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Original article

The Impact of a TPA Unit during the COVID-19 Pandemic on Inpatient Length of Stay and Outcomes for Ischemic Stroke

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Abstract

Background: Resource allocation can be problematic in ischemic stroke receiving IV thrombolysis (tPA) during COVID-19 pandemic as only a subset requires critical care interventions. It is also unknown whether the usage of non-ICU stroke unit for post-tPA care has better patient outcome compared to ICU. ***Methods:*** A pilot study in a single tertiary medical center, in which one-bed tPA unit was created in a non-ICU Stroke Unit during the COVID-19 pandemic, with the provision of ICU level of nursing care. We included 123 consecutive ischemic stroke patients treated with tPA, included in an institutional registry between October 2020 and December 2021. The primary outcome of interest was inpatient length of stay (LOS). The secondary outcome of interest was the 90-day clinical outcomes. ***Results:*** Amongst a total of 123 patients, control group consisted of 98 (79.7%) patients who received standard post-tPA care in an ICU, and the study group consisted of 25 (20.3%) patients who received standard post-tPA care in Stroke Unit. There were no statistically significant differences between the 2 groups in terms of median LOS or median 90-day NIHSS. However, the median 90-day mRS was lower in the study group compared to the ICU group (0 IQR (0-1) vs. 2 (1-5); P=0.0011). The 90-day death outcome was also lower in the study group compared to the control (0% vs. 25.5%, P<0.05). ***Conclusion:*** Providing post-tPA care in non-ICU with the ICU level of neurological nursing care did not reduce length of stay but improved the functional outcome for post-tPA ischemic stroke.

Keywords: ***tPA Unit, improving Length of stay, post tPA***

Introduction

Recombinant tissue-type plasminogen activator (tPA) remains the first-line treatment option for eligible patients in an acute ischemic stroke, which is one of leading causes of worldwide morbidity and mortality [1]. Due to the potential risk of symptomatic intracranial hemorrhage complication post tPA, with the most symptomatic hemorrhages occurring within the first 12 hours of the treatment [2], these patients are typically observed in an intensive care unit (ICU) for close monitoring and recurrent neurological assessments [3]. While all these patients are subject to intensive monitoring in a dedicated intensive unit, only a subset requires critical care interventions [1]. This intensive resource allocation can be problematic, especially during the COVID-19 pandemic when hospitals are facing increased demands for critical care beds, emergency department (ED) over-boarding, and challenges surrounding limited resources [4].

Although dedicated inpatient stroke units are known to improve patient outcomes [5], it is not known whether immediate post tPA care in dedicated non-ICU units are standardized in the United States to provide intensive neurological monitoring in patients receiving tPA. It has been proposed to consider a low-intensity post tPA monitoring protocol for ischemic strokes with mild-moderate deficits (e.g., NIHSS <10 with low risk of brain herniation and low risk of symptomatic intracranial hemorrhages) as less than 1% of these strokes requiring ICU level of care [6]. OPTIMIST (Optimal Post Tpa-IV Monitoring in Ischemic Stroke) trial demonstrated the pragmatism and the safety of post-tPA precautions in a non-ICU stroke unit, which was a telemetry unit without the critical care capability [7]. It has also been shown that tPA patients may be safely and cost-effectively managed in non-ICU units by utilization of expert nursing care [8]. However, it is unknown whether the usage of non-ICU stroke unit for post-TPA care leads to safe and feasible patient outcome compared to the post-tPA patients managed in an ICU.

Our study aims to evaluate the effect of a non-ICU stroke unit for post-tPA care during the pandemic. By providing the ICU level of post-tPA monitoring in a non-ICU telemetry stroke unit, we hypothesized potential reduction in inpatient length of stay (LOS)

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and improvement in 90-day clinical outcome in ischemic strokes that received tPA in a single academic medical center.

Methods

Study Cohort

We retrospectively analyzed prospectively accrued adult patients (greater than age 18 years) who were admitted for post-tPA management at the University of Massachusetts Memorial Medical Center (UMMMC) in Worcester, Massachusetts for an acute ischemic stroke between October 2020 and December 2021. As a Joint Commission certified comprehensive stroke center, the study site followed the American Heart Association guidelines for an acute ischemic stroke management including post-tPA monitoring [9]. The study was approved by our Institutional Review Board (IRB), and a Health Insurance Portability and Accountability Act (HIPPA) waiver of informed consent was approved. Our manuscript was prepared according to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines (http://www.strobe-statement.org) [10].

