Anesthetic Management of Endovascular Treatment of Acute Ischemic Stroke During COVID-19 Pandemic: Consensus Statement from Society for Neuroscience in Anesthesiology & Critical Care (SNACC)

Endorsed by Society of Vascular & Interventional Neurology (SVIN), Society for NeuroInterventional Surgery (SNIS), Neurocritical Care Society (NCS), and European Society of Minimally Invasive Neurological Therapy (ESMINT)

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Abstract:

The pandemic of coronavirus disease 2019 (COVID-19) has unique implications for the anesthetic management of endovascular therapy (EVT) for acute ischemic stroke (AIS). The Society for Neuroscience in Anesthesiology and Critical Care (SNACC) appointed a task force to provide consensus-based timely expert recommendations using available evidence for safe and effective anesthetic management of EVT for AIS during COVID-19 pandemic. The goal of this consensus statement is to provide recommendations for anesthetic management considering (1) optimal neurological outcomes for patients (2) minimizing the risk for healthcare professionals, and (3) facilitating judicious use of resources while accounting for existing variability in care. It provides a framework for selecting optimal anesthetic technique (general anesthesia or monitored anesthesia care) for a given patient and offers suggestions for best practices for anesthesia care in this setting. Individual providers and institutions are encouraged to adapt these recommendations to best suit their unique circumstances.

MeSH Keywords: conscious sedation, COVID-19 pandemic, general anesthesia, patient-to-professional transmission, stroke, thrombectomy

Introduction

Anesthesiologists worldwide are currently involved closely in caring for patients impacted by the coronavirus disease 2019 (COVID-19) pandemic caused by the novel severe acute respiratory syndrome-coronavirus 2 (SARS-CoV-2).[1] A number of healthcare personnel have been reported to have contracted COVID-19. Cardiovascular or cerebrovascular disease has been reported in 16.4% and ischemic stroke in 5% of COVID-19 patients.[2, 3] It is plausible that patients with COVID-19 may require endovascular therapy (EVT) for acute ischemic stroke (AIS). In addition, patients requiring EVT may be carriers of SARS-CoV-2 from community exposure.

The choice of anesthetic technique, specifically, the preference for general anesthesia (GA) or monitored anesthesia care (MAC) for EVT of AIS is controversial.[4-15] The current evidence based on randomized control trials indicates potential advantages of GA over MAC for neurological outcomes.[16-18] However, there is considerable variability in practice with some institutions routinely using GA, others routinely using MAC and yet others offering either anesthetic technique.[19, 20] Essentially, while many patients receive MAC for EVT, urgent conversion to GA is undesirable especially when COVID-19 is suspected. The current pandemic has significant implications for anesthesiology and perioperative care.[1, 21-29] Specific to EVT, there is also significant concern for potential risk to healthcare providers as these patients are rapidly transported across various hospital locations (emergency department, imaging, intervention suite, intensive care units or post anesthesia care units) over a brief period of time, with little or no opportunity for testing for infection. While the Society for Neuroscience in Anesthesiology and Critical Care (SNACC) has previously published consensus recommendations for anesthetic management of EVT,[30] the current situation has led to an urgent need for expert recommendations using best available evidence to provide guidance to healthcare professionals during the pandemic.

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Aim

To make consensus-based expert recommendations using available evidence for safe and effective anesthetic management of endovascular treatment of AIS during COVID-19 pandemic in order to (1) provide best neurological outcomes for patients (2) minimize the risk for healthcare professionals, and (3) facilitate judicious use of resources.

Task Force Members

The task force writing this consensus statement was appointed by SNACC. It comprises experienced Neuroanesthesiologists with expertise in stroke who have published original research in the field of AIS and who currently work at high volume stroke centers. The team has representation from North America, Europe and Asia. The consensus is vetted by the SNACC board of directors and members of the society. The recommendations were critically reviewed by official representatives of Society of Neurointerventional Surgery (SNIS), Society of Vascular and Interventional Neurology (SVIN), European Society of Minimally Invasive Neurological Therapy (ESMINT) and Neurocritical Care Society (NCS) who provided inputs to the consensus prior to finalizing the document and formal endorsement.

Scope

This consensus statement is being generated in a time-sensitive manner and the scope is limited to recommendations during COVID-19 pandemic. This is not intended to be a comprehensive recommendation or guideline for anesthetic management of EVT during ordinary circumstances. This document also does not comprehensively cover all aspects of general principles and practices of anesthetic management and exposure prevention during COVID-19.

The recommendations provided here reflect expert consensus based on the information available at the time of writing this document. The recommendations herein are expected to provide guidance in the context of the current pandemic and should not be interpreted as standard of care. Institutions and providers are encouraged to adapt these to suit local needs considering existing practice standards and resource availability to ensure safety of their patients and providers.

