

# Updated New York City Emergency Medical Services Acute Stroke Triage Protocol Reduces Interfacility Transfers and Time to Endovascular Thrombectomy for Emergent Large Vessel Occlusion Stroke Patients

Jacob R. Morey,<sup>a</sup> Brian D. Kim,<sup>b</sup> Michael Redlener,<sup>a</sup> Xiangnan Zhang,<sup>c</sup> Naoum Fares Marayati,<sup>c</sup> Stavros Matsoukas,<sup>c</sup> Emily Fiano,<sup>c</sup> Laura K. Stein,<sup>b</sup> J Mocco,<sup>c</sup> Johanna T. Fifi<sup>b,c</sup>

<sup>a</sup>Department of Emergency Medicine, Icahn School of Medicine at Mount Sinai, New York, NY, USA

<sup>b</sup>Department of Neurology, Icahn School of Medicine at Mount Sinai, New York, NY, USA

<sup>c</sup>Department of Neurosurgery, Icahn School of Medicine at Mount Sinai, New York, NY, USA

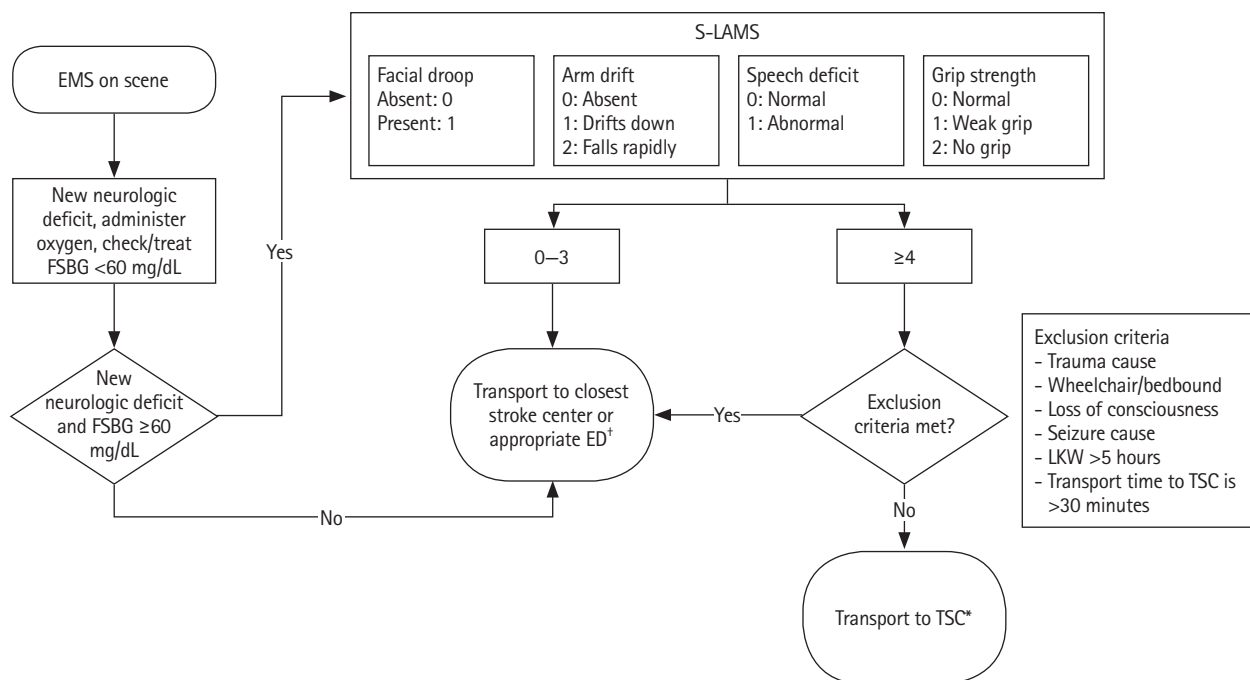
Dear Sir:

