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Nicole Coleman  
colemann3@student.lasalle.edu

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**Emergency Department Protocol for Diagnosis and Treatment of Ischemic Strokes**

Nicole Coleman

La Salle University

## **Introduction**

Strokes, or cerebrovascular attacks (CVA), are events that lead to loss of blood supply in the brain causing hypoxia and neuronal cell death in surrounding tissues which can vastly alter mentation and physical functions and may result in permanent disability. Strokes are the leading cause of permanent disability among adults in the United States and the third leading cause of death in the United States (Advani, Naess, & Kurz, 2006). Emergency departments are often the frontline in patient care for acute strokes thus making the timely and efficient diagnosis of strokes imperative thus emergency department staff as well as EMS personnel are trained to recognize stroke symptoms through various implemented scales and to treat stroke according to guidelines of protocol (Nor et al., 2005). The recognition and proper triaging of strokes via these recognition scales is what initiates the implementation of a pre-designated set of labs and imaging to confirm the presence of an ischemic stroke which ultimately results in treatment known as a protocol (Advani et al., 2006). Stroke protocols around the world are continuously being altered and advanced to cut down on the time it takes for a patient to be recognized as a possible stroke to imaging confirmed to being treated as each year there is more evidence that treatment is more effective the closer it can be administered to the initial onset of symptoms (Yew & Cheng, 2015).

Strokes can be classified into several types based on where in the brain they occurred and the pathology of the event. The two major types are ischemic strokes which are caused by infarction of the blood vessels disrupting perfusion of blood to the brain and hemorrhagic strokes which are caused by the rupture of blood vessels in the brain (Yew & Cheng, 2015). Risk factors for strokes, like many diseases, are numerous and include a variety of factors including age and genetic predisposition but the major risk factors are hypertension, coronary artery disease, atrial

fibrillation, and smoking (Yew & Cheng, 2015). Ischemic strokes are more common than hemorrhagic strokes and it has been estimated that 87% of diagnosed strokes in the United States are ischemic while 13% are hemorrhagic (Yew & Cheng, 2015). It is imperative that emergency physicians be able to differentiate effectively between hemorrhagic and ischemic strokes as thrombolytics are only effective in treating ischemic strokes and not hemorrhagic strokes, hemorrhaging is a contraindication for thrombolytic agents (Kothari, Brott, Broderick, & Hamilton, 1995). Transient Ischemic Attacks (TIAs) fall under the category of an ischemic stroke, they are caused by an infarction but unlike a true ischemic stroke they are temporary or transient and thus resolve on their own. While TIAs are relatively benign as the symptoms associated with it often resolve, they do significantly increase the risk of having a stroke by 0.2-10% in the first 7 days and by 1.2-12% in the following 90 days after a TIA (Perry et al., 2011).

Ischemic stroke and TIA patients commonly present with complaints of headaches, limb paresthesia, speech disturbance, facial weakness, subjective limb weakness, and non-orthostatic dizziness, patients suffering from ischemic strokes will often report waking up with these symptoms (Yew & Cheng, 2015). While thrombolytic treatments have been proven to be effective in treating ischemic strokes and are an internationally accepted treatment, strokes are a time sensitive condition. Studies have estimated that over two million neurons die each minute after the onset of the infarction as tissue is deprived of oxygenated blood (Köhrmann et al., 2011). Without reperfusion, the area affected by ischemic strokes grows from a localized area surrounding the infarct to a larger “infarct core” resulting in worsening of disability effects until the area is reperfused or stabilizes (Köhrmann et al., 2011).

Hemorrhagic strokes have a different presentation and a different treatment protocol due to the nature of its pathology. Hemorrhagic strokes involve the rupturing of a vessel that can be

caused by an aneurysm or a traumatic brain injury (TBI). The most common symptoms of hemorrhagic stroke patients include nausea and vomiting, severe headaches, dysarthria, and unilateral weakness (Yew & Cheng, 2015). Approximately 80% of subarachnoid hemorrhagic stroke patients present with the complaint of “the worst headache of their life” which often leads physicians to suspect a hemorrhagic stroke but a definitive diagnosis of a hemorrhagic stroke can only be made through CT or MRI imaging (Yew & Cheng, 2015). Depending upon the location and severity of the bleed, the protocol varies from therapeutic non-invasive management to emergent surgical intervention to clear the hematoma (Yew & Cheng, 2015).

