ACUTE ISCHEMIC STROKES: OUTCOMES OF TIME- SENSTIVE INTERVENTIONS FOLLOWING AEROMEDICAL TRANSFER

by

Zoey Moore

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Zoey Moore

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Approved By:

Mary Jo Nimmo, DNP RN-BC

Advanced Nursing Practice and Education, College of Nursing

Introduction

Acute ischemic strokes are a critical condition in which time is valuable. Air medical transport is often used to transfer acute ischemic stroke patients to tertiary care centers where they can receive medical interventions with better resources. An air transport team in Greenville, NC, transports a large volume of acute ischemic stroke patients by helicopter. However, the extent of the time-sensitive interventions, such as mechanical thrombectomy and intravenous thrombolysis, within the transport window remains unknown. This research project will focus on evaluating the proportion of acute ischemic stroke patients being transported by air who receive interventions within the first hour of care at a tertiary care center, and the factors influencing this care (Sani et al., 2021)

Background

Stroke is the second leading cause of death worldwide, representing a significant global health burden that continues to grow with aging populations and lifestyle-related risk factors. In the United States, ischemic strokes- caused by an obstruction within a blood vessel supplying blood to the brain- account for a majority of all strokes. Alarmingly, North Carolina is ranked fifth in the nation for deaths related to ischemic stroke. In 2022 alone, 6,189 deaths occurred from ischemic strokes, highlighting the need for improved stroke management and care. These statistics represent the need for timely intervention, especially in areas with limited access to comprehensive stroke centers, making air transport a vital part of patient care (Centers for Disease Control and Prevention, 2022).

One effective strategy for improving stroke outcomes is the seamless integration of air medical services with ground emergency medical services (EMS) and hospital networks. Helicopter Emergency Medical Services (HEMS) play a crucial role in reducing transport times

for patients in rural or underserved areas, where access to comprehensive stroke centers is often limited. This reduction in time is vital, as stroke treatment is highly time sensitive. The American Heart Association emphasizes that intravenous alteplase should be administered as soon as possible, ideally within 4.5 hours of symptom onset, while mechanical thrombectomy is most effective when performed within 6 hours (Powers et al., 2019). Studies have shown that helicopter emergency services often reduce transport times in rural areas (Tal & Mor, 2021). However, timely interventions do not rely on the transport team alone- the hospital stroke team must be prepared to initiate life-saving treatments immediately upon arrival.

Literature Review

The research conducted in the literature review focused on the function and effects of emergency medical services, particularly helicopter transport, in treating acute ischemic stroke patients. Tal and Mor (2021) conducted a systematic review evaluating 30 studies to assess how HEMS affects healthcare structures, clinical processes, and patient outcomes in acute ischemic stroke (AIS). While some studies showed that HEMS sometimes reduced transport times for patients in rural areas, it did not consistently improve mortality or disability rates compared to ground EMS. When it came to the process-related benefits of air transport, such as faster access to thrombolysis or mechanical thrombectomy, results were also inconsistent. This is due to air transport being associated with higher rates of stroke mimics, making up 20% of transported patients. While this systematic review included studies from reputable databases, it lacks robust results and a high proportion of stroke-mimic cases, making it a weak source.

The article by Spencer et al. (2023) is a retrospective observational study to evaluate the role of emergency medical services (EMS) in supporting AIS patients who received thrombolysis at a primary stroke center. This study reviewed 80 EMS incident reports from 2001 to 2005 in

which prehospital timelines, including dispatch-to-scene, on-scene, and transport durations, were examined. The mean age of the study was 69 years, with 68% of patients being female. While this study offers a different view of EMS response times in relation to the percentage of patients treated, it does not mention helicopter transport. This study also refrains from providing accurate times of when the thrombolysis for each patient was initiated.

