Anesthetic Management for Endovascular Treatment of Stroke in Patients With Coronavirus Disease 2019: A Case Series

Richa Sharma, MBBS, Peter D. Yim, MD, and Paul S. García, MD, PhD

A significant number of patients with coronavirus disease 2019 develop strokes with large vessel obstructions that may require endovascular treatment for revascularization. Our series focuses on periprocedural issues and the anesthetic management of these patients. We analyzed medical records of 5 patients with positive reverse transcription polymerase chain reaction tests for severe acute respiratory syndrome coronavirus 2 during their hospitalization who underwent endovascular treatment at our hospital between March and mid-June 2020. We found that our patients were different from the typical patients with ischemic stroke in that they had signs of hypercoagulability, hypoxia, and a lack of hypertension at presentation. (A&A Practice. 2021;15:e01458.)

GLOSSARY

ACE-2 = angiotensin-converting enzyme 2; BiPAP = bilevel positive airway pressure; CABG = coronary artery bypass graft; CAD = coronary artery disease; COVID-19 = coronavirus disease 2019; M1, M2 = horizontal and Sylvian segment of middle cerebral artery; MAC = minimum alveolar concentration; MODS = multiple organ dysfunction syndrome; OSA = obstructive sleep apnea; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2; SpO2 = pulse oxygen saturation; TICI = thrombolysis in cerebral infarction; tPA = tissue-type plasminogen activator; WBC = white blood cells

In this retrospective case series, we outline the underlying medical conditions, perioperative course, complications, and outcomes in 5 patients with coronavirus disease 2019 (COVID-19) with large vessel obstruction strokes. Our study was approved by the Columbia University Institutional Review Board, and written informed consent was obtained from all subjects or their legal surrogates. This article adheres to the applicable guidelines for case reports.

The Society for Neuroscience in Anesthesiology and Critical Care recognizes that the threshold for the use of general anesthesia for endovascular treatment may be reduced during the COVID-19 pandemic. They describe suitable candidates for monitored anesthesia care during the COVID-19 pandemic as those who (a) have an anterior circulation or nondominant hemispheric stroke and a National Institutes of Health Stroke Scale <15, Glasgow Coma Scale >9, (b) do not have hypoxemia requiring high-flow oxygen, and (c) are not actively coughing or vomiting, and are able to protect their airways. Patients with COVID-19 have multiple physiologic derangements that may worsen with disease progression. Severe coughing, high oxygen requirements, or altered mental status may or may not be apparent when a patient presents with stroke. Other factors possibly associated with COVID-19 infection, including clot fragmentation and migration, can complicate the procedure, causing acute changes in mental status or hemodynamic lability.

CASE DESCRIPTIONS

We included patients who had interventions for ischemic stroke in the neuroradiology suite between March 1 and June 14, 2020, and who tested positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). All patients underwent general anesthesia for angiography and mechanical thrombectomy. Clinical data and the anesthetic management of the 5 patients who consented are outlined in a tabular format (Tables 1, 2).

Ischemic stroke is frequently accompanied by hypertension, but all 5 of our patients presented with systolic blood pressure <140 mm Hg and required vasopressor support during general anesthesia. Hypoxia is common in patients with COVID-19. All our patients had a history of recent pulmonary symptoms, and 2 presented with oxygen saturation <92%. Two patients had concurrent major arterial thrombotic events (myocardial infarction and pulmonary embolism). Clot fragmentation during mechanical thrombectomy was common, and available pathology described the clots as friable. Two patients had a hemorrhagic conversion.

Although interventions for many strokes in our hospital are frequently performed with monitored anesthesia care, general anesthesia was selected in all 5 of these patients.
Several factors contributed to this decision: the inability of the patient to cooperate, tenuous respiratory status, hemodynamic lability, or expectation of a long procedural time. The patients were maintained with sevoflurane with inspired oxygen concentration titrated to a pulse oximetry goal of 100%. All patients showed at least some need for