Due to the treatability of ischemic strokes, they have become the driving force behind stroke protocol initiatives to cut down on the time it takes for a patient to be triaged to the administering of treatment. The American Stroke Association has lead multiple initiatives to improve stroke care including Get With The Guidelines – Stroke, the Brain Attack Coalition, Mission: Lifeline, and now Target: Stroke (Fonarow et al., 2011). The current accepted guideline for intravenous tPA administration is four and a half hours, however, a multitude of studies and data from the American Stroke Association have shown for treatment to be most effective within an hour of symptom onset (Tai & Yan, 2013). Emergency departments around the world are perpetually seeking a more effective protocol to diagnose ischemic strokes that are eligible for thrombolysis in order to minimize the time-sensitive effects of stroke (Tai & Yan, 2013).

### **Diagnostic Methods in Emergency Medicine: The First Step in Stroke Protocol**

Diagnosing a patient with stroke or clinically evaluating the potential for stroke is the first step in emergency stroke protocol. The signs and symptoms of ischemic strokes can present differently in each patient but there are diagnostic tools and scales that are used to initially diagnose a stroke along with the use of non-contrast CT imaging of the brain to definitively

confirm stroke diagnosis (Yew & Cheng, 2015). While advancements in neuroimaging are at the forefront of innovation for early detection and treatment of strokes, clinical diagnostics are vital to gauge severity of stroke and to accurately diagnose strokes in areas without access to emergent neuroimaging (Stürmer, Schlindwein, Kleiser, Roempp, & Brenner, 2002). FAST and ROSIER are among the most widely used clinical tools for rapidly assessing for strokes both in the field by paramedics and in the emergency department (Whiteley, Wardlaw, Dennis, & Sandercock, 2011). In addition to clinical scales to diagnose stroke, there are tools that have been developed to gauge severity of strokes including the NIHSS (Yanghi et al., 2011). Ultimately, neuroimaging using either CT or MRI is the best way to effectively diagnose stroke and to rule out any contraindications for thrombolysis which is the primary method of treatment in emergency medicine (Yew & Cheng, 2015).

FAST is a diagnostic test that was developed in 1998 and is still widely used by EMTs and paramedics to assess for stroke while in route to the emergency department. FAST is an acronym for Face Arm Speech Test in which the patient is assessed for facial weakness, arm weakness, and speech disturbance (Mohd et al., 2004). While FAST is not a definitive diagnostic measure, it allows paramedics to assess for three simple neurological symptoms to diagnose possible strokes which in turn allows them to notify the emergency department in advance to save on time and increase the likelihood that the patient will be a candidate for TPA (Mohd et al., 2004). In addition to emergency personnel, FAST has also been campaigned for use by the public as it is a short and simple acronym that not only conveys the signs of stroke but also conveys urgency and increases the likelihood that the public will recognize these symptoms and arrive at the emergency department sooner with acute stroke (Nor et al., 2005).

In a 2004 study, 278 patients were referred as suspected strokes by ambulance personnel using the FAST assessment. Of the 278 patients, 95% were admitted and 78% were confirmed by admitting physicians to have had a stroke or TIA (Mohd et al., 2004). In addition to assessing the accuracy of the test itself, researchers also assessed how effective the paramedics were at administering the test by measuring agreement between physicians and the paramedics on each stroke sign. Among the confirmed 217 stroke patients, physicians and paramedics were in 98% agreement that the patient exhibited arm weakness, 89% agreement that patient exhibited speech disturbance, and 78% agreement that the patient exhibited facial weakness (Mohd et al., 2004). The study also found that the disagreements on non-stroke cases were attributed to paramedics mistakenly assessing a sign as being present which resulted in false alarms. Overall, the study found FAST to be effectively administered by paramedic personnel and for arm weakness to be the most prevalent at predicting acute onset strokes in the field (Mohd et al., 2004).

