Cerebrovascular Accident Survival: Strategies of Flight Nursing and Aeromedical Transport

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Abstract

Cerebrovascular accidents (CVA), known as strokes, are a leading cause of death worldwide. The delivery and timing of treatment for CVAs is a critical factor in restoring health to the patient. One of the variables in recovery is the method of transport used in bringing the patient to a health care facility. Aeromedical transport remains a valuable resource to achieve full recovery in stroke patients. An ongoing debate of risk versus benefit of helicopter emergency services will be included as well as examination of variables including location, time, physiology of the flight, and the patient's condition to be scrutinized. In conclusion, aeromedical service will be evaluated to determine the efficacy in transport of CVA patients and survivability outcomes.

Keywords: stroke, golden hour, helicopter transport, aeromedical transport, cerebrovascular accident, critical care, emergency medicine

Cerebrovascular Accident Survival through Strategies of Flight Nursing and Aeromedical Transport

The debate in the world of emergency medical care between mechanisms of patient transport and effectiveness of outcomes continue without a definitive decision ever reached. Investigating the benefits and deficits of aeromedical transport is vital especially when focusing on the large disparity of stroke care. With faster response times and increased survival rates, helicopter emergency medical programs seem to be more efficient and patient-friendly, but the following analysis will display the benefits and risks associated with life-saving aeromedical transport.

Pathophysiology of a Cerebrovascular Accident

Understanding the vasculature of the complex cerebral system is crucial to understanding the quick response of emergency medical staff in the area of ischemic and hemorrhagic strokes. The cerebral vasculature of the brain leaves multiple opportunities for a hemorrhage or infarct with numerous effects left to the patient in areas of verbal, memory, motor, or auditory function. Beginning with the anterior circulation, two internal carotid arteries perfuse the frontal and parietal lobes of the brain while dissecting into the anterior choroidal and thalamic, ophthalmic, posterior communicating, and middle cerebral arterial branches (Book, 2009). One of the most common locations for cerebral infarcts, the middle cerebral artery is responsible for perfusing the areas of auditory function, language and understanding, and motor as it brings blood flow to the temporal lobes and the postcentral and superior temporal gyrus (Book, 2009). Vertebral arteries are the primary vasculature of the posterior lobes of the brain (Book, 2009). Contrary to the anterior vasculature entering from the carotids, the posterior vasculature enters from the subclavian artery through the foramen magnum in the back of the skull (Book, 2009). The posterior aspects of the brain such as the cerebellum, medulla oblongata, and pons are perfused by the vertebral arteries (Book, 2009). An infarct in this area would manifest in symptoms such as balance and dysregulation of respiratory drive. The circle of Willis is described as “this anastomosis of arteries can provide continued circulation if blood through one of the main vessels is disrupted” (Book, 2009, p.1317). Although the vessels may create anastomoses, the ischemia will progress within the area of the infarct if blood is occluded in another region. In addition to arterial vasculature, strokes may occur in the venous vasculature as well and present with different signs and symptoms were ischemia to occur.

The venous vasculature system of the brain draws blood out through the internal jugular veins as it circulates through the sinuses and dura in response to increasing intracranial pressure and ischemic states (Book, 2009). The deep cerebral system and the superficial system work in tandem to return blood flow to the heart through the internal jugular vein (Book, 2009). Areas such as the subarachnoid space and dura mater are critical points of pressure that if left with increasing intracranial fluid and blood could possibly cause herniation of the brain stem (Book, 2009). By looking at the vasculature system of the brain, understanding is reached in the importance of quick response in order to restore perfusion to the tissue. Without quick thinking of the healthcare team members, deficits of a cerebral vascular accident are difficult to recover from. Additionally, discussion of the pathophysiology of both types of strokes are crucial to gain an understanding of the process of hemorrhagic and ischemic strokes and the necessity of a therapeutic time frame to thrombolysis.

Hemorrhagic Stroke

The pathophysiology of a hemorrhagic stroke leaves more devastating effects and risks than an ischemic stroke for many patients. Per Perna and Temple (2015), “half of all patients with primary ICH (intracerebral hemorrhage) die within the first month after the acute event” (para. 3). Intracerebral and subarachnoid hemorrhages are the most commonly occurring types of hemorrhagic strokes due to hypertension or vasospasm following a ruptured aneurysm (Book, 2009).