Relevant Practical Considerations

(1) COVID-19 is a serious viral infection with a high risk of spreading through droplets, aerosols, or contaminated surfaces.[1, 31, 32] It is controversial whether COVID-19 can be transmitted via an airborne route (small particles which remain aloft in the air for longer periods of time). However, a recent study demonstrated the ability of the virus to persist in aerosols for hours, making aerosol transmission plausible.[33]

(2) There is a lack of agreement between guidelines regarding the use of airborne precautions during routine care although airborne precautions are universally recommended for aerosol-generating procedures.

(3) In the setting of AIS requiring emergent EVT, testing and confirming COVID-19 is currently not practical. Given the current pandemic, the majority of patients presenting for EVT are expected to be either "unknown" or "suspected" COVID-19.

(4) Bag-mask ventilation, intubation, extubation, suctioning, and active cardiopulmonary resuscitation may result in aerosolization of respiratory secretions increasing the likelihood of exposure to healthcare personnel.[26, 29] The American Society of Anesthesiologists (ASA) has also highlighted these issues relevant to anesthesia care.[34]

(5) Leak from tracheal tube cuff, manipulation or adjustment of tracheal tube and disconnection of breathing circuit may lead to aerosolization and should be avoided unless essential.

(6) Sneezing may produce as many as 40,000 droplets 0.5-12 μm in diameter that may be expelled at speeds up to 100 m/s and coughing may produce up to 3000 droplet nuclei.[35-37] According to the Centers for Disease Control (CDC), the contribution of small respirable particles (aerosols or droplet nuclei) to close proximity transmission of COVID-19 is currently uncertain.[38] However, coughing and sneezing in spontaneously breathing, COVID-19 positive patients may increase aerosolization and increase both the distance that viral particles spread and the time they remain airborne, posing potential risk of healthcare workers in proximity. This may increase the risk of exposure to healthcare personnel not only during EVT (anesthesia providers, interventional neuroradiology staff) but also during early management in the emergency department, imaging studies and transport between hospital locations before and after EVT.

(7) Working in close proximity of the airway and airway interventions such as chin-lift and jaw thrust may expose anesthesia providers to the increased risk of airborne infection.

(8) Increasing oxygen flow rates increases aerosol dispersion for both nasal cannula and simple mask.[39, 40] High-flow oxygen was associated with increased transmission of the SARS coronavirus.[41] It is possible that high flow oxygen in a spontaneously breathing COVID-19 positive patient may result in aerosolization with increased likelihood of exposure to healthcare personnel.

(9) Covering a patient's nose and mouth with a surgical mask decreases the distance of aerosol spread during coughing which can reduce the transmission of airborne infections.[42, 43]

(10) Coughing during EVT is unsafe for the patient (due to possible movement related vascular complications) and the interventional and anesthesia teams working in close proximity.

(11) Emergent conversion from MAC to GA during EVT is undesirable given the risk of producing aerosol contamination in an uncontrolled situation.

(12) Based on data from randomized control trials, GA is non-inferior to MAC for neurological outcomes after EVT for AIS and in fact, may be associated with better neurological outcomes as long as hemodynamic stability is maintained.[15-18]

(13) Outside of EVT setting, not all COVID-19 positive patients require intubation / mechanical ventilation. The risk of infection to healthcare personnel providing care to these patients can be reduced using airborne Personal Protective Equipment (PPE).[34]

(14) During pandemic situations, there is the possibility of resource limitations including ventilators and PPE.

(15) Drastic changes in clinical care and workflow are typically not desirable, particularly in the absence of strong evidence. However, unprecedented situations like this pandemic will require flexibility and careful consideration of changes in practices and workflow. Protection of healthcare staff is critical to the overall ability to manage the pandemic.

Recommendations for Choice of Anesthetic Technique

(1) The vast majority of patients will have to be considered “suspected COVID-19” or “unknown COVID-19” when presenting for EVT. Irrespective of the choice of anesthetic technique, we recommend airborne precautions for all these patients. Testing to rule out COVID-19 should occur as soon as feasible without delaying EVT. The task force is aware of rare cases where patients received nasal swabs in the emergency department for COVID-19 testing and had

significant epistaxis following administration of heparin during thrombectomy. While this is uncommon, we believe it is important to alert all involved in the care of AIS patients about the possible risk. COVID-19 testing and its timing should account for this possibility.

(2) Anesthesia personnel should use properly fitted N95 masks or PAPRs (Powered Air Purifier Respirator, for those who are not fit-tested, have facial hair, or fail N95 fit-testing) when caring for patients with known or suspected COVID-19 and when performing intubation or other procedures that may generate aerosolized particles. Surgical face masks protect against droplet transmission but do not protect against aerosolized particles. Given the possible shortage of N95 masks, N95 masks may have to be reused according to individual institutional guidance. In addition, surgical cap, eye protection (goggles and face shield), full gown / double gloves should be used. Proper donning and doffing practices should be practiced.