Another widely used stroke diagnostic scale is known as ROSIER (Recognition of Stroke in the Emergency Room) which consists of 7 assessment items including facial weakness, arm weakness, leg weakness, speech disturbance, visual defect, syncope, or seizure activity (Whiteley et al., 2011). Like FAST, ROSIER is a tool that can be used to quickly and effectively assess for stroke without emergent neuroimaging. The addition of assessment for syncope and seizure-like activity to the ROSIER scale increases its effectiveness at teasing out “stroke mimics” or conditions that are often mistaken for stroke (Nor et al., 2005). In a 2005 study, 343 possible stroke patients were evaluated using the ROSIER scale found the tool to have a sensitivity of 92% and a specificity of 86% with incorrect diagnosis of 10% of the confirmed stroke cases of which 10 were false positives and 7 were false negatives (Nor et al., 2005). As in the FAST scale

study, it was found that the most predictive item in the ROSIER scale was extremity weakness followed by speech disturbance and facial weakness (Nor et al., 2005).

The medical field is constantly advancing and attempting to create new scales to rapidly assess for stroke with FAST and ROSIER being the most widely used today. When compared to one another, FAST and ROSIER both boil down to the three most indicative signs of stroke (Whiteley et al., 2011). A cross-sectional study compared the two scales by assessing the same set of 356 patients and assessing the accuracy of the scales by comparing their findings to that of an expert panel of neurologists with access to neuroimaging. This study found that ROSIER had a sensitivity of 83% and a specificity of 44% while FAST had a sensitivity of 81% and a specificity of 39% resulting in no statistical significance in the efficacy of these two diagnostic tools (Whiteley et al., 2011). This study concluded that while both scales are equally effective, FAST may be more convenient due to its smaller number of variables which could in turn lend this tool to widespread use by paramedics and laypersons (Whiteley et al., 2011).

The National Institute of Health Stroke Scale (NIHSS) is a tool used in emergency medicine to evaluate the severity of a stroke by gauging mentation, limb ataxia, facial paresis, weakness, speech disturbances, and visual field deficits and neglect. Physicians often use NIHSS scores to assess the need for tPA, if a physician finds a stroke to be minor and deficits to be “non-disabling” they may withhold tPA (Yaghi et al., 2016). Approximately a third of patients with ischemic stroke are not given thrombolytic agents due to criteria in which an NIHSS score of less than 5 is considered a mild deficit that does not warrant the use of tPA (Yaghi et al., 2016). A retrospective study of patients in the Stroke Warning Information and Faster Treatment (SWIFT) database included 861 patients who had NIHSS scores of less than 5. Of the 861 patients, 19% of them were not discharged home due to their disability and were instead

transferred to a long-term care facility (Yaghi et al., 2016). This study found that the likelihood of a patient being discharged home directly correlated with their NIHSS scores with 42.4% of patients with a score of 5 being unable to be discharged home. While NIHSS provides an overall view of stroke severity, it was found to only be a fair predictor of minor stroke disability outcomes with the assessment factor of motor deficits being the best predictor of stroke outcomes (Yaghi et al., 2016). Some studies have also found NIHSS to be a useful predictor for subtype of ischemic stroke, one study assessed the effectiveness of NIHSS categories in predicting stroke subtype and found best language, visual fields, hemispatial neglect, and hemiparesis with brachial predominance to be effective at differentiating lacunar strokes (Leira, Adams Jr, Rosenthal, & Torner, 2008). This study found that with abnormal responses to these 4 NIHSS categories there was a 50% probability of atherothrombotic stroke, 39% probability of cardioembolic stroke, and 0.1% probability of lacunar stroke (Leira et al., 2008).

Non-contrast brain CT imaging is the widely accepted standard for stroke diagnostic tests, non-contrast CTs are sensitive enough to detect hemorrhaging and brain lesions. MRIs have higher resolution and therefore higher sensitivity for diagnosing ischemic strokes and are approximately equivalent in sensitivity to non-contrast CT imaging in detecting hemorrhage (Yew & Cheng, 2015). While MRIs have higher resolution and sensitivity, CT imaging remains the preferred method of diagnosis because it is quicker in acute onset cases to better expedite possible tPA administration (Yew & Cheng, 2015).