Effect of Hypertension. Hypertension is a shearing force to the vessels not only within the cardiac vasculature but within the cerebral vasculature as well. A comorbidity such as atherosclerosis is a common precipitating factor for hypertension as plaque begins to line the interior of the vessel disrupting blood flow and perfusion of the intended tissue or organ. Blood pressure is regulated by the autonomic nervous system using baroreceptors and chemoreceptors to gauge the levels of pressure, sympathetic response, and oxygen demand needed in the body (Porth, 2009). Baroreceptors sense pressure and resistance of the vessels in addition to sending messages to the brain stem in order to dilate or constrict the smooth vascular muscle (Porth, 2009). If perfusion of tissue or organs is not met, the chemoreceptors react due to the current levels of carbon dioxide, oxygen, or hydrogen ion within the vessels (Porth, 2009). When the patient is in an acidic state of high carbon dioxide levels and low oxygen, the chemoreceptors produce vasodilation within the vessels to increase cardiac output and oxygen perfusion to prevent ischemia (Porth, 2009). In addition, the renin-angiotensin-aldosterone system (RAAS) responds to low blood pressure or the presence of increased sodium within the body affecting the fluid retention functions. The product of RAAS is angiotensin II which acts as a vasoconstrictor for decreased blood pressure values and works to activate reabsorption of sodium in the kidneys (Porth, 2009). Atherosclerosis also increases blood pressure as continued resistance within the vessel is added as the lumen of the vessel becomes narrowed from plaque. Hypertension's direct effect on hemorrhagic strokes is seen as pressure exerted from prolonged, uncontrolled blood pressure continues to shear the vessels until the vessel cannot withstand the force. In the process of vessel lysing, blood is exerted into the area in which the vessel has ruptured and hemorrhage occurs. According to Zomorodi (2014), one of the most modifiable risk factors is treatment of hypertension and can lower the risk of stroke by 50%. Hypertension also is a root cause of ischemic strokes in which increased plaque and narrowed lumens of the vasculature cause decreased perfusion to the brain tissue and thus deplete the tissue of needed oxygen.

Risk Associated with Hemorrhagic Stroke. Vasospasm and hydrocephalus are two of the most common risks patients may face during and following a stroke. Using the Monro-Kellie Hypothesis, any change in the levels of cerebrospinal fluid, blood, or edema of the brain tissue within the cranium will disturb the perfect balance and equilibrium within the cranial cavity (Book, 2009). Following hemorrhage, increased levels of blood can cause rising intracranial pressure (ICP) within the skull cavity. As Book (2009) describes, small increases in cerebrospinal fluid or blood is first compensated by reabsorption. Compensation does not last for long as the increasing intracranial pressure soon manifests in decreasing cerebral pulse pressure (CPP) and therefore ischemia as there is no room left for the vessels to perfuse the brain tissue (Book, 2009). Herniation of brain tissue is the last indication of increasing ICP as the brain stem is pressed into the foramen magnum and death quickly follows (Book, 2009). The herniation of the brain stem results in beginning bradycardia, hypertension, and widened pulse pressure, but as the pressure increases on the brain stem soon there is an altered level of consciousness, pupil dilation, and respiratory arrest (Book, 2009). With hemorrhagic strokes, quick correction and surgery is needed to decompress the pressure from the brain with quick transport from the scene of the trauma to the nearest emergency department. Likewise, quick transport is needed for ischemic strokes as will be discussed below.

Ischemic Stroke

Ischemia is the absence of oxygen within a brain tissue that leads to an infarct, which is death of a tissue. Two forms of ischemic strokes exist including thrombotic strokes, which are stationary blockages, as well as embolic strokes which are moving clots (Book, 2009). Due to vessel damage or blockage, a group of brain cells experiencing ischemia, known as a penumbra, lose electrical activity and function as the lack of oxygen to this band of cells continues to increase (Book, 2009). As the ischemia increases to this area, toxic metabolites are released and further ischemia spreads to surrounding brain tissue (Book, 2009). Throughout the evolution of the stroke, symptoms such as motor, verbal, or vision deficits begin to show as certain areas of the brain are deprived of oxygen. A thrombotic stroke is caused by atherosclerotic plaque blockage in the lining of the vessel’s lumen and decreasing the amount of blood available to perfuse brain tissue (Book, 2009). Book (2009) states, “[t]hese infarcts often affect the cortex, causing aphasia or neglect, visual field defects, or transient monocular blindness (amaurosis fugax)” (p.1320). An embolic stroke travels through an artery and becomes lodged in a smaller vessel and thus causes the process of ischemia to begin (Book, 2009, p.1320). Varying comorbidities may make a patient more inclined and susceptible to an ischemic stroke as discussed below.

