CASE REPORT

Coronavirus disease 19 (COVID-19) and Cerebral venous sinus thrombosis (CVST): A case series and review of the literature

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Abstract
A large proportion of patients with coronavirus disease 19 (COVID-19) suffer from excessive coagulation activation and coagulopathy which predisposes them to a wide spectrum of thrombotic events including in situ pulmonary thrombosis, deep-vein thrombosis, and associated pulmonary embolism, as well as arterial thrombotic events. Cerebral venous sinus thrombosis (CVST) have also been reported but in a very small number of cases. This report aims to increase awareness about CVST as a potential neurological thromboembolic complication in patients with coronavirus disease. We report three COVID-19 patients presenting with CVTS. We also review all previously described cases and present an overview of their demographic, clinical, and diagnostic data. We describe three patients with concomitant coronavirus disease and CVST among 1000 hospitalized COVID-19 patients (2 males, 1 female, and mean age of 37 years). One patient was previously healthy, while the two others had a history of chronic anemia and ulcerative colitis, respectively. CVST symptoms including seizure in two patients and headache in one patient occurred day to weeks after the onset of COVID-19 symptoms. Three months of anticoagulant therapy was given for all three patients with favorable outcomes. No neurological sequelae and no recurrence occurred within 6 months after hospital discharge. Our search identified 33 cases of COVID-19 complicated by CVST. The mean age was 45.3 years, there was a slight male predominance (60%), and more than half of cases were diagnosed in previously healthy individuals. All cases of CVT were clinically symptomatic and were observed in patients with a different spectrum of coronavirus disease severity. Headache was the most common complaint, reported by just less than half of patients. There was a high mortality rate (30.3%). CVT is a very rare, but potentially life-threatening complication in patients with COVID-19. It’s mainly reported in relatively young individuals with no or little comorbid disease and can occur even in patients who do not display severe respiratory symptoms. Atypical
INTRODUCTION

The coronavirus disease 2019 (COVID-19) is a universal health emergency due to a beta coronavirus called severe acute respiratory syndrome-coronavirus 2 (SARS-CoV-2). It was initially viewed as primarily a respiratory disease but is now recognized as a complex multisystemic disorder with heterogeneous involvement including COVID-19-induced coagulopathy. This coagulopathy predisposes to a wide spectrum of thrombotic events such as in situ pulmonary thrombosis, deep-vein thrombosis, and associated pulmonary embolism, as well as arterial thrombotic events (stroke, myocardial infarction, and limb artery thrombosis). Cerebral venous sinus thrombosis (CVST) have also been reported but in a very small number of cases. CVST is a rare form of stroke (<1%), caused by occlusion of the dural venous sinuses and/or cerebral veins. In the current report, we present three cases with CVST as a potential complication for coronavirus disease 2019. We also review all previously described cases and present an overview of their demographic, clinical, and diagnostic data.

METHOD

2.1 A case series analysis

Within the period from March 2020 to July 2021, 1000 patients with SARS-CoV-2 infection were admitted to the COVID-19 medical care unit at our department. Of these, we identified 3 patients (Table 1) with concomitant CVST and SARS-CoV-2 infection, deriving an incidence of 3/1000 (0.003%) or 3 per 1000 SARS-CoV-2 cases.

2.2 Literature search strategy

Bibliographic databases including MEDLINE, google scholar, and Science Direct were searched from December 1, 2019, before the first case of SARS-CoV-2 infection was reported, to July 15, 2021. The following keywords were used: “COVID-19”, “SARS-CoV-2”, “novel coronavirus”, “Coronavirus”, “severe acute respiratory syndrome coronavirus 2”, “Cerebral venous thrombosis (CVT)”,