Diagnosing an acute ischemic stroke is the first step in the cascade that follows in emergency department stroke protocols, a missed diagnosis could be catastrophic for a patient especially as stroke treatments are time sensitive and a missed diagnosis could result in a missed opportunity for treatment. A study of 2,027 acute ischemic stroke cases in Kentucky and Ohio

emergency departments found that 14% of acute ischemic stroke cases were not diagnosed in the ER (Madsen et al., 2016). It was found that decreased level of consciousness was associated with 3.58 times greater chance of a missed acute ischemic stroke diagnosis and were often admitted with diagnoses of altered mental status, cardiac disorders, and neurological disorders (Madsen et al., 2016). In this study, only 1.1% of the 283 missed stroke diagnoses were tPA eligible and only 7% of the accurately diagnosed acute ischemic stroke patients were tPA eligible. As evidenced by this study, new diagnostic tools need to be developed to assess possible strokes in patients with decreased levels of consciousness (Madsen et al., 2016).

### **Emergency Department Ischemic Stroke Protocols**

Stroke protocols vary in emergency departments around the world but the uniting factor is the emphasis on cutting down on “door-to-needle (DTN) times” as intravenous thrombolysis is the internationally accepted treatment method for ischemic strokes (Kamal et al., 2017). Standard emergency department protocol includes rapid triaging by either emergency personnel in the field or the ER staff, assessment and differentiation of stroke subtypes performed by physicians, and emergent non-contrast CT imaging if available (Stürmer et al., 2002). One of the most common stroke protocol types is a code stroke protocol in which a possible stroke is announced on an overhead system to multiple departments to prepare a rapid cascade of labs and neuroimaging (Tai & Yan, 2013). Some hospitals, especially in urban areas, may have access to acute stroke units or stroke center hospitals and transfer to such a facility is incorporated in the protocol as seen in the Triage, Treat, and Transfer protocol (Middleton et al., 2016). Other protocol methods tend to include additional types of imaging in an attempt to streamline inpatient work-up, although this is not always the most time or cost effective type of protocol (Smith et al., 2003).

Over the last few decades it has become common practice for hospitals to coordinate their stroke protocols with local Emergency Medical Services to enable pre-hospital initiation of protocol (Patel et al., 2011). Stroke protocols were developed initially to cut down on door-to-needle “DTN” times but this value alone cannot guarantee to reduce time elapsed since the onset of the stroke. Modern stroke protocols are incorporating the time that it takes for an acute stroke patient to be transported to the hospital, triaged, and to be seen by emergency department personnel (Patel et al., 2011). The pre-hospital time is being measured as onset-to-door “OTD” time during which patients either choose to visit the emergency department via private transport or by EMS. When a patient arrives to the emergency department, they must wait to be triaged by the nursing staff further adding onto the time elapsed since onset of their symptoms (Patel et al., 2011). In a stroke protocol that incorporates EMS, paramedics can make the stroke assessment using a diagnostic tool such as FAST and alert the emergency department of an incoming stroke which then triggers the protocol allowing the physicians and staff to be prepared to draw labs and to free up any neuroimaging units that they have in preparation for receiving the stroke (Patel et al., 2011).

A common emergency department stroke protocol known as a code stroke system involves the alert of a code stroke on an overhead paging system once the possible stroke is triaged as such thus initiating the protocol (Tai & Yan, 2013). A code stroke type protocol was implemented in a Pennsylvania hospital in 2010 in which the stroke alert was initiated after confirmation of both signs of stroke and onset of symptoms through rapid triaging. (Hoegerl, Goldstein, & Sartorius, 2011). Once the protocol was initiated, labs including coagulation and platelet count are drawn and sent to the lab which had been notified to streamline lab tests in adherence to the stroke alert. Likewise, the CT department is notified as part of the protocol to

ensure an available machine for rapid neuroimaging and interpretation to rule out hemorrhagic stroke after which the neuro department is consulted prior to administering tPA (Hoegerl et al., 2011). Studies have shown that code stroke protocol can reduce the median DTN time by 18 minutes from a median of 90 minutes to 72 minutes (Tai & Yan, 2013). A further improvement on code stroke protocol is known as streamlined code stroke protocol in which the ED is notified by EMS of a code stroke and a nurse and physician then prepare the department and meet the patient at the door for immediate physical exam. Once the physician deems the patient stable they are immediately transferred to CT where some hospitals have tPA pre-mixed and ready for administration (Tai & Yan, 2013).