The article by Bosson et al. (2023) is a retrospective study conducted in Los Angeles County from July 2018 to March 2019. The study examined 830 EMS transports, all of which had received a final diagnosis of AIS. Researchers analyzed the frequency of endovascular thrombectomy in relation to the pre-hospital determined last known well time (LKWT) within 24 hrs. The study found that 28.2% of patients received EVT, with frequencies of 29.8% in the ≤6-hour window, 24.1% in the >6 to ≤16-hour window, and 19.5% in the >16 to ≤24-hour window. Results showed that prompt EMS activation was associated with higher treatment rates and successful reperfusion; however, no patients received treatment within the first hour of hospital arrival. While this study focuses on ground EMS in a non-rural area, it provides evidence on the last known well time, door-to-puncture time, functional independence at discharge, and successful reperfusion rates that could help advance this research.

In the retrospective study by Lin et al. (2012), the study investigates whether EMS prenotification leads to higher rates of tissue plasminogen activator (tPA) administration within the recommended time window. The study examined 371,988 EMS-transported AIS patients from hospitals across the United States from April 2003 to March 2011. It found that prenotification, used in 67% of cases, was associated with significantly faster door-to-imaging times (26 vs. 31 minutes), door-to-needle times (78 vs. 80 minutes), and symptom onset-to-needle times (141 vs. 145 minutes), as well as higher rates of timely tissue plasminogen activator

(tPA) administration (73.0% vs. 64.0% overall; 82.8% vs. 79.2% in NIHSS-documented cases). Although this data is primarily focused on ground EMS and lacks prehospital protocol details, it provides strong evidence on the timing of AIS patient care.

Persaud et al. (2023) conducted a retrospective cohort study to evaluate the utilization of Helicopter Emergency Medical Services (HEMS) for direct-from-field transport of suspected acute ischemic stroke (AIS) patients to a comprehensive stroke center (CSC) in South Florida. From October 15, 2020, to July 31, 2021, 52 adult patients transported by air were examined and compared with 501 ground EMS cases. The study found HEMS provided faster door-to-needle times (15 vs. 25 minutes) for thrombolysis, although differences in door-to-puncture times for mechanical reperfusion were not statistically significant. Persaud et al. is a strong reference as this study directly compares HEMS with GEMS in the rural context. It also provides evidence to support HEMS on door-to-needle and door-to-puncture times for thrombolysis procedures. The available data demonstrate that EMS systems, including both air and ground units, significantly enhance stroke treatment outcomes; however, additional studies are required to determine the most effective transport and intervention approaches.

Purpose of Study

The purpose of this study is to evaluate acute ischemic stroke patients who are flown by aeromedical service and receive interventions upon arrival at the tertiary facility.

Research question

Among the ischemic stroke patients being transported by helicopter, what proportion receives time-sensitive interventions, such as thrombolysis or mechanical thrombectomy, within 1 hour of arrival at the tertiary care center?

Methodology

Using a retrospective cohort design to evaluate the timeliness of interventions in ischemic stroke patients transported via helicopter to a tertiary care center. The primary outcome is the proportion of patients who receive stroke-specific interventions within one hour of arrival at the receiving hospital. The study was conducted at a hospital in eastern North Carolina, a tertiary care hospital receiving patients from regional helicopter transport services. The study population will include adult patients (aged ≥18 years) diagnosed with ischemic stroke who were transported directly to the hospital via helicopter between January 2025 and December 2025. Patients will be eligible for inclusion if they (a) are aged 18 years or older, (b) have a documented diagnosis of acute ischemic stroke, and (c) were transported via helicopter from a pre-hospital location or a facility without stroke intervention capability. Patients will be excluded if they (a) are diagnosed with hemorrhagic stroke or a transient ischemic attack (TIA), (b) were transferred from another hospital with the ability to initiate stroke interventions, or (c) have missing or incomplete records regarding arrival or intervention timing.

Artificial intelligence (ChatGPT, OpenAI 2026) was used to assist with data organization, exploratory data analysis, and the generation of summary tables. All outputs were reviewed, verified, and validated by the research team to ensure accuracy and consistency with the original dataset. The use of artificial intelligence did not replace statistical software or independent analytic judgment but served as a supplementary tool to enhance efficiency and organization. SPSS software was used to verify data outcomes.

