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# Direct transfer for thrombectomy in patients with large vessel occlusions on computed tomography angiography results in safe revascularization

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## Abstract:

**INTRODUCTION:** Endovascular mechanical thrombectomy (EVT) has become the standard of care treatment for both intravenous tissue plasminogen activator eligible and ineligible patients presenting with an acute ischemic stroke due to a large vessel occlusion (LVO) within 24 h. Due to limited access to EVT, patients typically present to a non-EVT-capable center and are transferred to a larger, EVT-capable center. Quality improvement work has focused on improving this process to shorten the time to definitive recanalization of the affected vessel.

**MATERIALS AND METHODS:** We retrospectively reviewed 98 consecutive patients who were transferred from an outside institution to our Comprehensive Stroke Center from July 2019 to September 2021. Thirty-nine of these patients had a diagnosed LVO at the transferring center on computed tomography angiography and were transferred directly to the angiography suite (DAT) whereas 59 patients were transferred to our Emergency Department for further imaging (EDT). Three of the patients in the DAT group did not undergo thrombectomy as there was no LVO identified on catheter angiography and were excluded from the study.

**RESULTS:** Demographic and medical comorbidities were similar between the two groups. The DAT group had more severe strokes on presentation compared to the EDT group as measured by the National Institute of Health Stroke Severity (17.5 vs. 15,  $P = 0.048$ ). Last known well (LKW) to arrival time in the angiography suite was significantly shorter in the DAT group (280 min vs. 474 min,  $P = 0.002$ ). Patients in the DAT group were revascularized faster than the EDT group relative to LKW (320 min vs. 534 min,  $P < 0.001$ ) while door-to-groin puncture and door-to-revascularization rates were similar. Modified Rankin score, incidence of symptomatic intracranial hemorrhage, and need for decompressive hemicraniectomy were similar between the two groups. Successful revascularization as measured by thrombolysis in cerebral infarction score occurred at a higher rate in the DAT group but was not statistical significance (97% vs. 85%,  $P = 0.055$ ).

**DISCUSSION/CONCLUSION:** DAT resulted in safe EVT compared to EDT with significant improvement in LKW to angiography suite presentation and subsequent vessel recanalization. Patients who underwent DAT experienced similar functional outcomes compared to EDT despite experiencing more severe strokes.

## Keywords:

Acute stroke, computed tomography angiography, large vessel occlusion, mechanical thrombectomy

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## Introduction

Acute ischemic strokes secondary to large vessel occlusions (LVO) are highly morbidity and frequently fatal.

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Reperfusion with intravenous or intra-arterial lytic therapy has been proven to reduce disability if performed timely. Multiple randomized control trials have shown that endovascular mechanical thrombectomy (EVT) is superior to medical therapy alone and has extended the time window wherein revascularization may be performed.<sup>[1-5]</sup> Since these landmark studies, emphasis has been placed on improving systems of care to minimize time to reperfusion as outcomes are inversely related to time from initial imaging to reperfusion.<sup>[6,7]</sup> Because of limited access to thrombectomy in rural communities, a “spokes” and “hub” model has been adopted in many areas where a specialized center with mechanical thrombectomy capabilities – the “hub” – will receive patients after initial triage at a local community hospital – the “spokes.”

Unfortunately, delays may occur at many different points both at the non-EVT-capable center and at the EVT-capable center. Targeted quality improvement processes to streamline the transfer may help improve time to reperfusion and thereby long-term disability.<sup>[8,9]</sup> Certain “spokes” have access to advance imaging and are able to perform computed tomography (CT) angiography to identify an LVO before transfer. In these circumstances, it may be favorable to bypass triage in the emergency room of the “hub” and proceed directly to the operating room.<sup>[10,11]</sup> Oftentimes, this means forgoing a repeat noncontrast CT at the EVT-capable institution in favor of more timely presentation to the angiography suite.