Comorbidities and Health Disparities

The varying comorbidities to an ischemic or hemorrhagic stroke may include hypertension as discussed above in addition to smoking, diabetes mellitus, race, hyperlipidemia, alcohol or drug use, and heart disease such as atrial fibrillation (Book, 2009, p.1319). For example, one of the most common comorbidities from race seen with a cerebral vascular incident are from the African American population due to lack of nocturnal dip in the regulation of blood pressure. Additionally, location also influences the incidence of stroke as the Southeastern United States is most commonly referred to as "The Stroke Belt". A study in The Stroke Belt identified that the greatest risk factor was race in the commonality of strokes in other areas outside the region (Cushman, et al., 2008). The study conducted by Sergeev (2001) in the area outside the Stroke Belt found that the largest comorbidities were African American descent and living in a rural environment. Health disparities such as socioeconomic status and access to healthcare services when in a rural community may play a vital role in the incidence of stroke as well. According to *Stroke* (2013), the majority of areas affected by higher rates of cerebrovascular disease occurred with families of lower incomes living in urban areas with high poverty rates. In addition, many of these families did not have members with any kind of diploma or degree (Schieb, Mobley, George, & Casper, 2013). The area in which patients live also has a vital factor in receiving critical care during the precious window of time for treatment during a stroke as will be discussed further below with transportation measures in rural communities. With predisposition to stroke, rapid treatment must be performed to achieve quality of life and positive outcomes following a stroke.

Treatment

In addition to health comorbidities, time constraints for the rapidly needed treatment of ischemic CVAs may pose problems due to location, environment, or access to a certified stroke or trauma center. The recommendation for treatment of an ischemic stroke for the most favorable outcome is the use of recombinant tissue plasminogen activator or tPA (rt-PA). Tissue plasminogen activator is a revolutionary thrombolytic drug that has brought considerable transformation of stroke symptoms in patients for years since its original production. The pharmacologic mechanism of tPA uses plasminogen to undergo conversion into plasmin (Lehne, 2013). Plasmin attacks clotting factors such as fibrinogen and fibrin and allows for restored blood flow to the vein or artery (Lehne, 2013). In 2009, the American Heart Association changed the recommended guidelines of administration from three hours by extending it to four and a half hours (Lehne, 2013). The symptom onset, diagnosis of ischemic stroke, and administration of tPA must be completed within this four and a half-hour window.

The significance of tPA was recognized in a trial conducted by patients having an acute myocardial infarction in the GUSTO-I (Global Utilization of Streptokinase and tPA for Occluded Coronary Arteries) (Lehne, 2013). Patients that received tPA within two to four hours had a mortality rate of 6.6% compared to receiving tPA after four to six hours of symptoms onset in which the mortality rate was 9.4% (Lehne, 2013). In addition, prenotification of patients with stroke-like symptoms arriving by emergency medical services (EMS) has greatly improved the likelihood of tPA administration within the window of three to four and a half hours (Lin et al., 2012). According to Lin et al. (2012), "[l]ess than one third of patients with acute ischemic stroke treated with tPA receive treatment within 60 minutes of hospital arrival" (para. 1). In review of a study conducted by Lin et al (2012), 249,197 (67.0% of the patient population) patients with EMS prenotification had shorter door-to-imaging times and were more likely to receive tPA within 120 minutes of arrival and symptom onset (para.11). The treatment of ischemic strokes within this golden window of time is crucial for decreasing patient mortality. Mortality is also increased with the risk of intracerebral hemorrhage that may occur after administration of tPA (Lehne, 2013). After confirmation of an ischemic stroke and administration of tPA, the stroke may convert into an intracerebral hemorrhage after degradation of the clotting factors fibrinogen and fibrin (Lehne, 2013). If this occurs, the patient faces large deficits in visual, motor, and auditory fields depending on the area of the brain that has hemorrhaged. The hemorrhage must be evacuated through surgical means such as a craniectomy depending on the location of the hemorrhage. As discussed above, time is a vital aspect to ischemic and hemorrhagic stroke care in order to increase the quality of the patient's life after suffering a cerebrovascular accident. The elusive golden hour in emergency and trauma medicine is the most coveted challenge to be met when it involves stroke and neurologic trauma care.

The Golden Hour

As discussed above in the treatment of stroke, the practice of obtaining treatment within three to four and a half hours is crucial to achieving long-lasting recovery in patients of ischemic strokes. Ischemic stroke care within the golden hour will be discussed as the majority of cerebrovascular accidents involve ischemia instead of hemorrhage. In addition, the time limit of recombinant tissue plasminogen activator of three to four and a half hours is a strict guideline to prevent the risk of transition to cerebral hemorrhage and risk of bleeding in other tissues. In an analysis of the term "golden hour", Lerner and Moscati (2001) describe how the term was commandeered by trauma and emergency medical personnel. R. Adams Cowley was the originator of the term "golden hour" as he supported the vital time constraint that trauma and stroke treatment needs emphasis (Lerner & Moscati, 2001). There is ongoing research and improvement within trauma goals that "golden hour" implementation brings a difference in the outcome of patients since R. Adams Cowley first described the rapid treatment needed for improving quick deterioration of patients in 1976 (Lerner & Moscati, 2001). In the following discussion, the implementation of the idea of rapid transportation and treatment of cerebrovascular accident patients will be studied.