All diagnoses were first established by the treating board-certified neurologist and confirmed by abstracting physicians (A.G. & E.G.). Conflicting diagnoses were resolved by consensus after adjudication by a board-certified vascular neurologist (A.J.O.).

tPA unit design vs. ICU

Stroke Unit, or tPA unit, was defined as an organized non-ICU telemetry inpatient unit in the hospital managed by a multidisciplinary team of vascular neurologists, stroke trained nurses, and therapists [11]. Prior to the study design, post-tPA patients were managed in ICU for 24 hours and then transferred to a stroke unit in non-ICU telemetry floor. However, a specialized one-bed unit was established within Stroke Unit in October 2020 to provide one-to-one intensive unit level nursing care for post-tPA care to de-burden the ICU in the study center. The nursing staff was trained to standard ICU level of post-tPA care, including neuro-checks, cardiac monitoring, and management of intravenous antihypertensive medications. Patients that were ineligible for the tPA unit were those who had an initial NIHSS greater than 11, Middle cerebral infarction (MCA) that was greater than one third MCA territory, basilar artery occlusion, cerebellar infarction at risk of brain herniation, acute myocardial infarction, and/or were expected to have neurosurgical intervention, required osmotherapy for cerebral edema, or had hemodynamic instability and were at risk of intubation and sedation. The NIHSS cut off score of 11 used for patient selection for the Stroke Unit since NIHSS>11 is known to be associated with potential higher symptomatic post-tPA hemorrhages and extended ICU needs [12].

For study comparison, the control group consisted of ischemic strokes who received post-tPA precautions in the ICU. ICU Patients were considered ineligible for the study if they died or had withdrawal of life-sustaining measures with anticipation of death, or if they presented with preadmission mRS of 5. The control group consisted of 98 patients who received standard post-tPA care in an intensive care unit. The study group consisted of 25 patients who received standard post-tPA care in a Stroke Unit, a dedicated non-ICU telemetry unit.

Data Collection

Patient demographics (race and ethnicity), admission length of stay (LOS), co-morbidities, preadmission medications, admission National Institutes of Health Stroke Scale (NIHSS), admission modified Rankin Score (mRS), discharge status, total admission cost in dollars, and admission status (ICU unit vs. tPA unit on telemetry stroke unit) were collected for all patients by review of the medical records through the electronic medical record system. The incidence of 90-day major adverse cardiovascular events, including death and 30-day unpreventable hospital readmissions were captured based on the available records. If 90-day NIHSS and mRS were not documented in charts, they were reconstructed and estimated using a standard and validated process based upon available documentations of neurological exams and functional status, respectively [13]. Patients who were lost to follow-up were excluded from this part of the data analysis.

Statistical Analyses

Data were reported as median (interquartile range) unless otherwise stated. We used $\chi 2$, Wilcoxon rank-sum and Fisher exact tests to analyze categorical variables. Continuous variables were compared using 2-sided, 2-sample t tests. All tests of statistical significance were 2-tailed and considered to be significant at $P < 0.05$. All statistical analyses were performed using JMP Pro 15.0 statistical software (version 9.4, SAS Institute, Cary, NC). All statistical analyses were performed using JMP Pro 15.0 statistical software (version 9.4, SAS Institute, Cary, NC).

Results

Figure 1 depicts the flow chart of the study. We identified 812 ischemic strokes, of whom 123 fulfilled the study criteria. Among total 123 patients, 98 (79.7%) were admitted to ICU and 25 (20.3%) were admitted to the Stroke Unit for standard post-tPA precautions.

Patient Characteristics

Patient characteristics are described in Table 1. Overall, there are no significant differences between control group and the study group in terms of race, ethnicity, age, gender, discharge status, presenting deficits defined by NIHSS, and hospitalization total costs (in dollars). The presenting functional status defined by mRS was worse in the control group compared to the Stroke Unit group (0 (0-2) vs. 0 (0-0); P=0.0023). In terms of co-morbidities, patients in the ICU had higher prevalence of hypertension, diabetes, dyslipidemia, history of stroke, atrial fibrillation, coronary artery disease, congestive heart failure, and peripheral arterial disease compared to the Stroke Unit group (P<0.05). However, there were no significant differences in discharge status between these 2 groups (P>0.05). In terms of medication history, the patients in ICU had higher prevalence of statin, anti-hypertensive medications, anti-diabetic medications, and oral anticoagulant usages compared to the Stroke Unit group (P<0.05).

