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The impact of telestroke services on diagnosis, patient outcomes, and treatment

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THE IMPACT OF TELESTROKE SERVICES ON DIAGNOSIS, PATIENT OUTCOMES, AND TREATMENT

ABSTRACT

Introduction: In 2011, an estimated 20% of U.S. residents lacked timely access to stroke care. As of 2019, that number plummeted to 4% of patients. A reason for this improved access was the implementation of telestroke services. Telestroke services have utilized remote stroke specialists to help guide local emergency department physicians in reviewing imaging, diagnosing, treating, or transferring patients appropriately.

Purpose: The purpose of this research was to analyze the impact of telestroke implementation in the hospital setting. The study hypothesized the implementation of telestroke services in the hospital setting maintained an accurate stroke diagnosis, decreased inappropriate hospital transfers, reduced time to mechanical or intravenous thrombolytic intervention, increased rates of thrombolysis, and decreased post-stroke patient mortality.

Methodology: This study utilized a literature review of articles identified using PubMed. PRISMA was used and 13 articles were referenced in the results of this research. The results were supported by a semi-structured interview of a fellowship-trained stroke specialist.

Results: The results showed that implementation of telestroke services in the hospital maintained an accurate stroke diagnosis, decreased inappropriate hospital transfers, reduced time to mechanical or intravenous thrombolytic intervention, increased rates of thrombolysis, and decreased post-stroke patient mortality.

Discussion/Conclusion: The findings of this literature review and interview of a fellowship-trained stroke specialist supported the discussion that telestroke service implementation in the hospital setting improved the above listed patient outcomes by maintaining accurate stroke diagnosis rates, reducing

inappropriate hospital transfers, decreasing the time to mechanical or intravenous thrombolytic therapy, increasing the rates of thrombolysis, and decreasing 90-day post-stroke mortality.

Keywords: Diagnosis, Hospital, Mortality, Telestroke, Thrombolysis

INTRODUCTION

According to the Centers for Disease Control and Prevention (CDC), in 2023, every 40 seconds someone in the United States (U.S.) had a stroke, with one person dying every 3 minutes and 14 seconds. Of the 610,000 new strokes per year in 2023, around 87% were classified as ischemic strokes (CDCa, 2023). In 2019, stroke accounted for around 1 of every 19 deaths in the U.S. and has consistently been ranked in the top five among all causes of death in the U.S. (Tsao et al., 2022). The U.S. death rates associated with strokes have continued to increase, with 38.8 deaths per 100,000 strokes in 2020 and 41.1 deaths per 100,000 strokes in 2021 (CDCa, 2023). The CDC defined a stroke as a brain attack that occurs when there has been a blockage in the blood supply to the brain or when a blood vessel supplying the brain has burst. The two types of major stroke are ischemic and hemorrhagic (CDCb, 2023). An ischemic stroke has been defined as a blockage of the blood vessels to the brain caused by blood clots or a build-up of plaque (fatty deposits), which decreases oxygenation and causes cell death in minutes. In contrast, a hemorrhagic stroke is when an artery flowing to the brain leaks blood or ruptures, causing an increase in intracranial pressure, which damages the tissue. A transient ischemic attack (TIA), or ministroke, differs from a major stroke in that the blood flow to the brain has been temporarily blocked, usually for less than five minutes, and symptoms typically resolved without the need for acute intervention (CDCb, 2023). Telestroke or stroke telemedicine has been described as a treating hospital virtually consulting an outside stroke expert to aid in caring for a stroke patient (Wechsler et al.,2016).

There are several models and delivery mechanisms for telestroke care. One model that has been used in the U.S. has been the hub-and-spoke model. In this model, the closest comprehensive

stroke center, typically a large academic medical center, has been referred to as the hub. The hub would provide telestroke services to several distant sites within their geographical catchment. In the hub and spoke model, the stroke expert at the hub has been typically credentialled at the spoke facility, allowing the consulting stroke specialist to document in the electronic medical record and order intravenous thrombolytic therapy (tPA). When transfers have been necessary, the patient would be transferred to the hub facility for an escalated level of care (Wechsler et al.,2016).