Golden Hour and Stroke Care

Numerous studies have been conducted recently in an effort to evaluate the effectiveness of following golden hour stroke care interventions to measure patient survivability and recovery. Studies using golden hour requirements of receiving treatment within sixty minutes of last normal presentation of the patient, show favorable outcomes in the trial conducted by Saver et al (2010). During the study, 253,148 ischemic strokes were analyzed in regards to the use of thrombolysis and time management. 28.3% of the study's population received thrombolytic therapy more readily as they arrived to the local emergency department in sixty minutes of less (Saver, et al., 2010). Only 12.9% of patients that arrived between 61-180 minutes of symptom onset received thrombolytic therapy and thus had a more severe, traumatic recovery from brain injury (Saver, et al., 2010). The disadvantage found within this trial was that although the golden hour patients arrived more quickly and more frequently received tPA, their administration time was much slower than that of patients who were not within the golden hour (Saver, et al., 2010). As Saver et al. (2010) states, “These findings support public health initiates to increase early presentation and shorten door-to-needle times in patients arriving within the golden hour” (para. 4). One of the most fascinating avenues of research within this field is using prehospital diagnostic tools and treatment for ischemic strokes which occur more frequently in present populations. Prehospital notification, triage, and thrombolysis are critical aspects in improving the likelihood of full CVA recovery for an affected patient.

Prehospital notification. When time is of the essence emergency medical personnel can make great strides to value every minute when it comes to cerebrovascular care. A seemingly simple act of dispatching appropriate details from the EMS vehicle whether helicopter or truck can shorten delays to the patient receiving tPA. Although not a large difference in delay, times were noted in a study in *Prehospital Emergency Care* that displayed a 17% shorter time from door to computed tomography (CT) scan and an increase in the likelihood of using tPA changing from 21% to 41% with the use of prehospital notification (Abdullah, Smith, Biddinger, Kalenderian, & Schwamm, 2008). In addition, stroke studies in North Carolina were used to assess the effectiveness of tPA administration with prenotification by EMS in comparison to private transport of the patient (Patel, Rose, O'Brien, & Rosamond, 2011). For patients using emergency medical services, the time of imaging was within twenty-five minutes of arrival and an interpretation of the scan by a neurological specialist was completed within forty-five minutes (Patel, Rose, O'Brien, & Rosamond, 2011). In a similar review of the delays of stroke treatment, several methods of improving treatment were discussed including TeleStroke in ambulances help to improve triage and possible avenues of treatment that can be performed at the scene of the incident (Audebert, Saver, Starkman, Lees, & Endres, 2013). In addition, a diagnostic test of transcranial duplex sonography allows for quick results to confirm an ischemic or hemorrhagic stroke and notify the receiving stroke center or emergency room to prepare (Audebert, Saver, Starkman, Lees, & Endres, 2013). Not only is prenotification a large tool in the stroke golden hour process, but the early use of en-route thrombolytic therapy can allow for vast improvement of a stroke patient's symptoms due to ischemia.

Prehospital thrombolytic therapy. One of the most advanced delivery methods of stroke treatment being tested now is the stroke emergency mobile unit (STEMO) currently used in Berlin, Germany (Ebinger, et al., 2015). Patients in Germany who requested for emergency service personnel due to possible stroke symptoms were received with a regular ambulance in addition to STEMO (Ebinger, et al., 2015). Not only does the stroke emergency mobile unit use telemedicine to communicate with stroke specialists, but a computed tomography (CT) scanner and a point-of-care laboratory are located within the extended ambulance to extensively diagnose the presence of a hemorrhagic or ischemic stroke and begin rapid treatment (Ebinger, et al., 2015). The most vital aspect of STEMO is the ability to provide on-site thrombolytic therapy with tPA to patients while en-route to a stroke or trauma center (Ebinger, et al., 2015). This procedure drastically decreases the time of added transportation in order to reach a facility for diagnostic testing and confirmation of the stroke. In a range of thirty-nine to fifty-four minutes, patients were able to be seen, tested, diagnosed, and have thrombolytic therapy started on scene by using STEMO (Ebinger, et al., 2015). Using this method of pre-hospital thrombolytic therapy greatly increases the efficacy of emergency medical transport and patient's recovery outcomes due to cerebral ischemia. The onset to needle time for patients is dramatically reduced and the outcome of stroke recovery is significantly increased with onsite therapy. Evaluations of other delays in treatment can also benefit the emergency medical team in seeking ways to deliver stroke care within the golden three to four-and-a-half-hour treatment window.