In addition to standard stroke protocol non-contrast CT imaging, some protocols incorporate extra imaging to expand the ability to rule out comorbidities and streamline hospital admissions. While adding additional imaging measures to stroke protocol may reduce admission time and aid in rapid work-ups, it does add time onto the protocol which could be detrimental to treating acute onset strokes (Smith et al., 2003). An urban hospital instated this advanced imaging protocol and assessed speed and efficacy for 53 patients which were assessed using non-contrast CT imaging, CT perfusion imaging, and CT angiography imaging. This protocol was executed using an advanced rapid helical CT scanner which is not widely available in hospitals across the country (Smith et al., 2003).

Ultimately, an emergency department protocol for an acute ischemic stroke ends with the administration of tPA. tPA is an internationally recognized treatment for acute ischemic stroke that greatly reduces the damage to neuronal tissue if administered within a certain time after onset of stroke symptoms (Fonarow et al., 2011). The American Stroke Association and international guidelines do not recommend tPA after four and a half hours have passed since

onset as there is no proven benefits, however, new studies have shown that tPA is most effective within 60 minutes of onset (Fonarow et al., 2011). Using data provided by the Get With the Guidelines database, more studies are finding that benefits sharply decrease after three hours in what is becoming known as the “three-hour effect”. Quicker reperfusion using tPA has been shown to reduce risks of hemorrhaging and with every 15 minutes’ reduction in “door-to-needle” time the risk of mortality decreases by 5% (Fonarow et al., 2011). The time-sensitive nature of this final step is what drives emergency departments around the world to seek to create quicker and more effective stroke protocols.

### **Efficacy of Emergency Ischemic Stroke Protocols**

The efficacy of an emergency department stroke protocol can be measured in what is known as “door-to-needle (DTN) time” which refers to the amount of time it takes for a patient to enter the emergency department, be effectively triaged, and for intravenous thrombolysis (IVT) or tissue plasminogen activator (t-PA) to be administered (Köhrmann et al., 2011). The recommended DTN time, per the American Stroke Association, is less than 60 minutes for optimal benefits and minimal risks (Kamal et al., 2017). In addition to DTN times, protocol may also be evaluated by “onset-to-door (OTD) time” during which the protocol may be initiated by EMS in the field during pre-hospital assessments (Patel et al., 2011). International guidelines for emergency department protocols involve proper and timely triaging to identify possible strokes, CT imaging of the brain to confirm ischemic strokes, and the administering of IV t-PA (Middleton et al., 2016).

The North Carolina Stroke Care Collaborative (NCSSC) collected data from 2008 and 2009 to assess the efficacy of EMS stroke protocol initiation on the reduction of in-hospital delays found a significant reduction in time to CT and evaluation upon arrival (Patel et al. 2011).

This study involved 13,894 patients of which 45% arrived via private transport and 55% via EMS and of those arriving via EMS 58% were stroke alerts initiated pre-hospital. Patients that arrived via EMS with prenotification of the ER were more likely to have their imaging completed within the recommended protocol time of 25 minutes and interpreted within 45 minutes (Patel et al., 2011). In addition to reducing delays, patients who arrived via EMS with notification were significantly more likely to receive tPA. The NCSSS found in further studies that use of pre-hospital stroke protocol resulted in a 0.2 hour delay reduction from 2005 to 2008 further supporting the efficacy of EMS pre-hospital notification (Patel et al., 2011).