Systems of care for emergent large vessel occlusion (ELVO) stroke patients have evolved from a sole focus on intravenous thrombolysis (IVT) to also incorporate timely access to endovascular thrombectomy (EVT).<sup>1,2</sup> Prehospital Emergency Medical Services (EMS) triage has historically transported these patients to the closest stroke center for IVT, regardless of stroke center classification, with a subsequent transfer if the initial facility was not a Thrombectomy Capable Stroke Center (TSC). Triage of ELVO stroke patients directly to TSCs, possibly bypassing primary stroke centers (PSCs), has been modeled to improve treatment times and access to EVT.<sup>3</sup> These protocols have led to higher rates of EVT, improved time to EVT without delays to IVT, and potentially less disability at 3 months.<sup>4-6</sup> Our objective is to determine whether an updated New York City (NYC) EMS Acute Stroke Triage Protocol reduced the proportion of ELVO stroke patients requiring interfacility transfers and time to EVT.

This is a retrospective observational study using prospectively collected data (IRB-20-03285) at our health system (Mount Sinai Health System, New York, NY, USA), which consists of six emergency departments with three additional covered through affiliate agreements. Written informed consent by the patients was waived due to the retrospective nature of our study. Of these nine hospitals, four were TSCs (Supplementary Figure 1). These four TSCs are a subset of the 22 total TSCs across NYC participating in the updated NYC EMS Acute Stroke Triage Pro-

col enacted in April 2019 (Supplementary Figure 2). The protocol (Figure 1) was developed by the NYC Regional Emergency Medical Advisory Committee, NYC Fire Department, Greater New York Hospital Association, and American Heart Association.<sup>7</sup> It utilizes the Los Angeles Motor Scale with the addition of Speech (S-LAMS). This scale was chosen for ease of training EMS personnel and accuracy of detecting ELVO strokes, as compared to LAMS without Speech.<sup>7,8</sup> Direct medical oversight (DMO) is required and consists of emergency physicians trained in oversight of EMS with specific training in neurological emergencies. They are equipped with TSC availability and EMS medical records. Prior to the updated protocol, stroke patients were transported to the closest stroke center, regardless of classification, without contacting DMO. As with most high acuity conditions, there was still a pre-notification to the emergency department from EMS and the Cincinnati Prehospital Stroke Scale was used to communicate exam findings.

The study population included all ELVO stroke patients who underwent EVT between April 2018 to March 2020. Other inclusion criteria included a last known well (LKW)-to-EMS Arrival  $\leq 5$  hours. Exclusion criteria were inpatient status at time of stroke, non-EMS transport, or unknown LKW or EMS Arrival times. The primary endpoint was the proportion of ELVO stroke patients requiring an interfacility transfer for EVT and secondary endpoints were the time from EMS arrival to EMS left scene, initial hospital arrival, IVT, TSC arrival, and EVT access (Supplementary Methods and Appendix 1).



**Figure 1.** New York City Emergency Medical Services (NYC EMS) acute stroke triage protocol. S-LAMS, Los Angeles Motor Scale with the addition of Speech; FSBG, finger stick blood glucose; ED, emergency department; TSC, Thrombectomy Capable Stroke Centers; LKW, last known well; DMO, direct medical oversight. \*Per DMO approval; †e.g., trauma, treated hypoglycemia with resolved symptoms.