In this study, we examine our institution’s outcomes for patients directly transferred to the angiography suite (DAT) after undergoing CT angiography at the transferring center to identify an LVO. Our primary objective was to evaluate the safety of forgoing emergency room triage as assessed by short and long-term clinical outcomes. Secondly, we were interested in analyzing the impact on the last known well (LKW) to revascularization and other time process metrics. Moreover, finally, we sought to assess whether direct transfer to the angiography suite would result in favorable clinical outcomes when compared to the conventional transfer method through the emergency department (EDT).

## Materials and Methods

This study in its entirety was approved by our institution’s Institutional Review Board (IRB) with consent exemption given the retrospective nature of the study and low risk to patient safety. Our study population was a single-institution retrospective case-control of patients transferred to our Comprehensive Stroke Center from July 2019 to September 2021. These

patients were all 18 years of age or older and had an acute ischemic stroke with an LKW within 24 h of presentation to our institution. All patients initially presented to a non-EVT-capable center and were transferred to our institution. LVO was defined as an occlusion of the 1<sup>st</sup> division of the anterior cerebral artery, internal cerebral artery, middle cerebral artery (MCA) within the 1<sup>st</sup> or 2<sup>nd</sup> subdivisions, basilar artery, or 1<sup>st</sup> subdivision of posterior cerebral artery as identified on CT angiography by the local reviewing physician.

All patients who met the guideline criteria for intravenous tissue plasminogen activator (IV-tPA) were treated accordingly.<sup>[12]</sup> All patients underwent noncontrast enhanced CT and were evaluated by a transferring neurologist through the telestroke system to obtain a National Institute of Health Stroke Severity (NIH-SS) score at the non-EVT-capable center. CT angiography was obtained by transfer centers where timely access to this technology was available. Patients ( $n = 39$ ) who had a diagnosed LVO on CT angiography and met criteria for direct transfer thrombectomy (LKW within 6 h, NIH-SS  $> 6$ , Alberta Stroke Program Early CT Score  $> 6$ , and modified Rankin score [mRS]  $< 4$ ) were transferred directly to our angiography suite for revascularization. Three of these patients did not undergo thrombectomy as there was no LVO identified on catheter angiography and were excluded from the study. These patients were compared to consecutive patients ( $n = 59$ ) over the same time period who were transferred to our emergency department for further triage and eventually underwent EVT.

One patient was excluded from this group who was transferred with an NIH-SS that was initially too low to qualify for thrombectomy and after several hours deteriorated in the Emergency Department and underwent EVT. Endovascular treatments included primary aspiration or retrievable stents with or without aspiration. Clinical outcomes included thrombolysis in cerebral infarction (TICI) score, length of stay, discharge mRS, 90-day mRS, need for decompressive hemicraniectomy, and symptomatic intracranial hemorrhage.<sup>[13]</sup> Successful revascularization was defined as TICI score of 2b or greater at the end of the procedure as interpreted by the treating physician.<sup>[14]</sup>

Demographic, baseline characteristics, and clinical outcomes for EDT patients and those transferred directly to DAT patients were compared. Univariate analysis was conducted on categorical and continuous variables to determine statistical significance. A Chi-squared test for significance was used to determine the significance of categorical variables, and a Mann-Whitney independent  $t$ -test was used to determine the significance for continuous variables. A  $P < 0.05$  was considered

statistically significant. Statistical analysis was done in JASP 0.16.4 (Amsterdam, The Netherlands) statistical software.

## Results

Baseline patient characteristics are grouped in Table 1. There were 59 patients in the group that underwent conventional transfer from outside institutions to our emergency department (EDT), and 36 patients who were transferred directly to the angiography suite for thrombectomy (DAT). Overall, demographic and medical comorbidities were similar between the two groups. The DAT group had more severe strokes on presentation compared to the EDT group ( $P = 0.048$ ). Table 2 organizes the outcome times based on the group. LKW to arrival at the facility time in the angiography suite was significantly shorter in the direct transfer group ( $P = 0.017$ ). Patients in the direct transfer group were revascularized faster than the EDT group ( $P < 0.001$ ). Table 3 shows a comparison of clinical outcomes between the two groups. mRS, incidence of symptomatic intracranial hemorrhage, and need for decompressive hemicraniectomy were similar between the two groups. Successful revascularization as measured by TICI score occurred at a higher rate in the direct angiography transfer group; however, this narrowly missed statistical significance ( $P = 0.055$ ).

