



Original research

# Monitored anesthesia care during mechanical thrombectomy for stroke: need for data-driven and individualized decisions

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## ABSTRACT

**Background** The optimal anesthesia management for patients with stroke undergoing mechanical thrombectomy (MT) during the COVID-19 pandemic has become a matter of controversy. Some recent guidelines have favored general anesthesia (GA) in patients perceived as high risk for intraprocedural conversion from sedation to GA, including those with dominant hemispheric occlusions/aphasia or baseline National Institutes of Health Stroke Scale (NIHSS) score >15. We aim to identify the rate and predictors of conversion to GA during MT in a high-volume center where monitored anesthesia care (MAC) is the default modality.

**Methods** A retrospective review of a prospectively maintained MT database from January 2013 to July 2020 was undertaken. Analyses were conducted to identify the predictors of intraprocedural conversion to GA. In addition, we analyzed the GA conversion rates in subgroups of interest.

**Results** Among 1919 MT patients, 1681 (87.6%) started treatment under MAC (median age 65 years (IQR 55–76); baseline NIHSS 16 (IQR 11–21); 48.4% women). Of the 1677 eligible patients, 26 (1.6%) converted to GA including 1.4% (22/1615) with anterior and 6.5% (4/62) with posterior circulation strokes. The only predictor of GA conversion was posterior circulation stroke (OR 4.99, 95% CI 1.67 to 14.96, P=0.004). The conversion rates were numerically higher in right than in left hemispheric occlusions (1.6% vs 1.2%; OR 1.37, 95% CI 0.59 to 3.19, P=0.47) and in milder than in more severe strokes (NIHSS ≤15 vs >15: 2% vs 1.2%; OR 0.62, 95% CI 0.28 to 1.36, P=0.23).

**Conclusions** Our study showed that the overall rate of conversion from MAC to GA during MT was low (1.6%) and, while higher in posterior circulation strokes, it was not predicted by either hemispheric dominance or stroke severity. Caution should be given before changing clinical practice during moments of crisis.

## INTRODUCTION

The optimal anesthesia management for patients with acute ischemic stroke undergoing mechanical thrombectomy (MT) during the COVID-19 pandemic has become a matter of significant controversy.<sup>1–3</sup> Given the known limitations to access to medical history in the setting of acute

stroke and the fact that most patients with stroke are confused, aphasic, or otherwise incapable of providing the required information for COVID-19 screening, a temporary emergency guidance from the American Heart Association/American Stroke Association (AHA/ASA) recommended that every Code Stroke patient should be treated as potentially infected.<sup>4</sup> Endotracheal intubation is a high-risk procedure for the transmission of SARS-CoV-2 infection due to the excessive generation of aerosols.<sup>5</sup> Thus, intubation should be performed under the most controlled possible environment which would ideally include a negative pressure room and the use of video-assisted intubation devices.<sup>5,6</sup> In order to avoid the added risks associated with unplanned intraprocedural intubation, the Society for Neuroscience in Anesthesiology and Critical Care (SNACC) recommended the upfront use of general anesthesia (GA) for all stroke patients undergoing MT who are perceived as having high risk for intraprocedural conversion from sedation to GA, including those with dominant hemispheric occlusions/aphasia, posterior circulation occlusions, or severe neurological deficits (baseline National Institutes of Health Stroke Scale (NIHSS) score >15), while favoring monitored anesthesia care (MAC) for those presenting with non-dominant hemispheric strokes and a baseline NIHSS score <15.<sup>1</sup> Similarly, the Society of NeuroInterventional Surgery (SNIS) recommended prophylactic intubation for patients with dominant hemisphere occlusions, very high NIHSS score, or posterior circulation occlusions if their COVID-19 status was positive or unknown.<sup>2</sup>

However, there is a paucity of data on the predictors of GA conversion during MAC for MT and the evidence to support that either hemispheric dominance or stroke severity should guide decisions is suboptimal. Unwarranted changes in workflow might lead to treatment delays and worse outcomes. Moreover, these recommendations might increase the risk of exposure due to a potentially large number of unnecessary intubations during a time of crisis when rational utilization of personnel and resources becomes even more critical. Against this background, we aimed to identify the rates and predictors of emergent conversion to GA during

MT in a high-volume center where MAC is the default anesthesia modality.