**Table 1.** Primary and secondary endpoints

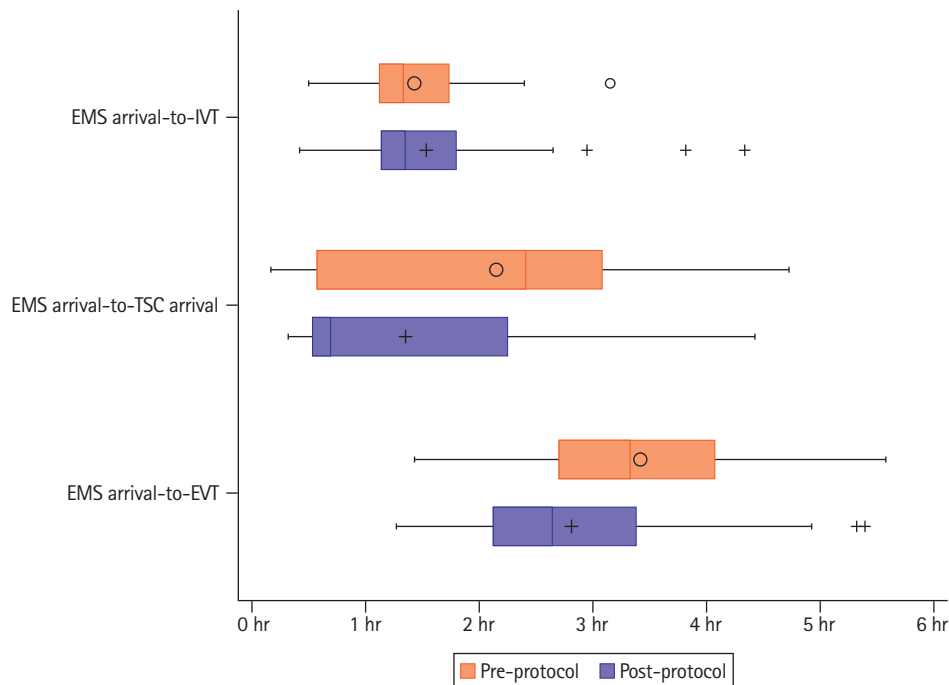
Variable	Pre-protocol (n=97)	Post-protocol (n=96)	P
Primary endpoint, % (n)			
Proportion of patients require an interfacility transfer	63.9 (62/97)	37.5 (36/96)	<0.01
Secondary endpoints, median (95% CI)			
EMS arrival-to-left scene	20.0 (17.0–21.0)	24.0 (22.0–26.0)	0.02
EMS arrival-to-IVT*	80.5 (75.0–87.0)	81.5 (73.0–95.0)	0.42
EMS arrival-to-initial hospital arrival†	28.0 (26.0–30.0)	33.5 (31.0–38.0)	<0.01
EMS arrival-to-TSC arrival	150.0 (115.0–161.0)	44.5 (39.0–55.0)	<0.01
EMS arrival-to-EVT access	209.0 (196.0–226.0)	164.0 (143.0–181.0)	<0.01

CI, confidence interval; EMS, Emergency Medical Services; IVT, intravenous thrombolysis; TSC, Thrombectomy Capable Stroke Center; EVT, endovascular thrombectomy.

\*54 pre-protocol, 62 post-protocol; †96 pre-protocol, 94 post-protocol.

Among 415 EVT cases, 193 patients were included and separated into pre- (April 2018 to March 2019; n=97) and post-protocol (April 2019 to March 2020; n=96) cohorts (Supplementary Figure 3). The cohorts were similar in age, sex, and past medical history, except for a higher proportion with atrial fibrillation in the pre-protocol cohort (46.4% vs. 31.3%, *P*=0.04). The median admission National Institutes of Health Stroke Scale was similar but the pre-stroke modified Rankin Scale was less in the post-protocol cohort (0.0 [2.0] vs. 0.0 [1.5], *P*=0.02). The breakdown of ELVO locations was different and LKW-to-EMS arrival and procedural details were similar. In the post-protocol cohort 28.1% were triaged as positive (Supplementary Table 1).

The primary endpoint, the proportion of ELVO stroke patients requiring an interfacility transfer, was significantly reduced following the implementation of the updated protocol (63.9% vs. 37.5%, *P*<0.01). The median EMS arrival-to-left scene (20.0 minutes vs. 24.0 minutes, *P*=0.02) and EMS arrival-to-initial hospital arrival (28.0 minutes vs. 33.5 minutes, *P*<0.01) were significantly longer post-protocol implementation but EMS arrival-to-IVT was similar (80.5 minutes vs. 81.5 minutes, *P*=0.42). The median EMS arrival-to-TSC arrival (150.0 minutes vs. 44.5 minutes, *P*<0.01) and EMS arrival-to-EVT access (209.0 minutes vs. 164.0 minutes, *P*<0.01) were both significantly faster post-protocol implementation (Table 1 and Figure 2).



