensorimotor demyelinating neuropathy with conduction block. Multimodal evoked potentials were abnormal. A left sural nerve biopsy was suggestive of an inflammatory demyelinating neuropathy. He was treated with injected methyl prednisolone (500 mg for 5 days) followed by oral steroids, after which there was significant improvement, and at the last follow-up he was being monitored in outpatient services (Table 1).

Central nervous system demyelination
Four patients had presented with central nervous system (CNS) demyelination postvaccination. The index case is described here and the other three cases (cases 8, 9, and 10) are presented in Table 1.

Case 7: A 20-year-old female presented with a history of difficulty walking and paresthesia of left upper and lower limbs for 10 days. She had received Covishield 2 weeks previously. She had left-side hemiparesis with impaired posterior column sensation. Brain MRI was suggestive of a tumefactive demyelination in the right temporoparietal region (Fig. 2A-C). CSF was normal, and serum neuromyelitis optica and myelin oligodendrocyte glycoprotein antibodies were negative, as was the serum vasculitis profile. Visual evoked potentials were abnormal bilaterally. She was treated with pulse methyl prednisolone at 1 g daily for 5 days. She improved to become ambulant with minimal support.

VIPIT syndrome
Two patients had presented with VIPIT syndrome postvaccination. The index case is described here, and the other case (case 12) is presented in Table 1.

Case 11: A 79-year-old male presented with a history of fever and altered sensorium on day 3 after Covishield vaccination. He had thrombocytopenia. His RT-PCR for SARS-CoV-2 was negative. High-resolution computed tomography
(HRCT) of the chest was normal. His initial brain MRI was normal. He was treated with platelets and steroids, after which there was mild improvement, and he was discharged from the hospital. However, 48 hours later he returned with sudden altered sensorium. Plain brain CT images showed multiple intracranial hemorrhages infarcts with bilateral subdural hemorrhages with intraventricular extension. His condition steadily worsened despite all our efforts, and he required intubation. He succumbed to the illness 9 days after admission.

**Acute vestibular neuronitis**

**Case 13:** A 51-year-old female presented with the acute onset of giddiness at 3 days after the second dose of Covishield. She had horizontal nystagmus with impaired tandem walking. She was treated with high-dose betahistine along with antiemetics and fluid replacements. She improved over 4–5 days.

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**Fig. 2.** Spectrum of demyelination. A-C: A 20-year-old female with hemiparesis and sensory abnormalities (Case 7). T2-weighted image (A) shows a heterogeneous mass-like lesion involving the right thalamocapsular region with perilesional edema extending into the subcortical region. Note the relative lack of a mass effect. Diffusion-weighted image (B) shows patchy diffusion restriction at the periphery of the lesion. Post contrast T1-weighted image (C) shows irregular patchy peripheral enhancement of the lesion. A diagnosis of tumefactive demyelinating lesion was made. D-F: A 30-year-old male with lower limb weakness and facial dysesthesias (Case 6). Postcontrast T1-weighted images (D and E) show abnormal enhancement of the cauda equina (arrow in D). Postcontrast T1-weighted image of the brain (F) shows abnormal enhancement of the trigeminal nerves, more so on the right (arrow).
Primary intracranial hemorrhage
Case 14: A 72-year-old female presented with the sudden onset of giddiness with headache and multiple episodes of vomiting 5 days after the first dose of Covishield. She had left upper motor neuron facial palsy with neck stiffness and left spastic hemiparesis. Her brain MRI showed intraparenchymal hematoma. Her platelet count was normal. She was treated with antiedema measures and recovered within 5 days.

Cranial nerve palsies
Two patients had presented with cranial nerve palsies post-vaccination.
Case 15: A 55-year-old male presented with sudden-onset weakness of bilateral facial muscles along with difficulty in speaking at 3 weeks after the first dose of Covishield. Brain MRI showed enhancement of the left seventh cranial nerve. He improved significantly after being treated with a short course of oral steroids.
Case 16: A 77-year-old female presented with a history of impaired outward movement of right eye, which was first noticed 10 days after the second dose of Covaxin. She had isolated right sixth cranial nerve palsy. She improved significantly after being treated with a short course of oral steroids.

Seizures
Case 17: A 77-year-old female presented with her first seizure episode at 3 days after the second dose of Covishield. She had no other risk factors for these seizures, and there was no family history of seizures. She was treated with antiepileptic medications.

Myasthenia gravis
Case 18: A 50-year-old female presented with difficulty in chewing and swallowing along with double vision and drooping of both eyelids that she first noticed 7 days after the first dose of Covishield. A repetitive nerve stimulation study was suggestive of a decreased response, and the neostigmine test was positive. She was treated with a short course of steroids and oral pyridostigmine. She recovered completely and at the last follow-up she was being followed regularly (Table 1).

DISCUSSION
We have reported a diverse range of neurological complications following COVID-19 vaccination. COVID-19 vaccines operate via four major mechanisms based on DNAs, mRNAs, proteins, and inactivated virus. Covishield is a DNA-based vaccine and Covaxin uses an inactivated virus. Most of the identified complications occurred following Covishield, with an additional three cases occurring after Covaxin vaccination. Fourteen and 4 patients had complications after the first and second doses, respectively: 13 and 2 for the Covishield vaccine, respectively, and 1 and 2 for the Covaxin vaccine. Many of these patients developed complications at 3–4 weeks after the vaccination, with a definite temporal relationship. A few of them developed symptoms as early as 3 days post-vaccination. All had negative RT-PCR for SARS-CoV-2 and normal HRCT findings, since this was a prerequisite for inclusion. The score on the Naranjo adverse-reaction scale ranged between 6 and 8 for these complications, suggesting a possible-to-plausible association between vaccination and the neurological complication.