(3) The choice of anesthetic technique should be carefully individualized accounting for the patient's neurological and medical status as well as the risk of infection to healthcare personnel. The threshold for tracheal intubation will need to be altered by the situation presented and is likely to be impacted by availability of equipment and personnel. In general, the threshold for the use of GA for EVT may be reduced during COVID-19 pandemic. If the anesthesiologist has any concerns for possible urgent conversion from MAC to GA during EVT, it is advisable to start with GA. However, not all patients undergoing EVT need to be intubated solely for the purpose of reducing the risk to healthcare personnel. In fact, intubation may increase the risk of aerosolization and hence, the exposure.

(4) Not all COVID-19 positive / suspected positive patients require GA for EVT because

   a. Most COVID-19 positive patients (including those not suffering from AIS) do NOT require intubation / mechanical ventilation unless they are in respiratory failure.

Infection risk to healthcare personnel providing care to the patients who are stable and not intubated can be managed using Personal Protective Equipment (PPE).

b. Bag-mask ventilation, intubation, extubation and airway interventions result in aerosolization of respiratory secretions, thereby increasing the likelihood of exposure to the anesthesiologists and other personnel in the room. Airway interventions require airborne precaution including possible use of PAPR and hence, extra time which may delay puncture time and revascularization.

(5) Figure 1 outlines a suggested scheme to decide GA versus MAC during COVID-19. The following criteria may be used to identify patients who may be preferred candidates for GA during the COVID-19 pandemic:

a. Known / suspected COVID-19 positive patients with AIS who have:
    i. acute respiratory distress / hypoxemia / requiring high flow oxygen or
    ii. active cough or
    iii. inability to protect airway or
    iv. active vomiting
b. Posterior circulation / dominant cerebral hemisphere occlusions
c. Severe stroke (NIHSS >15) or GCS <9
d. Agitated / uncooperative patients / aphasic patients

(6) The following criteria may be used to identify patients who may be suitable candidates for MAC during COVID-19 pandemic:

a. Patients who do not have acute respiratory distress or hypoxemia requiring high flow oxygen, are not actively coughing or vomiting, and are able to protect their airway
b. Anterior circulation / non-dominant cerebral hemisphere occlusions

c. NIHSS < 15 and GCS >9

(7) The decision to intubate and use GA should be made early, based on close communication between anesthesiologist, interventionalist, neurologist and the emergency medicine team. Ideally, intubation / induction of GA should be performed in an airborne isolation room that has negative-pressure relative to the surrounding area. This may have to be performed in the emergency department to avoid exposure to personnel in subsequent locations (CT scanner, transport and IR suite). Importantly, this should be viewed as induction of anesthesia in the emergency department (as opposed to emergent intubation) and careful attention should be paid to strict maintenance of hemodynamic and ventilation goals. Airway should be managed by the most experienced person available. However, it is recognized that induction of anesthesia in the ED may not be logistically feasible or safe for many institutions and intubation will need to occur in an alternative negative-pressure location or the interventional radiology (IR) suite.

(8) Patients suffering from AIS while already in the hospital and requiring GA for EVT based on above criteria should be intubated safely in a suitable negative pressure location while minimizing delays in cerebral reperfusion.

(9) At some centers that receive transfers for EVT from other hospitals, patients are sometimes brought directly to the IR suite by EMS personnel. In such circumstances, it is recommended to have the patient received in a suitable negative pressure location where anesthetic technique decision and induction of anesthesia can be performed if needed.

(10) Situations when intubation may have to be performed in IR suite:

a. COVID-19 positive patient actively coughing or in respiratory distress / hypoxemia who is not already intubated.

b. Need to convert from planned or ongoing MAC to GA due to changes in patient's respiratory condition, acute neurological deterioration or procedure-related complication.

(11) Each institution should carefully adapt the above recommendations to optimally suit local workflow. Institutional adaptions of these recommendations should balance timeliness of EVT, safety of healthcare personnel and available resources while accounting for possible implications on institutional workflow.

General recommendations for anesthetic management of EVT in known / suspected COVID-19 positive patients (irrespective of the anesthetic technique)

Previously published general recommendations for anesthetic management should be followed.[25-29] Below are some special considerations relevant to patients requiring emergent EVT.[30, 44]

(1) Airborne precautions should be used for all patients and number of personnel should be reduced to essential (any patient may potentially be asymptomatic carrier of SARS-CoV-2 even in the absence of concerning clinical symptoms for severe viral infection or aerosolization). Lead apron should be worn prior to "donning" PPE.

(2) Irrespective of the anesthetic technique, GA or MAC, hemodynamic stability and oxygenation / ventilation should be optimized and maintained in the recommended range. According to the current guidelines, systolic blood pressure should be maintained between 140 and 180 mmHg.[30] Blood pressure goals may need to be readjusted after reperfusion in discussion with interventionalists and stroke team. Normocapnia should be maintained and inspired oxygen concentration titrated to maintain oxygen saturation > 94%.[44]

(3) Any delays in cerebral reperfusion as a result of change in practice, specifically due to the increased use of GA should be minimized while accounting for essential COVID-19 precautions. It is anticipated that door-to-puncture times may be delayed but every effort should be made to minimize this.

(4) The use of PAPR / PPE and any changes in workflow may create difficulties in communication. Extra care is warranted to ensure effective communications.