**Figure 2.** Time intervals pre- and post-protocol implementation. EMS, Emergency Medical Services; IVT, intravenous thrombolysis; TSC, Thrombectomy Capable Stroke Center; EVT, endovascular thrombectomy.

We know from the Multicenter Randomized Clinical Trial of Endovascular Treatment for Acute Ischemic Stroke in the Netherlands (MR CLEAN) and Systematic Evaluation of Patients Treated With Stroke Devices for Acute Ischemic Stroke (STRATIS) registries that ELVO stroke patients requiring an interfacility transfer had significant delays to EVT, translating to worse outcomes at 3 months.<sup>9,10</sup> The updated protocol significantly reduced interfacility transfers and EMS arrival-to-EVT, similar to another high population density region, Stockholm, Sweden, which decreased interfacility transfers from 76% to 27% ( $P < 0.01$ ) and saved 69 minutes from LWK-to-EVT (206.0 vs. 137.0,  $P < 0.01$ ).<sup>4</sup>

Post protocol implementation, 28.1% of patients were triaged as positive and 37.5% required an interfacility transfer for EVT. Notably, none of the transferred patients were triaged as positive using the updated protocol (52.2% in this cohort who were not triaged as positive required interfacility transfer). Possible causes may be proper protocol adherence, protocol exclusion criteria, and unpredictable wait times from DMO. Per the protocol, DMO approval is required for direct transport to a TSC (even if it is the closer than a PSC). Therefore, EMS may not be able to follow the protocol if the DMO wait time is long. This may have led to the prolonged on-scene time interval (although this did not adversely impact treatment times) and a spillover effect of transporting patients directly to TSCs without DMO approval (hence the relatively low positive triage).

In a prior study, when a speech abnormality was added to a LAMS of 3, there was a sensitivity, specificity, and negative predictive value of 61%, 70%, and 90%, respectively, for detection of ELVO strokes.<sup>8</sup> This was similar to the Rapid Arterial Occlusion Evaluation (RACE) and an improvement upon LAMS (without speech), Cincinnati Prehospital Stroke Severity Scale, and 3-Item Stroke Scale.<sup>11</sup> A limitation of our study was the limited population of only ELVO stroke patients who underwent EVT.

The updated NYC EMS Acute Stroke Triage Protocol reduces the proportion of ELVO stroke patients requiring interfacility transfer for EVT, decreases time to EVT, and does not delay time to IVT. This study provides preliminary evidence that may be used for other regions to individualize triage protocols to decrease time to EVT in areas with TSC availability within a reasonable travel time.

## Supplementary materials

Supplementary materials related to this article can be found online at <https://doi.org/10.5853/jos.2022.01200>.

## References

1. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, et al. Guidelines for the early manage-