Study Outcomes: primary and secondary

The median length of stay was shorter in the Stroke Unit group compared to the ICU group although not statistically significant (2 IQ (1-4) vs 3 IQ (2-5) days, P=0.326). However, median length of stay was found to be significantly lower for the Stroke Unit group when compared to all ischemic stroke ICU admission regardless of tPA status (2 (1-4) N=25 vs. 4(2-7), N=525, P<0.05). We also observed that patients discharged from the Stroke Unit had a higher prevalence of transitional outpatient stroke nurse navigator services compared to the ICU group (72 % vs. 52%, P = 0.05).

For secondary outcomes, the median 90-day NIHSS between the 2 groups were not statistically significant (0 (0-3) ICU vs. 0 (0-1) Stroke Unit, P=0.466). However, the median 90-day mRS was lower in the Stroke Unit group compared to the ICU group (0 (0-1) vs. 2 (1-5); P=0.0011). There was no statistical difference between the 2 groups in terms of unpreventable 30-day readmission prevalence following the index admission (5.1% ICU vs. 4% Stroke Unit, P=0.81).

In terms of 90-day major adverse cardiovascular events, the ICU group had a higher prevalence of death within 90 days from the index admission compared to Stroke Unit group (25.5% vs. 0%, P<0.0001). The Stroke Unit had a higher rate of no major complications compared to the ICU group (80% vs. 60%, P=0.0353). There was no statistical significance in terms of 90-day major cardiovascular complications of stroke, coronary artery disease, myocardial infarction, or heart failure between the ICU group and Stroke Unit group (6.1% vs. 8.0 %, P=0.75).

Subgroup analysis of patient outcome analyses with NIHSS <8

Due to the baseline imbalances in the NIHSS scores between the two groups, a matched analysis complete to compare patient characteristics with low NIHSS. NIHSS <8 cut off was chosen based upon available initial baseline NIHSS ranges. A total number of 73 patients were identified for the subgroup analysis, with 53 (72.6%) admitted to the ICU and 20 (27.4%) in the stroke unit. Overall, there were no significant differences between the two subgroups in terms of unpreventable 30-day readmission, median length of stay, 90-day outcome events of death (P>0.05), although the median length of stay was shorter in the stroke unit subgroup compared to the control (median 2 (1-4) vs. 3 (2-4), P=0.112). The median 90-day NIHSS between the 2 subgroups were not different between the study subgroup compared to the ICU subgroup (0(0-1) vs. 0 (0-1), P>0.05), but the 90-day mRS was lower in the study subgroup compared to the control (0 (0-1) vs 2 (1-3), P=0.0006).