(5) It is recognized that anesthesiologists are not routinely involved in EVT at some institutions. It is recommended that during the pandemic, such institutions consider using a lower threshold to involve anesthesiologists in EVT since emergent intubation may be associated with higher risk of exposure for all personnel in IR suite. Early communication with anesthesia is recommended to better plan human resources in what may be a human resource scarce situation.

Recommendations for GA / intubation during COVID-19 pandemic

Previously published general recommendations for intubation and anesthetic management should be followed. [25-29] Below are some special considerations relevant to patients requiring emergent EVT.

(1) Airborne precautions should be used for intubation. These include PAPRs / properly fitted N95 masks, goggles, face shields, protective clothing and double gloves.

(2) As stated above, intubation / induction of GA should be performed in an airborne isolation room that has a negative-pressure relative to the surrounding area.

(3) Any delays in cerebral reperfusion as a result of change in practice, specifically due to the use of GA should be minimized while accounting for essential COVID-19 precautions. Since the

preparation for intubation in a known / suspected COVID-19 positive patient is likely to take longer than a regular intubation, it is critical that hemodynamic parameters be strictly maintained in the recommended range while awaiting intubation.

(4) Airway devices, medications including anesthetic and vasoactive drugs, suction device, ventilators and monitors should be ready prior to induction of anesthesia. Rapid, focused assessment of neurological status, hemodynamics and airway should be performed. Patients with COVID-19 may have associated myocardial injury exposing them to a greater risk of hemodynamic instability.[2, 45-47]

(5) Following a 5-minute preoxygenation with good mask seal, rapid sequence induction should be performed using videolaryngoscopy, carefully avoiding hypotension. It is recommended that vasopressors and / or inotropes be readily available. Two pieces of wet gauze can be considered to cover the mouth and nose of patients.[25] Sufficient doses of neuromuscular blocking agent should be given to ensure no cough reflex during intubation.

(6) Avoid the use of laryngeal mask airway (LMA) for GA unless it is for rescuing a difficult airway.

(7) A High efficiency particulate air (HEPA) filter should be placed directly on the tracheal tube immediately after intubation. Additionally, viral filters should be placed between the expiratory limb and the anesthesia machine to prevent contamination of the machine. Breathing circuits should be carefully discarded after every use**.**

(8) Disconnections of breathing circuits and changes of ventilators should be avoided to reduce the risk of aerosolization and contaminating multiple ventilators. There may also be a reduced availability of ventilators during the pandemic requiring conservation of ventilators / anesthesia machines (which may be needed to be deployed as ICU ventilators). It may be

desirable to use the same ventilator (in some cases, a transport ventilator) for transport as well as during thrombectomy as well as in ICU. This implies that intravenous anesthesia may have to be used for anesthetic management.

(9) If changes in ventilator or breathing circuits are required, standard precautions should be used to minimize aerosolization during disconnection. These include ensuring that no breaths will be taken during the disconnect by using neuromuscular blockade and clamping the tracheal tube prior to the ventilator change. A HEPA filter should remain connected to the tracheal tube while changing breathing circuit or ventilator.

(10) Capnography should be used throughout the duration of mechanical ventilation to avoid inadvertent hypo / hyperventilation.

(11) The gas sampling tubing should also be protected by a HEPA filter, and gases exiting the gas analyzer should be scavenged and not allowed to return to the room air.[48]

(12) It is recommended that anesthesiologists continue to use medications that they are most familiar with in this setting to maintain physiological goals.

(13) Nasal / esophageal temperature probes should be avoided. Bladder temperature or skin temperature monitoring are preferred.

(14) Extubation following GA should be ideally performed in an airborne isolation room that has negative-pressure relative to the surrounding area, preferably in the ICU. Sedation and neuromuscular blockade should be titrated to facilitate early extubation under supervision of an anesthesiologist. Extubation should not be delayed unless there is neurological or respiratory deterioration. Standard extubation criteria should be applied. It is recognized that in resource limitation scenarios, patients may need to be extubated in the IR suite. In such

cases, extubation should be carefully performed under airborne precautions and special attention to preventing coughing during extubation. The patient should wear a surgical mask after extubation and receive low flow oxygen as needed. Droplet and contact precautions should continue until COVID-19 status is confirmed negative.

Recommendations for MAC during COVID-19 pandemic

(1) The use of MAC using the criteria recommended above is best suited for experienced anesthesiologists and centers with a low rate of conversion from MAC to GA. There is a lack of prediction tools or established risk factors for conversion from MAC to GA. Clinicians should exercise judgement and avoid MAC if there is any concern that a patient will require conversion to GA.

(2) While using MAC, the patient should wear a surgical mask.[42, 43] Surgical mask should be placed on top of the nasal prongs or under face mask.

(3) Oxygen flow through nasal cannula should be as low as possible to achieve SpO_2 > 94%.[44] Avoid oxygen flow rates > 5L/min to minimize aerosolization and carefully consider conversion to GA if patient continues to remain hypoxemic.[39] If available, oxygen masks with expiratory viral filters may be used.