## METHODS

### Patients and procedures

We conducted a retrospective review of a prospectively maintained MT database of a high-volume comprehensive stroke center for the period from January 2013 to July 2020. Patients were included in the primary analysis if they presented with acute ischemic stroke and underwent MT under MAC as the initial anesthesia modality. Patients in whom GA was used from the beginning of the procedure were assessed in a secondary analysis. Evaluated variables included patients' demographics, stroke-related risk factors, and other baseline clinical characteristics as well as the rates of successful reperfusion (modified Thrombolysis in Cerebral Infarction (mTICI) 2b–3), symptomatic intracranial hemorrhage (sICH, defined as any ICH on follow-up imaging associated with  $\geq 4$ -point increase in the NIHSS), good outcomes (modified Rankin Scale (mRS) score  $\leq 2$ ), and mortality at 90 days. The primary analysis aimed to identify the potential predictors of intraprocedural conversion from MAC to GA as well as the GA conversion rates in predefined subgroups of interest including baseline NIHSS score (both continuous and dichotomized at  $\leq 15$  vs  $> 15$ ), stroke laterality (right vs left hemisphere), occlusion site involving the posterior circulation occlusion, age, body mass index (both continuous and dichotomized at  $\leq 30$  vs  $> 30$ ), and ejection fraction on transthoracic echocardiography. Secondary analyses were performed to explore differences in characteristics of patients undergoing upfront GA versus MAC. The Institutional Review Board approved this study.

### Institutional anesthesia protocol for mechanical thrombectomy in stroke

Our anesthesia care team includes an attending anesthesiologist supervising a nurse anesthetist or anesthesiologist assistant. The anesthesiology team is involved in all MT cases and the decisions regarding the anesthesia modality are made by the anesthesiologist in conjunction with the stroke and neuroendovascular teams. MAC is the default modality in our center for all patients who are non-intubated on hospital arrival, with GA typically being reserved for patients who present with acute respiratory distress and/or hypoxemia, active vomiting, uncontrollable cough, severe and refractory agitation as well as those who are unable to protect their airways. Specifically, we do not consider stroke severity, laterality, and occlusion site (including distal occlusions and vertebrobasilar occlusions) as indications for the upfront use of GA in the absence of the aforementioned factors. Over 95% of our MAC procedures use dexmedetomidine infusion (loading dose 0.5–1  $\mu\text{g}/\text{kg}$  delivered for 10 min followed by a maintenance infusion of 0.5–1  $\mu\text{g}/\text{kg}/\text{hour}$ ) with supplemental fentanyl and midazolam as needed. For most patients, blood pressure (BP) measurements are non-invasive and arterial lines are usually reserved for patients with known or suspected cardiac dysfunction. For patients receiving intravenous alteplase, we follow established BP guidelines ( $< 180/105$  mmHg). Otherwise, we aim to maintain the target BP as close to the preprocedural levels as possible (systolic between 140 and 180 mm Hg),<sup>7</sup> carefully avoiding any fall in mean arterial pressure from baseline  $\geq 10\%$  as we have previously identified this as a strong risk factor for poor outcomes.<sup>8</sup> Once reperfusion is achieved, we start aggressive blood pressure control with the goal of systolic BP  $< 130$  or 140 mm Hg.

## Statistical analysis

Continuous variables were described using medians and interquartile ranges (IQR) and were compared using the Mann–Whitney U test. Categorical variables were reported as frequencies and percentages and were compared using Pearson's  $\chi^2$  and Fisher's exact tests as appropriate. The associations between hypothesized predictors and conversion from MAC to GA were evaluated using ORs, areas under the ROC curve (AUC), and their respective 95% confidence intervals. ORs were computed for each potential predictor using separate binary logistic regressions. Adjusted analyses were not conducted due to the small sample size for the GA conversion group in face of its very low event rates. Multivariable analyses were performed to identify predictors of procedure start under GA in the overall and anterior circulation only populations; all variables with  $P < 0.1$  in univariate analyses were included in a logistic regression model. Analyses were conducted using R Version 3.5.1 R Core Team).