The availability of stroke care has grown substantially in the U.S. over the past 15 years. In 2011, an estimated 20% of U.S. residents lacked timely access to stroke care. As of 2019, that number plummeted to a mere 4% of patients being greater than 60 minutes from an emergency department with stroke care. A major reason for this improved access was the implementation of telestroke services. Zachrison and colleagues concluded that in 2019, 45% of emergency departments in the U.S. had telestroke services (Zachrison et al., 2022). Telestroke services have utilized remote stroke specialists to help guide local emergency department physicians in reviewing imaging, diagnosing, treating, or transferring patients appropriately (Richard et al., 2020). These services have been important because for ischemic stroke the window to administer intravenous tPA or perform a mechanical thrombectomy is patient-specific and time-sensitive (Zachrison et al., 2022). As literature surrounding the use of intravenous tPA and endovascular mechanical thrombectomy has expanded, there has been an ever-growing body of evidence to support that reduced door-to-needle times have improved patient outcomes at discharge, reduce 1-year mortality rates, reduce readmission rates, and improve functional outcomes (Emberson et al., 2014; Fonarow et al., 2014; Man et al., 2020; Man et al., 2023; Mulder et al., 2018; Saver et al., 2013).

The purpose of this research was to analyze the impact of telestroke implementation in the hospital setting on the accuracy of stroke diagnosis, appropriateness of stroke patient hospital transfers,

time to mechanical (door-to-groin) or intravenous (door-to-needle) thrombolytic intervention, rates of thrombolysis, and post-stroke patient mortality.

METHODOLOGY

The working hypothesis was that the implementation of telestroke services in the hospital setting maintained an accurate stroke diagnosis, decreased inappropriate hospital transfers, reduced time to mechanical (door-to-groin) or intravenous (door-to-needle) thrombolytic intervention, increased rates of thrombolysis, and decreased post-stroke patient mortality.

The methodology for this qualitative study was a literature review complemented by a semi-structured interview of a fellowship-trained stroke specialist who routinely worked as the consulting physician of a hub-and-spoke model telestroke service in West Virginia. The inclusion criteria were literature published from the years 2015-2024 when conducting literature research. The articles were limited to the English language. Critical keywords included within this literature research were “impact” AND “telestroke” AND “implementation” AND “diagnosis” OR “mechanical thrombolytic intervention” OR “intravenous thrombolytic intervention” OR “outcomes” OR “thrombolysis” OR “post-stroke patient mortality”. These keywords were also a part of the inclusion criteria. This article focused on ischemic strokes as the interventions related to telestroke services are more applicable to ischemic strokes.

PubMed was utilized to obtain credible academic peer-reviewed literature. The literature search was completed by Dustin Baum. A.C. validated the literature review who acted as a second reader and verified that the references of this literature met the study inclusion criteria. Using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses method (PRISMA), this search identified 270 relevant citations. The search excluded 257 that had not met the criteria for review. All 13 of the articles

subject to a full review and used in the results were identified using PubMed. See Figure 1. For the PRISMA approach to the database search and eligibility screening described above.

The in-person interview was recorded, and the relevant information was transcribed. Only the relevant answers from the interview were used to contextualize and supplement the information found in the literature review. The questions asked in the interview have been displayed in the appendix. This study was IRB-approved by Marshall University's IRB board.

RESULTS

Barragan-Prieto and colleagues examined the accessibility of specialized stroke care before and after the implementation of a centralized telestroke network in hospitals in Andalusia. The pre-implementation phase consisted of a 12-month period before January 2019 and the post-implementation phase was 12 months after the program was initiated. In the pre-implementation period, 5,005,477 (59.72%) Andalusians had access to specialized stroke care within 30 minutes of their location, of which 12% were greater than 90 minutes from specialized stroke care. After the implementation of the centralized telestroke program, this number increased significantly to 7,832,988 (93.45%) of Andalusians being within 30 minutes of stroke care. The mean number of total reperfusion treatments per telestroke spoke center per year increased significantly (pre-implementation: 7 vs post-implementation: 15), with the combined average intravenous thrombolysis increasing by 142% (92 vs 223) and the combined average of endovascular thrombectomies increasing by 244% (65 vs 224) (Barragan-Prieto et al., 2022).

In a retrospective chart review, Arumuganathan and colleagues analyzed the usage of telestroke services in three critical access hospitals participating in a hub-and-spoke telestroke model in West Virginia from September 2020 to February 2021. Of the 12,685 patients who presented to the Emergency Departments (EDs) during this time, 252 were pooled as possible Transient Ischemic Attack (TIA) or Acute Ischemic Stroke (AIS). Out of the 252 patients, 32 met the criteria for activation of a

telestroke consultation, and 14 patients were evaluated by phone or audio-visual consultation. The final diagnosis of TIA or AIS was confirmed in 13 of the 14 patients (92.86%) who underwent a telestroke consultation. (Arumuganathan et al., 2023).