## Discussion

Retrospective data comparing direct transfer to the angiography suite to conventional transfer has shown improvement in time to revascularization with a safety profile similar to that of conventional transfer.<sup>[10,11]</sup> As the stroke community awaits the results of the DIRECT ANGIO trial, a randomized multicenter-controlled trial comparing conventional transfer to direct transfer, many centers continue to experiment with targeted quality improvement interventions to improve time to revascularization.<sup>[15]</sup> In our retrospective, single-center work, we found that bypassing further triage and repeat noncontrast CT in the Emergency Department resulted in safe revascularization. Re-imaging in the emergency department may have efficacy in detecting intracranial hemorrhage specifically in cases of IV-tPA administration or precluding individuals with worsening cerebral ischemia from mechanical revascularization. To this point, rates of symptomatic intracranial hemorrhage did not differ between the DAT and EDT groups (12% vs. 14%,  $P = 0.773$ ) as did rates of decompressive hemicraniectomy (6% vs. 7%,  $P = 0.812$ ) with similar short- (33% vs. 37%,  $P = 0.746$ ) and long-term mRS (39% vs. 46%,  $P = 0.525$ ).

DAT resulted in improved time metrics. Patients arrived to our operating room more quickly (280 min vs. 474 min,  $P = 0.002$ ) and had shortened time to reperfusion

**Table 1: Comparison of baseline characteristics by transfer type**

Baseline patient characteristics			
Variable	Transfer location		P
	EDT (%)	DAT (%)	
Number of patients (percentage of total)	59 (62.1)	36 (37.9)	
Age (median)	69	66.5	0.452
Male	46	47	0.89
Prior CVA	14	17	0.679
CAD	17	14	0.691
Hypertension	71	64	0.458
DM	25	22	0.724
AF	31	28	0.777
Cancer	14	19	0.445
Smoker	53	64	0.279
Aspirin or clopidogrel	34	28	0.534
DOAC	8	11	0.67
Warfarin	5	11	0.305
mRS (median)	0	0	0.219
NIH-SS (median)	15	17.5	0.048*
Left-sided	60	47	0.243
ICA	27	19	0.397
M1	51	44	0.545
M2	24	31	0.464
P1	4	0	0.264
Basilar	4	6	0.61
IV-tPA	59	53	0.324
GA	47	64	0.119
Tandem lesions	17	11	0.436

\*denotes statistical significance ( $P$ -value  $< 0.05$ ). EDT: Emergency department, DAT: Directly to the angiography suite, CVA: Cerebrovascular accident, CAD: Coronary artery disease, DM: Diabetes mellitus, AF: Arterial fibrillation, DOAC: Direct-acting oral anticoagulants, mRS: Modified Rankin score, NIH-SS: National institute of health stroke severity, ICA: Internal cerebral artery, M1: 1<sup>st</sup> subdivision of the middle cerebral artery, M2: 2<sup>nd</sup> subdivision of the middle cerebral artery, BA: Basilar artery, PCA: 1<sup>st</sup> subdivision of posterior cerebral artery, IV-tPA: Intravenous tissue plasminogen activator, GA: General anesthesia

**Table 2: Comparison of time metrics by transfer type**

	Outcome times		
Variable (min)	Transfer location, mean (IQR)		P
	EDT	DAT	
LKW to arrival	421.2 (186-652)	280 (183-295)	0.017*
Arrival to OR	70.1 (25-64)	-	-
Door to puncture	6.0 (5-6.2)	5.6 (5-6)	0.203
Door to revascularization	35 (23-39)	40 (35-52.5)	0.469
LKW to revascularization	534 (286-884)	320 (226-334)	<0.001*