## RESULTS

### Primary analysis

A total of 1919 patients underwent MT at our center over the study period. Of these, 1681 (87.6%) patients had their procedures initiated under MAC. The median age was 65 years (IQR 55–76), 813 (48.4%) were women, and the median baseline NIHSS score was 16 (IQR 11–21). After exclusion of four patients (three with bilateral stroke and one with azygos anterior cerebral artery occlusion), 1677 patients were eligible for the primary analysis. Only 26 (1.6%) patients were converted from MAC to GA. Table 1 summarizes the baseline characteristics and outcomes in patients who completed the entire procedure under MAC versus those who required conversion to GA. Figure 1 provides a breakdown of the overall MAC cohort into the different patient subgroups according to site of occlusion, stroke laterality, and clinical severity along with their respective conversion rates. On unadjusted comparisons, the conversion rates were higher in posterior circulation than in anterior circulation occlusions (6.5% vs 1.4%; OR 4.99, 95% CI 1.67 to 14.96,  $P = 0.004$ ). However, the rates were comparable between right and left hemispheric occlusions (1.6% vs 1.2%; OR 1.37, 95% CI 0.59 to 3.19,  $P = 0.47$ ), and in the presence of more severe versus milder strokes (NIHSS  $> 15$  vs  $\leq 15$ , 1.2% vs 2%; OR 0.62, 95% CI 0.27 to 1.36,  $P = 0.23$ ).

The only identifiable predictor of emergent conversion to GA was posterior circulation strokes (table 2, figure 2). Baseline NIHSS score was not associated with conversion to GA when considered either as a continuous variable (OR 0.96, 95% CI 0.90 to 1.02,  $P = 0.96$ ; AUC = 0.58, 95% CI 0.46 to 0.69) or when dichotomized at 15. Stroke laterality was not a predictor of conversion to GA; however, there were greater numerical odds with right hemisphere occlusions than with left hemisphere occlusions. Similarly, body mass index (BMI) was not a significant predictor when entered as a continuous predictor (OR 1.02, 95% CI 0.97 to 1.07,  $P = 0.52$ ) or dichotomized at 30 (OR 1.06, 95% CI 0.47 to 2.40,  $P = 0.89$ ). Finally, neither age nor ejection fraction on echocardiography were found to be predictors of conversion to GA. Notably, compared with patients who completed the entire procedure under MAC, converted patients had significantly longer procedural times (median (IQR) 53 (34–80) vs 101.5 (72.5–130) min,  $P < 0.001$ ) and showed significantly lower rates of functional independence at 90 days (mRS 0–2, 51.6% vs 28.6%,  $P = 0.037$ ). However, there were no significant differences in the rates of successful reperfusion, sICH, or 90-day mortality across the groups (table 1).

**Table 1** Baseline characteristics and outcomes in patients who completed the procedure under monitored anesthesia care (MAC) versus those who required conversion to general anesthesia (GA)