| Patient | 1 | 2 | 3 | 4 | 5 |
|---------|---|---|---|---|---|
| Age/sex | 58/male | 64/male | 57/male | 37/female | 71/female |
| Diabetes | No | No | No | Yes | Yes |
| Body mass index | 25 | 43 | 40 | 46 | 39 |
| Hypertension | No | No | Yes | Yes | Yes |
| Comorbidities | Chronic obstructive pulmonary disease and lung cancer, status post partial lobectomy; CAD, status post-CABG; thymoma with pericardial involvement, status post-thoracotomy | Recent prostate cancer diagnosis, status post radiation | Hyperlipidemia, CAD status post percutaneous intervention with bare metal stent 11 y ago | Empty sella turcica syndrome, chronic headaches, recent pregnancy status post dilation and curettage 2 mo ago | OSA on home BiPAP Restricted lung disease, hyperlipidemia, previous mitral valve repair, hypothyroidism. New dilated nonischemic cardiomyopathy severe left atrial enlargement |
| Other manifestations of hypercoagulability | No | Pulmonary embolism | Brachial artery occlusion, ST-elevation myocardial infarction | No | No |
| Acute respiratory distress syndrome | Yes | Yes | Yes | No | No |
| Agitation, lack of cooperation or aphasia | Unknown | Yes | Yes | Yes | Yes |
| Symptoms of COVID-19 | Yes | Yes | Yes | Yes | Yes |
| Days between first symptoms of COVID-19 and stroke symptoms | 11 | 2 | 6 d between experiencing unstable angina which was the first manifestation of COVID-19 and stroke | 14 d between first starting empiric treatment for presumed bronchitis and stroke | 7 |
| Initial blood pressure | 120/80 mm Hg (sedated, no pressor) | 120/70 mm Hg | 118/81 mm Hg | 133/90 mm Hg | 130/76 mm Hg |
| Initial oxygen saturation | Unknown | 98% | 96% (intubated) | 90% | 83% |
| WBC count (10^9/L) | 20.5 | 11.6 | 11.2 | 359 | 6.9 |
| Platelet count (10^9/L) | 437 | 273 | 140 | 8.68 | 242 |
| C-reactive protein (normal ≤0.00–10.00 mg/L) | 79.89 | 282.35 | 250.65 (6 d after stroke) | >20 | 5.62 |
| D-dimer (normal ≤0.80 μg/mL) | >20 | >20 | 9.93 (13 d after stroke) | >20 (after tissue plasminogen activator) |
| Procalcitonin (ng/mL) | 0.26 | 0.78 | 3.21 (13 d after stroke) | 0.04 | 0.12 |
| Fibrinogen (mg/dL) | 497 | Not applicable | 549 (16 d after stroke) | <60 | 32.2 |
| Interleukin-6 (normal ≤5.0 pg/mL) | Not applicable | 65.2 | 18 (6 d after stroke) | 8.9 | 1.49 |
| Creatinine (peak) (mg/dL) | 1.29 | 1.08 | 1.55 | 0.45 | Not performed |
| Time to thrombectomy | 120 min | 265 min | 183 min | 263 min | 9 |
| Prestroke NIH stroke scale score | 27 | 29 | 23 | 95 min | 125 min |
| Thrombus location | Left middle cerebral artery, left internal carotid artery (proximal) | Left internal carotid artery/ left middle cerebral artery | Right vertebral 4, proximal left vertebral 4 and proximal/mid basilar components | Distal right internal carotid artery clot, right M1 cutoff with reconstitution of vessels distally | Short segment occlusion of the perisylvian M2 |
| Time to tissue plasminogen activator | 48 min | 85 min | 92 min | 95 min | 125 min |
| Clot pathology | Multiple, irregular soft, tan-brown to dark red subcentimetric <2 cm pieces | Path not available | Multiple, irregular soft, tan-brown to dark red subcentimetric <2 cm pieces | 5 irregular pieces of soft, tan-brown to dark red tissue measuring from 0.4 × 0.4 × 0.1 cm to 0.9 × 0.8 × 0.2 cm | No clot retrieved |

Abbreviations: BiPAP, bilevel positive airway pressure; CABG, coronary artery bypass graft; CAD, coronary artery disease; COVID-19, coronavirus disease 2019; M1, M2, horizontal and Sylvian segment of middle cerebral artery; OSA, obstructive sleep apnea; WBC, white blood cells.
### Table 2. Summaries of Anesthetic Management