Data Collection and Variables

Data was abstracted from the hospital's electronic health record (EHR) system and flight transport logs provided by the regional aeromedical service. A standardized data collection tool was used to extract the following variables:

- Patient demographics (age, sex, race/ethnicity)
- Stroke type and NIH Stroke Scale (NIHSS) score at presentation
- Time of helicopter dispatch and arrival
- Time of arrival at the emergency department
- Type and timing of intervention
- Time of symptom onset (if documented)

The primary outcome variable was the receipt of a stroke-specific intervention within 60 minutes of emergency department arrival, operationalized as a binary variable (yes/no). Descriptive statistics were used to characterize the study population and determine the proportion of patients who received timely intervention. Time intervals—such as door-to-needle and door-to-puncture times—were calculated and reported using means, medians, and interquartile ranges. Prior to data collection, the study protocol was submitted to the Institutional Review Board (IRB) at East Carolina University for review and approval. As this is a retrospective review of existing medical records, a waiver of informed consent was requested. All data was de-identified prior to analysis to ensure compliance with HIPAA regulations and protect patient privacy.

Results

After data collection, 157 cases were reviewed. A total of 9 cases were removed during data review: 7 were not true ischemic strokes, and 2 had hemorrhagic conversion. The final sample data included 148 (N= 148) patients with confirmed acute ischemic strokes. The average

age of clients transported by an aeromedical transport of Eastern North Carolin was 65.5 (SD ± 13.7), with a median age of 67 years (Interquartile Range [IQR] 57-74). Out of the 148 cases, there were 87 males (59.2%) and 60 females (40.8%). Two cases were missing gender data.

The data showed that most patients (n = 135, 91.2%) were transported from another hospital, while the remaining (n = 13, 8.8%) were transported directly from the scene. The stroke severity scores were available for (n = 115) patients. The average score was 3.65 (SD = ±2.83) with a median of 4 (IQR 1-6). This score means that most strokes were mild to moderate according to the NIH scale. However, 33 patients had no documented stroke score. Race and ethnicity were excluded from the final data review because a large portion of the data were missing.

Out of the 148 patients included in the final sample, 99 (66.9%) had procedures documented. Out of the 99 documented, thrombectomy was performed in 53 (35.8%), while Tenecteplase (TNK) was performed in 43 (29.1%). A combination of surgical procedure and TNK was performed in 3 (2.0%) patients. The remaining 49 (33.1%) patients had no procedures documented. Of the 49 cases, 25 had no comments on the care provided for the stroke. However, the remaining 24 cases included justifications for withholding interventions. The top comments regarding why no procedures were initiated were: treatment ineligibility, contraindications to thrombolytics, being outside the treatment window, or lack of candidacy even with large-vessel occlusions. Specific documentation showed that the absence of TNK administration was noted 28 times, frequently recorded as “no TNK given” or “no TNK related to...”. LVO without intervention was documented in 27 cases, often including statements such as the patient was “not a candidate” or that “no intervention was appropriate.” Finally, the term “out of window (OOW)”

appeared in 16 cases, further showing that time constraints were a significant barrier to treatment.

It is important to note that all documented interventions were initiated within one hour of the patient's arrival at the tertiary care facility. This indicates strong adherence to time-sensitive treatment upon the patient's arrival at the hospital. Transfer time intervals were then analyzed for the data set (N=148) to evaluate the efficiency of aeromedical transport. The key time intervals that were examined are: received to en route, en route to patient arrival, patient contact to receiving facility arrival, and total transfer time. The mean time from receiving the call to en route departure was 28.4 minutes (SD ± 29.5). The median time it took Areomedical Transport of Eastern North Carolin was 18 minutes (IQR: 12-29). This interval showed the greatest variability, with transfer time exhibiting the largest range, from 0 to 240 minutes.

The mean time from en route to the patient's arrival at the hospital was 31 minutes (SD = 10.1). The median time was 30 minutes (IQR: 24-26). Overall, the range of this transport time was 12- 65 minutes. This interval reflected relatively consistent transport durations once the flight team was mobilized. The mean time for patient contact to receiving facility arrival was 47.6 minutes (SD = ± 19.8). The median time it took was 45 minutes (IQR: 34-58). Overall, the range was 8-159 minutes, reflecting variability likely influenced by patient stabilization and transport logistics. For the 148 cases, the mean for total transfer time was 106.5 minutes (SD = ±44.8). The median time was 98 minutes (IQR: 76-121) with a range of 17-345 minutes. This data represents the variability Aeromedical Transport of Eastern North Carolin faces on a case-by-case basis.