- ment 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.
2. Jauch EC, Schwamm LH, Panagos PD, Barbazzeni J, Dickson R, Dunne R, et al. Recommendations for regional stroke destination plans in rural, suburban, and urban communities from the Prehospital Stroke System of Care consensus conference: a consensus statement from the American Academy of Neurology, American Heart Association/American Stroke Association, American Society of Neuroradiology, National Association of EMS Physicians, National Association of State EMS Officials, Society of NeuroInterventional Surgery, and Society of Vascular and Interventional Neurology. Endorsed by the Neurocritical Care Society. *Stroke* 2021;52:e133–e152.
  3. Bosson N, Gausche-Hill M, Saver JL, Sanossian N, Tadeo R, Clare C, et al. Increased access to and use of endovascular therapy following implementation of a 2-tiered regional stroke system. *Stroke* 2020;51:908–913.
  4. Mazya MV, Berglund A, Ahmed N, von Euler M, Holmin S, Laska AC, et al. Implementation of a prehospital stroke triage system using symptom severity and teleconsultation in the Stockholm Stroke Triage study. *JAMA Neurol* 2020;77:691–699.
  5. Kass-Hout T, Lee J, Tataris K, Richards CT, Markul E, Weber J, et al. Prehospital comprehensive stroke center vs primary stroke center triage in patients with suspected large vessel occlusion stroke. *JAMA Neurol* 2021;78:1220–1227.
  6. Cabal M, Machova L, Vaclavik D, Jasso P, Holes D, Volny O, et al. New prehospital triage for stroke patients significantly reduces transport time of EVT patients without delaying IVT. *Front Neurol* 2021;12:676126.
  7. Magdon-Ismael Z, Benesch C, Cushman JT, Brissette I, South-erland AM, Brandler ES, et al. Establishing recommendations for stroke systems in the thrombectomy era: the upstate New York stakeholder proceedings. *Stroke* 2017;48:2003–2006.
  8. Brandler ES, Thode H, Fiorella D. The Los Angeles Motor Scale as a predictor of angiographically determined large vessel occlusion. *Intern Emerg Med* 2020;15:695–700.
  9. Venema E, Groot AE, Lingsma HF, Hinsenveld W, Treurniet KM, Chalos V, et al. Effect of interhospital transfer on endovascular treatment for acute ischemic stroke. *Stroke* 2019;50:923–930.
  10. Froehler MT, Saver JL, Zaidat OO, Jahan R, Aziz-Sultan MA, Klucznik RP, et al. Interhospital transfer before thrombectomy is associated with delayed treatment and worse outcome in the STRATIS Registry (Systematic Evaluation of Patients Treated With Neurothrombectomy Devices for Acute Ischemic Stroke). *Circulation* 2017;136:2311–2321.
  11. Ganti L, Oostema JA. How accurate are the stroke severity scales for identifying large vessel occlusions? *Ann Emerg Med* 2020;75:494–496.
- 
- Correspondence:** Johanna T. Fifi  
Department of Neurosurgery, The Mount Sinai Hospital, Klingenstein Clinical Center, Icahn School of Medicine at Mount Sinai, 1–N, 1450 Madison Ave, New York, NY 10029, USA  
Tel: +1-212-241-3400  
Fax: +1-646-537-2299  
E-mail: johanna.fifi@mountsinai.org  
<https://orcid.org/0000-0001-7786-5668>
- Received: April 11, 2022  
Revised: April 11, 2022  
Accepted: May 9, 2022
- The authors have no financial conflicts of interest.
-

## Supplementary Methods

### Data source

Data was sourced from our institution's prospectively collected stroke quality assurance database. The number of events were measured as counts and proportions where appropriate. Units of time were measured in minutes.