(4) Capnography may be feasible using recommendations provided by Anesthesia Patient Safety Foundation (APSF).[48]

(5) Minimal sedation necessary should be used in order to avoid the need for insertion of oropharyngeal airways or the use of jaw thrust / chin lift. Anesthesiologists should continue to use pharmacological agents they are most familiar with for MAC in this setting.

(6) Extra caution is warranted in case pooling of secretions requiring suctioning.

(7) Anesthesiologists should be prepared to safely convert to GA if needed.

Recommendations for urgent conversion from MAC to GA during COVID-19 pandemic

(1) Conversion to GA may be required due to changing patient or procedural conditions. Emergency intubations may be associated with a higher risk of aerosolization and may be linked to higher transmission events.[25]

(2) In the event that urgent conversion to GA is necessary, all non-essential personnel should leave the room during intubation. Rapid sequence intubation should be performed using videolaryngoscopy by the most experienced person available using airborne precautions.[25-27]

(3) As with a planned general anesthetic, vasopressors should be immediately available in order to maintain a systolic BP > 140 mmHg. Once the patient is intubated, ventilation should be managed to achieve normoxia and normocapnia.

(4) After urgent conversion to GA aerosolization may be a risk but with routine airborne precautions already in place, it is possible to resume EVT quickly.

Recommendations for within hospital transport during COVID-19 pandemic

(1) Transport for post-EVT imaging should be limited as much as possible. It is recommended that post-EVT imaging only be performed in the setting of concern for neurological compromise and to rule out hemorrhagic conversion if it cannot be done using a flat-panel CT in the IR suite. Patients receiving GA should remain intubated for imaging.

(2) HEPA filter should remain connected directly to the tracheal tube for intubated patients and capnography used throughout the transport to avoid inadvertent hypo / hyperventilation.

(3) Coughing / disconnections of breathing circuits should be avoided as described above.

(4) Hemodynamics should be strictly maintained during transport using standard guidelines.[30, 44]

(5) Patients who are not ventilated during transport should wear a surgical mask. Oxygen can be administered by nasal cannula under the mask or face mask over the surgical mask during transport.

(6) Personnel transporting an intubated patient should wear PPE since contact with patient and equipment is expected. Ideally, they should be accompanied by another member of the care team (not in PPE) to help interact with the environment as needed. The PPE that was used during airborne procedures must be doffed before leaving the room and should not be worn for transport.

Administrative recommendations during COVID-19 pandemic

(1) Changes in institutional practice during COVID-19 pandemic should be carefully implemented to prevent inadvertent consequences.

(2) Multidisciplinary consensus and education should be organized accounting for unique local needs.

(3) Quality measures for AIS and patient outcomes should be carefully monitored during the pandemic and institutions should have a plan to return to regular practice at the end of the pandemic.

Anticipated impact of recommendations

(1) Increased utilization of GA for EVT in AIS

(2) Potential delays in door-to-puncture times and hence reperfusion times in patients receiving GA (attributable largely to precautions necessary for airway management). These delays may be unavoidable in the current extraordinary circumstances.

(3) Enhanced safety of healthcare providers

Limitations

(1) Data directly examining the impact of COVID-19 or other respiratory infections of the outcomes of AIS are unknown.

(2) This recommendation does not address the process for special "COVID-19 only" designation of CT scanners, MRIs, IR suites or their decontamination after exposure.

(3) The recommendations may not be universally applicable in entirety; all institutions are expected to variably adapt to this recommendation accounting for local processes of care and resource availability.

(4) These recommendations assume the current turn-around time of about 2 hours for COVID-19 test results to become available. The recommendations may need to be updated if a rapid diagnostic test for COVID-19 were to become available.

Summary and Conclusions

This expert consensus provides a framework for careful selection and implementation of anesthetic technique for EVT for AIS during COVID-19 pandemic. Institutions currently using GA for all EVTs should continue to do so with added airborne precautions. Institutions using MAC for all or majority of EVTs should consider lowering the threshold for using GA using the criteria suggested above. Airborne precautions should be used in all cases. All institutions should carefully implement changes to existing workflows anticipating impact on patients as well as providers. If possible, any drastic changes in workflow should be avoided. The issues and solutions described herein may be generalizable to future pandemics which conceivably could present similar medical issues and resource constraints. Additionally, these recommendations may have to be updated as new information about COVID-19 becomes available.