| TABLE 1 | Characteristics of Three COVID-19 patients presenting with cerebral venous sinus thrombosis |
|---------|---------------------------------------------------|
|         | Patient 1                                        | Patient 2                                   | Patient 3                                    |
| Age (years) | 45                                               | 48                                          | 22                                           |
| Sex      | Female                                           | Male                                        | Male                                         |
| comorbidities | none                                             | Pulmonary embolism                          | None                                         |
|          | Ulcerative colitis                               | Anemia, raised CRP, raised WBC              | Normal anti-dsDNA                           |
| Symptoms of covid-19 infection: | Dyspnea, cough and headache                       | fever, cough, and shortness of breath       | None                                         |
| COVID-19 severity | Moderate                                       | Mild                                        | Mild                                         |
| Symptoms of CVT  | Facial palsy                                    | Seizure                                     | Seizure                                     |
| Days from COVID-19 symptoms | 20 days                                        | 15 days                                     | Same day                                    |
| Location of CVT  | Superior sagittal sinus                          | Sigmoid and lateral sinuses                 | superior sagittal sinus and frontal cortical veins |
| Prothrombotic work-up | Anemia, Normal anti-dsDNA/antiphospholipid antibodies | Anemia, raised CRP, raised WBC              | Raised CRP                                 |
| Treatment | ACC                                              | ACC-AED                                     | ACC-AED                                     |
| Outcome (death, alive) | Discharged                                      | Discharged                                  | Discharged                                  |

Abbreviations: ACC, anticoagulation; AED, anti-epileptic drug; COVID-19, coronavirus disease 2019; CVT, cerebral venous thrombosis.
“Cerebral venous sinus thrombosis”, “Venous thrombotic events (VTE)”, and “Stroke in young”. Lists references of all included studies were also inspected to extract additional eligible studies. Only studies with case descriptions were included.

3 | RESULTS

3.1 | Case 1

A non-smoker healthy 45-year-old woman tested positive for SARS-CoV-2 was admitted to the ward with a 20-day history of cough, shortness of breath and persistent headache despite Step 2 analgesics. No clinical abnormalities were identified at her initial physical examination. Notable microcytic anemia with hemoglobin of 5.6 g/dL (determined to be due to iron deficiency) on admission was the only identified abnormality by laboratory tests. Chest CT-scan showed peripheral unilateral ground-glass opacities in the upper and lower right lobes with low CT-extent (less than 10% of parenchymal involvement). The patient received low molecular weight heparins (LMWH) for thromboprophylaxis (enoxaparin 40 mg daily). On the 2nd day of her admission, she developed facial nerve palsy. Cerebral CT angiography revealed a floating thrombus of the superior sagittal sinus. As the time of onset was unknown, acute reperfusion therapies with thrombolysis could not be expected to be any more effective. Thus, LMWH therapy at curative dose was started, then switched to oral anticoagulation with warfarin, which led to complete regression of facial palsy within 10 days. Biological tests revealed negative results for common acquired and inherited thrombophilic conditions. The patient was discharged home on warfarin for 3 months.

3.2 | Case 2

A non-smoker 48-year-old man presented with 5 days of cough, shortness of breath, and fever. He had a history of venous thromboembolism in 2010, and ulcerative colitis treated with long-term corticosteroid therapy. He was hospitalized in a ward for 10 days after being tested positive for SARS-CoV-2 via nasopharyngeal swab RT-PCR. Two weeks after discharge, he was readmitted because of a generalized seizure. Vital signs on admission included a blood pressure of 110/70 mmHg, pulse rate of 100 beats/minute, respiratory rate of 16 cycles/minute, SpO2 of 97% on room air, and body temperature of 37.5 degrees Celsius. The neurological examination was unremarkable. Laboratory tests showed elevated levels of CRP (113 mg/L), increased white cell count with 10% lymphocytes, normocytic normochromic anemia (hemoglobin of 8.6 g/dL), while levels of serum creatine kinase (CK) and lactate dehydrogenase (LDH) were normal. Chest CT angiogram showed focal ground-glass opacities in the right upper lobe affecting less than 10% of the lung parenchyma. Bilateral pulmonary embolism with signs of pulmonary arterial hypertension was also identified. A Cerebral CT angiogram revealed cerebral venous thrombosis of the lateral sinus. Next to anticonvulsive therapy, the patient was started on therapeutical anticoagulation with LMWH (enoxaparin) followed by oral anticoagulation (Warfarin). His neurologic status remained stable over his hospital course. He was discharged home on oral anticoagulation after 20 days. At a 5-month follow-up, the patient was entirely asymptomatic and had no seizure recurrence.

