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Quality indicators for patients presenting to emergency departments with cerebrovascular events: A chart review and prospective study of transient ischemic attacks and stroke within the Alberta Health Services-Edmonton Zone

By

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A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of

Master of Science

in

Epidemiology

School of Public Health

Spring 2013
Edmonton, Alberta

Abstract

This thesis presents the results from a retrospective chart review of medical records and a prospective patient interview of stroke patients within the AHS Edmonton-Zone emergency departments. Of 7330 charts reviewed, 17% had a diagnosis other than stroke/TIA (misclassified). Of the 336 patients interviewed, standardized questionnaires significantly outperformed ED charting for documentation of timing of symptom onset, location of stroke event, and smoking histories. Analysis of quality of care indicators (QCI) demonstrated that the AHS-Edmonton Zone EDs performed variably when treating stroke; however, they failed to meet nationally accepted benchmarks for all critical time requirements. QCIs are merely a mechanism to evaluate performance and stimulate change within clinical settings; however, they also have the potential to generate new ideas and directions regarding how management (e.g., stroke) can be improved. Robust performance evaluation and feedback can identify areas for improvements and drive clinical care change.

Acknowledgement

This research was funded by a grant from Health Canada, Canadian Institutes of Health Research, and the University of Alberta.

Numerous people made this research possible: first and foremost to my supervisor, Dr. Brian Rowe. Brian, his wisdom, guidance and most importantly – patience, served as invaluable resources towards the creation of my thesis. You have been an inspiration in the pursuit of my academic goals. I would also like to thank my thesis committee members Drs. Don Voaklander and Ken Butcher as well as my external reader Dr. William Sevcik for their contributions.

The University Of Alberta Department Of Emergency Medicine (DEM) Research Group's members were pivotal in logistical support, data collection, and the Health Canada manuscript preparation. The entire DEM staff was an invaluable assistance, but especially, Debbie Boyko for coordination between AHS staff and DEM staff, Justin Lowes and Scott Kirkland for their tireless efforts with chart reviews and patient recruitment, and Cristina Villa-Roel for biostatistics guidance. I would also like to thank Mira Singh, Jason Randall, Angeline Martin, and Tracy Stasiw for their assistance with patient screening and recruitment.

To my family and friends, without your support and encouragement this work would have never been possible. The challenges this work presented were ameliorated by your constructive advice and thoughtful help; especially Victoria Cook, for all the long hours spent providing me with your insight and wisdom.

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Abbreviations

AFF	Atrial fibrillation flutter
AHS	Alberta Health Services
APSS	Alberta Provincial Stroke Strategy
ASA	Acetylsalicylic acid
CAEP	Canadian Association of Emergency Physicians
CADTH	Canadian Agency for Drugs and Technologies
CSS	Canadian Stroke Strategy
CT	Computerized tomography
CTAS	Canadian triage and acuity score
CVA	Cerebrovascular accident
DVT	Deep venous thrombosis
ED	Emergency department
EDIS	Emergency department information system
EMS	Emergency medical service
ICES	Institute for Clinical Evaluative Sciences
ICH	Intracerebral hemorrhage
IQR	Interquartile range
LOS	Length of stay
MD	Medical Doctor
MRI	Magnetic resonance image
NYD	Not yet diagnosed
OECD	Organization for Economic Co-operation and Development
QoC	Quality of care
QCI	Quality of Care Indicator
PFO	Patent foramen ovale
RA	Research Assistant
RAH	Royal Alexandra Hospital
TIA	Transient ischemic attack
TLP	Triage liaison physician
TPA	Tissue plasminogen activator
SAH	Subarachnoid hemorrhage
SDH	Subdural hematoma
UAH	University of Alberta Hospital

Chapter 1

Quality indicators for patients presenting to emergency departments with cerebrovascular events: A chart review and prospective study of transient ischemic attacks and stroke within the Alberta Health Services-Edmonton Zone.

1.1 Introduction and Thesis Summary

Approximately twelve million emergency department (ED) visits are made every year in Canada.[1] With one quarter of the nation's population utilizing this resource, there are significant concerns regarding limited access and overcrowding.[2] In addition, overcrowding can influence the delivery of care; therefore the use quality of care indicators are now widely regarded as a necessity for health services monitoring.[3] It is important to obtain objective measures of how EDs function in the provision of healthcare to Alberta residents. These indicators identify areas for improvement and have a significant impact on improving healthcare delivery; therefore, the need for a baseline assessment is required so any service or system changes in care can be compared. The question that needs to be answered is: are hospitals meeting these recommended quality of care standards?

This thesis has chosen ED clinical management of stroke as a quality of care indicator of interest. Given the consequences of stroke, it represents a typical and important example of patient flow through an ED. Management of acute stroke is vital for patient outcomes and timely access to this type of care is reflective of how efficiently an individual ED and the emergency system in general functions. Rapid access to ED management is known to reduce mortality and morbidity.

The primary goal of this thesis is to analyze the treatment of stroke patients presenting to EDs in the Alberta Health Services (AHS) – Edmonton Zone (formally known as Capital Health Region) and identify how well EDs are meeting quality of care standards; as well, our goal will be to identify any barriers these patients face in the delivery of their care and suggest solutions to problems that occur during the ED phase of their treatment. These data will potentially yield insights into how ED quality of care indicators can be used to improve patient outcomes through alleviating overcrowding by reducing patient wait times and identifying access blocks to timely treatment. Our secondary goal is to analyze medical record documentation validity and reliability, specifically examining how smoking status in ED stroke patients is being recorded. Smoking is a modifiable risk factor in these patients and guided interventions towards cessation can have beneficial effects on a stroke patient's outcome.