Poongkunran and colleagues evaluated the diagnostic accuracy of telestroke consultations using a retrospective observational study of Oschner Health's telestroke program between April 2015 and April 2016. Of the 904 telestroke consultations identified, 874 were included in the study, of which 460, 106, and 15 were diagnosed with AIS, TIA, or an intracerebral hemorrhage, respectively. Of the 874 total patients included in the study, 739 received an accurate diagnosis (85%). The initial telestroke diagnosis was compared to the final diagnosis on discharge and each event was classified into one of four categories true positive, true negative, false positive, or false negative. There were 124 patients excluded from this analysis because of either an uncertain diagnosis during the initial consultation or after the final evaluation. Of the 568 initial stroke/TIA diagnoses made via telestroke services, 532 (93.7%) were categorized as true positives. Of the 182 stroke mimics initially diagnosed through telestroke services, 170 (93.4%) were categorized as true negatives. Fifteen patients (11%) who were misdiagnosed received intravenous thrombolytic therapy, with one of them experiencing non-fatal bleeding complications. The most commonly identified stroke mimics were encephalopathy (n=63), conversion disorder (n=35), migraine (n=34), and seizure (n=33) (Poongkunran et al., 2023).

In a 2023 systematic review, Mohamed and colleagues sought to identify whether or not the implementation of Telestroke Medicine (TM) improved clinical outcomes, functional independence, and critical treatment times when compared to the traditional Non-Telestroke (NTM) treatment of AIS. They included 20 retrospective studies, 10 prospective studies, and 2 randomized controlled trials in their analysis. A total of 12,540 AIS patients were identified, of which 7,936 received thrombolytic therapy (mechanical or intravenous), with 3,873 (48.3%) in the NTM control group and 4,150 (51.7%) in the TM

group. The analysis did not identify a statistical significance between the TM and NTM groups with regards to successful recanalization (TM = 69% vs NTM = 74%), discharge NIHSS scores, or 90-day stroke-related mortality. The likelihood of scoring a good clinical outcome, represented by a modified Rankin scale (mRS) score of 0-2 at 90 days, did not differ between the two groups. While the mean time from symptom onset to intravenous tPA administration was higher in the NTM group (147.18 min vs 144.09 min), there was not a statistically significant difference. Nor was there a statistically significant difference when comparing NTM to TM (65.91 min vs 73.03 min) door-to-needle times. The rates of intravenous thrombolysis and mechanical thrombectomy were also similar between the TM (30.86% IV tPA and 11.8% mechanical thrombectomy) and the NTM (20.5% IV tPA and 18.7% mechanical thrombectomy) groups (Mohamed et al., 2023).

Through a retrospective chart review of 2021 patient data, Ho and Fawcett reported the efficacy and safety outcome differences of patients suffering from AIS who presented to their comprehensive stroke center in 2021 and were treated via either telestroke or in-person assessments. Their study consisted of 247 patients treated via in-person assessment (113 with IV tPA, 66 with endovascular thrombectomy, and 68 treated with both) and 55 patients treated via telestroke (25 with IV tPA, 17 with endovascular thrombectomy, and 17 with both). Telestroke was used to manage 18.2% of cases, with 91% of them being treated after-hours. The was no difference identified in median door-to-needle times between telestroke and in-person assessment (35.5 min vs 33 min) or median door-to-groin times for thrombectomy (86.5 min vs 85 min). Of the 11 neurologists who took acute stroke call in 2021, only 7 of them chose to use telestroke for their assessments. For the neurologists who treated patients using both telestroke and in-person assessments, there was no difference identified between telestroke and in-person outcomes with door-to-needle (35.5 min vs 34 min) or door-to-groin times (88 min vs 81.5 min). With regards to safety, there was no difference in the risk of symptomatic intracranial hemorrhage

between the telestroke and in-person assessments (0% vs 1.63%). For those that could be assessed (34 out of 55 telestroke and 181 out of 247 in-person assessments), there was no difference in 3-month mortality (20.6% telestroke vs 22.1% in-person assessment) (Ho & Fawcett, 2023).

