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Mobile Stroke Unit Computed Tomography Angiography Substantially Shortens Door-to-Puncture Time

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Abstract

Background and Purpose: Endovascular thrombectomy (ET) door to puncture time (DTPT) is a modifiable metric. One of the most important, yet time consuming steps, is documentation of large vessel occlusion (LVO) by CT angiography (CTA). We hypothesized that obtaining CTA on board a Mobile Stroke Unit (MSU) and direct alert of the ET team shortens DTPT by over 30 minutes.

Methods: We compared DTPT between patients having CTA on board the MSU then subsequent ET from 9/2018 to 11/2019 to MSU patients from 8/2014 to 8/2018, when on-board CTA was not yet being used. We also correlated DTPT with change in National Institutes of Health Stroke Scale (NIHSS) between baseline and 24 hours.

Results: Median DTPT was 53.5 (95% CI [35, 67]) minutes shorter with on-board CTA and direct ET team notification: 41 minutes (interquartile range, IQR 30.0–63.5) vs 94.5 minutes (IQR 69.8–117.3) ($p<0.001$). Median on-scene time was 31.5 minutes (IQR 28.8–35.5) vs 27.0 minutes (IQR 23.0–31.0) ($p<0.001$). Shorter DTPT correlated with greater improvement of NIHSS (correlation=−0.2, p=0.07).

Conclusion: Pre-hospital MSU management including on-board CTA and ET team alert substantially shortens DTPT.

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Subject Terms:

ischemic stroke; cerebrovascular disease/stroke; cerebrovascular procedures

Introduction:

Time from Emergency Department (ED) arrival to start of endovascular thrombectomy (ET) (door to puncture time, DTPT) is a modifiable metric. One of the most time-consuming steps within DTPT is documenting large vessel occlusion (LVO) by computed tomography angiography (CTA).

Prehospital management of acute ischemic stroke on a mobile stroke unit (MSU) can establish efficient workflow to reduce time to treatment. From 2014–2018, when CTA was deferred to after ED arrival, we found shorter DTPT when patients were evaluated and treated with tissue plasminogen activator (tPA) on a MSU than with standard Emergency Medical Services (EMS) management, but still averaged more than one hour (1). After 2018, in an effort to shorten DTPT, we obtained CTA on board the MSU and alerted the ET team en route if LVO was detected. We hypothesized this would shorten DTPT by over 30 minutes.

Methods:

The Benefits of Stroke Treatment Using a Mobile Stroke Unit (BEST-MSU) is a multi-center prospective cluster-randomized comparative effectiveness study of tPA eligible patients managed on a MSU vs EMS (NCT02190500) (2). BEST-MSU was Institutional Review Board approved, and consent obtained in all patients. Data supporting the findings of this study are available from the corresponding author.

Patients with suspected stroke within 4.5 hours of last seen normal are enrolled into BEST-MSU and evaluated on the MSU with non-contrast computed tomography (CT). tPA eligible patients are then immediately treated on scene. Patients from 2014 to the present are comparably selected and managed by the same MSU team. In this single-center BEST-MSU sub-study, after September 2018, on-board CTAs were obtained routinely after the tPA bolus in patients with NIHSS > 5 or cortical signs using a Ceretom 8 slice CT scanner with an OptiStat hand injector system (4milliliter/second). All imaging occurred on scene while the MSU was stationary following strict radiation safety guidelines. Patients with LVOs were then transported directly to a Comprehensive Stroke Center. The destination ED and ET team were notified en route, with direct transfer from ED to endovascular suite. All data, including time metrics, were recorded by the MSU team into the study database and compared to similarly obtained data on MSU ET patients from 2014–2018 having on-board CT only.

Baseline characteristics were summarized using descriptive statistics for categorical variables, and mean or median for continuous variables. A confidence interval for the difference in DTPT medians between the two groups was computed using bootstrap resampling. Groups were compared using Chi-square or Fisher's exact tests for categorical variables, and independent two-sample t-test or Wilcoxon rank-sum test for continuous variables. DTPT was correlated to change in NIHSS from baseline to 24 hours for the entire cohort using Spearman's. Analyses were conducted in R and significance level set at 0.05.