1.2 Stroke Epidemiology and Demographics:

Overall, stroke is the third leading cause of mortality in Canada, with approximately 14000 Canadians dying each year due to a stroke event. Deaths from stroke within Canada peaked in 1997 due to the aging population, since then both the crude and age standardized rates have been on the decline.[4] The decline in rates is a reflection of intervention strategies, such as improved hypertension management and declining smoking prevalence. Stroke is one of the major causes of morbidity and disability in developed countries: approximately 317,000 in Canada are currently suffering its effects. [5] Cerebrovascular disease accounted for 2.0% of all hospitalizations in 2005 in Canada with 55.6% of these individuals were aged 65 to 84, making this a disease that disproportionately affects the elderly.[6] Since stroke may also occur in children and young adults, the use of adult only statistics underestimates the consequence of this disease.[5] Overall, 20% percent of strokes are fatal and the 75% that survive stroke are burdened with some form of long term disability.[7]

From a provincial perspective, there are approximately 5500 new stroke events per year in Alberta and there are currently 25000 stroke survivors.[7] Based on 2003 figures, healthcare cost, loss of economic output, and associated long-term disability from stroke annually has been estimated at 4 to 5 billion dollars in Canada and 200 to 300 million dollars in Alberta.[8] One of the more troubling and feared aspects of stroke is the potential for disability; a recent survey reported

that 80% individuals that have had a stroke have stated that they consider long-term disability worse than death.[9]

1.3 Stroke and Emergency Department Utilization

Hospitalizations due to stroke only provide an estimation of these events within Canada, the true prevalence and incidence remains unknown. For example, some strokes are mild, mimic a flu-like illness, and as such are not always identified and assessed at the time of onset. As a result, they are only detected and confirmed at a time remote to the stroke event. In addition, many TIA and mild stroke patients are not admitted to hospital. A population based audit for 2004 by the Registry of the Canadian Stroke Network (RCSN) showed that one-third of all individuals having a stroke or TIA seen in an ED were not admitted to hospital.[10] These hospitalization data do not include patients seen and discharged directly from EDs or individuals who die of stroke before presenting to an ED. Therefore for every individual that has a stroke there is an estimated ten people that have an undetected or undiagnosed stroke resulting in a neurological deficit.[11] It would therefore be safe to assume that the current rates of stroke in Canada are under-represented. An individual's length of stay in hospital (LOS) is an accurate predictor of cost associated with a health issue; stroke is associated with a relatively long LOS and is proportionally more expensive than other neurological diseases.[12] Based on 2004 statistics LOS

increased with increased age across all stroke types.[4] LOS is governed by the severity of the brain injury but is also influenced by factors outside of hospital controls, such as, availability of rehabilitation, community and family support structures, and other factors.

1.4 Stroke Clinical Presentation

Stroke is considered a medical emergency due to its acute manifestation and the specific set of acute symptoms patients develop. Public awareness and recognition of these warning signs is critical for improving the survival and recovery of patients with stroke. By contacting emergency medical services as quickly as possible this ensures each potential stroke will receive the time sensitive care that is required. The Heart and Stroke Foundation has established five warning signs of stroke that should be recognized by the general public even if they are only temporary. First is weakness, sudden loss of tone in the face, arm or leg. Second is **trouble speaking**, sudden difficulty speaking or understanding or sudden confusion. Third is **vision disturbance**, sudden trouble with vision. Fourth is **headache,** which can be sudden, severe or unusual. Fifth is **dizziness**, sudden loss of balance, especially with any of the above signs.

Timely medical attention can greatly improve outcomes, especially since the introduction of “clot-busting” drugs called fibrinolytics in the treatment of

acute strokes. One common agent is tissue plasminogen activator (tPA). From a known symptom onset there is a three hour window for which these drugs can be administered; however, Canadian stroke treatment guidelines have implemented an expanded window of 4.5 hours due to the ECASS III clinical trial data which demonstrated improved outcomes still occur at this new time point.[13] The Canadian Stroke Strategy (CSS) has outlined a set of best practice recommendations that treat stroke as a medical emergency involving a response chain that contains four steps. First is rapid recognition of and reaction to stroke warning signs. Second is immediate contact with emergency medical system services. Third is priority transport with pre-notification to the patients to the nearest appropriate hospital, bypassing all non-stroke treatment hospitals. Fourth is rapid and accurate diagnosis and treatment at the hospital. The majority of stroke patients do not receive adequate therapy because they do not reach the hospital in time, the symptoms do not receive attention prior to the time-limit, and/or the hospital is unable to administer the therapy. When these steps are carried out, the disabling effects of stroke are minimized.[14]