### Statistical analysis

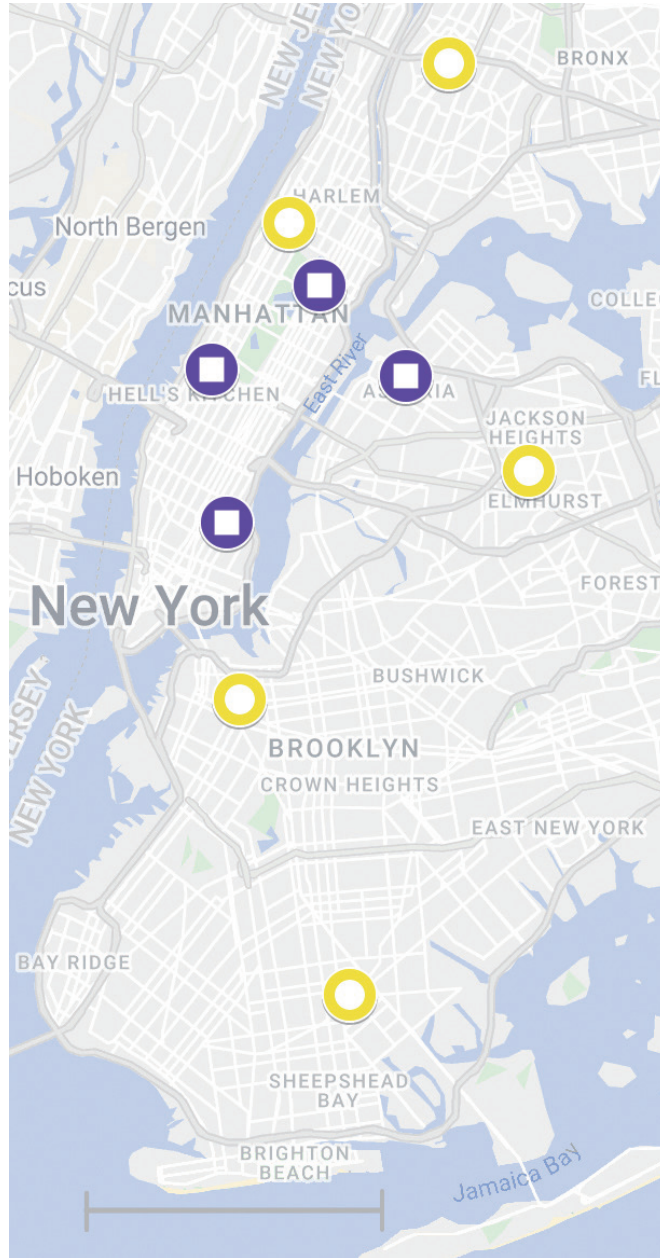
Continuous variables were compared with a Kaplan-Meier analysis and categorical variables were compared with the

Fisher's exact test or Cochran-Mantel-Haenszel test, where appropriate. Group statistics were reported as mean±standard deviation and median with interquartile ranges for continuous variables and counts with percentages for categorical variables. Statistical significance was set at  $P<0.05$ . Statistical analysis was performed with SAS version 9.4 (SAS Institute Inc., Cary, NC, USA). This study followed the Strengthening and Reporting of Observational Studies in Epidemiology reporting guidelines (Appendix 1).

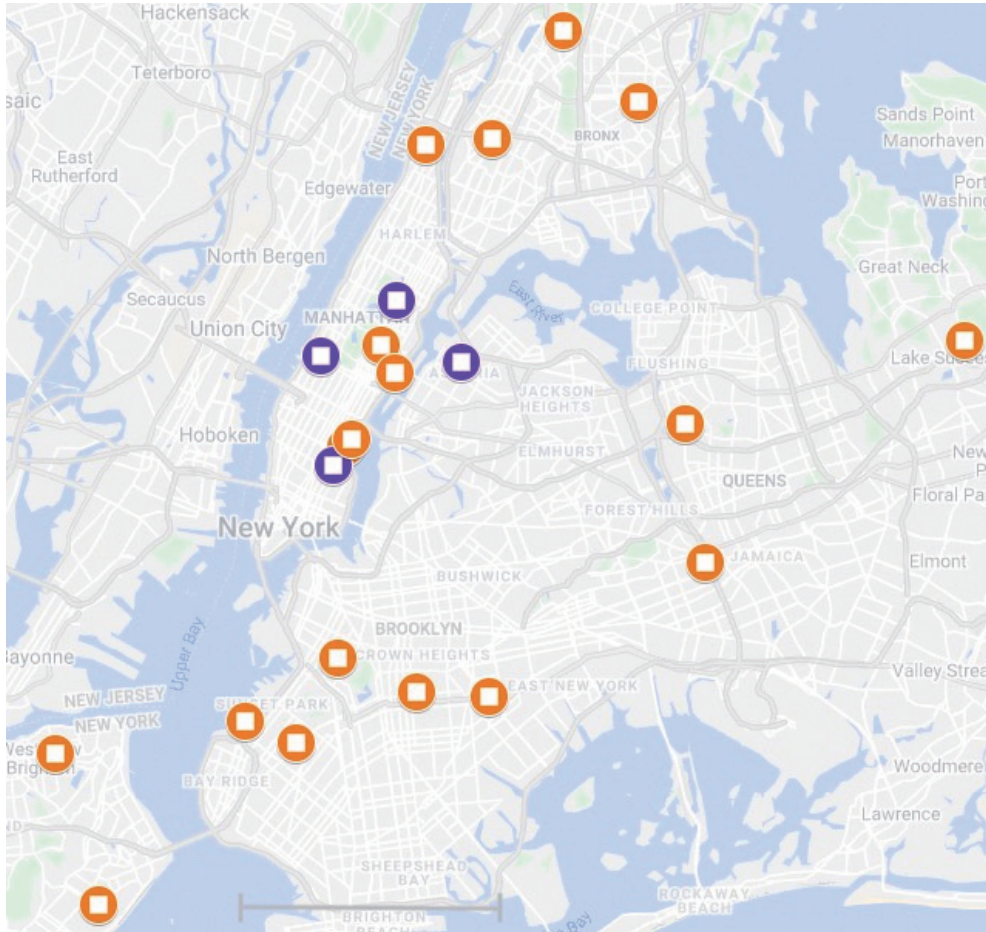
**Supplementary Table 1.** Baseline characteristics and treatment details