3.3 | Case 3

A non-smoker healthy 22-year-old man was admitted to the ward with a first generalized tonic–clonic seizure. On admission, physical and neurological examinations revealed nothing particular. Serum CRP level was increased at 84 mg/L, otherwise results of laboratory tests were within normal limits. Meningitis was excluded as cerebrospinal fluid analysis from lumbar puncture showed no abnormalities. Brain CT-scan and Magnetic resonance imaging (MRI) were performed and identified CVT of the superior sagittal sinus and the frontal cortical veins complicated by hemorrhage. Nasal swab polymerase chain reaction (PCR) was positive for COVID-19. The patient was started on intravenous adjusted-dose unfractionated heparin and transitioned to enoxaparin, then to oral anticoagulation (Warfarin). He remained clinically stable during hospitalization, and he was discharged home on warfarin on 15th hospital day. Screening tests for a thrombophilic state were within normal amounts. Brain MRI performed 1 month after hospital discharge showed complete resolution of the venous thrombosis.

3.4 | Review of the literature results

The information from the literature review is summarized in Table 2. A total of 24 descriptive studies and case reports involving 33 patients with CVT, and Coronavirus disease were pooled in our final analysis. The mean age was 45.3 years, one patient was 2-year-old, and patients under 40 make up nearly half of reported cases (n = 14; 42.42%). There was a slight male predominance (60%), and more than half of cases were diagnosed in previously healthy individuals (n = 17; 51%). CVT was observed in
| Study       | Country | Patients | Age  | Comorbidity | COVID-19 severity | Neurological symptoms | Day from COVID-19 symptoms | Location of CVT | Prothrombotic work-up | Treatment outcome |
|-------------|---------|----------|------|-------------|-------------------|----------------------|---------------------------|----------------|------------------------|-------------------|
| Cavalcanti  | US      | M 38     | Mild ASD | Mild     | Critical          | AM S                   | 10 | Distal superior sagittal sinus | Raised D-dimer   | EVT ACC | Death                  |
|             |         | F 41     |        | Mild        | AM Saphia         | GCS drop              | 7 | Distal straight sinus           | EVD ACC          | ACC | Death                  |
| Klein       | F 29    |          | Mild  | Post-ictal AMS Apathia Facial palsy Seizure |
|             |         |          |       | Facial palsy | AMS Aphasia        | GCS drop              | > 7 | Distal L transverse and sigmoid sinus | Raised CRP, D-dimer, LDH, anti-CL IgM, Low ferritin | ACC AED | Alive                  |
| Garaci      | Italy   | F 44     | Severe | AM S Aphasia Headache R hemiparesis | 14 | Vein of Galen, L internal cerebral vein, straight sinus | Raised CRP, D-dimer, LDH, anti-CL IgM, anti-dsDNA IgM | ACC | Death                  |
| Maleniacchi | M 81    | F 59     | Prostate CA | Critical | AM S GCS drop | R sigmoid sinus | Raised CRP, D-dimer, LDH, Normal fibrinogen | ACC | Discharged              |
| Hughes      | UK      | M 59     | Obesity HTN DM | Moderate | AM S Aphasia R hemiparesis R hypoponhisia | R transverse and sigmoid sinus | 4 | R transverse and sigmoid sinus | Raised fibrinogen, CRP, ESR | ACC | Alive                  |
| Dahl-Cruz   | Spain   | M 58     | Severe | AM S Aphasia Headache R hemiparesis | 7 | Vein of Galen, R internal cerebral vein, straight sinus | Raised CRP, D-dimer | ACC AED | Discharged              |
| Pollon      | France  | F 62     | Obesity | Moderate | AM S GCS drop Headache R hemiparesis | L transverse sinus | 15 | Vein of Galen, L internal cerebral vein, straight sinus, L transverse sinus | Raised D-dimer | ACC | Discharged              |
|            |         | F 54     | Breast CA | Moderate | AM S Headache | R sigmoid sinus | Raised CRP, D-dimer, Normal LDH | ACC | Discharged              |
| Hemusan     | Iran    | M 65     | Mild  | AM S GCS drop Seizure | Raised LDH Normal CRP, ESR | ACC AED | Discharged              |
| Li          | China   | M 32     | Severe | AM S Headache | Raised D-dimer, Normal fibrinogen | ACC | Discharged              |
| Tu          | SG      | M 30     | Mild  | AM S Headache | Raised CRP, D-dimer, anti-CL IgM and IgG | ACC | Discharged              |
|             |         | M 30     |        | Mild        | Seizure           | Raised CRP, D-dimer, Homoocysteine, LAC, low protein C activity | ACC AED | Discharged              |
| Rehan Asif  | UK      | M 18     | NO    | AM S Headache, photophobia | Normal CRP, D-dimer, anti-CL IgM, and IgG | ACC | Discharged              |
| Banzar       | Brussels | F 35    | Oral contraception | Moderate | AM S Headache, seizure | Left parietal cortical CVT | Raised Fribinogen and D-dimer | ACC | Discharged              |
| Felix Nwogu  | Boston  | F 68     | NO    | AM S Headache, photophobia | Normal CRP, D-dimer, anti-CL IgM, and IgG | ACC | Discharged              |
|             |         | F 79     |        | HTN        | Headaches         | Increased inflammatory markers | ACC | Discharged              |
|             |         | F 25     |        | Evans Syndrome, idiopathic thrombocytopenic purpura on astatrombopag, von- Willebrand Disease | Headaches | The right transverse sinus | ACC | Discharged              |
|             |         |          |       |            | Headaches, blurry vision, tingling of the right upper extremity | Superior sagittal sinus | 120 | | |
| Study | Country | Patients | Age | Gender | COVID-19 severity | Neurological symptoms | Location of CVT | Prothrombotic work-up | Treatment outcome |
|-------|---------|----------|-----|--------|------------------|----------------------|-------------------|----------------------|-------------------|
| Chougar | France | M | 32 | F | MO | Mild | Sudden left hemiparesis, AMS | Right internal cerebral veins and the vein of Galen | ACC | Death |
| Katarina Dakay | US | M | 17 | M | Obesity | Headache, blurry vision | The left transverse and sigmoid sinuses extending to the left internal jugular and jugular bulb | Elevated D-dimer | ACC | Discharged |
| Lai Chee Chow | Malaysia | F | 72 | F | Polycythemia vera | Severe AMS, right-sided body weakness | Straight sinus, vein of Galen, and bilateral internal cerebral veins | ACC & Aspirin & Prednisone | Discharged |
| Paul Redi | UK | M | 63 | M | Cancer | Left-sided weakness and inability to stand | Extensive venous sinus thrombosis with bilateral venous cortical infarcts and acute cortical hemorrhage | Elevated D-dimers | ACC | Discharged |
| Safwat Abouhashem | Egypt | M | 32 | F | Seizure | Left transverse sigmoid sinus thrombosis | The same time | ACC | Death |
| Ameeka Thompson | UK | M | 50 | M | ND | Severe AMS | Superior sagittal sinus, left transverse sinus and left sigmoid sinus | Normal fibrinogen, positive anti-cardiolipin antibodies | ACC | Discharged |
| Yohsuke Sugiyama | Japan | M | 56 | M | Headache and vomiting | Confluence of sinuses to left transverse sinus | Raised D-dimer | ACC & EVD | Discharged |
| Farida Essajee | South Africa | F | 2 | F | Tuberculosis meningitis | Left-sided weakness and lethargy | Before | Raised D-dimer and inflammatory markers | Discharged |
| Fabricio Roy-Gash | France | M | 63 | M | Polycythemia vera | Severe AMS, right-sided body weakness | Before | CVT and hemorrhage | Discharged |