BEST-MSU will complete enrollment in 2020, after which the full range of ET process metrics including last seen normal, alert, on-scene and ED DTPTs, as well as the proportion of patients receiving ET and clinical outcomes in study-wide MSU vs EMS groups will be analyzed.

Results:

Forty-four patients had on-board CTA after September 2018, of which 40 were technically satisfactory. Twenty of these patients went for ET and were compared to 84 ET patients from 2014–2018 having on-board CT only. Baseline characteristics including NIHSS score and frequency of tPA were comparable (Table 1). The only differences were less frequent vessel imaging in the ED prior to groin puncture with the CT group (76.2% vs 100.0% of patients) (p=0.01), and fewer perfusion scans in the CT/CTA group (5.0% vs 36.9% of patients) (p=0.01).

Median DTPT was 53.5 (95% CI [35, 67], p<0.001) minutes shorter with on-board CTA and direct alert of the ET team from the MSU; 41.0 minutes (IQR 30.0–63.5) vs 94.5 minutes (IQR 69.8–117.3) (Table 2). If 2014–2018 data were confined only to the final year (1), the time saved was 28.0 minutes (41.0 minutes vs 69.0 minutes). Figure 1 shows the overall shift in the frequency distribution of DTPT towards significantly shorter times, with 25% of MSU CT/CTA cases having DTPT less than 30.0 minutes. Despite additional time to obtain the CTA on the MSU, on-scene times and alert to ED arrival were only slightly prolonged and did not offset the reduction in DTPT. A shorter DTPT correlated with greater improvement in NIHSS for the entire cohort (r=−0.2, p=0.07).

Discussion:

The main finding of our report is that obtaining a CTA on a MSU allows substantially faster ET treatment than "standard" MSU management with CT alone. Minimizing treatment times is pivotal in stroke, and guidelines call for organized systems of care to improve workflow (3). In addition to increased and faster thrombolytic treatment (4–7), MSUs could potentially improve the speed and accuracy of pre-hospital triage for ET.

Besides more frequent CTA and shorter DTPT, perfusion imaging was done less often in the MSU CT/CTA group. Although perfusion imaging requires extra minutes, it is unlikely to substantially contribute to the longer DTPT in the MSU CT group. Furthermore, the utility of advanced imaging within the early time window is unknown and perfusion imaging is not required within 6 hours of onset (3). Omitting perfusion imaging did not adversely affect outcome since the CT/CTA group had a trend to better outcome related to overall faster treatment.

An analysis of ET patients is a pre-specified sub-study of BEST-MSU. This analysis of DTPT was conceptualized to assure quality improvement in patient management in BEST-MSU since ET has altered trends in patient management during the course of the study. In our recently published paper, while ET evaluation on a MSU resulted in faster DTPT compared to standard management by EMS (1), DTPT was greater than 60 minutes in both groups. To further improve our workflow, we began to routinely obtain CTA on our MSU and directly alert the ET team at receiving hospitals if LVO was identified. We conducted the present analysis of DTPT in MSU patients prior to analysis of the entire ET sub-study and prior to the primary study results because: (1) DTPT is only one component of the ET sub-study whose focus is alert to start of the procedure, (2) DTPT is an important dynamic metric evolving as a result of practice pattern changes in the ED and MSU that needs to be optimized for quality assurance purposes, (3) none of the primary or secondary outcomes of the BEST-MSU study were analyzed for this analysis; the investigators remain blinded to those outcomes.

Our study has limitations. Comparison of non-randomized patients over different time epochs is prone to confounding by evolving management besides CTA, as reflected in shorter DTPT seen yearly from 2014–2018 (1). It is possible that other factors besides on-board CTA contributed to faster DTPT after 2018 as well. This single center analysis limits generalizability to other centers with MSUs. Furthermore, DTPT is only one component of the overall impact of the MSU on time and can be improved further. In the final study analysis, we will be reporting last seen normal and alert to tPA (if given), imaging, door and puncture times to determine how the MSU affects each metric, and their relation to clinical outcomes. Our results are of importance even in the absence of outcome data to reflect changes in ED practice in MSU patients.

Conclusions:

Pre-hospital identification and notification of LVO by MSU substantially reduces DTPT. Earlier identification of LVO, efficient pre-hospital notification of ET teams, and a direct MSU to endovascular suite process may lead to better patient outcomes.