Figure 1. Patient Flow

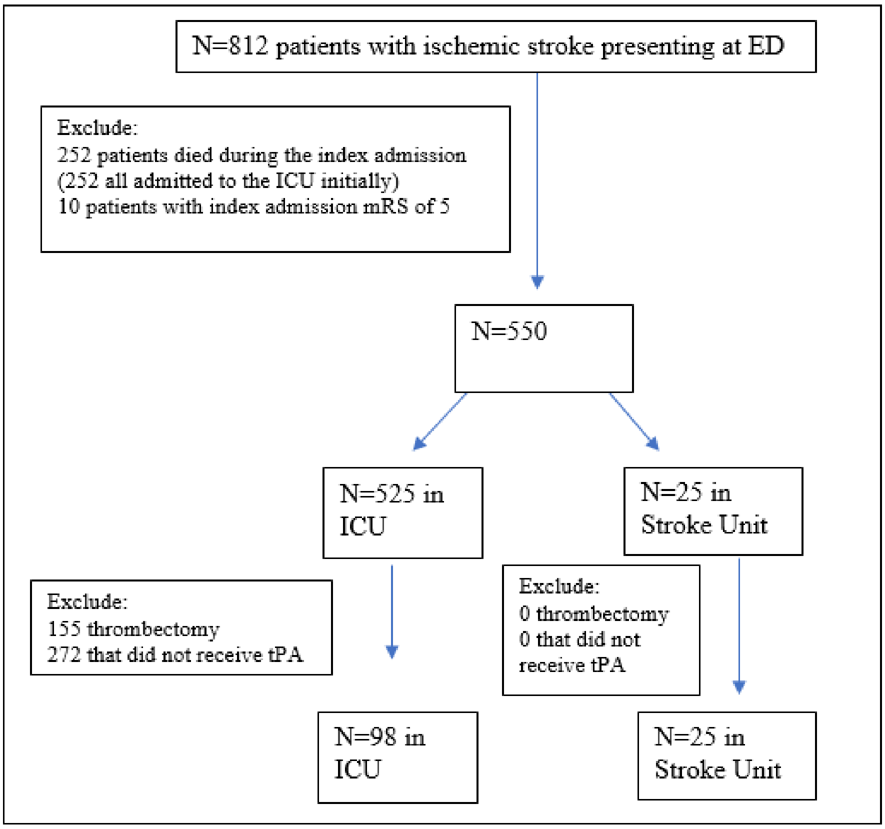

Table 1. Patient Characteristics in Ischemic Stroke status post tPA

	Control group, N=98	**Study group, N=25**	***P* value**
Race			0.334
White	84 (85.7%)	21 (84%)	
Black	6 (6.1%)	0 (0)	
Other	5 (5.1%)	2 (8.0%)	
Asian	1 (1.0%)	1 (4.0%)	
Unknown	2(2.0%)	1 (4.0%)	
Ethnicity			0.974
Hispanic origin	4(4.1%)	1 (4.0%)	
Non-Hispanic origin	89 (90.8%)	23 (92.0%)	
Unknown	5 (5.1%)	1 (4.0%)	
Age, median (IQ Range)	70 (59-78)	61 (54-75)	0.479
Gender, Female	48 (49%)	15 (60.0%)	0.325
Total cost, median, IQR ($)	24,164 (11,996-28679)	21,465 (6,401-24,934)	**0.479**
Presenting NIHSS, median (IQR)	7(2-12)	4 (3-7)	**0**.129
Index admission mRS, Median (IQR)	0 (0-2)	0 (0-0)	0.003

Discharge status home hospice skilled nursing facility inpatient rehab transfer to another hospital	 49 (50%) 5 (5.1%) 17 (17.3%) 27(27.6%) 0 (0 %)	 17 (68.0%) 0 (0%) 3 (12.0%) 5 (20.0%) 0 (0%)	0.353
Hypertension	83 (84.7%)	14 (56.0%)	0.002
Hyperlipidemia	91 (92.9%)	11 (44.0%)	<0.0001
Diabetes	37 (37.8%)	3 (12.0%)	0.0014
History of Stroke	29 (29.6%)	1 (4.0%)	0.008
Atrial Fibrillation	31 (31.6%)	1 (4.0%)	0.005
Coronary Artery Disease	28 (28.6%)	3 (12.0%)	0.088
Congestive Heart Failure	19 (19.4%)	1 (4.0%)	0.063
Peripheral Arterial Disease	26 (26.5%)	0 (0%)	0.004
Smoking History	47 (48.0%)	15 (60.0%)	0.282
Statin Use	58 (59.2%)	9 (36.0%)	0.038
Anti-hypertensives Use	69 (70.4%)	12 (48.0%)	0.035
Anti-Diabetics Use	30(30.6%)	2 (8.0%)	0.021
Anti-Platelets Use	41 (41.8%)	8 (32.0%)	0.370
Oral Anticoagulants Use	16 (16.3%)	0 (0%)	0.030

IQR: interquartile range

Discussion

Our study demonstrated that providing ICU level of nursing care for post-TPA patients is feasible on a non-ICU floor, and the dedicated post-tPA bed on a regular telemetry stroke unit is associated with reduced hospital length of stay, with positive 90-day outcomes, including reduction of 90-day mRS and major adverse event of death. We confirm as suggested by prior studies that an actual intensive care unit is not necessary to provide post-tPA care in select patients [1,12]. This is important especially when hospitals confront limited resources, especially during the time of ICU shortages [6]. We also observed that the patients in the dedicated post-tPA stroke unit had increased outpatient services reflected by the higher utilization of outpatient stroke nurse navigator services after discharge compared to the patients who received tPA and were managed in the ICU. This is likely explained by the system issue in which patients who received direct care from the dedicated stroke team had increased access to stroke follow-up cares compared to patients who were admitted into a closed intensive care unit without direct stroke team ownership.

The reduced length of stay in patients utilizing the post-tPA stroke unit is an important finding, as shorter length of the stay contributes to improved patient flow, especially during the COVID-19 pandemic, when optimizing available resources take priority. By providing specialized nursing care, hospitals can potentially free up beds in the ICU. Reduction in length of stay is important as it can potentially reduce healthcare associated infections, delirium, healthcare cost [14-16] while encouraging early mobilization [17].

Currently, there is limited available information regarding the impact of creating a post-tPA stroke unit for patients requiring close neurological monitoring yet not requiring critical care level treatments, especially in the first 12 hours post tPA administration [2]. It is well know that not all patients who receive tPA require an intensive care unit admission [3,8,12], and the ability to identify patients who may benefit from low risk monitoring can be used to support development of such intermediate care beds to avoid the cost of ICU care or ICU bed construction, especially when resources are limited [3,12]. OPTIMIST trial even suggests that post-tPA precautions can be safely completed in non-ICU level nursing care [7], which is very promising especially during the resource shortage during COVID-19 pandemic [6].