Abbreviations: ACC, anticoagulation; AED, anti-epileptic drug; AMS, altered mental status; ASD, autism spectrum disorder; CA, cancer; COVID-19, coronavirus disease 2019; CVT, cerebral venous thrombosis; DM, diabetes mellitus; EVD, external ventricular drain; EVT, endovascular thrombectomy; F, female; GCS, Glasgow coma scale; LAC, lupus anticoagulant; M, male; US, United States; UK, United Kingdom.
patients with a different spectrum of Coronavirus Disease severity, ranging from mild \( (n = 41.66\%) \), to moderate \( (n = 20.8\%) \), and severe \( (n = 37.5\%) \). In most cases \( (n = 31, 93\%) \), clinical manifestations of CVT developed with or after (1 day–16 weeks) the emergence of respiratory or systemic symptoms of Coronavirus disease. However, in 2 cases, CVT occurred few days before. All cases of CVT were clinically symptomatic. Headache was the most common complaint, reported by just less than half of patients \( (n = 14, 42.4\%) \), and was the only symptom of CVT in 3 cases. Altered mental status and hemiparesis were identified in 30.3% \( (n = 10) \) and 24.2% \( (n = 8) \) of cases, respectively, while aphasia and epileptic seizures were present both in 21.2% \( (n = 7) \) of cases. The most frequently involved sinuses were the transverse sinus (39.3%), and the sigmoid sinus (27.2%), followed by the superior sagittal sinus and the straight sinus, both involved in 21% of cases, and in nearly one-third of all affected patients \( (n = 33\%) \), multiple venous sinuses were involved. The most commonly reported laboratory abnormalities were elevated serum CRP and D-dimer levels in 30.3% and 45.4% of cases, respectively.