References

1. Zhu N, Zhang D, Wang W, et al. A Novel Coronavirus from Patients with Pneumonia in China, 2019. *N Engl J Med* 2020;382: 727-733.
2. Li B, Yang J, Zhao F, et al. Prevalence and impact of cardiovascular metabolic diseases on COVID-19 in China. *Clin Res Cardiol* 2020.
3. Li Y, Wang M, Zhou Y, et al. Acute Cerebrovascular Disease Following COVID-19: A Single Center, Retrospective, Observational Study. [2020. Available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3550025.
4. Jumaa MA, Zhang F, Ruiz-Ares G, et al. Comparison of safety and clinical and radiographic outcomes in endovascular acute stroke therapy for proximal middle cerebral artery occlusion with intubation and general anesthesia versus the nonintubated state. *Stroke* 2010;41: 1180-4.
5. Davis MJ, Menon BK, Baghirzada LB, et al. Anesthetic management and outcome in patients during endovascular therapy for acute stroke. *Anesthesiology* 2012;116: 396-405.
6. van den Berg LA, Koelman DL, Berkhemer OA, et al. Type of anesthesia and differences in clinical outcome after intra-arterial treatment for ischemic stroke. *Stroke* 2015;46: 1257-62.
7. Berkhemer OA, van den Berg LA, Fransen PS, et al. The effect of anesthetic management during intra-arterial therapy for acute stroke in MR CLEAN. *Neurology* 2016;87: 656-64.
8. Abou-Chebl A, Yeatts SD, Yan B, et al. Impact of General Anesthesia on Safety and Outcomes in the Endovascular Arm of Interventional Management of Stroke (IMS) III Trial. *Stroke* 2015;46: 2142-8.
9. Brinjikji W, Murad MH, Rabinstein AA, et al. Conscious sedation versus general anesthesia during endovascular acute ischemic stroke treatment: a systematic review and meta-analysis. *AJNR Am J Neuroradiol* 2015;36: 525-9.
10. Campbell BCV, van Zwam WH, Goyal M, et al. Effect of general anaesthesia on functional outcome in patients with anterior circulation ischaemic stroke having endovascular thrombectomy versus standard care: a meta-analysis of individual patient data. *Lancet Neurol* 2018;17: 47-53.
11. Sivasankar C, Stiefel M, Miano TA, et al. Anesthetic variation and potential impact of anesthetics used during endovascular management of acute ischemic stroke. *J Neurointerv Surg* 2016;8: 1101-1106.
12. Schonenberger S, Uhlmann L, Hacke W, et al. Effect of Conscious Sedation vs General Anesthesia on Early Neurological Improvement Among Patients With Ischemic Stroke Undergoing Endovascular Thrombectomy: A Randomized Clinical Trial. *JAMA* 2016;316: 1986-1996.
13. Lowhagen Henden P, Rentzos A, Karlsson JE, et al. General Anesthesia Versus Conscious Sedation for Endovascular Treatment of Acute Ischemic Stroke: The AnStroke Trial (Anesthesia During Stroke). *Stroke* 2017;48: 1601-1607.
14. Simonsen CZ, Yoo AJ, Sorensen LH, et al. Effect of General Anesthesia and Conscious Sedation During Endovascular Therapy on Infarct Growth and Clinical Outcomes in Acute Ischemic Stroke: A Randomized Clinical Trial. *JAMA Neurol* 2018;75: 470-477.

15. Rasmussen M, Simonsen CZ, Sharma D. Letter by Rasmussen et al Regarding Article, "Anesthesia-Related Outcomes for Endovascular Stroke Revascularization: A Systematic Review and Meta-Analysis". *Stroke* 2018;49: e20.
16. Schonenberger S, Henden PL, Simonsen CZ, et al. Association of General Anesthesia vs Procedural Sedation With Functional Outcome Among Patients With Acute Ischemic Stroke Undergoing Thrombectomy: A Systematic Review and Meta-analysis. *JAMA* 2019;322: 1283-1293.
17. Campbell D, Diprose WK, Deng C, et al. General Anesthesia Versus Conscious Sedation in Endovascular Thrombectomy for Stroke: A Meta-Analysis of 4 Randomized Controlled Trials. *J Neurosurg Anesthesiol* 2019.
18. Zhang Y, Jia L, Fang F, et al. General Anesthesia Versus Conscious Sedation for Intracranial Mechanical Thrombectomy: A Systematic Review and Meta-analysis of Randomized Clinical Trials. *J Am Heart Assoc* 2019;8: e011754.
19. Rusy DA, Hofer A, Rasmussen M, et al. Assessment of Anesthesia Practice Patterns for Endovascular Therapy for Acute Ischemic Stroke: A Society for Neuroscience in Anesthesiology and Critical Care (SNACC) Member Survey. *J Neurosurg Anesthesiol* 2019.
20. Rasmussen M, Simonsen CZ, Sorensen LH, et al. Anaesthesia practices for endovascular therapy of acute ischaemic stroke: a Nordic survey. *Acta Anaesthesiol Scand* 2017;61: 885-894.
21. Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72314 Cases From the Chinese Center for Disease Control and Prevention. *JAMA* 2020.
22. Johns Hopkins Center for Systems Science and Engineering. Coronavirus COVID-19 Global Cases. [Available at: https://coronavirus.jhu.edu/map.html. Accessed 2 April 2020.
23. Kharasch ED, Jiang Y. Novel Coronavirus 2019 and Anesthesiology. *Anesthesiology* 2020.
24. Bowdle A, Munoz-Price LS. Preventing Infection of Patients and Healthcare Workers Should Be the New Normal in the Era of Novel Coronavirus Epidemics. *Anesthesiology* 2020.
25. Chen X, Liu Y, Gong Y, et al. Perioperative Management of Patients Infected with the Novel Coronavirus: Recommendation from the Joint Task Force of the Chinese Society of Anesthesiology and the Chinese Association of Anesthesiologists. *Anesthesiology* 2020.
26. Meng L, Qiu H, Wan L, et al. Intubation and Ventilation amid the COVID-19 Outbreak: Wuhan's Experience. *Anesthesiology* 2020.
27. Zuo MZ, Huang YG, Ma WH, et al. Expert Recommendations for Tracheal Intubation in Critically ill Patients with Noval Coronavirus Disease 2019. *Chin Med Sci J* 2020.
28. Greenland JR, Michelow MD, Wang L, et al. COVID-19 Infection: Implications for Perioperative and Critical Care Physicians. *Anesthesiology* 2020.
29. Luo M, Cao S, Wei L, et al. Precautions for Intubating Patients with COVID-19. *Anesthesiology* 2020.
30. Talke PO, Sharma D, Heyer EJ, et al. Society for Neuroscience in Anesthesiology and Critical Care Expert consensus statement: anesthetic management of endovascular treatment for acute ischemic stroke*: endorsed by the Society of NeuroInterventional Surgery and the Neurocritical Care Society. *J Neurosurg Anesthesiol* 2014;26: 95-108.