1.5 Stroke Pathophysiology

There are two major classes of stroke: ischemic and hemorrhagic, constituting eighty and twenty percent of all stroke events, respectively.[15] Ischemic stroke results from a lack of blood flow caused by arterial blockage in one or more of the blood vessels that supplies the brain; the resultant decrease

in blood flow leads to dysfunction of the proximal brain tissue. Prolonged disruption of blood flow, whether it is focal or global, leads to an ischemic cascade which can result in neuronal necrosis (Figures 1.1 & 1.2).[16] Brain tissue will cease to function if deprived of oxygen for greater than 60-90 seconds while neuronal cell death will occur within 4 to 8 minutes at normal body temperature. Damage occurs once the loss of oxygen and glucose reaches a threshold which results in the collapse of energy producing processes. Ischemia results in cell hypoxia and depletion of cellular adenosine triphosphate (ATP); without ATP cells are no longer are able to maintain ionic gradients across cell membranes and depolarization occurs. With an influx of sodium ions, calcium ions, and passive diffusion of water into the cell, cytotoxic edema shortly follows.[17;18] The resulting influx of calcium leads to the release of a number of neurotransmitters, including large quantities of glutamate, which in turn activates N -methyl-D-aspartate (NMDA) and other excitatory receptors on other neurons.[19] These neurons then become depolarized, causing further calcium influx, further glutamate release, and local amplification of the initial ischemic insult. This massive calcium influx also activates degradative enzymes, leading to the destruction of the cell membrane and other essential neuronal structures.[20]

With focal ischemia there is usually some collateral circulation that permits varying degrees of perfusion. An ischemic core or penumbra can be associated with acute vascular occlusions produced from heterogeneous regions of ischemia proximal (“up stream”) to the affected vascular territory. The level of

local perfusion is made up of any residual flow in the major arterial source and the collateral supply. Regions of the brain with collateral blood flow (CBF) lower than 10 mL/100g of tissue/min are referred to collectively as the core, and these cells are presumed to die within minutes of stroke onset. Zones of decreased or marginal perfusion (CBF < 25 mL/100g of tissue/min) are collectively called the ischemic penumbra.[21] Tissue in the penumbra can remain viable for several hours because of marginal tissue perfusion. This is of clinical significance because cell death can be prevented with early intervention to restore blood flow. Beyond the focal origin of an ischemic stroke is a zone of infarction. The degree and duration of the infarction will determine the amount of necrotic tissue formed; this area will swell rapidly because of the increased intracellular and intercellular water content that has been displaced. The term “penumbra” zone is used to describe a marginally perfused region that contains at risk, yet still viable, neurons. This zone is at the margin of an infarction core that already has undergone irreversible damage and is destined to become necrotic.[22] These stunned neurons are of great clinical significance, they can be salvaged if blood flow is restored in a timely fashion. Sources of these events can be from either a thrombotic or embolic origin.

Prolonged ischemia directly results in dysfunction of the cerebral vasculature: breakdown of the blood-brain barrier occurs within 4-6 hours after infarction.[23] Following the barrier’s breakdown, proteins and water flood into the extracellular space, leading to vasogenic edema. Vasogenic edema causes

brain swelling and mass effect which peaks at 3-5 days and will resolve over the next several weeks through reabsorption of water and proteins.[24] Within hours to days after a stroke, specific genes are activated, leading to the formation of cytokines and other inflammatory messengers that, in turn cause further inflammation and microcirculatory dysfunction.[20] Ultimately, the ischemic penumbra is enveloped by these successive insults, coalescing with the infarcted core, often within hours of the onset of the stroke. Infarction results in the death of astrocytes as well as the supporting oligodendrocytes and microglia. The infarcted tissue eventually undergoes necrosis and is removed by macrophages resulting in parenchymal volume loss. The evolution of these chronic changes may be seen through neurovascular imaging in the weeks to months following the infarction.

1.6 Stroke Types

Acute cerebrovascular events, also known as “strokes”, are disabling and potentially deadly events whereby disturbance of blood flow within the brain results in damage to the surrounding tissue. They are considered medical emergencies because they can cause irreparable damage, permanent disability and even death. Strokes are a group of pathological conditions characterized by sudden, non-convulsive loss of neurological function due to focal brain ischemia or intracranial hemorrhage. Strokes can be classified into two categories:

ischemic and hemorrhagic. Based on the Trial of Org 10172 in Acute Stroke Treatment (TOAST) ischemic strokes can be further divided into three types: thrombotic, embolic, and lacunar. Furthermore, hemorrhagic strokes can be further divided into two types: intracerebral and aneurysmal.[25] Stroke etiology is defined by the anatomic location, vasculature involved, age of the affected individual, and hemorrhagic vs. non-hemorrhagic pathology. Ischemic strokes can occur through local thrombosis or through embolic thrombus travel, while hemorrhagic strokes can occur through leakage of blood from an artery into the brain or aneurysmal dilation at the branching points of the Circle of Willis.[26] Irrespective of the stroke type, these events result from a pathologic process within the blood vessels of the brain; an occlusion of the lumen by thrombus or embolus (ischemic), rupture or altered permeability of a vessel wall, or a change in the viscosity or quality of blood moving through these vessels is what causes the associated damage to the surrounding tissue (hemorrhage).[27;28]