\*denotes statistical significance ( $P$ -value  $< 0.05$ ). LKW: Last known well, OR: Odds ratio, IQR: Interquartile range, EDT: Emergency department, DAT: Directly to the angiography suite

compared to EDT (320 min vs. 534 min,  $P < 0.001$ ) while the time from arrival to the operating room to groin puncture and to successful revascularization were similar for the two groups. DAT and EDT groups had similar baseline characteristics with the exception of presenting NIH-SS (17.5 vs. 15,  $P = 0.048$ ). Despite having more severe strokes at presentation, the DAT group had similar functional outcomes suggesting the benefit of expedited transfer and more rapid recanalization.

**Table 3: Clinical outcomes by transfer type**

Clinical outcomes			
Variable	Transfer location		P
	EDT (%)	DAT (%)	
TICI 2b-3	85	97	0.055
sICH	12	14	0.773
DHC	7	6	0.812
LOS (median)	8	8.5	0.56
Discharge mRS (0-2)	37	33	0.746
90d mRS (0-2)	46	39	0.525

TICI: Thrombolysis in ischemic stroke, sICH: Symptomatic intracranial hemorrhage, DHC: Decompressive hemicraniectomy, LOS: Length of stay, mRS: Modified Rankin score, EDT: Emergency department, DAT: Directly to the angiography suite

While it has now been consistently demonstrated retrospectively that direct transfer improves time to reperfusion, the effect on functional outcomes has varied. Sarraj *et al.* retrospective reviewed 327 patients who were transferred directly to angiography and found lower 3-month mortality and improved functional independence overall in the DAT group compared to the conventional transfer method.<sup>[10]</sup> However, Jadhav *et al.* retrospectively analyzed 111 patients directly transferred to the operating room showing comparable long-term outcomes with improved time to recanalization relative to the control group.<sup>[11]</sup> Preliminary prospective, single-center work done by Pfaff *et al.* showed improved time from imaging to groin puncture; however, this did not result in a difference in time to final reperfusion.<sup>[16]</sup> Our study differs in that we specifically rely on a CT angiography diagnosis of an LVO as a prerequisite to transfer to the operating room where as the aforementioned studies have used certain features of noncontrast CT such as a hyperdense MCA sign, magnetic resonance angiography, or conducted imaging in the angiography suite, which may introduce variability in thrombectomy selection.

There are several limitations to our study. It is retrospective in nature and nonrandomized with a relatively small sample size; however, our findings are consistent with previous retrospective work. The ability to conduct a direct transfer relies on the transferring centers access to timely CT angiography. It is likely that these centers have different triage protocols than centers without access to timely CT angiography that may result in more immediate transfers to our center in general. In our study, the time to arrival at the facility was longer in the EDT group potentially introducing selection bias. This may be due to the mechanism by which the patient was transferred (air versus ground) or a lack of health system alacrity due to the unknown likelihood of intervention. Delayed transfer times may place patients outside of our institution's 6-h window to forgo CT cerebral perfusion analysis further lengthening the time to intervention in the EDT group. Selection bias

may also be introduced based on the time of day of the transfer as direct transfer at our institution can only be performed during regular business hours when there is an in-house technical staff. Previous work has shown shorter times to treatment in DAT groups during work and on-call hours suggesting the benefit would likely be extended to overnight direct transfers given staff is able to be rapidly mobilized during both business and on-call hours.<sup>[10]</sup>

## Conclusion

DAT resulted in timely EVT compared to EDT with significant improvement in time to angiography and time to vessel recanalization. Functional outcomes including mRS, symptomatic intracranial hemorrhage, and need for decompressive hemicraniectomy were similar between the two groups. Further work is needed to elucidate the potentially efficacy of DAT compared to conventional transfer protocols.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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