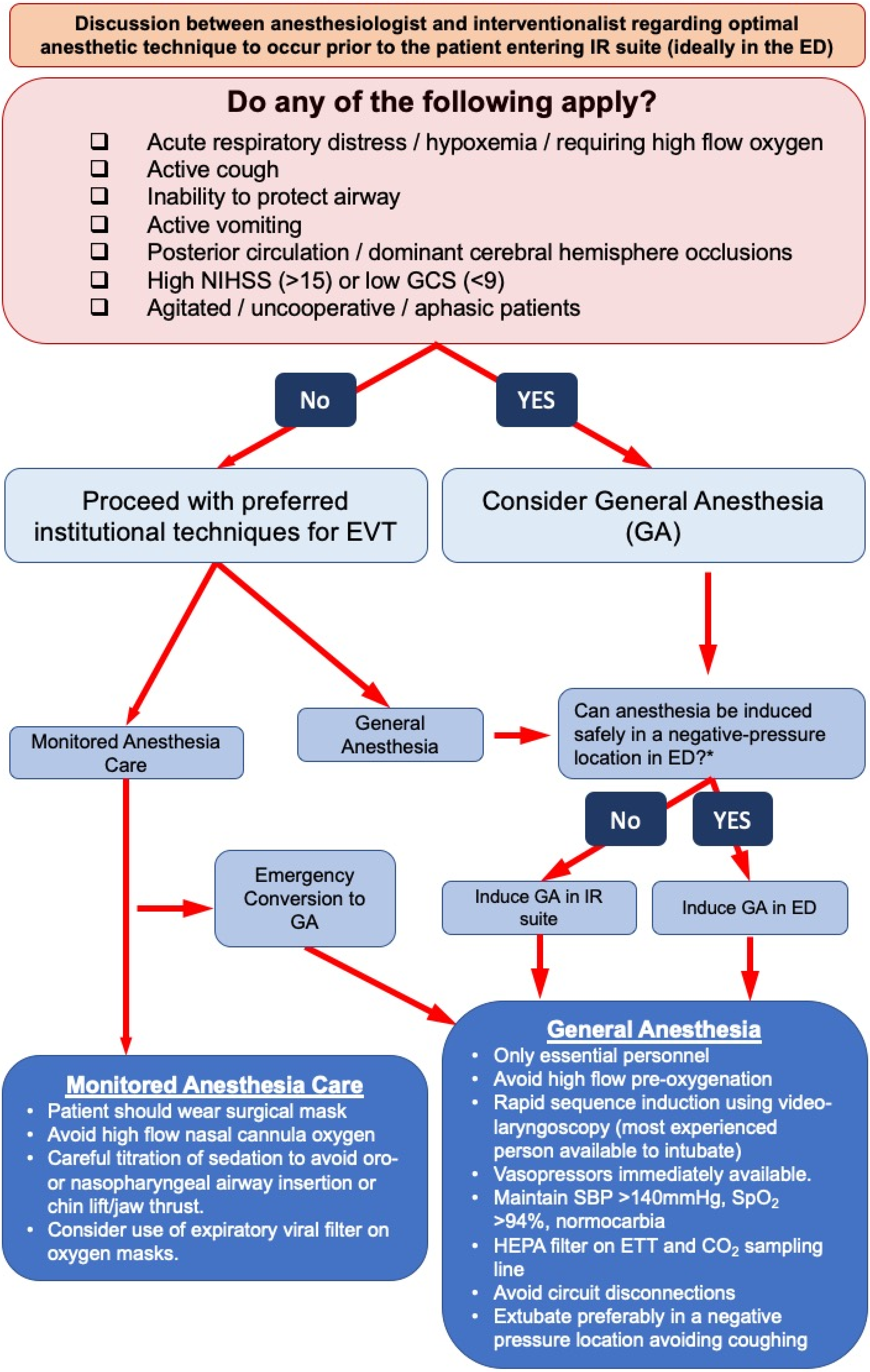
31. Li Q, Guan X, Wu P, et al. Early Transmission Dynamics in Wuhan, China, of Novel Coronavirus-Infected Pneumonia. *N Engl J Med* 2020;382: 1199-1207.
32. Del Rio C, Malani PN. COVID-19-New Insights on a Rapidly Changing Epidemic. *JAMA* 2020.
33. van Doremalen N, Bushmaker T, Morris DH, et al. Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. *N Engl J Med* 2020.
34. ASA Committee on Occupational Health. Coronavirus Resources for Anesthesiologists. [Available at: https://www.asahq.org/about-asa/governance-and-committees/asa-committees/committee-on-occupational-health/coronavirus. Accessed 2 April 2020.
35. Cole EC, Cook CE. Characterization of infectious aerosols in health care facilities: an aid to effective engineering controls and preventive strategies. *Am J Infect Control* 1998;26: 453-64.
36. Tang JW, Li Y, Eames I, et al. Factors involved in the aerosol transmission of infection and control of ventilation in healthcare premises. *J Hosp Infect* 2006;64: 100-14.
37. Atkinson J, World Health Organization. *Natural ventilation for infection control in health-care settings*. Geneva: World Health Organization; 2009.
38. Centers for Disease Control and Prevention. Interim Infection Prevention and Control Recommendations for Patients with Suspected or Confirmed Coronavirus Disease 2019 (COVID-19) in Healthcare Settings. [Available at: https://www.cdc.gov/coronavirus/2019-ncov/infection-control/control-recommendations.html. Accessed 2 April 2020.
39. Hui DS, Chow BK, Chu L, et al. Exhaled air dispersion and removal is influenced by isolation room size and ventilation settings during oxygen delivery via nasal cannula. *Respirology* 2011;16: 1005-13.
40. Hui DS, Hall SD, Chan MT, et al. Exhaled air dispersion during oxygen delivery via a simple oxygen mask. *Chest* 2007;132: 540-6.
41. Yu IT, Xie ZH, Tsoi KK, et al. Why did outbreaks of severe acute respiratory syndrome occur in some hospital wards but not in others? *Clin Infect Dis* 2007;44: 1017-25.
42. Tang JW, Liebner TJ, Craven BA, et al. A schlieren optical study of the human cough with and without wearing masks for aerosol infection control. *J R Soc Interface* 2009;6 Suppl 6: S727-36.