Some risk factors for CVT have been identified in six among the 33 affected patients, including solid tumors,\(^3\) long-term oral contraception,\(^6\) polycythemia vera,\(^7\) concomitant tuberculosis meningitis in a 2-year-old child,\(^8\) Evans Syndrome, idiopathic thrombocytopenic purpura, and von-Willebrand Disease.\(^9\) Regarding therapeutic management, anticoagulant therapy was administered to the majority of patients \( (n = 27, 81.8\%) \), endovascular reperfusion therapy was performed in 2 patients only, while antiplatelet therapy was prescribed to the pediatric patient.\(^5\) Elsewhere, 6 patients received anticonvulsive medication, and one patient had external ventricular drainage inserted due to cerebral venous infarction with hemorrhagic transformation. Out of the 33 affected patients, 10 of them died. This gives a mortality rate of 30.3%.

4 | DISCUSSION

We report unusual presentations of COVID-19 disease with CVT in three young patients, all of whom survived with favorable neurologic outcomes. Our cases corroborate the current and growing body of literature describing COVID-19 disease as a coagulopathy that can involve both arterial and venous systems. Several laboratory tests have been consistent with hypercoagulable state in COVID-19 such as increased plasma levels of fibrinogen, D-Dimère and factor VIII as well as the presence of circulating antiphospholipid antibodies (aPL).\(^{10}\) Systemic inflammatory response syndrome was suggested as a major contributor to COVID-19-associated coagulopathy, but virus-induced angiitis might also be involved.\(^{11,12}\) In our cases, 2 prothrombotic risk factors were present including anemia in case 1, and ulcerative colitis in case 2; however, COVID-19 have probably contributed as a precipitating factor.

Clinical manifestations of the COVID-19-related coagulopathy include deep-vein thrombosis, pulmonary embolism, catheter-associated thrombosis, myocardial infarction, limb ischemia, while cerebrovascular thrombosis is uncommonly reported. In our cases, CVT occurred with no other clinical signs of systemic coagulopathy. The incidence of CVT in COVID-19 patients remains unknown and varied widely across studies (Table 2): 0.001% among all patients diagnosed with COVID-19 in Singapore,\(^{13}\) 0.02% to 1% in multicenter cohorts of hospitalized patients with COVID-19,\(^{14}\) and 0.06% among hospitalized patients with SARS-CoV-2 infection referred for neurological assessment.\(^{15}\) In a systemic review by Baldini and al.,\(^{16}\) the estimated frequency of CVT among patients hospitalized for SARS-CoV-2 infection was 0.08% and CVT accounted for 4.2% of all cerebrovascular disorders in individuals with COVID-19. In another systemic review, the incidence of CVT in COVID-19 patients was estimated to be approximately 3 times higher than previously published population incidence (4.5 per 100,000 vs. 1.6 per 100,000). These results underline the relatively high incidence of CVT in SARS-CoV-2 patients when compared with an expected rate of only 5 to 20 per million per year in the general population. Many reports indicate that elderly patients with COVID-19 are more likely to progress to severe disease and have worse outcomes compared with young and middle-aged. Surprising, COVID-19-related CVT are mainly reported in relatively young individuals with no or little comorbid disease. In our literature review, the mean age of patients was 45.3 years.