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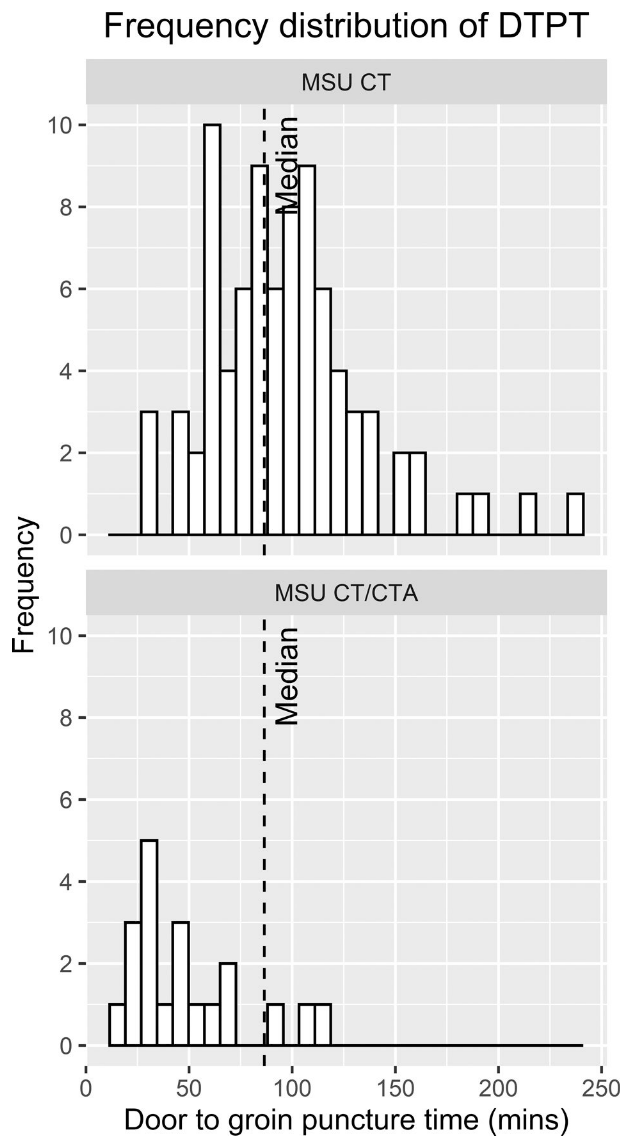

Figure 1:

Frequency distribution of DTPT between MSU CT and MSU CT/CTA groups.

Table 1:

Baseline cohort characteristics between MSU CT and MSU CT/CTA groups.

	MSU CT (n=84)	MSU CT/CTA (n=20)	p-value
Age (yr), mean (SD)	67 (14)	69 (12)	0.54
Male, n (%)	48 (57%)	12 (60%)	1.00
Initial NIHSS, median (IQR)	20.0 (12.8, 24.3)	19.5 (17.0, 22.3)	0.73
24hr NIHSS, median (IQR)	7.5 (1.8, 16.0)	13.0 (3.8, 17.5)	0.34
IV tPA, n (%)	75 (89%)	19 (95%)	0.68
Vessel imaging, n (%)	64 (76%)	20 (100%)	0.01
Perfusion imaging, n (%)	31 (37%)	1 (5%)	0.01

Abbreviations: Mobile stroke unit (MSU), computed tomography (CT), computed tomography angiography (CTA), year (yr), standard deviation (SD), National Institutes of Health Stroke Scale (NIHSS), interquartile range (IQR), tissue plasminogen activator (tPA)

Table 2:

Time metrics between MSU CT and MSU CT/CTA groups.

	MSU CT (n=84)	MSU CT/CTA (n=20)	p-value
DTPT (mins), median (IQR)	94.5 (69.8, 117.3)	41.0 (30.0, 63.5)	<0.001
MSU on-scene time (mins), median (IQR)	27.0 (23.0, 31.0)	31.5 (28.8, 35.5)	<0.001
Alert to ED arrival time (mins), median (IQR)	63.5 (53.0, 72.3)	68.5 (59.3, 79.0)	0.12

Abbreviations: Mobile stroke unit (MSU), computed tomography (CT), computed tomography angiography (CTA), door-to-puncture time (DTPT), minutes (mins), interquartile range (IQR), emergency department (ED)