1.6.1 Atherothrombotic infarction

Thrombotic strokes are generally thought to originate on ruptured atherosclerotic plaques; due to this mechanism a smaller number of large-artery occlusions may arise from plaque ulceration and in situ thrombosis which occur as atherosclerotic lesions in the carotid, vertebrobasilar, and cerebral arteries, typically proximal to their respective arterial branches. Thrombogenic triggers

may include injury to endothelial cells, exposing the subendothelium, causing platelet activation, activation of the clotting cascade, and inhibition of fibrinolysis. Arterial stenosis can cause turbulent blood flow, which can increase the risk for thrombus formation, atherosclerosis (ie, ulcerated plaques), and platelet adherence; all cause the formation of blood clots that either embolize or occlude the artery. The blockage of the artery occurs as a gradual process, deficits do not manifest while collateral perfusion still maintained. A good example of this type of mechanism is the anterior communicating artery (AcoA) and posterior communicating arteries (PcoA) of the circle of Willis. They provide the main route for collateral blood flow in cases of severe internal carotid artery (ICA) stenosis or occlusion.[29] Absence of collateral function due to hypoplasia or atherostenosis of collateral arteries may lead to a higher risk of stroke in patients with severe ICA occlusive disease.[30] A secondary characteristic of a thrombotic infarction is that even if it is a non-occluding it can still lead to an embolic event where the thrombus breaks free, at which point it becomes an embolus (thromboembolism; Figure 1.3). Plaques preferentially form at curves or branching points within the cerebral arteries, most commonly the internal carotid, vertebral, middle cerebral, posterior cerebral, and anterior cerebral. Atherosclerotic plaques can develop silently over decades; the only point at which they become symptomatic is when they occlude the associated artery or release a thrombus and embolize downstream. Since the thrombus does not occlude the artery completely from the moment of its inception, blockage may

occur after a few hours, thus explaining the temporal profile of an atherothrombotic stroke. Upon complete occlusion the thrombus may migrate to the next branching point and block an additional channel.

The clinical picture of an extracranial atherothrombotic stroke is much more variable than that of an intracranial larger artery stroke due to involvement of either the intracranial (basilar carotid) or extracranial (carotid or vertebral) arteries. Commonly the event is preceded by a TIA with symptoms of focal neurological dysfunction. These transient events are harbingers of oncoming vascular catastrophes, thus determining a clinical history of these events is of paramount importance in preventing this type of stroke. Thrombotic strokes develop over the course of a few hours, characterized by an intermittent progression of neurological deficit. Contrast this to the abrupt onset of an embolic mechanism; thrombotic strokes follow a very different time course in its clinical presentation. The event may partially occur and even dissipate temporarily over the course of several hours after which there is a progression to the completed deficit. Multiple regions may be effected all at once or just a single one, but occurs in a stepwise manner. Events can be episodic as well, whereby weakness, tremor, or blurred vision that lasts 5-10 minutes occurs spontaneously or through physical activity. Each of these individual pathological events can be identified as saltatory components of the yet to be completed stroke event.

1.6.2 Embolic Infarction

Embolic infarction is the most common cause of stroke. These events are characterized by an abrupt onset of neurological deficit triggered by an occluded artery within the brain. The event occurs when an embolus, originating from another location, travels via the arterial bloodstream to the brain. The source of this embolus is most likely a thrombus fragment originating from the carotid vessels, the chambers of the heart (cardioembolic), or a deep vein thrombosis (DVT); however, the embolus can also be from other types of particles. (Figure 1.4) Atrial fibrillation is a predisposition to this type of stroke (which is a special case discussed later) due to the formation of a mural thrombus within the left atrium and/or its appendage. Other sources are from an intra-arterial thrombus within the lumen of an occluded or stenotic artery, intracardiac thrombus, atheromatus plaques in the aorta, infected material (endocarditis) that adheres to heart valves, and from fat or tumor cells (atrial myxoma).

The embolus travels until it becomes impeded at a natural constriction of an intracranial vessel, consequently ischemic infarction follows. The middle cerebral artery is most frequently involved, which can affect both cerebral hemispheres equally, but any region of the brain can be affected. The size of the embolic clot will determine the termination site and blockage; this can range from the blockage of the carotids in the neck to tiny vessels as small as 0.2mm (small vessel arteriorlar occlusion) in diameter. The latter occlusion usually

results in a lacunar stroke, likely with hemiplegia, while the former results in a significant deficit. The embolic fragment can remain as a complete blockage of the lumen but more commonly it will disintegrate into smaller fragments that migrate to smaller vessels making pathological determination of their final location very difficult.

1.6.3 Lacunar Stroke

Lacunar infarction is a type of stroke which occurs within small penetrating cerebral arteries that provide blood to the brain's deep structures, arising specifically from the Circle of Willis, cerebellar and basilar arteries. Lacunes can be defined as small subcortical infarcts that occur in arteries that are 50 to 200 microns in diameter and demonstrate a specific set of clinical manifestations that were originally described by Fisher.[31] Unfortunately, the classical lacunar syndromes established by Fisher and their radiologic appearances are not unique to lacunes, since originally they were defined pathologically, but are now diagnosed on clinical and radiologic grounds.[32] There is a strong association between the lacunar state and a combination of chronic hypertension and to a lesser degree diabetes. A population based study by Sacco et. al. found that 81 percent of patients with lacunar infarctions were also hypertensive.[33] In North America, lacunar stroke accounts for approximately 15-25% of all ischemic strokes.[34]