CVT was reported in three patients. There are several case reports of CVT following Covishield. A study from Germany found 45 cases of CVT cases following the first dose of the Covishield vaccine, with a female predominance. All three affected patients in the present study were male, and it is known that CVT is rare in males. The incidence of CVT is >10-fold higher in patients who receive a first Covishield vaccination compared with the highest CVT incidence rate estimated from empirical data. Antibodies against thrombocytes are identified in a large proportion of patients with vaccine-induced CVT patients, which could be a plausible mechanism and associated thrombotic state.

GBS was reported in two patients. One study identified the first case of GBS. Seven cases have recently been reported from Kerala, south India. A review study of 19 patients found that GBS developed mainly after the first dose of the vaccine. The Covishield vaccine was implicated in 14 patients, the Pfizer-BioNTech vaccine in 4 patients, and the Johnson & Johnson vaccine in 1 patient. The latency between vaccination and GBS onset ranged from 3 h to 39 days, with an equal male:female ratio. The postulated mechanisms are an immune-mediated inflammatory response or secondary to molecular mimicry.

This study identified a novel complication of CIDP in one patient for the first time. The patient underwent left sural nerve biopsy, which confirmed a demyelinating inflammatory neuropathy, and he responded to steroids. It has been proposed that a postvaccination neurological syndrome could result from the generation of host antibodies that cross-react with proteins present in peripheral myelin.

Four patients developed CNS demyelination following COVID-19 vaccination. Extensive workups for the other causes such as both primary and secondary demyelinating syndromes were negative. One of the patients had symptoms of an acute cerebellar syndrome. There are case reports of exacerbation of pre-existing primary demyelinating disorders such as multiple sclerosis and neuro-myelitis optica spectrum disorder following COVID-19 vaccination. A literature review revealed a
case report from India of myelitis following Covishield vaccination.\(^8\,9\) Two cases of transverse myelitis were reported following Covishield vaccination initially in 2020.\(^1\,10\) There is also the possibility of autoimmune responses triggered by reactions between anti-SARS-CoV-2 spike protein antibodies and tissue proteins, as well as interactions between spike proteins and angiotensin-converting enzyme-2 receptors.\(^12\)

VIPIT syndrome has been described when thrombotic events follow Covishield vaccination, and it is associated with thrombocytopenia.\(^1,13,14\) Our first patient developed multiple intracranial hematomas and succumbed to the illness. The second patient improved after being treated with IVIG. The main pathophysiological mechanism underlying VIPIT syndrome is immune-mediated antibodies directed against platelet factor 4 (PF4). Our second patient was weakly positive for anti-PF4 antibodies. Antibodies have been reported in 79% of these patients.\(^15\)

We identified one case of bilateral facial palsy. Although there have been several reported cases of facial palsy following COVID-19 vaccination,\(^16,17\) bilateral facial palsy has not been reported previously. Another patient had right sixth cranial nerve palsy following Covaxin vaccination. There is a case report of sixth cranial nerve palsy following Pfizer-BioNTech COVID-19 vaccination in a 59-year-old female.\(^18\) Although the pathophysiology underlying postimmunization ocular nerve palsies remains unknown, it is hypothesized to be related to immune-mediated damage resulting in demyelination or localized vasculitis. Facial nerve and abducens nerve palsies are the most frequent after routine immunization, followed by oculomotor and trochlear nerve palsies.\(^19\) Abducens nerve palsies have also been reported for measles-mumps-rubella, hepatitis B, and annual influenza vaccines, with the onset time ranging from 2 days to 3 weeks after vaccination.\(^19\)

Dizziness is a common side effect of COVID-19 vaccination. One of our patients developed severe vestibular neuritis (VN) requiring hospitalization and treatment with high-dose betahistine and bed rest. There is a case report of a 54-year-old male who developed VN within 3 days of COVID-19 vaccination, and also of a Korean case of VN after COVID-19 vaccination. The exact etiopathogenesis remains unknown.\(^19\)

Primary intracranial hemorrhage was reported in an elderly normotensive female. A study from Germany found four cases of primary intracerebral hemorrhages.\(^2\) The plausible explanatory mechanisms are secondary to arterial microthrombi with platelet dysfunction. Most intracerebral hemorrhages are associated with thrombocytopenia.\(^15\)

Seizure occurred in an elderly female with no known comorbidities. There are reports of worsening of pre-existing seizures following vaccination due to fever and other stressors. However, very few cases of the primary onset of seizures following vaccination have been reported. There is a single case report of focal onset seizure with transient episodic behavioral abnormalities following the first dose of COVID-19 vaccine.\(^20\) Seizure with or without fever is a known serious adverse event following the administration of many vaccines, which could be immune-mediated or secondary to underlying genetic or molecular abnormalities.\(^20\)

One patient in our series developed her first episode of myasthenia gravis following Covishield vaccination. She was positive for anti-acetylcholine-receptor antibody. There is a case report of myasthenic crisis following Moderna COVID-19 vaccination, which was attributed to the vaccine causing regulatory cells to become defective or inducing a mechanism similar to the cytokine storm.\(^21\)

In conclusion, as the number of people vaccinated against SARS-CoV-2 increases worldwide, many types of postvaccination neurological complications have been reported. There is no doubt that the benefits of vaccination far outweigh its risks. However, clinicians must be vigilant about the possibility of serious neurological adverse events following COVID-19 vaccination and its management. A worldwide collaboration is needed to fully document the complications of COVID-19 vaccinations.

**Availability of Data and Material**
The datasets generated or analyzed during the study are available from the corresponding author on reasonable request.

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**Conflicts of Interest**
The authors have no potential conflicts of interest to disclose.

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