Improving Delays and Treatment

One of the most-effective ways to improve recognition and time to treatment of any kind of stroke is to educate the population. Not only do healthcare providers and team members need to quickly recognize the signs and symptoms of a stroke, but family members surrounding the present victim of a CVA are most vulnerable for patient understanding. A widely used educational tool is the acronym of F.A.S.T.. The letters of F.A.S.T. stand for Facial Droop, Arm Weakness, Speech, and Time. Detection of one of these signs is a sign to call for emergency services as quickly as possible. Facial droop can be detected by asking a patient to talk or attempt to smile. Arm weakness is seen by using the pronator drift test in which the patient holds both arms out in front of their body with the palms facing upward and keeping his or her eyes closed. The inability to hold the arms up at a level plane for the majority of the test is considered a neurological deficit and further testing is needed to see what is the root of the deficit. The speech aspect of the acronym of F.A.S.T. is a simple measure of the quality of the patient's speech. Signs of slurring or inability to comprehend words indicate cerebral ischemia. The last aspect of the acronym is the factor of time. As repeatedly discussed, once a single aspect of this stroke tool is noticed within a patient, family member, or friend, time is of the essence to seek emergency care, especially if the stroke is confirmed to be ischemic. (American Heart Association & American Stroke Association, 2017)

An additional aspect to improving treatment may depend on the qualification and training of the EMS team members. In either helicopter or ambulance, EMS team members are the frontline of rapid critical thinking and quick action for stroke patients. As the first responders arriving to the scene of trauma and crisis, EMS teams must have an extensive training in anatomy, physiology, and pathophysiology in order to make a rapid assessment of the patient’s condition and to develop a plan of care. In-depth experience is an excellent prior qualification to possible improved outcomes of patients. A question to ask is: Would staffing an ambulance or helicopter with a physician or advanced practice nurse improve patient outcome? One such study in Pakkanen et al (2016) used a comparison of patients transported due to traumatic brain injuries by a paramedic staffed EMS in relation to a physician staffed EMS. Within this study, 458 patients were used in the population of traumatic brain injuries over a six year period (Pakkanen, et al., 2016). Only 4% of the patients in both groups were hypotensive but the paramedic group had a larger percentage of patients that were hypoxic during treatment due to the physician staffed services using intubation methods more frequently (Pakkanen, et al., 2016). In conclusion, the level of training impacted the patients adversely in the paramedic group as there was a higher mortality rate of 57% in comparison to 42% from the physician treated group (Pakkanen, et al., 2016). Discussion below will further reinforce the benefit of qualification of EMS providers more specifically in helicopter based emergency medical services in addition to the efficacy of aeromedical transport.

Helicopter Emergency Medical Services

Beginning my studies, I had regarded helicopter emergency medical services (HEMS) as a better standard of transportation for cerebrovascular accident patients regardless of time, location, or severity. Furthermore, following my research with a revelation to the cost-effectiveness, effects of aeromedical flight physiology, patient survivability rates, and stressors of the aeromedical flight teams, I had concluded with a critical view of the use for helicopter emergency medical services. Measuring the benefits and risks of HEMS, I believe that I have a greater appreciation for the use of this service in critical care patients and have a better understanding for the utilization of this life-saving medical service. The critical analysis and research included aspects of this system with cost-effectiveness, flight physiology in relation to the patient, stressors of the aeromedical flight team, and the increase of survivability of stroke patients through HEMS transportation. Following this research below, conclusions of the efficacy and necessity of aeromedical flight transportation will be included.

Cost Effectiveness of Flight Transport

When patients or healthcare insurance agencies hear the use of helicopter transport, one of the first thoughts that comes to mind is the enormous cost of a single flight. According to an exposé by *The New York Times,* ambulance prices are a competing market and ever increasing to meet the rising costs of healthcare provider services (Rosenthal, 2013). Hospitals, fire departments, and privately-operated EMS services can vary in prices depending on the urgency of the patient's condition, the time, the location, and whether the patient is insured or not (Rosenthal, 2013). Ranging from a few hundred dollars to $2,000 or more, ambulance service prices may vary depending the needs of the patient ranging from basic life support to advanced life support and treatment (Rosenthal, 2013). Unbeknownst to the patient, the emergency medical service transporters only receive 30%-40% of the total cost of the transportation due to copayments, Medicaid, or Medicare reimbursements but often try to exceed the price in order to gain more profit (Rosenthal, 2013). For Medicare patients, ground ambulance and aeromedical helicopter transport is covered in most life-threatening, emergency situations (Medicare.gov, 2017). Medicaid covers costs of ambulance as well but may have a small copay of $1-3 depending upon which state the patient resides in (KCMU Medicaid Benefits Database, 2012).