43. Hui DS, Chow BK, Chu L, et al. Exhaled air dispersion during coughing with and without wearing a surgical or N95 mask. *PLoS One* 2012;7: e50845.
44. Powers WJ, Rabinstein AA, Ackerson T, et al. Guidelines for the Early Management of Patients With Acute Ischemic Stroke: 2019 Update to the 2018 Guidelines for the Early Management of Acute Ischemic Stroke: A Guideline for Healthcare Professionals From the American Heart Association/American Stroke Association. *Stroke* 2019;50: e344-e418.
45. Shi S, Qin M, Shen B, et al. Association of Cardiac Injury With Mortality in Hospitalized Patients With COVID-19 in Wuhan, China. *JAMA Cardiol* 2020.
46. Bonow RO, Fonarow GC, O'Gara PT, et al. Association of Coronavirus Disease 2019 (COVID-19) With Myocardial Injury and Mortality. *JAMA Cardiol* 2020.
47. Guo T, Fan Y, Chen M, et al. Cardiovascular Implications of Fatal Outcomes of Patients With Coronavirus Disease 2019 (COVID-19). *JAMA Cardiol* 2020.
48. Anesthesia Patient Safety Foundation. FAQ on Anestheisa MAchine Use, Protection, and Decontamination During the COVID-19 Pandemic. [Available at:

https://www.apsf.org/faq-on-anesthesia-machine-use-protection-and-decontamination-during-the-covid-19-pandemic/#gas. Accessed 2 April 2020.

Figure 1: Flow chart to guide anesthetic management of patients presenting for endovascular therapy (EVT) of acute ischemic stroke (AIS) during the pandemic of coronavirus disease 2019. Abbreviations: NIHSS National Institutes of Health Stroke Scale/Score, ED emergency department, IR interventional radiology, HEPA high efficiency particulate air, ETT endotracheal tube. *It is recognized that patients in acute respiratory distress / hypoxemia may require emergent intubation in the emergency department.

Endovascular Therapy for Acute Ischemic Stroke

(All EVTs Should Proceed With Airborne Precautions)



*It is recognized that patients in acute respiratory distress / hypoxemia may require emergent intubation in ED. Patients suffering from AIS while already in hospital and requiring GA for EVT should be intubated safely is a suitable negative pressure location while minimizing delays in reperfusion.