	MAC n=1651	Converted to GA n=26	P value
<b>Demographic and clinical characteristics, n (%)</b>			
Age (years), median (IQR)	65 (55–76)	63.5 (54.25–76)	0.87
Female	799 (48.4)	11 (42.3)	0.54
Ethnic background			
White	738 (44.7)	12 (46.2)	
Black/African American	684 (41.4)	12 (46.2)	
Hispanic	60 (3.6)	1 (3.8)	
Asian	37 (2.2)	0 (0)	
Other	132 (8)	1 (3.8)	0.95
BMI (kg/m <sup>2</sup> ), median (IQR)	27.90 (24.20–32.28)	28.05 (23.90–34.41)	0.82
BMI (kg/m <sup>2</sup> )			
>30	n=1455 517 (35.5)	n=24 9 (37.5)	
≤30	938 (64.5)	15 (62.5)	0.84
Hypertension	1217 (73.7)	23 (88.5)	0.11
Diabetes mellitus	560 (33.9)	12 (46.2)	0.19
Smoking	338 (20.9)	7 (28)	0.38
Hypercholesterolemia	554 (33.6)	13 (50)	0.08
Atrial fibrillation	537 (32.5)	11 (42.3)	0.92
White blood cell count (x10 <sup>9</sup> /L), median (IQR)	8.3 (6.4–10.8)	9 (7.6–11.45)	0.18
Ejection fraction (%), median (IQR)	55 (50–60)	57.5 (50–65)	0.35
Baseline NIHSS score, median (IQR)	16 (11–21)	13 (9.75–18.5)	0.18
Baseline NIHSS score			
>15	n=1640 888 (54.1)	n=26 11 (42.3)	
≤15	752 (45.9)	15 (57.7)	0.23
Site of occlusion			
Anterior circulation			
Cervical ICA	71 (4.3)	1 (3.8)	
Intracranial ICA	247 (15)	2 (7.7)	0.06
MCA-M1/M2	1193 (72.3)	17 (65.4)	
MCA-M3	41 (2.5)	1 (3.8)	
ACA	41 (2.5)	1 (3.8)	
Posterior circulation	58 (3.5)	4 (15.4)	
Stroke side			
Left	849 (51.4)	10 (38.5)	0.018
Right	744 (45.1)	12 (46.2)	
ASPECTS median (IQR)	8 (7–10)	9 (6.5–10)	0.45
rCBF <30% mL, median (IQR)	6 (0–22.1)	9.55 (0–34.15)	0.28
Tandem occlusion	169 (10.2)	1 (3.8)	0.51
Last known well to puncture (min), median (IQR)	368.5 (225–675)	458 (222–731)	0.68
Procedure duration (min), median (IQR)	53 (34–80)	101.5 (72.5–130)	<0.001
IV-tPA	576 (34.9)	8 (30.8)	0.66
<b>Outcome n (%)</b>			
Successful reperfusion (mTICI 2b–3)	1579 (95.6)	23 (88.5)	0.11
sICH	65 (3.9)	0 (0)	0.62
90-day mRS 0–2	661/1282 (51.6)	6/21 (28.6)	<b>0.037</b>
90-day mortality	233/1282 (18.2)	6/21 (28.6)	0.22

ACA, anterior cerebral artery; ASPECTS, Alberta Stroke Program Early CT Score; BMI, body mass index; ICA, internal carotid artery; IV-tPA, intravenous tissue plasminogen activator; MCA, middle cerebral artery; mRS, modified Rankin Scale; rCBF, relative cerebral blood flow; NIHSS score, National Institute of Health Stroke Scale score; sICH, symptomatic intracranial hemorrhage.

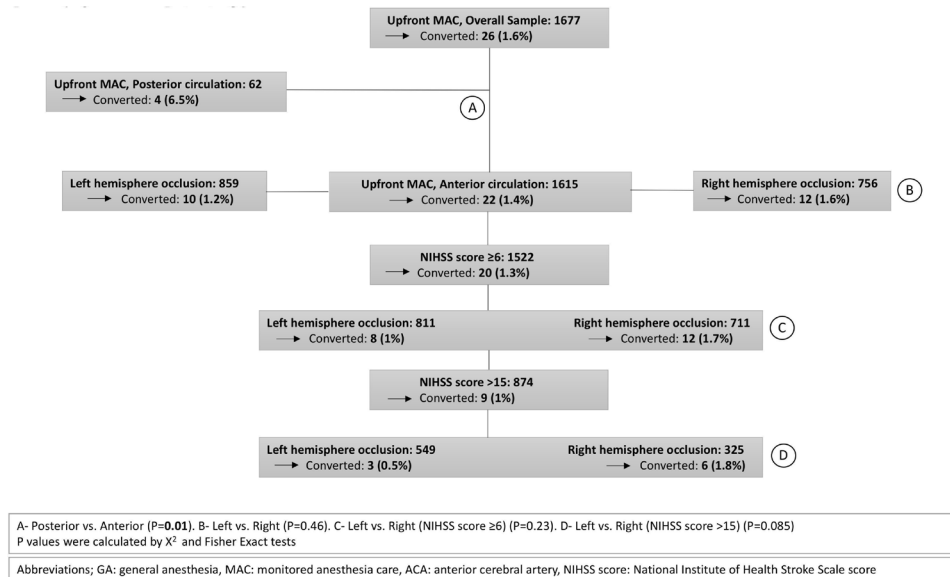


Figure 1 Conversion rates to general anesthesia.