Looking at the use and transportation of helicopter services, the cost is astronomical. As Silbergeit, Scott, and Lowell (2003) describe, the cost alone of thrombolytic therapy performed in the emergency department with the added cost of helicopter transportation can deplete a patient's savings and resources in a short amount of travel time. Accessing the costs of my own metropolitan city in North Carolina, the cost of helicopter use, assuming the insurance coverage is 70%, would be around $13,000 (Fair Health, Inc., 2017). Using the University of Michigan air medical service for an estimation of costs, the average patient incurs a bill on average of $3,749 just accounting for flight transportation (Silbergleit, Scott, & Lowell, 2003). In addition to transportation costs, the ischemic stroke candidate pays for thrombolytic therapy which was accounted to be around $2,500 in addition to angiography costs of $4,000 (Silbergleit, Scott, &

Lowell, 2003). Cost-effectiveness is difficult to pinpoint with HEMS as it is difficult to calculate the severity of the patient being triaged and the necessity of transportation in contrast to the costs of operation for the aircraft and aeromedical team. In contrast, an analysis of cost-effective research articles had a central theme underlining several studies using the quality-adjusted life year aspect, otherwise known as QALY. This feature is used in cost-effective analyses to measure the economic burden and financial strain of a patient's disease by looking at the severity, quality, and quantity of life after the post-traumatic incident. According to Taylor et al (2010), the quality adjusted life year amount saved per patient on average ranged from $7,138 to $12,022 through the use of helicopter emergency services. Looking at the QALY aspect, patients are financially relieved through HEMS use as there is quicker service and thus an increase in patient outcome. Not all transfers of patients through aeromedical transport have a financial benefit as seen in research from the journal, *Annals of Emergency Medicine.*

Delgado et al. (2013) argues that many patients in his research would have reached the same outcome of treatment and care were they to be transferred by ground ambulance care rather than by helicopter use and thus had a lessened expense not only for patients but for insurance companies as well. This is an important aspect of consideration in aeromedical transport use with CVA patients to evaluate the efficacy of use. Delgado et al. (2013) disagrees with the efficacy of helicopter EMS use by using a cost-utility analysis approach and a risk-reduction mortality survey. Overtriage, or an over-estimation of injuries in patients, is seen to increase costs of helicopter transportation especially within areas of urban trauma and stroke centers (Delgado, et al., 2013). In urban areas with high volumes of trauma and transport, patients' quality-adjusted life year cost is $100,000 per year or more depending on the location of transport to the designated trauma center (Delgado, et al., 2013). To make each quality-adjusted life year to be more cost effective to the patient or insurance company, a mortality reduction of 26% per 100 lives transported would be needed (Delgado, et al., 2013). Not only do areas of cost-efficacy affect the desired use of aeromedical transport, but the location of each patient has a role in the frequency of use and whether the cost of the distance is worth the life being saved.

Location Efficacy of Helicopter Transport

In contrast, the use of aeromedical emergency services provides stroke patients living in rural communities an avenue of reaching the golden window of thrombolytic therapy. According to a recent study from rural areas of Georgia and Florida, ischemic stroke patients had an increased margin of success with thrombolytic therapy due to quick helicopter transportation (Silliman, Quinn, Huggett, & Merino, 2003).Silliman et. al (2003) seeks to improve the efficacy of rural transport and quality of life post-stroke with increased use of thrombolytic therapy through transportation as he states that less than 5% of ischemic stroke patients receive tPA within the suggested 3.0-4.5-hour guideline. Teaching triage guidelines to each EMS department within the surrounding counties, the main stroke center was designated as it was the only hospital with a 24-hour continuous CT scan program and on-call neurologist (Silliman et al., 2003). The rural areas covered by this program stretched for 5,762 square miles over nine counties total (Silliman et. al, 2003). Using helicopter services, 85% of patients arrived within the 3-4.5-hour time window and could receive thrombolytic therapy if needed within the golden timeframe (Silliman et al., 2003). On average the patient cost in this study was

$4,623 for a distance ranging from eleven to ninety miles (Silliman et al., 2003). As seen above, although the costs associated with this aeromedical transportation may be higher, the rapid access to treatment for patients that may be located far away from a certified stroke center takes precedence of the quality of the patient's life over the level of cost.