In a retrospective chart review of a South Australian health system, Goh and colleagues compared prospectively collected post-telestroke implementation data from June 2018 through December 2019 to retrospectively collected pre-implementation data from December 2017 through May 2018. They sought to compare a composite score for quality indicators (door-to-needle times, tele support availability, early access to physiotherapy, speech pathology, and rehabilitation services, and adherence to best practice guidelines) and mortality up to one-year post-stroke. In the post-implementation period, 14 out of 17 quality indicators (82%) improved or remained the same with door-to-needle times improving but not showing statistically significant differences in the pre- vs post-implementation groups (121 min vs 90 min). Lower statistically significant patient mortality at both 6 and 12 months was observed in the post-implementation period (6-month: 23% pre-implementation vs 12% post-implementation; 12-month: 23% pre-implementation vs 13% post-implementation). The proportion of patients who received intravenous thrombolysis was similar between the two groups (pre-63.6 % vs post-62.3 %) (Goh et al., 2023).

Ranta and colleagues evaluated the impact of telestroke services on thrombolysis rates and door-to-needle times. Data was collected from 6 months before initiation (pre-) and 6 months after implementation (post-). The rates of thrombolysis increased significantly following the implementation of telestroke services (pre-6.1% vs post-15.7 %). The overall average door-to-needle time was significantly reduced after the implementation of telestroke services (pre-79.6 min vs post-62.7 min) (Ranta et al., 2017).

At a West Virginia University Hospital serving as the telestroke hub to 29 spoke hospitals, Rawson and colleagues identified the primary factors contributing to target door-to-groin times (target time <60 minutes) for patients with large vessel occlusion acute ischemic strokes (LVO-AIS) undergoing endovascular thrombectomy. The authors performed a retrospective chart review which pulled data from January 2016 through September 2021. During that time, 383 patients met inclusion criteria with 189 (49%) presenting directly to the hub hospital and 194 being transferred (51%). The door-to-groin times were statistically significantly shorter in the transfer patients when compared to the direct-to-hub patients (62 min vs 83 min). There was also a higher proportion of transfer patients (47%) who met the target door-to-groin time of <60 minutes when compared to the direct-to-hub group (17%). Of the 194 patients transferred to the hub facility, 71% of them had received a telestroke consult before transfer. A sub-group analysis revealed that the median door-to-groin times (61 min telestroke vs 83 min direct-to-hub) were lower and the proportion of patients with door-to-groin times under 60 minutes was higher in the telestroke transfer patients compared to direct-to-hub patients (50% vs 17%). While the numbers did trend in favor of telestroke transfers, there were no significant differences in the median door-to-groin times (61 min vs 78 min) or target door-to-groin rates (50% vs 38%) when comparing telestroke to non-telestroke transfers. Significantly more telestroke transfer patients received a computed tomography angiography (CTA) before transfer when compared to non-telestroke transfers (59% vs 40%). Median door-to-groin times were significantly lower for patients who received a CTA before transfer compared to those who did not (45 min vs 83 min) (Rawson, Petron, & Adcock, 2023).

In 2018, Ranta and Busch evaluated the impact of a Central New Zealand spoke hospital's decision to discontinue telestroke services. The authors compared a 6-month pre-implementation period, 6 months with telestroke services, and a 6-month post-discontinuation period. The authors found thrombolysis rates of 8.7% pre-implementation, 23.0% with telestroke services, and 7.9% post-

discontinuation of telestroke services. The odds ratio of receiving thrombolytic therapy during the 6 months of active telestroke services vs the 12 months without was 3.33 (1.47-7.86) (Ranta & Busch, 2018).

Alhajala studied the impact of telestroke service expansion from emergency departments (pre-implementation) to routine inpatient consultation services (post-implementation) in the Promedica Stroke Network (19 spoke hospitals with The Toledo Hospital being the hub) on transfer rates from the spoke to the hub institution, diagnostic accuracy of TIA and AIS, thrombolytic therapy usage and time efficiencies. Stroke admission rates at spoke hospitals increased significantly with the change (pre-18 per month vs post-40 per month). Regarding all stroke code activations, there was a significant reduction in the number of patients transferred to the hub hospital after the expansion of services (pre-1,608 (35.19%) vs post-1,187 (23.5%). Both the use of intravenous tPA (pre-7.32% vs post-5.35 %) and the door-to-needle times (pre-75.29 min vs post-70.05 min) remained statistically similar between the two groups. (Alhajala et al., 2023).