Secondary analysis

Online supplemental tables show the details for MAC versus GA cohorts as well as the predictors of procedure start under GA in the overall population (online supplemental tables I and II) and the anterior circulation only population (online supplemental tables III and IV). A total of 238 (12.4%) patients underwent MT under GA over the study period. Compared with MAC patients, GA patients were younger (median (IQR) 64 (52.75–74) years vs 65 (55–76) years, P=0.04), with a trend to fewer women (41.6% vs 48.4%, P=0.05), higher baseline NIHSS score (22 (17–29) vs 16 (11–21), P<0.001, although evaluation was confounded by intubation status), higher white blood cell count (10 (7.7–13) vs 8.4 (6.5–10.8) × 10<sup>9</sup>/L, P<0.001), and more often with posterior circulation occlusions (60.3% vs 39.7%, P<0.001) as well as left anterior circulation occlusions (64.1% vs 53.2%, P<0.001). On multivariate analysis, patients with a higher baseline NIHSS score (OR 1.160, 95% CI 1.124 to 1.198, P<0.001), posterior circulation occlusions (OR 15.577, 95% CI 9.174 to 26.447, P<0.001), higher white blood cell count (OR 1.037, 95% CI 1.013 to 1.062, P=0.003), and higher BMI (OR 1.027, 95% CI 1.001 to 1.055, P=0.045) were significantly more likely to be treated with upfront GA than with MAC. However, these findings could have been confounded by decisions made

at the outside hospitals as 140 (58.8%) of the 238 patients who received GA arrived at the angiosuite intubated. In fact, the rates for pretreatment intubation in our angiosuite were similar for left and right hemispheric occlusions (4.8% (43/902) vs 4.2% (33/789), P=0.56) (online supplemental figure 1) and left hemispheric occlusion was not a predictor of upfront treatment under GA (OR 0.888, 95% CI 0.571 to 1.382, P=0.60), even when including the patients who were intubated prior to arrival at our center. There was a trend towards longer procedural duration (57 (35–93) vs 53 (34–81) min, P=0.07) in patients undergoing MT under GA versus MAC. The rates of 90-day functional independence were significantly lower (26.7% vs 51.3%, P<0.001) and the rates of both sICH (21.7% vs 3.9%, P=0.009) and 90-day mortality (43.6% vs 18.3%, P<0.001) were significantly higher in patients undergoing MT under GA versus MAC. However, these findings might be confounded by the presence of more severe strokes in the GA group.

DISCUSSION

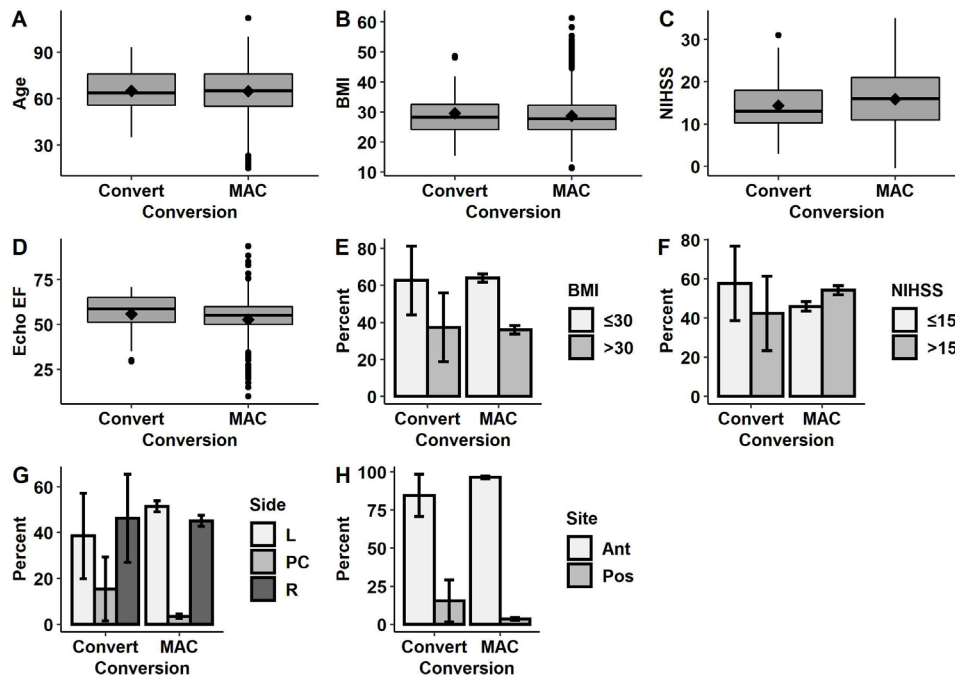
In the current study, performed in a high-volume stroke center with extensive experience with MAC for MT, the overall rate of intraprocedural conversion to GA was very low at only 1.6%,