CVT can be the initial clinical manifestation of the infection, but the majority of CVTs develop within a median of 7 days after onset of COVID-19 symptoms, with a wide range of a few days up to several weeks,\(^{16}\) as was the case in our patients. This suggests that patients who have recovered from SARS-CoV-2 might continue to have a hypercoagulable state and be at increased risk for venous and arterial thrombosis for a long period after recovery.\(^{17}\)

Neurological symptoms of COVID-19 related CVT are quite common, including mainly headache in 5.6% to 70.3% and encephalopathy in 7.5% to 84.3%. Seizure may also be a common presenting symptom, even in those without prior history of epilepsy.\(^{18}\) These non-specific neurological symptoms may obscure the early presenting findings of CVST, particularly in critical illness where toxic-metabolic derangement is common which makes the diagnosis of CVST in COVID-19 patients particularly challenging.\(^{19}\) As a result, we suggest that any neurologic symptom in patients with COVID-19 such as headache,
mental status deterioration, or seizure, should lead us to suspect CVT even in the absence of focal neurological deficits. Women with COVID-19 seem to be at higher risk for CVST, as this is the case in non-COVID-19 patient populations and tend to seek care sooner than men. However, as women are known to have a higher frequency and intensity of COVID-19-related headaches, and suffer more often from migraines than men, they are more likely to be misdiagnosed when they are having a COVID-19-related CVT.

Our literature review showed that CVT in COVID-19 patients is associated with a higher mortality rate as compared with CVT in non-COVID-19 patients (30% vs 15%, respectively). It remains unclear whether this increased mortality in patients with COVID-19 and CVT is related to the neurological involvement or the severity of COVID-19 disease, as reports considered in this review of the literature did not provide enough details about the underlying causes of death. However, CVT seems more likely to be involved as most deaths occurred in patients with mild respiratory symptoms.

Anticoagulation with unfractionated heparin (UFH) or (LMWH) combined with aggressive hydration is the main stay for the treatment of patients with acute CVT, while endovascular thrombolysis and mechanical thrombectomy are reserved for very selected cases. Early initiation of anticoagulation in COVID-19 patients with suspected CVT or predisposed to developing CVT is thought to be helpful to decrease further propagation of clot and pulmonary embolism and reduce the mortality rate. Although, there is still a general lack of scientific evidence of the effectiveness of anticoagulation in COVID-19 patients, as hemorrhagic complications have also been reported, including acute hemorrhagic necrotizing encephalopathy and increased rates of intracerebral hemorrhage in patients on therapeutic anticoagulation for systemic VTE. In addition, there is no yet universal consensus regarding the timing, dosage, choice, and duration of anticoagulation in patients with COVID-19 and CVT. Our patients had received initial therapy with LMWH and then switched to oral anticoagulation with warfarin for a total duration of 3 months. All of them survived with favorable neurologic outcomes.

**CONCLUSION**

CVT is a very rare, but potentially life-threatening complication in patients with COVID-19. It’s mainly reported in relatively young individuals with no or little comorbid disease and can occur even in patients who do not display severe respiratory symptoms. Atypical clinical presentations may pose a challenge to the early diagnosis and treatment. Thus, high suspicion is necessary and CVT should be kept in as a differential diagnosis when patients with COVID-19 present with headache, encephalopathy, seizure, or focal neurologic deficit. Early diagnosis and prompt treatment with anticoagulation in all patients with COVID-19 and CVT could contain the mortality rate and improve neurological outcomes in these patients.

**AUTHOR CONTRIBUTIONS**

This work was carried out in collaboration among all authors. Authors Kallel Nesrin, Saidani Amal, and Maddeh Sabrine have made substantial contributions to acquisition and interpretation of data. Kotti Amina, Gargouri Rahma, and Moussa Nadia have been involved in drafting the manuscript. Msaad Sameh and Feki Walid had given final approval of the version to be published. All authors read and approved the final manuscript. All authors had contributed to the reduction of this article.

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**CONFLICT OF INTEREST**

The authors do not have any conflict of interest.

**ETHICAL APPROVAL**

Ethical approval has been collected and preserved by the authors.

**CONSENT**

Written informed consent was obtained from the patient to publish this report in accordance with the journal’s patient consent policy.