Kasab and colleagues evaluated the impact of establishing an inpatient teleneurology service to supplement the existing telestroke network on transfers from the spoke facilities to the hub hospital. Of the 4,296 stroke patients evaluated, 2,493 were seen before implementation and 1,803 after implementation. Patients seen in the pre-intervention group were more likely to be transferred to the hub hospital than those seen after inpatient teleneurology services were established (29.4% vs 20.2%) (Kasab et al., 2021).

Jun-O'Connell and colleagues explored the differences in outcomes between telestroke consultation transfer patients who received a neurological intervention (mechanical thrombectomy, intravenous tPA, craniectomy, electroencephalogram, or external ventricular drain) and those who did not receive any neurological intervention. Of the 181 telestroke-related patient transfers, 114 (63%)

received a neurological intervention and 67 (37%) did not. Overall hospital mortality was not significantly different between the two groups (intervention 17.5% vs non-intervention 10.4%) and the 90-day mortality rates (intervention 22.8% vs non-intervention 20.9%) were similar (Jun-O'Connel et al., 2023).

Majersik and colleagues evaluated emergency medicine providers' satisfaction with telestroke implementation, how it affects their knowledge and confidence in treating stroke patients, and the effects of telestroke implementation on patient management decisions. Of the 112 survey requests sent to EM providers, 48 were returned from 42 different EM providers. The most common reasons for consulting telestroke services were to determine eligibility for IV tPA (n=34, 71%), conform to hospital protocols (n=24, 50%), assist in diagnosis (n=23, 48%), and determine eligibility for endovascular thrombectomy (n=7, 15%). Emergency medicine providers felt that the telestroke consultation resulted in a change to the final diagnosis in 60% of cases. Intravenous tPA was administered in 13 cases. Of the providers who administered IV therapy, 85% believed that the therapy would not have been given without a telestroke consultation (Majersik et al., 2023).

DISCUSSION

The purpose of this research was to analyze the impact of telestroke service implementation in the hospital setting on the accuracy of stroke diagnosis, hospital transfer rates, time to mechanical or intravenous thrombolytic therapy, rates of thrombolysis, and 90-day post-stroke mortality. The findings of this literature review and interview of a fellowship-trained stroke specialist supported the discussion that telestroke service implementation in the hospital setting improved the above listed patient outcomes by maintaining accurate stroke diagnosis rates, reducing inappropriate hospital transfers, decreasing the time to mechanical or intravenous thrombolytic therapy, increasing the rates of thrombolysis, and decreasing 90-day post-stroke mortality.

Of the thirteen studies included in this literature review, three reported on 90-day mortality rates and one reported mortality rates at 6 and 12 months. While 90-day mortality rates were not statistically significantly different between in-person and telestroke assessments, they did trend towards a reduction. In the one study that reported them, mortality rates at six and twelve months were both statistically significantly reduced in the telestroke group. Door-to-needle times were reported in three studies, with one showing a statistically significant reduction in telestroke patients, one showing a non-significant reduction, and one showing no difference. As one would expect with the reported significant increase in access to stroke care, two studies reported significantly increased thrombolysis rates after implementing telestroke services. Two of the studies reported accurate stroke diagnoses occurring in 85 to 93% of patients that were assessed via telestroke consultation. Both of the studies that reported on patient transfer rates from spoke to hub hospitals showed a statistically significant decrease in patient transfers after the implementation of telestroke services. This was further supported by our expert's experiences with telestroke utilization and patient transfer rates. They reported a slight reduction in hospital transfer rates but emphasized that telestroke utilization led to more appropriate patient transfers (i.e., those transferred were deemed as needing a higher level of care). Although the available studies were limited, the implementation of telestroke services increases access to stroke care while providing safe and effective patient care.

Study Limitations

Limitations to this study would include the number of electronic databases that were utilized, the lack of available prospective research on this topic, and the potential for research bias.

Practical Implications

This literature review has shown that there is more research and review that could be conducted to identify statistical differences in outcomes with telestroke implementation. It appears to

be clear that the implementation of telestroke services increased stroke care availability, especially in rural areas. However, data is still lacking regarding clinical outcomes of these patients when compared to traditional in-person stroke services.

CONCLUSION

This literature review supported the hypothesis that implementation of telestroke services in the hospital maintained an accurate stroke diagnosis, decreased inappropriate hospital transfers, reduced time to mechanical (door-to-groin) or intravenous (door-to-needle) thrombolytic intervention, increased rates of thrombolysis, and decreased post-stroke patient mortality.