Table 2 Predictors of intraprocedural conversion from monitored anesthesia care (MAC) to general anesthesia (GA)

Predictor	OR			AUC	
	OR	95% CI	P value	AUC	95% CI
Age	1.00	0.98 to 1.03	0.99	0.51	0.39 to 0.63
BMI (continuous)	1.02	0.97 to 1.07	0.52	0.47	0.34 to 0.59
BMI >30 kg/m <sup>2</sup>	1.06	0.47 to 2.40	0.89	–	–
NIHSS (continuous)	0.96	0.90 to 1.02	0.96	0.58	0.46 to 0.69
NIHSS >15	0.62	0.28 to 1.36	0.23	–	–
Echo ejection fraction	1.02	0.98 to 1.06	0.29	0.55	0.44 to 0.66
Occlusion site					
Right vs left	1.37	0.59 to 3.19	0.47	–	–
Posterior vs anterior	4.99	1.67 to 14.96	0.004	–	–

BMI, body mass index; NIHSS, National Institutes of Health Stroke Scale.





**Figure 2** Box and whisker plots depicting (A) age; (B) BMI; (C) NIHSS; (D) echo ejection fraction as a function of conversion status. For all box and whisker plots, the median is depicted as the horizontal line contained within each box and the mean is depicted as the diamond. Bar graphs depicting (E) BMI (dichotomized at 30); (F) NIHSS (dichotomized at 15); (G) lesion side (basilar/left/right); (H) lesion site (anterior/posterior) as a function of conversion status.

including 1.4% of the anterior circulation strokes and 6.5% of the posterior circulation strokes. Since the only predictor of intraprocedural conversion to GA was posterior circulation stroke, our findings call into question some of the recommendations made by the recent SNACC and SNIS guidelines for MT anesthesia management during the COVID-19 pandemic. Specifically, in our study, when considering both the overall patients as well as the subgroups of those presenting with baseline NIHSS  $\geq 6$  (stroke severity threshold for MT in the AHA guidelines)<sup>9</sup> and NIHSS  $> 15$ , patients with right hemispheric occlusion were numerically more likely to require intraprocedural conversion to GA than those with left hemispheric occlusions. Similarly, on a numerical basis, patients who presented with NIHSS score  $\leq 15$  were more likely to require GA conversion than those with NIHSS score  $> 15$ . In these specific scenarios, our findings are in contradiction to the aforementioned guidelines which support the preferential use of GA in patients with dominant hemispheric occlusions and/or aphasia as well as those presenting with high stroke severity (NIHSS  $> 15$ ). We therefore suggest caution when considering these criteria as neither stroke laterality nor clinical severity in isolation seem to provide any meaningful guidance in the decision-making process regarding anesthesia modality during MT.

During moments of crisis, we are pressed to make changes in response to new and often not well-known stressors. As such, it is understandable that initial responses may need to be revisited as more and better evidence emerges over time. Moreover, the knowledge about best anesthesia management for patients with stroke during the pandemic is understandably a rudimentary one and is mostly based on expert opinion in the face of very limited data. Indeed, no data were provided by SNACC guidelines to support the rationale for the preferential use of GA in patients with dominant hemispheric occlusions or high NIHSS ( $> 15$ ) on presentation, while the SNIS guidelines quoted the work of Hassan *et al* as a reference.<sup>1 2 10</sup> In this study, the authors