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**REFERENCES**

1. Tu TM, Goh C, Tan YK, et al. Cerebral venous thrombosis in patients with COVID-19 infection: a case series and systematic review. J Stroke Cerebrovasc Dis. 2020;29(12):105379.
2. Hughes C, Nichols T, Pike M, Subbe C, Elghenzai S. Cerebral venous sinus thrombosis as a presentation of COVID-19. Eur J Case Rep Intern Med. 2020;7. doi:10.12890/2020_001691
3. Dakay K, Cooper J, Bloomfield J, et al. Cerebral venous sinus thrombosis in COVID-19 infection: a case series and review of the literature. J Stroke Cerebrovasc Dis. 2021;30(1):105434.
4. Poillon G, Obadia M, Perrin M, et al. Cerebral venous thrombosis associated with COVID-19 infection: Causality or coincidence? J Neuroradiol. 2020;48:121-124.
5. Malentacchi M, Gned D, Angelino V, et al. Concomitant brain arterial and venous thrombosis in a COVID-19 patient. Eur J Neurol. 2020;27:e38-e39.
6. Baudar C, Duprez T, Kassab A, Miller N, Rutgers MP. COVID-19 as triggering co-factor for cortical cerebral venous thrombosis? *J Neurolondial*. 2021;48(1):65-67.

7. Chow LC, Chew LP, Leong TS, Mohamad Tazuddin EE, Chua HH. Thrombosis and bleeding as presentation of COVID-19 infection with polycythemia vera. A case report. SN Comprehensive. *Clin Med*. 2020;2(11):2406-2410.

8. Essajee F, Solomons R, Goussard P, Van Toorn R. Child with tuberculous meningitis and COVID-19 coinfection complicated by extensive cerebral sinus venous thrombosis. *BMJ Case Rep*. 2020;13(9):e238597. doi:10.1136/bcr-2020-238597

9. Nwajei F, Anand P, Abdalkader M, et al. Cerebral venous sinus thromboses in patients with SARS-CoV-2 infection: three cases and a review of the literature. *J Stroke Cerebrovasc Dis*. 2020;29(12):105412.

10. Panigada M, Bottino N, Tagliabue P, et al. Hypercoagulability of COVID19 patients in intensive care unit. A report of thromboelastography findings and other parameters of hemostasis. *J Thromb Haemost*. 2020;18(7):1738-1742. doi:10.1111/jth.14850

11. Fifi JT, Mocco J. COVID-19 related stroke in young individuals. *Lancet Neurol*. 2020;19:713-715.

12. Varga Z, Flammer AJ, Steiger P, et al. Endothelial cell infection and endotheliitis in COVID-19. *Lancet*. 2020;395:1417-1418.

13. Koh JS, De Silva DA, Quek AML, et al. Neurology of COVID-19 in Singapore. *J Neurol Sci*. 2020;2020:418.

14. Siegler JE, Cardona P, Arenillas JF, et al. Cerebrovascular events and outcomes in hospitalized patients with COVID-19: the SVIN COVID-19 multinational registry. *Int J Stroke*. 2021;16(4):437-447.

15. Rifino N, Censori B, Agazzi E, et al. Neurologic manifestations in 1760 COVID-19 patients admitted to Papa Giovanni XXIII Hospital, Bergamo, Italy. *J Neurol Sci*. 2020;268:2331-2338.

16. Baldini T, Asioli GM, Romoli M, et al. Cerebral venous thrombosis and severe acute respiratory syndrome coronavirus-2 infection: A systematic review and meta-analysis. *Eur J Neurol*. 2021;28:3478-3490.

17. Carfi ABR, Landi F, Gemelli Against C-P. Persistent symptoms in patients after acute COVID-19. *JAMA*. 2020;6(324):603-605.

18. Anand P, Al-Faraj A, Sader E, et al. Seizure as the presenting symptom of COVID-19: a retrospective case series. *Epilepsy Behav*. 2020;112:107335.

19. Helms J, Kremer S, Merdji H, et al. Delirium and encephalopathy in severe COVID-19: a cohort analysis of ICU patients. *Crit Care*. 2020;24:491.

20. Coutinho JM, Zuurbier S, Gaertman AE, et al. Association between anemia and cerebral venous thrombosis: case-control study. *Stroke*. 2015;46:2735-2740.

21. Medicherla CB, Pauley RA, de Havenon A, Yaghi S, Ishida K, Torres JL. Cerebral venous sinus thrombosis in the COVID-19 pandemic. *J Neuroophthalmol*. 2020;40(4):457-462.

22. Ferro JM, Canhao P. Cerebral venous sinus thrombosis: update on diagnosis and management. *Current Cardiol Rep*. 2014;16(9):523.

23. Yeo LL, Lye PP, Yee KW, et al. Deep Cerebral Venous Thrombosis Treatment: endovascular Case using Aspiration and Review of the Various Treatment Modalities. *Clin Neurolondial*. 2020;30(4):661-670.