There are three well established mechanisms for lacunar stroke: lipohyalinosis and fibrinoid necrosis, atheromas, and embolisms. First is a local type of fibrohyalinoid arteriosclerosis called lipohyalinosis and appears as an eosinophilic deposit in the connective tissue of the vessel wall. The associated condition is fibrinoid necrosis, which is found in the capillaries of the brain, retina, and kidneys in patients with malignant hypertension. These lesions are theorized to occur as a corollary to damaged cerebrovascular autoregulation, which occurs with aging and higher blood pressure levels.[35] Second, is atherosclerosis of a large trunk vessel that occludes the origin of a smaller vessel. This type of intracranial branch atheromatous disease is believed to be the most common etiology underlying lacunae that cause symptoms.[35] The microatheroma is the catalyst of a tiny focus of atheromatous deposit, similar to plaques seen in larger arteries. In patients with chronic hypertension, atheromatous lesions are widespread in both large and small arteries; therefore, over time eventually cause penetrating vessel stenosis or occlusion, resulting in a lacunar infarction. Third, is due to the entry of small embolic material into one of vessels. Fisher demonstrated that micro and macroembolisms were etiologies for lacunar infarcts, since feeding penetrating arteries were found in pathologic studies of some lacunar infarct.[36;37] Additionally, from Fisher's subsequent pathologic studies, large-vessel occlusions were found in patients with small deep infarcts.[38] Studies using diffusion-weighted imaging (DWI) have

demonstrated that, in patients presenting with classic lacunar infarcts, multiple infarcts can be present, suggesting an embolic mechanism.[39]

1.6.4 Hemorrhagic Stroke

There are two types of hemorrhagic stroke which are the result of a disturbance in cerebral blood flow caused by vessel rupture and accumulation of blood anywhere within the skull. The first is an intracerebral hemorrhage occurs when blood leaks from a small artery directly into the brain, forming a hematoma within the brain parenchyma, ventricles or sometimes the subarachnoid space. (Figure 1.5) After the leakage has stopped the accumulated blood gradually is absorbed over a period of weeks and months. This mass of clotted blood results in a physical disruption or displacement of the surrounding brain tissue. The second cause of a hemorrhagic stroke can be a result of bleeding that originates from an aneurysm at the branching point of the Circle of Willis. The blood is contained within the subarachnoid space and is referred to as a subarachnoid hemorrhage (SAH). Large SAHs can cause a direct mass effect that will lead to rapid deterioration in patients, while indirect effects cause a delayed cerebral ischemia via vasospasm of the Circle of Willis and its primary branches. Also, SAHs can leak into the ventricles and cause obstructive hydrocephalus and significant issues to those patients. For a hypertensive cerebral hemorrhage the onset is abrupt, deficits are static or progress rapidly

over a period of minutes or hours versus a subarachnoid hemorrhage which would be relatively instantaneous. A special type of hemorrhage that also should be mentioned, although it is not a stroke, is subdural hemorrhage (SDH). It is a specific type of intracranial blood collection which is caused by traumatic brain injuries. A SDH is characterized by blood collecting between the dura mater and the arachnoid mater.

These types of hemorrhages can be further classified by anatomical regions within the skull: intra-axial hemorrhage which is bleeding within the brain itself (this category includes intraparenchymal hemorrhage [IPH] - bleeding within the brain tissue and intraventricular hemorrhage [IVH] - bleeding within the brain's ventricles) and extra-axial hemorrhage which is bleeding that occurs within the skull but outside of the brain tissue (this category includes three subtypes: epidural hemorrhage - occurs between the dura mater and the skull which is caused by trauma, subdural hemorrhage [SDH] - results from tearing of the bridging veins in the subdural space between the dura and arachnoid mater, and subarachnoid hemorrhage [SAH] - occurs between the arachnoid and pia meningeal layers which can result either from trauma or from ruptures of aneurysms or arteriovenous malformations).[40]

1.6.5 Intracranial Hemorrhage

Intracerebral hemorrhage (ICH) is an acute and spontaneous extravasation of blood into the brain parenchyma in which bleeding into the ventricles or subarachnoid space can occur.[41] ICH is a subtype of stroke with high morbidity and mortality which accounts for approximately 15% of all deaths from stroke.[42] Approximately 12-15% of stroke patients admitted to Canadian hospitals are due to ICH, these events are associated with high rates of mortality between 25-50% in the first 30 days, thus emphasizing the acute severity of this type of stroke.[4;43]

The underlying cause of bleeding classifies ICH as either primary or secondary. Primary ICH, which accounts for approximately 75-85% of cases, originates from the spontaneous rupture of small vessels damaged by chronic hypertension or cerebral amyloid angiopathy (CAA). Secondary ICH occurs in association with trauma, vascular abnormalities, tumors or impaired coagulation.[44] Primary hypertensive related hemorrhages occur in deep areas of the brain such as the basal ganglia and thalamus because vessels in these areas are located close to the high pressure of the circle of Willis.[45;46] While Cerebral amyloid angiopathies (CAA) result from the deposition of the insoluble amyloid-beta (Aβ) peptides. This deposition causes replacement of smooth muscle cells in the artery walls by (Aβ) that increases exponentially with age, thus making the artery less compliant and more susceptible to rupture. Secondary ICHs can also be caused by iatrogenic sources which can be broadly divided into two groups:

those due to self-administration of substances with adverse effects (e.g., alcohol, cocaine, and amphetamines) and those due to therapeutic manipulations (e.g., anticoagulation, fibrinolytic therapy, and carotid endarterectomy). Heavy alcohol consumption can lead to ICH by inducing hypertension, through inhibiting platelet function or by causing liver dysfunction. While, cocaine and amphetamines trigger elevated blood pressures through their sympathomimetic effects.[47;48]