compared 60 aphasic patients who were electively intubated for MT with another 60 who did not undergo preprocedural intubation. Six of the 60 (10%) patients without preprocedural intubation required unplanned intraprocedural intubation. Notably, this 10% rate is within a similar range of patient series that have included all-comers (vs just aphasic patients), where the rates for emergency GA conversion have ranged between 6.3% and 15.6%, typically due to excessive patient movement or agitation.<sup>11–15</sup> In fact, Hassan *et al*<sup>10</sup> cautiously pointed out that aphasia was just anecdotally associated with a higher risk of unplanned intraprocedural intubation while reporting that times from imaging to arterial puncture were significantly longer, rates of good outcomes at discharge were significantly lower, and rates of any ICH and in-hospital mortality were significantly higher among aphasic patients undergoing preprocedural intubation. Finally, their study only included patients treated from 2003 to 2011, a period that preceded the incorporation of stent retrievers and large-bore catheters, which are the mainstream techniques in more contemporaneous times and are associated with shorter procedural times and also better reperfusion and improved functional outcomes. In contrast, we only included in our study patients treated after the year 2012 when the stent retriever technology was cleared by the Food and Drug Administration and was broadly used in our practice.<sup>16 17</sup> In another recent study, 25 (9.8%) of 254 patients with anterior circulation strokes undergoing MT required emergency conversion to GA while 94 (37%) were successfully treated under local anesthesia, 76 (29.9%) conscious sedation, and 59 (23.2%) primary GA. There were no significant differences in terms of baseline NIHSS (median (IQR) 17.0 (13.0–19.0) vs 15.0 (11.0–18.0)) or side of occlusion (left, 51.3% vs 50%) across patients who converted to GA versus those who did not. Time to reperfusion and the rates of successful reperfusion and functional independence in patients requiring emergent GA conversion were similar to those who had primary GA, supporting the view that intraprocedural

conversion is not necessarily a deleterious event.<sup>13</sup> It is important to mention that the SNACC guidelines clearly stated, at the time the directives were written, that there was a lack of prediction tools or established risk factors for conversion from MAC to GA.<sup>1</sup> Our study represents an early attempt to provide better data on this topic through the inclusion of over 1600 patients treated under MAC using contemporary MT techniques. Our findings of more GA conversions in right hemispheric occlusions is consistent with previous observations suggesting that acute confusional state and agitated delirium are more common presentations in right-sided as opposed to left-sided strokes, reflecting the right hemisphere dominance in terms of directed attention.<sup>18–20</sup> In fact, in our anecdotal experience, patients with neglect rather than aphasia are the ones who tend to be less cooperative and more agitated.

The recent SNACC and SNIS guidelines also recommended the upfront use of GA in patients with posterior circulation occlusions. A decreased level of consciousness requiring emergent intubation for airway protection is common in the setting of acute vertebrobasilar occlusion. Moreover, even in patients who are sufficiently alert on presentation, the possibility of intraprocedural changes in clot position possibly leading to sudden onset of bulbar weakness and/or depressed level of consciousness with inability to properly clear oral secretions and protect the airway has led to an overall preference for GA. In the current analysis, posterior circulation stroke was a predictor of intraprocedural conversion to GA (OR 4.99, 95% CI 1.67 to 14.96,  $P=0.004$ ); however, the conversion rates in patients with posterior circulation stroke were still relatively low (4/62, 6.5%). This suggests that, while the individual experience with the different anesthesia modalities and the local incidence of COVID-19 should remain the main considerations, it seems reasonable to adopt lower thresholds for upfront GA in the setting of posterior circulation occlusions.

We concur with the SNACC guidelines that centers currently using GA for most MTs should continue to do so with additional airborne precautions and that urgent conversion to GA is very likely associated with a higher risk of SARS-CoV-2 infection and, as such, should be avoided to the best of one's capabilities. However, as pointed out in the SNACC guidelines, there are many potential disadvantages surrounding the overuse of GA during the COVID-19 pandemic including the additional exposure to the anesthesia and ICU personnel involved in the intubation and extubation processes, the added risks associated with disruptions of the GA circuit (ie, cuff leak, suctioning, endotracheal tube manipulation), and the expected treatment delays associated with the modified GA workflows.