Baseline characteristic	Pre-protocol (n=97)	Post-protocol (n=96)	P
Age (yr), mean±SD	71.8±13.4	70.6±15.8	0.57
Male sex, % (n)	46.4 (45/97)	54.2 (52/96)	0.31
Atrial fibrillation, % (n)	46.4 (45/97)	31.3 (30/96)	0.04
Diabetes mellitus, % (n)	38.1 (37/97)	28.1 (27/96)	0.17
Hypertension, % (n)	75.3 (73/97)	68.8 (66/96)	0.34
Previous ischemic stroke or transient ischemic attack, % (n)	24.7 (24/97)	13.5 (13/96)	0.07
Admission NIHSS, mean±SD, median (IQR)	17.9±6.0, 18.0 (14.0–22.0)	16.6±6.3, 17.0 (14.0–21.0)	0.16
Pre-stroke mRS, mean±SD, median (IQR)	1.1±1.4, 0.0 (0.0–2.0)	0.7±1.2, 0.0 (0.0–1.5)	0.02
S-LAMS positive, % (n)	-	28.1 (27/96)	-
Occlusion location, % (n)			<0.01
ICA	20.6 (20/97)	9.4 (9/96)	
MCA (M1)	41.2 (40/97)	47.9 (46/96)	
MCA (M2)	18.6 (18/97)	22.9 (22/96)	
Basilar	13.4 (13/97)	6.3 (6/96)	
Other	6.2 (6/97)	13.5 (13/96)	
LKW-to-EMS arrival, median (95% CI)	36.0 (23.0–56.0)	48.0 (34.0–62.0)	0.44
Procedure details			
IVT, % (n)	55.7 (54/97)	64.6 (62/96)	0.24
Passes, mean±SD, median (IQR)	2.9±2.2, 2.0 (1.0–4.0)	2.5±2.0, 2.0 (1.0–3.0)	0.22
TICI 2B/3, % (n)	95.9 (93/97)	93.8 (90/96)	0.54