The efficacy of the code stroke protocol type that was implemented in a Pennsylvania hospital in 2007 was evaluated by comparing stroke treatments in the ER from the year prior to the first year of protocol implementation and found significantly reduced DTN times and increased administration of tPA (Hoegerl et al., 2011). This study looked at the 132 stroke patients that had been seen in the ER the year prior to the new protocol and 101 stroke patients seen the year following the new protocol. Patients who arrived in the ER within three hours of symptom onset saw a reduction of median arrival to CT time from 65.5 minutes to 54 minutes and those that arrived within 3 to 6 hours of symptom onset had a reduction of 94.5 minutes to 48.5 minutes (Hoegerl et al., 2011). Median DTN times also improved from 85.5 minutes to 48.99 minutes which resulted in more patients being treated within the optimal window for tPA administration (Hoegerl et al., 2011). The Pennsylvania emergency department had administered tPA 4 times in the year prior to protocol implementation and 12 times the year following with no significant patient demographic change thus reflecting a highly effective implementation of a code stroke protocol (Hoegerl et al., 2011). Even more effective than code stroke protocol, some studies have shown streamlined stroke protocol in which CT scans are acquired immediately

upon arrival to have median DTN times as short as 20 minutes resulting in drastically reduced risk and maximum benefit with tPA (Tai & Yan, 2013).

Advanced imaging protocol in the emergency department could theoretically shorten hospitalization or forego admission altogether as advanced imaging would be able to rule-out TIA vs CVA and can distinguish between minor and acute strokes (Smith et al., 2003). A study evaluating such a protocol found that using an advanced helical CT scanner a non-contrast CT of the brain, a contrast CT, and a CTA could be obtained in 27 minutes spent in the imaging suite (Smith et al., 2003). While this protocol could be useful for admission purposes, 27 minutes is a significant time to spend while 60 minutes is the recommended window for tPA administration by the American Stroke Association (Kamal et al., 2017). In addition to time constraints, the type of CT scanner used in this study may not be reflective of true time it would take to complete the suggested imaging in hospitals that do not have a helical CT scanner.

An analysis of data from the American Stroke Association's Get With The Guidelines campaign evaluated the care received by 55,296 stroke patients who received intravenous tPA while in United States emergency departments from 2012 to 2015. This study found that 50.2% of patients were treated within the ideal 60-minute window of DTN time, 18.2% of patients were treated within greater than 60-minute DTN time with no documented reason for delay, and 31.5% of patients were treated within greater than 60-minute DTN time with a documented reason (Kamal et al., 2017). 23% of the total patients had documented delays associated with delay in diagnosis and eligibility determination and management of other conditions including hypoglycemia and seizure. Delays in diagnosis added on an additional 36 minutes in DTN times while management of conditions added on an additional 34 minutes in DTN times (Kamal et al., 2017). This study concluded that while delays in DTN time were associated with worse

outcomes including increased mortality and increased ambulatory dysfunction upon discharge, however, this association could at least in part be attributed to increased risk associated with the patient's preexisting medical conditions that caused some of the delays (Kamal et al., 2017).

### **Prognosis**

Quality of life is a primary concern for stroke patients and their families as they move forward after the emergency department. While an effective emergency department protocol can reduce the effects of ischemic stroke, the prognosis varies greatly on the location of infarct and the severity of the stroke. Ischemic strokes have much lower mortality rates than hemorrhagic strokes but these patients still suffer effects on their quality of life and risks of recurrences (de Haan R J, M, Van der Meulen J H, M, & K, 1995). One of the most devastating and most common aspects of life that may be compromised post-stroke is cognitive function (Hoffmann, Schmitt, & Bromley, 2009). Motor function is also a common disability in stroke patients, the severity and extent of which varies with location of infarct, and greatly affects a patient's ability for personal care and often leads to depression (RW.ERROR - Unable to find reference:20). If a patient is fortunate enough to arrive in the ED and be assessed via an effective protocol within 4.5 hours of acute onset of an ischemic stroke and is tPA eligible, studies have shown intravenous tPA to result in an increase in quality of life and life expectancy post-stroke (Lubeck et al., 2016).

The phrase "quality of life" is a qualitative measure and may be defined differently by each patient but for research purposes it is often evaluated on a four-dimensional scale to include physical, functional, psychological, and social health (de Haan R J et al., 1995). According to a study published by the American Stroke Association, quality of life post-stroke is affected by patient's age, comorbidities, stroke severity, and location and subtype of ischemic strokes (de

Haan R J et al., 1995). This study of 441 patients, including 55 hemorrhagic strokes, found that post-stroke quality of life, when adjusted for age, mainly affected physical functions rather than psychosocial functions. It was found that patients who had right hemispheric lesions had significant deterioration of bodily function including left-sided neglect, spatial disorientation, and impaired awareness when compared to patients who had left hemispheric lesions which primarily displayed speech disturbances (de Haan R J et al., 1995). Lacunar infarctions also had better quality of life and less disability in comparison to large vessel supratentorial strokes. These findings suggest that assessment of stroke treatments and prognoses are highly variant and must be assessed with adjustments for patient's preexisting comorbidities and age as well as the nature of the stroke in question (de Haan R J et al., 1995).