Risks Associated with Helicopter Transport and the Aeromedical Team

Transportation of any patient in any capacity whether by ground or air emergency medical services warrants a level of risk with each incident. Accidents are prone to occur in either transportation mode no matter the caution used by the driver, pilot, or medical team. Inevitably, helicopter transport often has more risk involved as additional variables are placed upon the medical team, pilot, and patient while flying to reach the designated trauma or stroke center. With increased distance comes increased risk of fatigue, changes in weather, increase of stress among the medical flight team and alterations in the patient's condition. The most vital risks to safety in helicopter transportation stem from two areas: flight team safety and the patient's condition. Within the flight team, risks of vision in weather and night missions, fatigue related accidents, and pressure from administrators of the flight operations center most often are to blame for accidents during the flight. For the patient, issues such as altitude play a factor in the condition during the flight. The National Transportation Safety Board (2006) sums the risks of aeromedical flight by saying, "Transporting a patient to the hospital is of utmost importance; however, if a flight is unable to safely reach the patient, the safety of the entire operation is compromised, and it may be to the patient's benefit to be transported by some other means, such as ground transportation" (p. 2). Exploring the world of flight and aeronautics, the three most common risks faced by pilots and aeromedical flight teams are visual problems in weather and night missions, fatigue after repeated trips, and pressure from aeromedical organization executives to take risks.

Weather-Related Accidents

Examining an emergency medical services aviation report from the *National Transportation Safety Board*, between three years of 2002-2005, there were 55 EMS aircraft accidents that occurred including multiple fatalities and injuries of patients, pilots, and emergency medical workers (National Transportation Safety Board, 2006). As stated, 38% of flights within this study occurred at night but factors involved with accidents included visibility and remote terrain in unfamiliar rural areas. Night flights with accidents accounted for 49% due to lack of visibility in the air (National Transportation Safety Board, 2006). Pilots must receive advanced training to fly in conditions in which visual flight rules are not the priority and instrument meteorological conditions are used instead (Walmsley & Gilbey, 2016). Instead of relying on conditions in which terrain could be visibly seen from the cockpit, the pilots would rely on the instruments of the aircraft to guide in conditions which most inevitably would lead to fatal accidents (Walmsley & Gilbey, 2016). In addition to decreased visibility, Walmsley and Gilbey (2016) believe that factors such as administrative workload, organizational stress, fatigue, and overcompensation of skills may affect the decision made to make a potentially risk flight.

Fatigue of Flight Team

Fatigue and cognitive function have been studied to show a decline not only in pilots responsible for the safety of the trip and aircraft, but it may also lead to decisional regret in the treatment of patients by the nurses. Examining 605 critical care nurses who reported fatigue during their shift, 29% of the population studied reported decision regret during the shift and care of their patients (Scott, Arslanian-Engoren, & Engoren, 2014). Coupled with the stress of critical care transport, the risk of flight variables, and the uncertain condition of the patient, fatigue may decrease cognitive functioning abilities to make sound judgement about the patient's care. As described in the report, most flight teams perform 24 hour shifts with very little time to sleep and can cause fatal accidents such as the one in Kansas with the aeromedical pilot who had been awake for 21 hours (National Transportation Safety Board, 2006). Consumed with fatigue, the increased stress from the medical flight company may allow pilots and aeromedical teams to comply with missions in which safety is not the priority.

Missional Stress

Pressure of time, money, and administrative decisions place undue stress upon medical teams to fly into areas, environments, and conditions in which cause high risk to the entire team, patient, and patient's family members if aboard. Per the Air Medical Physician Association, factors such as stress from flight organization supervisors, low fuel in aircrafts, and rapid preparation without details of the mission attributed to accidents made during the flight (National Transportation Safety Board, 2006). With stroke patients, a large burden placed on medical teams is that the window of thrombolytic therapy decreases with each increase in mileage to reach the patient and transport he or she to an appropriate stroke or trauma center. The National Aeronautics and Space Administration reported that a large percentage (44%) of accidents caused in aeromedical transports occurred due to the rapid deterioration of the patient's condition (National Transportation Safety Board, 2006). When deciding to perform a mission that is too dangerous to undergo in order to provide urgent transportation to a patient, a utilitarian approach must be made in which the lives of multiple crewmembers are valued and an alternative transportation is found for the patient that will be safe and preserve the quality of all lives involved.