Vessels involved are usually small arteries that branch from a larger parent artery. Extravasation of blood forms an oval mass within the brain that disrupts the surrounding tissue and will continue to grow as long as the bleeding occurs (Figure 1.6). After onset, the hemorrhage continues to grow and expand over several hours. Since most hematomas result from rupture of an artery or arteriole their expansion is due to continued bleeding from the primary source and to the mechanical disruption of surrounding vessels. As intracranial pressure increases the adjacent tissue is displaced through distortion and compression. In larger hemorrhages midline shifts can occur, where by structures are displaced to the opposite side of the cranium. Important midbrain and brain stem structures (e.g., reticular activating system and respiratory centers) can also be displaced, leading to coma and death. Secondary brain injury and edema is initiated by the hematoma which results in proximal neuronal damage. Edema typically develops over the first 24-96 hours and slowly resolves over several weeks. Subsequent clotting and complement cascade activation results in

disruption of the blood-brain barrier, direct cytotoxicity and more edema.[48] Neuronal death in the region around the hematoma is predominantly necrotic, with the presence of apoptosis.[44] The most common sites of ICH are cerebral hemispheres, basal ganglia, thalamus, brainstem (predominantly the pons), and cerebellum.[44]

The clinical picture of an ICH is reflected in the abruptness to which it occurs and how quickly the symptoms manifest: it is dependent on the size of the ruptured artery, location of the rupture (e.g., posterior cranial fossa bleeds are very dangerous due to compression of brainstem), speed, and expansion of the bleeding. The general features of ICH include acute reactive hypertension that can significantly elevate the patient's normal blood pressure level, emesis at the onset, severe headache, and coma only if bleeding into the ventricles is massive or distortion of the midbrain occurs.[43] ICH and ischemic stroke often cannot be distinguished through clinical presentation, therefore all potential stroke patients presenting to the ED require vascular imaging to determine the root cause of their symptoms.

1.6.6 Spontaneous Subarachnoid Hemorrhage

Spontaneous subarachnoid hemorrhage (SAH) or ruptured saccular aneurysm is the one of the least common causes comprising approximately 1–7% of all stroke events.[49] It can occur as the result of trauma or a spontaneous

event. SAH is bleeding into the subarachnoid space, which is the area between the arachnoid membrane and pia mater. In the case of spontaneous SAHs, the saccular aneurysms initially appear to be thin walled blisters protruding from the arteries of the Circle of Willis or its major branches (Figure 1.7). Upon rupture of the aneurysm, blood begins to flood the subarachnoid space, resulting in high pressure blood occupying the space. Most ruptures occur at bifurcations and branch points of these vessels and were assumed to be the result of congenital defects in arteries; however, their etiology has now been demonstrated to develop through the course of time, rather than from birth.[50] These types of aneurysms are uncommon in childhood but gradually increase in prevalence with age and peak between the ages of 35 and 65. Modifiable risk factors for SAH are hypertension, smoking, and excessive alcohol intake, all of which double the risk.[51] In terms of attributable risk, these modifiable risk factors account for two of every three hemorrhages, and genetic factors for only one of every ten.[52]

The clinical syndrome symptoms of a ruptured SAH are usually as follows: follows the rupture of the aneurysm; the most common sequence of events occurs where the patient initially experiences a sudden onset of an extreme generalized headache followed by vomiting and various degrees of alterations in neurological status. There are varying degrees of these events, for example, the patient may remain conscious and lucid with only neck stiffness; however, the rupture may also exhibit symptoms caused by a massive hemorrhagic stroke. With a significantly large hemorrhage death may occur within minutes to hours

without medical attention. Since the hemorrhage is usually contained within the subarachnoid space there are very few focal neurological symptoms, (i.e. hemiparesis, hemianopia and aphasia are absent).[53]

1.6.7 Subdural Hematoma

Subdural hematomas (SDH) are a specific class of hemorrhage that are generally resultant from physical trauma. Although they are not classified as "strokes" they are still relevant as their pathology is due to extra-axial bleeding within the skull. SDHs result from tearing of bridging veins which cross the subdural space. The primary effect of a SDH is an increase in intracranial pressure which can compress adjacent tissues. SDH's are often life-threatening when they occur acutely (i.e., when the blood accumulates rapidly). In chronic SDHs, the blood accumulates at a much slower rate and as such patients present later and usually with less serious symptoms, compared chronic types that are much more easily managed.[54] The severity of the hemorrhage depends on the speed of onset. Most acute SDHs are due to trauma are the most lethal of all head injuries and have a high mortality rate if they are not rapidly treated with surgical decompression.[55]

Acute bleeds often develop after high speed acceleration or deceleration injuries and are increasingly severe with larger hematomas. They are most

severe if associated with cerebral contusions.[56] Acute subdural bleeds have a high mortality rate that is approximately 60%.[57] Chronic subdural bleeds develop over a period of days to weeks, often after minor head trauma, though such a cause is not identifiable in 50% of patients.[58] Since these bleeds progress slowly, they present the chance for appropriate treatment before they cause significant compression. Symptoms of a chronic SDH have a slower onset than those of other hemorrhages. Less vascularized tissue tends to bleed more slowly when compared to arterial hemorrhages; therefore, symptoms can manifest over weeks instead of minutes. SDHs are also more prevalent in patients on anticoagulants, due to their susceptibility to active bleeding from minor trauma.[57]