While physical disabilities are devastating, cognitive disability is widely prevalent and debilitating factor that affects many stroke patients (Hoffmann et al., 2009). A study using the Comprehensive Cognitive Neurological Test (Coconuts test) assessed stroke patient's cognitive dysfunction 1 month post-stroke. This test assesses for five groups of cognitive symptoms categorized by the location of the brain most affected including left hemisphere, hippocampal, frontal subcortical, right hemisphere, and occipitotemporal networks (Hoffmann et al., 2009). The results of this study found 51% of 1,796 assessed stroke patients to suffer from cognitive syndromes affecting the frontal subcortical network and 36% of patients to suffer from left hemisphere syndromes resulting in speech disturbances (Hoffmann et al., 2009).

Intravenous tissue plasminogen activator or tPA is the internationally accepted treatment for acute ischemic strokes and as previously discussed can minimize neuronal tissue death if administered appropriately and is more effective when administered closer to acute onset of symptoms. In a study of Nationwide Inpatient Sample data from United States non-federal

hospitals from 1998-2011, tPA effects on both life expectancy and quality of life were assessed using “quality-adjusted life years” in which increases in life expectancy were adjusted with quality of life in terms of disability reduction (Lubeck et al., 2016). The extrapolation model used in this study estimated 183,235 ischemic stroke patients were treated with recombinant tPA over the 13-year period and 164,000 years in life expectancy were gained using tPA when compared to patients who did not receive tPA (Lubeck et al., 2016). After adjusting for quality of life, the study showed that 239,000 quality-adjusted life years were gained in the use of tPA when compared to patients who did not receive tPA (Lubeck et al., 2016). Per the American Stroke Association, the use of tPA in federal hospitals, which account for approximately 15% of all U.S. hospitals, is significantly higher than utilization in non-federal hospitals and thus this data may be an underestimation (Lubeck et al., 2016). The effects of tPA on quality of life prognoses further emphasizes a need for more effective stroke protocols to increase utilization of tPA for ischemic stroke patients.

## **Conclusions**

The emergency department is often the frontline of medical treatment for a wide variety of disease and injury including ischemic strokes or CVA. Emergency departments around the world have set guidelines known as protocols that are developed for all sorts of scenarios and especially the more severe and life-threatening diseases that they frequently treat. Protocols are developed nationally by copious amounts of research but are adopted by hospitals and healthcare networks on an individual basis. Stroke protocols are further developed by organizations such as the American Stroke Association who also advocate for better stroke protocols across the country with campaigns such as Get With The Guidelines (Fonarow et al., 2011). Stroke protocols include guidelines for patient care from initial triage to diagnosis to treatment and often

include pre-hospital guidelines to be carried out via EMS (Tai & Yan, 2013; Yew & Cheng, 2015).

Efficacy of an emergency department stroke protocol for ischemic strokes is measured in door-to-needle time which assesses the time it takes to assess and diagnose a patient before tPA is administered (Köhrmann et al., 2011). Per current research, streamlined code stroke type protocol is the most effective and most widely available emergency department stroke protocol with median door-to-needle times of 20 minutes (Tai & Yan, 2013). While streamlined code stroke protocol is the most effective, it may not be feasible for all hospitals as some areas may not have access to CT imaging or have properly trained EMS for pre-hospital notification. Despite the protocol put in place, the goal of all emergency departments is to administer tPA within the 60-minute recommended window to minimize risk and potential neuronal death (Fonarow et al., 2011). Acute ischemic strokes can be devastating for a patient's quality of life if not properly treated, emergency medicine is always evolving to provide the best and most effective care and protocols are an integral part of effective treatment.

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