The data were then analyzed to assess whether there was a correlation between stroke severity and transfer time. The cases were broken into two groups based on the median total

transfer time: ≤ 98 minutes (n=74) and ≥ 98 minutes (n=74). In the group with a transfer time of ≤ 98 minutes, 60 patients had documented stroke scores. The mean stroke scale score was 3.70 (SD = ± 2.80) while the median was 4 (IQR: 1-6). For the transfer time≥ 98 minutes, 55 patients had documented stroke scale scores, with a mean of 3.58 (SD = ± 2.88) and a median of 3 (IQR: 1). The mean comparison between the two groups was p = 0.79 for mean and p = 0.66 for median. As a result, this analysis revealed that stroke severity did not significantly influence transfer time.

Discussion

The purpose of this study was to evaluate the outcomes related to time-sensitive interventions in patients with acute ischemic strokes following aeromedical transfer. Data analysis shows that while some treatments were initiated quickly, barriers remain that prevent some patients from receiving interventions, including transfer time and treatment eligibility. A key finding is that all documented interventions were initiated within 1 hour of the patient's arrival at a tertiary care facility. This suggests that the hospital's stroke protocol is being followed effectively. Interventions such as thrombectomy and TNK are most effective when performed as early as possible. This indicates that once a patient is received after aeromedical transport, care is delivered efficiently.

However, it is important to note that one-third of patients did not undergo any intervention. The most common documented reasons are OOW, contraindications to thrombolytic therapy, or not being a candidate. Documentation for this portion of patients frequently included terms such as “no TNK given, “out of window,” and “not a candidate.” These findings suggest that delays occurring before hospital admission affect patients' ability to receive interventions.

During this study, aeromedical transfer time was evaluated, with an average total transfer time of approximately 106 minutes. However, there was a wide range of 17-345 minutes, suggesting delays due to external factors. The longest delays were experienced during the interval between receiving the call and departing for the patient. This suggests that system-level factors, such as dispatch processes or coordination between facilities, may contribute to delays. These delays are clinically significant because longer treatment delays can limit eligibility for interventions and negatively affect outcomes. While stroke severity in relation to transfer time was not significant, the findings suggest that logistical factors rather than patient conditions influence transfer time.

The findings of this study have important implications for clinical practice by affirming the importance of early recognition of stroke symptoms and rapid activation of emergency services. Healthcare professionals play a key role in identifying stroke symptoms, ensuring communication between teams, and initiating interventions. It is also important to note that accurate and complete documentation is essential, as missing data in this study limits the ability to fully evaluate some cases.

Patient education should also be considered, as many patients were not eligible for treatment due to being outside the treatment window. Increasing public awareness could prompt patients to seek immediate medical attention and may reduce the number of patients arriving outside the required time interval. Several limitations should be considered when looking at these results. There were some gaps in the data, including missing stroke scale scores and limited documentation for certain patients who did not receive interventions, which could impact the accuracy of the findings. This study also relied on retrospective chart review, meaning the results depend on the completeness and accuracy of the documentation. Additionally, other factors—

such as distance, weather, or resource availability—that could have affected transfer times were not included in this analysis. This study found that hospital treatment times are efficient. However, reducing transfer delays, enhancing coordination between facilities, and public education may increase access to time-sensitive interventions and improve patient outcomes.

Conclusion

This retrospective study will recognize the importance of rapid intervention in acute ischemic stroke care and evaluate the effectiveness of helicopter transport. Although air transport ensures quick hospital arrival, many aeromedical transport teams from Eastern North Carolina note that most acute ischemic stroke patients still do not receive interventions within the first hour of admission. By conducting a retrospective study, the researchers determined the proportion of patients transported by air who receive medical interventions within the first hour of tertiary care. This research adds value to the researcher's career path by identifying potential changes that could be made either during air transport or within the first hour of care for acute ischemic stroke patients. This study is expected to have a significant impact on both patient outcomes and the field of nursing. As of now, this research will be presented at East Carolina University.

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