Risks Associated with the Aeromedical Transported Stroke Patients

Stroke patients undergoing transport by helicopter are under physical stress as while traveling with increased altitude and pressure within the cabin of the helicopter. Per Kouliev, Richardson, and Glushak (2012), multiple studies have shown the effect of rapid altitude rise within the brain causing mild brain swelling in all passengers even while in a pressurized cabin. With these in mind, patients traveling with the likely diagnosis of an ischemic stroke may be at a susceptible state for developing an intracranial hemorrhage. There are eight aspects of stress correlated with helicopter emergency medical transportation per the research of The Association of Air Medical Services (2013). Included stressors are: "Reduction of the partial pressure of oxygen-hypoxia, reduction of the barometric pressure, reduction of temperature, moisture reduction-dehydration, noise, vibrations, acceleration forces, fatigue, oxygen partial pressure reduction-hypoxia" (Intas & Stergiannis, 2013). Focusing on the barometric pressure with stroke patients specifically, this value will rise as the aircraft climbs in altitude (Intas & Stergiannis, 2013). With rising pressure of the intracranial cavity, patients may experience symptoms such as headache and epistaxis as the force of pressure and altitude prevents the evacuation of air from the cavity (Intas & Stergiannis, 2013). In addition, when ascending in altitude, the patient may experience a decline in temperature sending the body into a survival mode and increasing the workload of the brain to configure the temperature of the body (Intas & Stergiannis, 2013). In addition to a temperature decrease, stress is placed on the body due to the vibration and acceleration forces of the aircraft. Intas and Stergiannis (2013) state that linear and angular acceleration forces can increase the intracranial pressure of the brain and increase vasoconstriction as well as create susceptibility for hemorrhage. Depending on the make of the aircraft, vibrations may increase the physical and mental stress of the patient with possible incidence of tachycardia and increased vasoconstriction (Intas & Stergiannis, 2013). Reinforcing the research of flight physiology on aeromedical patient transportation, an analysis conducted by Polikoff and Guiliano (2013) also stated that gravitational forces may exert effects on patients concerning the cardiac output of the patient. Depending on the positioning of the patient, the vasculature may succumb to vasoconstriction from pressure and gravitational pulls allowing blood to pool and increasing the resistance in the vasculature for return (Polikoff & Guiliano, 2013).

Specifically, for ischemic stroke patients, oxygenation is a large concern before thrombolytic therapy can be started to re-perfuse the impacted tissue. Adequate oxygenation throughout the process of treatment can help to decrease the incidence of further brain tissue ischemia or infarct with non-recoverable deficits. Ensuring oxygen for the patient within transport is a main priority that is used to subdue any incidence of hypoxia due to increasing altitude (Polikoff & Guiliano, 2013). A new technology being used in helicopter medical transportation is a transcranial oximetry device to measure levels of oxygen saturation while combating levels of altitude in flight (Burillo-Putze, et al., 2002). This LED light has two wavelengths to measure hemoglobin levels in brain blood oxygen saturation (rSO_2) (Burillo-Putze, et al., 2002). Placing the probe on the front temporal aspect of the patient's skull, brain blood oxygen saturation is monitored and thus the medical team can visualize the decrease in oxygen saturation during flight and increasing ischemia due to the stroke (Burillo-Putze, et al., 2002). This is a valuable device to assist transport of cerebrovascular accident patients.

Conclusion

In the beginning of my research in August of 2015, I was drawn to the topic of flight nursing for the rush of adrenaline as well as interest in the autonomy of the flight nurse. I desired the critical care aspect of nursing but without the walls of the intensive care unit or emergency department. In my own family, my father was a patient of helicopter transport after suffering with stable angina from coronary artery disease while on vacation in the Hawaiian Islands. Witnessing the detailed, fast-paced, and critical need for fast transportation, my interest in this topic peaked. Throughout my research in the debate of efficacy of helicopter emergency medical services, I conclude that I cannot take a firm stand on either side. Looking at costs, insurance coverage, risks, and time, helicopter services brings many variables that cannot be overlooked. These are the arguments of opposition to the increased use of helicopter emergency services in which the risks outweigh the benefits. In contrast, the speed of patient delivery and onset-to-needle time of stroke patients brings about a positive outcome that cannot be denied. From a benefits-focused perspective, an increase in helicopter emergency services may contribute to improved patient survival and widespread, quick access to healthcare for rural residents. In conclusion, I believe that the quality of life trumps all variables in the care of a patient suffering a cerebrovascular accident and all measures should be taken to preserve that life. I agree that the benefits may outweigh the risks and that each situation should be examined before a hasty conclusion has been reached in order to maximize the patient outcome and the safety of the helicopter emergency services team. Research opportunities still exist and are needed to further this area of advanced medicine.

Recommendations for future research may include a trial of mobile thrombolytic therapy services as seen in ambulance services in Berlin, Germany (Ebinger, et al., 2015). The increased prehospital use of thrombolytic therapy in ambulance settings may allow for further research to be conducted for aeromedical transportation services. From this review, current implications for practice can include increased education to healthcare professionals focused on response times and rapid treatment for patients presenting with stroke-like symptoms. Additionally, I desire to make implications for increased CVA survival in my own practice as an emergency department nurse by furthering my education in neurological studies, thrombolytic therapy advances, and advancing education to coworkers, patients, and family members. This research study has provided a new perspective on emergency aeromedical services and thrombolytic therapy of stroke patients that will continue onto my practice as an emergency nurse.

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