| Patient | Anesthetic General anesthesia | Site of intubation Outside hospital | Team performing intubation Anesthesiology | Rapid sequence intubation Yes | Airborne precautions Unknown | Induction drugs given at the time of intubation Arrived on fentanyl and propofol drips | Neurointervention 3 attempts using stent-retriever with simultaneous thrombolysis | TICI grade revascularization 2A | Hemorrhagic conversion of infarct ~12 h from endovascular treatment | Postoperative course Increasing need for vasopressor and inotropic support; increasing leukocyte counts | Neurointervention 3 attempts were performed for clot retrieval. Each attempt resulted in distal clot fragmentation and eventual downstream migration into the cortical segment of middle cerebral artery | Outcome Comfort care | Abbreviations: COVID-19, coronavirus disease 2019; MAC, minimum alveolar concentration; MODS, multiple organ dysfunction syndrome; SpO₂, pulse oxygen saturation; TICI, thrombolysis in cerebral infarction. |
|---------|-------------------------------|-----------------------------------|--------------------------------------|----------------------------|----------------------------|---------------------------------|-------------------------------------------------|----------------|----------------|-----------------|-------------------------------------------------|----------------|-----------------|
| 1       | General anesthesia            | Outside hospital                  | Unknown team                         | Unknown                   | Unknown                   | Arrived on fentanyl and propofol drips | Resulted in distal clot fragmentation and eventual downstream migration into the cortical segment of middle cerebral artery | 2A             | ~12 h from endovascular treatment               | Increasing need for vasopressor and inotropic support; increasing leukocyte counts | 3 attempts were performed for clot retrieval. Each attempt resulted in distal clot fragmentation and eventual downstream migration into the cortical segment of middle cerebral artery | Comfort care | |
| 2       | General anesthesia            | Emergency department              | Anesthesiology                       | Yes                       | Yes                       | Midazolam 10mg, propofol 50 mg, succinylcholine 160 mg, rocuronium 50 mg | Observation of clot migration into the cortical segment of middle cerebral artery | 2B             | ~12 h from endovascular treatment               | Vasopressor requirement decreased with sedation wean but neurologic examination failed to improve | 3 attempts using stent-aspiration combination therapy were made. Clot fragmentation with distal emboli into a new territory, the anterior cerebral artery, and into downstream middle cerebral artery branches was seen | Comfort care | |
| 3       | General anesthesia            | Arrived intubated from intensive care unit | Anesthesiology | No | No | No intervention performed | Observation of clot migration into the cortical segment of middle cerebral artery | 3 (anterior circulation), 2B (basilar occlusion) | Failure of neurologic examination to improve, fever, persistent hypoxia. Further investigation revealed positive COVID-19 (was not tested preprocedure). Later developed MODS | Vasopressor requirement decreased with sedation wean but neurologic examination failed to improve | Combination of stent-aspiration thrombectomy used. Despite 2 attempts, clot fragmentation and distal embolus to bilateral posterior cerebral arteries was seen | Death | |
| 4       | General anesthesia            | Neuroradiology suite              | Anesthesiology | Yes | Yes | Fentanyl 50 mg, propofol, 180 mg, succinylcholine 300 mg, rocuronium 100 mg | Observation of clot migration into the cortical segment of middle cerebral artery | 2B             | No | No | Failure of neurologic examination to improve, fever, persistent hypoxia. Further investigation revealed positive COVID-19 (was not tested preprocedure). Later developed MODS | Initial thrombectomy by “A direct aspiration first pass” technique and the “stent retriever with simultaneous aspiration technique” were unsuccessful. Primary suction aspiration was then performed | Rehabilitation | |
| 5       | General anesthesia            | Emergency department              | Emergency medicine                   | No | No | No | No intervention performed | No | No | No | The previously observed clot in the dominant middle cerebral artery branch was no longer observed, consistent with recanalization after tissue plasminogen activator administration | None | Rehabilitation |
vasopressor administration. Three patients died, and 2 patients were discharged to rehabilitation facilities.

**DISCUSSION**

Although respiratory complications are commonly associated with COVID-19, our case series highlights some other systemic complications of coronavirus infection. Approximately 70% of acute ischemic stroke patients present with hypertension (systolic blood pressure >140 mm Hg). Neurogenic hypertension occurs shortly after an ischemic insult to maintain cerebral perfusion pressure. It is mediated by an increased excitatory drive of the rostral ventrolateral medulla sympathoexcitatory neurons. It is possible that ventrolateral medulla neuronal dysfunction through viral infection could result in blunting of the sympathetic nervous response to cerebral ischemia. We cautiously speculate that this mechanism, which could provide some scientific rationale, should be investigated further. Neuroinvasiveness and transsynaptic retrograde axonal transfer are common properties of coronaviruses—phenomena that have been exemplified in studies where mice infected with severe acute respiratory syndrome coronavirus demonstrated virus in their thalami, cerebrum, and brainstem. The SARS-CoV-2 spike protein has a high binding affinity to the angiotensin-converting enzyme 2 (ACE-2) receptor. The rostral ventrolateral medulla has been demonstrated to express these receptors, where their overexpression augments the baroreceptor reflex and decreases blood pressure. Viral docking on these ACE-2 receptors is one mechanism by which SARS-CoV-2 may cause a lack of hypertensive response in ischemic stroke patients. Other mechanisms by which SARS-CoV-2 may cause a lack of hypertensive response include ischemia from capillary endothelial damage and direct cytopathic damage to neurons.