In this setting, we would like to caution about the untoward consequences of adopting an excessively low threshold for using GA based on the recently proposed stroke laterality or clinical severity criteria. For instance, of the 1681 patients in our series treated under MAC, only 425 (25.3%) presented with right hemispheric occlusions and baseline NIHSS score  $\leq 15$  and therefore GA would have been indicated to over three-quarters ( $n=1256$ ) of all our patients treated under MAC in order to avoid a few intraprocedural intubations. Notably, a recent study evaluating the experience of MT during the COVID-19 pandemic in 458 patients from 28 centers across five countries showed that, following scientific society recommendations, many centers adopted lower thresholds for intubation leading to significant workflow changes as the majority of these centers were not intubating most patients prior to the pandemic. Planned preprocedure GA occurred in 52.6% of the patients and was associated with significantly longer door to reperfusion times,

higher in-hospital mortality, and a lower likelihood of functional independence on discharge.<sup>21</sup> Notably, the overall rate of COVID-19 positive cases was low at 2.8% and only 1% (2/194) of all study patients required emergent unplanned intraprocedural intubation.

The present study has shown that patients converted to GA and those who had upfront GA had a higher white blood cell count than those who completed MT under MAC. Previous studies have reported that a raised white blood cell count before/after MT is a predictor of stroke severity, higher mortality, and lower rates of good functional outcomes.<sup>22,23</sup> In addition, patients with intraprocedural conversion to GA had a longer procedure duration than those who underwent the procedure under MAC, which could affect the outcome as well.

Finally, we feel it is important to revisit the existing data regarding optimal anesthesia options for MT and to understand that the evidence favors individualization in care rather than the prescription of any given modality. The HERMES meta-analysis pooled data from seven large multicenter randomized trials of anterior circulation thrombectomy versus the best medical management alone. While patients were not randomized to sedation versus GA, the multicenter nature allowed for the centers to choose the anesthesia modality with which they were most comfortable. Functional outcomes at 90 days were significantly better for patients who did not receive GA ( $n=561$ ) than for those who received GA ( $n=236$ ) (cOR 1.53, 95% CI 1.14 to 2.04,  $P=0.0044$ ).<sup>24</sup> Conversely, two recent meta-analyses<sup>25,26</sup> of three trials evaluating the impact of anesthesia modality on MT outcomes suggested that protocol-based GA ( $n=183$ ) was associated with better outcomes (cOR, 1.58, 95% CI 1.09 to 2.29,  $P=0.02$ ) than sedation ( $n=185$ ).<sup>26</sup> While this meta-analysis had the advantage of direct randomization to sedation versus GA, it only included three small single-center trials which limits the generalizability of the findings and also made the analysis prone to local biases in favor of anesthesia, as demonstrated by the significantly higher rates of reperfusion in the GA versus sedation groups (mTICI 2b–3: 85.2% vs 75.7%; OR 2.02, 95% CI 1.16 to 3.53,  $P=0.01$ ), a finding that lacks biological plausibility and has not been previously reported in any large prospective studies. However, these results do re-establish the equipoise regarding anesthesia in MT and highlight that decisions should be individualized and based on patients' characteristics and also on the experience of the treating centers. Notably, in our experience, the most common reasons for conversion to GA have been severe patient agitation (especially in prolonged procedures) and vomiting rather than respiratory depression/airway issues.

Our study has all the limitations inherent to any retrospective analysis. Moreover, as this was a single-center analysis, our results might be limited in generalization and be specific to high-volume centers with large experience performing MAC. In this setting, it also becomes important to consider that not all non-GA modalities are equal and differences in performance might exist across local anesthesia only, conscious sedation, and MAC. In addition, compared with our MAC patients, those in our upfront GA cohort tended to be younger, to have a higher baseline NIHSS score, and more often have posterior and left hemispheric occlusions. However, left-sided occlusion was not a predictor of GA, and as the patients in the GA cohort only represented a small proportion (12.4%) of our patients (of which 58.8% were intubated prior to our evaluation), it is unlikely that this could have served as a significant source of bias on our intraprocedural conversion rates. Finally, since MAC is the default anesthetic modality, the higher mortality and lower functional independence rates among the GA group might have been subjected to selection bias as patients given upfront GA

presumably had more severe strokes which could have served as a confounder despite our best attempts to adjust for imbalances.

## CONCLUSION

The rates of emergency conversion from MAC to GA during MT are low in experienced centers and are not predicted by either hemispheric dominance or stroke severity. Decisions regarding anesthesia modality in MT should consider both individual patient characteristics and local experiences. Caution should be given prior to adopting poorly studied criteria during a moment of crisis.

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