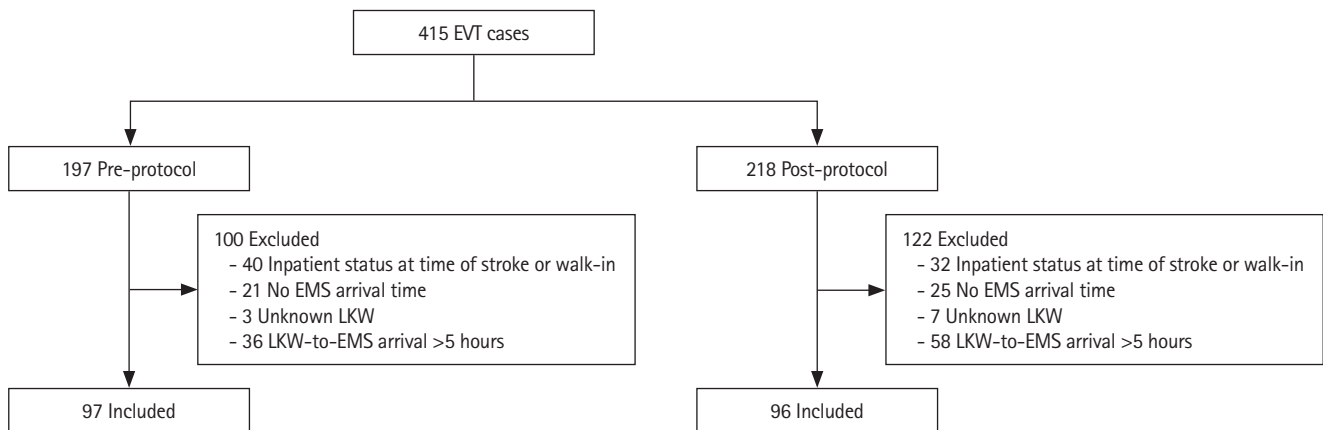
SD, standard deviation; NIHSS, National Institutes of Health Stroke Scale; IQR, interquartile range; mRS, modified Rankin Scale; S-LAMS, Los Angeles Motor Scale with the addition of Speech; ICA, internal carotid artery; MCA, middle cerebral artery; LKW, last known well; EMS, Emergency Medical Services; CI, confidence interval; IVT, intravenous thrombolysis; TICI, thrombolysis in cerebral infarction.



**Supplementary Figure 1.** Health system map. Map of the stroke center locations within our health system and affiliated referral hospitals. The purple squares designate the Thrombectomy Capable Stroke Centers and yellow circles designate the Primary Stroke Centers. The gray bar represents a 5-mile scale (Source: Google Maps, Google, Mount View, CA, USA).



**Supplementary Figure 2.** Map of Thrombectomy Capable Stroke Centers participating in the updated New York City (NYC) Emergency Medical Services (EMS) Acute Stroke Triage Protocol. Map of the Thrombectomy Capable Stroke Centers participating in the updated NYC EMS Acute Stroke Triage Protocol. The purple squares designate the Thrombectomy Capable Stroke Centers in our health system and orange squares designate the other Thrombectomy Capable Stroke Centers outside of our health system. The gray bar represents a 5-mile scale (Source: Google Maps, Google, Mount View, CA, USA).



**Supplementary Figure 3.** Cohort flow diagram. EVT, endovascular thrombectomy; EMS, emergency medical services; LKW, last known well.

Appendix 1. STROBE statement

	Item no.	Recommendation	Page no.
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found	1 NA
<b>Introduction</b>			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	2
<b>Methods</b>			
Study design	4	Present key elements of study design early in the paper	2
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	2
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (b) For matched studies, give matching criteria and number of exposed and unexposed	2, 3 NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	2
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5
Bias	9	Describe any efforts to address potential sources of bias	4
Study size	10	Explain how the study size was arrived at	2
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) If applicable, explain how loss to follow-up was addressed (e) Describe any sensitivity analyses	5 NA NA NA NA
<b>Results</b>			
Participants	13*	(a) Report numbers of individuals at each stage of study—e.g., numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	3, 5 5 5
Descriptive data	14*	(a) Give characteristics of study participants (e.g., demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (e.g., average and total amount)	5 5 NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	3
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorized (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	2, 3 NA NA
Other analyses	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	NA
<b>Discussion</b>			
Key results	18	Summarise key results with reference to study objectives	4
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	4
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	3, 4
Generalisability	21	Discuss the generalisability (external validity) of the study results	3, 4
<b>Other information</b>			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	NA

STROBE, Strengthening the Reporting of Observational Studies in Epidemiology; NA, not available.

\*Please see edits in the Supplementary Methods.