1.7 Transient Ischemic Attack Etiology

Transient ischemic attacks (TIA) are a specific subset of strokes and are also caused by focal ischemia within the brain, commonly they are referred to as "mini-strokes". Historically, TIAs were characterized by a brief neurological dysfunction that persists for less than 24 hours with no permanent neurological impairment.[59] Recently, this definition has been challenged because the timeframe for a TIA is arbitrary and as brain imaging has become more sophisticated and accurate, the arbitrary 24 hours is incorrect. For example, 30-50% of classically defined TIAs do in fact show brain injury when analyzed with

diffusion weighted magnetic resonance images (MRI). [60] Other operational definitions have been suggested by the Stroke Council of the American Heart Association: “A brief episode of neurological dysfunction caused by focal brain or retinal ischemia, with clinical symptoms typically lasting less than one hour and without evidence of acute infarction”.[59] The newer definition has yet to be endorsed by all organizations. When these TIA’s precede a stroke they predominantly indicate the underlying process as atherothrombotic involving a large vessel with vascular stenosis, especially if the episode recurs and are all uniform in presentation: these events are then commonly indicative of an impending vascular occlusion. These events are due to the nature of an atherosclerotic carotid artery plaque, whereby embolization of fibrin-platelet material from a distal site migrates to a distal location and occludes blood flow to the adjacent tissues.

Although TIAs are caused by focal ischemia, their mechanism is still not quite fully understood. The question has yet to be answered: are TIAs caused by reduced blood flow or embolic particles? Irrespective of the cause of the attacks, they are closely related to vascular stenosis and commonly ulceration resultant from atherosclerosis and thrombus formation. The clinical presentation can represent the involvement of any cerebral artery: carotid, cerebral, ophthalmic, vertebral, basilar, cerebellar, or brainstem (lacunar). A TIA may last from a few seconds up to an hour, with indication of an embolic infarction when the deficits

last longer than an hour. The attacks can be singular or multiple, but between each event there is no abnormality upon neurological evaluation.

1.7.1 Transient Ischemic Attack Epidemiology

The statistics for TIAs can be prone to under-reporting biases; however, it is estimated that 15000 TIAs occur per year in Canada.[4] A recent report by the American Heart Association (AHA) has estimated the rate between 200 and 500 thousand per year for a population that is approximately ten times the size of Canada's.[6] This translates into a prevalence of 2.3% or 5 million individuals in the US.[61] The precise rates are inherently difficult to estimate, due to the nature of the event itself and due to the varying criteria used by healthcare systems to identify a TIA. There is also a lack of public knowledge in identifying the symptoms that are associated with an attack, thus leading to large under-estimations of the actual number of events.[62] As with stroke, TIA incidence increases exponentially with age irrespective of race or sex. [63] The reason why TIAs are so dangerous is not necessarily the event itself, but rather the increased risk of a future stroke. It has been long understood that a TIA can precede a stroke; however, studies have demonstrated that the short term risk is particularly high, especially within the first few days after a TIA. For example, stroke risk is increased by 3% in the first 2 days, 5% in the first 7 days, up to 20% in the first 90 days, and up to 50% in the first year following a TIA.[64-66] The risk is

also “front loaded”, in that approximately half of the strokes occur within the first two days after the initial symptom onset. [67]

Implementation of coordinated efforts to combat these issues have been recently implemented, whereby EDs with advanced imaging, rapid referral and adequate access to anti-stroke therapy have been demonstrated to effective in reducing the recurrence rate for stroke.[68] Nonetheless, the TIA-stroke statistics are concerning and emphasize that TIAs and minor strokes are unstable conditions that are harbingers of high future risk of vascular events, stroke, or death. Thus the importance of aggressive intervention and management are critical in lowering the patient’s risk.

1.8 Stroke Risk Factors

1.8.1 Stroke Risk Factors (non-modifiable)

There are a multitude of risk factors that are associated with stroke and TIA, some are genetic (both non-modifiable and modifiable) and others are environmental/behavioral (modifiable). Over 40% of strokes can be prevented through management of these modifiable risk factors.[69] Age, sex, family history, and prior stroke/TIA are independent factors that can’t be changed. For age, every decade past the age of 55 the risk of stroke doubles, thus making it a disease that is acquired and becomes more prevalent with age.[70] More men than

women will have strokes each year; however more women will die from each event. This is because women tend to live longer than men, tend to more often be widowed, and have un-witnessed stroke events.[71] There is a genetic component that will increase the risk of stroke for individuals with family members who have a stroke by approximately 30%. This is most likely due to the heritability of stroke risk factors, familial sharing of cultural or environmental factors, and interaction between environmental and genetic factors.[72] Individuals that have already suffered a TIA or stroke have a much higher rate of subsequent events. For example, TIA sufferers have ten times higher risk for future stroke when compared to someone who has not.[66]