Our case series describes clot fragmentation and distal migration of the clot to various vascular territories. It is not known if clot composition is different in patients with COVID-19. Our patients’ clots were dark red to tan in color, suggesting an erythrocyte-rich, friable composition. Clots with more red blood cells than white blood cells and fibrin are associated with higher chances of breakage and migration. Tissue-type plasminogen activator (tPA) may further increase their fragility and migration, making them too distal to be approached by endovascular treatment. Clots with lower leukocyte counts and fibrin are associated with non-cardioembolic origin. While 1 patient had risk factors for a thrombus of cardioembolic origin, it is conceivable that our patients’ clots formed in situ in a prothrombotic and hyper-inflammatory milieu, as evidenced by the high D-dimer levels, hypercoagulable rotational thromboelastometry profiles, and high levels of interleukin-6 and C-reactive protein. Systemic inflammatory responses heighten the risk of intracranial hemorrhage with tPA administered for ischemic stroke. Therefore, further investigations into the hemorrhagic conversion of stroke in patients with COVID-19 who received tPA are warranted. In our study, all patients received tPA. Patient 5 had complete resolution of the clot with tPA only, but patients 1 and 2 developed hemorrhagic conversions after the endovascular treatment.

Some patients with ischemic stroke who undergo mechanical thrombectomy may have compelling reasons for systemic anticoagulation. Examples in our patients include main pulmonary artery embolism, brachial artery obstruction, myocardial ischemia, and severe hypoxemia, which is associated with a hypercoagulable state in the lungs of patients with COVID-19. Patients with COVID-19 with elevated D-dimer or sepsis-induced coagulopathy scores had lower mortality when treated with heparin compared with those not treated with heparin. Superlative caution must be exercised when starting heparin in patients with COVID-19 who are status postendovascular treatment. If heparin is administered, the patient must be followed closely with clinical and imaging examinations.

In our institution, we routinely perform endovascular treatment under either general anesthesia or monitored anesthesia care depending on individual patient considerations. For all of the 5 patients, general anesthesia was deemed to be the best choice, especially to prevent emergency intubation and exposure of personnel to an aerosolizing procedure. In retrospect, 4 patients in our case series had distal clot fragment migration. Thrombus migration, embolism, or development of new cerebrovascular thrombi due to a prothrombotic state may make endovascular treatment technically challenging, necessitating general anesthesia. However, patients with COVID-19 may need significant amounts of vasopressor support when under general anesthesia. Unless a difficult airway is encountered (as in patient 4), general anesthesia did not significantly delay intervention in our group of patients.

Patients with COVID-19 and ischemic stroke may have poor mental status at presentation or as a result of complications of their clot fragmentation, migration, or hemorrhagic conversion after thrombectomy. This may be confounded by deep sedation, and intubation is often needed for adequate ventilation. Therefore, daily sedation wean and awakening trials are of paramount importance. They would facilitate early detection of a new stroke or postprocedural complications.

In summary, ischemic stroke patients with COVID-19 have atypical features. They usually have some degree of pulmonary compromise, with many requiring high inspired oxygen and positive pressure for adequate blood oxygen saturation (>94%). The procedure may be prolonged and technically challenging due to abnormal coagulability. Starting the case with general anesthesia may be a better choice compared to monitored anesthesia care to prevent the emergency conversion from the latter to the former. Maintaining normal to high blood pressure (systolic blood pressure 140–180 mm Hg) in patients with COVID-19 under general anesthesia frequently requires vasopressors due to atypical hemodynamic parameters.

**DISCLOSURES**

Name: Richa Sharma, MBBS.
**Contribution:** This author made substantial contributions to the conception of the work, the acquisition, analysis, and interpretation of data for the work; and drafting the work, revising it critically for important intellectual content; and final approval of the version to be published.

Name: Peter D. Yim, MD.
**Contribution:** This author made substantial contributions to the design of the work; the interpretation of data for the work,
revising it critically for important intellectual content, final approval of the version to be published.

Name: Paul S. García, MD, PhD.

Contribution: This author made substantial contributions to the design of the work; the interpretation of data for the work, revising it critically for important intellectual content, final approval of the version to be published.

This manuscript was handled by: BobbieJean Sweitzer, MD, FACP.

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