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

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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; **Spo_2** = 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.[1] 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.

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Table 1. Summaries of Patient Presentations

Patient	1	2	3	4	5
Age/sex	58/male	64/male	57/male	37/female	71/female
Diabetes	No	No	Yes	Yes	Yes
Body mass index	25	43	30	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, Restrictive 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	7.8	6.9
Platelet count (10^9/L)	437	273	140	359	242
C-reactive protein (normal ≤0.00–10.00 mg/L)	79.89	282.35	250.65 (6 d after stroke)	8.68	5.62
D-dimer (normal ≤0.80 μg/mL)	>20	>20	9.93 (13 d after stroke)	15.87	>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)	79	<60
Interleukin-6 (normal ≤5.0 pg/mL)	Not applicable	65.2	18 (6 d after stroke)	8.9	32.2
Creatinine (peak) (mg/dL)	1.29	1.08	1.55	0.45	1.49
Time to thrombectomy	120 min	265 min	183 min	263 min	Not performed
Prestroke National Institutes of Health stroke scale score	27	29	23	9	18
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.

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

Table 2. Summaries of Anesthetic Management

Patient	1	2	3	4	5
Anesthetic	General anesthesia	General anesthesia	General anesthesia	General anesthesia	General anesthesia
Site of intubation	Outside hospital	Emergency department	Arrived intubated from intensive care unit	Neuroradiology suite	Emergency department
Team performing intubation	Unknown team	Anesthesiology	Anesthesiology	Anesthesiology	Emergency medicine
Rapid sequence intubation	Unknown	Yes	- (electively intubated for cardiac surgery in a prior encounter)	Yes	No
Airborne precautions	Unknown	Yes	No	Yes	Yes
Induction drugs given at the time of intubation	Arrived on fentanyl and propofol drips. Induction drugs unknown (intubation record unavailable)	Midazolam 10 mg, propofol 50 mg, succinylcholine 160 mg, rocuronium 50 mg	Off sedation and unresponsive when stroke suspected. Emergency transfer to neurointervention suite	Fentanyl 50 mg, propofol, 180 mg, succinylcholine 300 mg, rocuronium 100 mg	Etomidate and rocuronium
Periprocedural anesthesia complications	On arrival had Spo_2 50%–60%. Possible bronchospasm. Saturation improved with positive pressure and dilute epinephrine	Desaturation to Spo_2 60% during transfer between gurney and intensive care unit bed and Spo_2 increased with positive pressure	Continual titration between vasopressors and vasodilators to maintain brain perfusion and coronary vasodilation in the setting of his recent coronary arterial bypass grafting surgery and postoperative myocardial ischemia	Required multiple attempts by different anesthesiologists, failed ventilation by supraglottic airway, failed videolaryngoscope intubation. Final airway by direct laryngoscopy. Right main-stem intubation requiring 2 adjustments	None
Procedural anesthesia	Fentanyl and propofol infusions were continued along with ~0.4 MAC sevoflurane	Fentanyl infusion was continued along with ~0.5–1 MAC sevoflurane	Sevoflurane ~0.5 MAC in the first half of the case and later on a low dose propofol infusion. Rocuronium as needed	Maintained on sevoflurane - 0.5–1 MAC and intermittent boluses of fentanyl	Propofol infusion and rocuronium
Vasopressors administered (maximum dose)	Phenylephrine infusion (180 µg/min)	Phenylephrine infusion (250 µg/min)	Norepinephrine (12 µg/min), vasopressin (6 U/h) infusions	Phenylephrine boluses (80 µg)	Phenylephrine infusion (80 µg/min)
Systolic blood pressure range	125–155 mm Hg	125–175 mm Hg	125–180 mm Hg	125–200 mm Hg	125–160 mm Hg
Spo_2 range	72%–100%	100%	99%–100%	Low 90s	96%–100%
Fraction of inspired oxygen	100%	100%	68%–97%	50%–100%	60%–70%
Tissue plasminogen activator administered	Yes	Yes	Yes	Yes	Yes
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	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	Combination of stent-aspiration thrombectomy used. Despite 2 attempts, clot fragmentation and distal emboli to bilateral posterior cerebral arteries was seen	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	The previously observed clot in the dominant middle cerebral artery branch was no longer observed, consistent with recanalization after tissue plasminogen activator administration
TICI grade revascularization	2A	2B	3 (anterior circulation), 2B (basilar occlusion)	3	No
Hemorrhagic conversion of infarct	~12 h from endovascular treatment	~12 h from endovascular treatment	No	No	No
Postoperative course	Increasing need for vasopressor and inotropic support; increasing leukocyte counts	Vasopressor requirement decreased with sedation wean but neurologic examination failed to improve	Failure of neurologic examination to improve, fever, persistent hypoxia. Further investigation revealed positive COVID-19 (was not tested preprocedure). Later developed MODS	Uncomplicated recovery	Uncomplicated recovery
Outcome	Comfort care	Comfort care	Death	Rehabilitation	Rehabilitation

Abbreviations: COVID-19, coronavirus disease 2019; MAC, minimum alveolar concentration; MODS, multiple organ dysfunction syndrome; Spo_2, pulse oxygen saturation; TICI, thrombolysis in cerebral infarction.

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).[2] Neurogenic hypertension occurs shortly after an ischemic insult to maintain cerebral perfusion pressure.[3] It is mediated by an increased excitatory drive of the rostral ventrolateral medulla sympathoexcitatory neurons.[4] 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[5]—phenomena that have been exemplified in studies where mice infected with severe acute respiratory syndrome coronavirus demonstrated virus in their thalami, cerebrum, and brainstem.[6] The SARS-CoV-2 spike protein has a high binding affinity to the angiotensin-converting enzyme 2 (ACE-2) receptor.[7] The rostral ventrolateral medulla has been demonstrated to express these receptors, where their overexpression augments the baroreceptor reflex and decreases blood pressure.[8] 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.[9,10]

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.[11] Tissue-type plasminogen activator (tPA) may further increase their fragility and migration, making them too distal to be approached by endovascular treatment.[12] Clots with lower leukocyte counts and fibrin are associated with noncardioembolic origin.[13] 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 hyperinflammatory 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.[14] 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.[15] 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

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