A meta-analysis studying organized stroke inpatient care demonstrated that ultimately, dedicated multidisciplinary stroke management improved functional outcome and mortality in stroke compared to non-organized inpatient stroke management [11], which suggests that perhaps it is not the location of the management but the level of dedicated services in ischemic stroke management that has a positive impact on stroke outcome. By utilizing dedicated post-tPA monitoring on a telemetry unit, intensive care unit resources can be reallocated towards higher risk patients who require critical care management.

Our study adds to the growing body of evidence that specialized stroke care units can improve functional outcomes in acute stroke [8,11]. It is known that the implementation of dedicated stroke units in acute stroke management reduces long term mortality and length of stay [18,19]. Length of stay, 30-day readmission, and 30-day mortality are major important quality metrics in the United States, with the Centers for Medicare and Medicaid Services (CMS) connecting these measures with penalties and payment determinations for hospitals [20]. Considering that our study was able to reduce these markers of the quality metrics, there needs to be more studies invested on utilization of tPA in non-ICU stroke units.

The study limitation includes the small sample size due to the performance of the study during the pandemic. Moreover, the presenting functional status was worse on the control group compared to the study group at baseline, with greater co-morbidities, which may introduce bias and may potentially skew the outcome due to the initial differences in the baseline groups. Hence, the results need to be interpreted with caution. Second, the study design was retrospective, thus there may be potential bias. The study was performed as a pilot study in a single tertiary care center. Therefore, the study results need to be interpreted with caution, and the future studies with larger sample sizes are needed to confirm our findings. Contrast to OPTIMIST trial, we were able to carry out the ICU nursing level of one-to-one nursing care during the pandemic, as our stroke unit was able to maintain a sufficient ratio of nursing staff to patients. However, due to stringent criteria for the tPA unit bed in the stroke unit, the enrollment numbers for the unit bed were low, reflecting the small sample size. Furthermore, the study needs to be interpreted with caution as the patient comparisons between the ICU and non-ICU tPA units excluded sicker patients (for example, patients with NIHSS >11). The 90-day outcome events may also have been confounded due to higher overall comorbidities in ICU patients. From our pilot study, our expectation is to further increase the number of tPA unit beds in the non-ICU Stroke Unit. Despite our limitations, our study findings serve as a potential contribution to the ongoing conversation surrounding the optimization of acute ischemic stroke care in hospital organizations.

Conclusion

Providing post-tPA care in non-ICU with the ICU level of neurological nursing care is feasible, improving outcomes for post-tPA ischemic stroke. This suggests that a dedicated tPA care in a stroke unit can lead to improved patient flow and optimization of acute stroke care. Further research in this area is warranted to study the additional benefits of utilizing such intermediate care beds, to develop effective and sustainable solutions of post-stroke resource allocation and improve patient outcomes.

Informed Consent (Ethical Approval)

Informed consent was waived due to the retrospective nature of the study, and was reviewed and approved by IRB.

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Conflicting Interests

Adalia H. Jun-O'Connell: Dr. Jun-O'Connell receives compensation for adjudication of stroke outcomes in the Women's Health Initiative (WHI).
Akanksha Gulati: None
Eliza Grigoriciuc: None
Shravan Sivakumar: None
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Author Contributions (Authorship Statements)

Adalia H. Jun-O'Connell: Study concept and design, data acquisition, interpretation of data, drafting of the manuscript, critical revision of the manuscript for important intellectual content.
Akanksha Gulati: Data acquisition, interpretation of data, drafting of the manuscript, and critical revision of the manuscript for important intellectual content.
Eliza Grigoriciuc: Data acquisition, drafting of the manuscript, and critical revision of the manuscript for important intellectual content.
Shravan Sivakumar: Interpretation of data and critical revision of the manuscript for important intellectual content.
Brian Silver: Study concept, interpretation of data, and critical revision of the manuscript for important intellectual content.
Rakhee Lalla: Interpretation of data and Critical revision of the manuscript for important intellectual content.
Majaz Moonis: Critical revision of the manuscript for important intellectual content
Nils Henninger: Interpretation of data, Critical revision of the manuscript for important intellectual content

Data Sharing & Availability

The investigators will share anonymized data (with associated coding library) used in developing the results presented in this manuscript upon reasonable request to investigators who have received ethical clearance from their host institution.

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