1.8.2 Stroke Risk Factors (modifiable)

The set of risk factors that can be controlled or modified to reduce the risk for a future vascular event are: high blood pressure, heart disease, cholesterol levels, diabetes, atrial fibrillation, medications, and lifestyle choices such as smoking and physical inactivity. Hypertension is the single most important modifiable risk factor for stroke with a population attributed risk of approximately 50% and is quantitatively the largest single factor for premature death and disability due to the large number of people affected. [73] It is also the leading cause of intracranial hemorrhage and subarachnoid hemorrhage. The prevalence of hypertension in Canada is over twenty percent (ninety percent will

develop hypertension within in an average lifetime), with approximately only a sixth of this group being appropriately managed with medication or lifestyle adjustments.[74] The risk of stroke increases in a linear fashion even throughout the normal non-hypertensive range of blood pressure, therefore the higher the blood pressure the greater the risk of stroke.[75] Hypertension should not be regarded so much of a disease but more so as a treatable or reversible risk factor for premature death; therefore, blood pressure management though physical activity, medications, and diet are of paramount importance.[76]

Diabetes is an independent and partially modifiable risk factor for ischemic stroke. In patients with diabetes evidence estimates that the risk of stroke is increased 1.8 to nearly 6-fold, the risk for stroke recurrence is doubled, stroke outcomes have higher mortality, and the residual deficits are more severe.[77] A complex interplay between multiple hemodynamic and metabolic components of the diabetes syndrome are the most likely explanation for an increased risk of stroke in these patients. Components of the metabolic syndrome such as insulin resistance, truncal obesity, impaired glucose tolerance, and hyperinsulinemia both independently and collectively are associated with an increased risk of stroke.[78] The recent clinical trial: Action to Control Cardiovascular Risk in Diabetes (ACCORD) has demonstrated that targeting a lower systolic blood pressure of 120 mmHg, compared with the standard goal of 140 mmHg in patients with type 2 diabetes did not reduce a composite of major cardiovascular (CV) events [hazard ratio (HR) = 0.88; *P* = .20]. Although intensive

blood pressure management did reduce the risk of stroke by 41%, the number needed to treat over 5 years to prevent a single stroke was 89.[79]

AFF is the most common cardiac arrhythmia associated with strokes. One out of six ischemic stroke patients have AFF detected.[80] Under normal cardiac conduction conditions, an electrical impulse is generated by the sinoatrial (SA) node in the upper right atria of the heart, causing the right and left atria to contract. The electrical impulse then travels down the conducting system to activate the ventricles causing them to contract and eject blood from the ventricles. The signal is carried from the atrioventricular (AV) node to the ventricles by way of the HIS-Purkinje system. The ejection from the ventricles distributes blood to the lungs (from the right ventricle), the heart itself (from the coronary arteries) and the rest of the body (from the left ventricle through the aorta). In AFF the signal sent by the (SA) node is not carried in an organized fashion to the (AV) node, thus multiple signals compete for a chance to trigger the AV node and the ventricles.

These random impulses cause the heart to beat in a dyssynchronous manner causing blood to pool within the left atrium (especially the appendage) during AFF due to the improper contraction. This lack of movement of blood can lead to thrombus formation and potentially an embolic stroke (Figure 1.9). People with AFF have approximately five-fold higher risk for stroke which is the cause of 10-15% of all ischemic strokes.[69]

1.8.3 Risk Factors (lifestyle)

Smoking, diet, and physical activity are important lifestyle choices that can be modified to reduce the risk of stroke. In general, a healthy lifestyle can reduce the initial risk of stroke and subsequent future events. Smoking has a direct correlation to an increase in stroke risk. Research demonstrates that individuals who smoke 20 or more cigarettes a day have a two to four fold greater risk of stroke than non-smokers.[81] An estimated 25% of Canadian adults are current smokers; therefore approximately 18% of new stroke events can be attributed to current smoking.[80] Smoking also functions in a dose dependent manner: heavier smokers have a correspondingly higher risk than light smokers.[81] Early intervention through smoking cessation can show immediate benefits; mortality is significantly reduced in former smokers when compared to age and sex-matched patients who continue to smoke and this is also true in patients that have already suffered smoking related symptoms.[82]

1.8.4 Risk Factors (Medication / Pharmacological)

Medications may both prevent and contribute to stroke. One example is the use of hormonal therapy in women, such as hormone replacement and oral contraceptives, which pose special thrombogenic risks for stroke. [83] In addition, some chemotherapeutic agents (tamoxefin), anti-bleeding agents (fibrinogen, and anti-fibrinolytics), can stimulate unintended clotting events.[84]

1.9 Stroke Therapy

Upon arrival in the ED there are a set of best practice recommendations or standard of care strategies that stroke patients should receive. Core performance measures by the CSS recommend all eligible patients presenting with stroke should be treated with the appropriate use of antiplatelet, anticoagulant, and thrombolytic therapies following history, physical examination and advanced neuro-imaging.

1.9.1 Anti-Platelet Therapy

Unless contraindicated, all patients with a suspected ischemic stroke or TIA should be prescribed an antiplatelet medication for acute stroke management. Medications such as acetylsalicylic acid (ASA), clopidogrel (Plavix ™), and dipridamole (Aggrenox ™) reduce the risk of further vascular events.[85]

This effect is clinically useful since it is tolerated by the majority of patients who have suffered a thombo-embolic event.

1.9.2 Antithrombotic therapy for patients with atrial fibrillation and flutter (AFF)

Primary prevention of stroke in patients with AFF should be risk stratified first using predictive indices: specifically CHADS2 for stroke risk and HEMORR2HAGES for bleeding risk.[86] Patients with a CHADS2 score equal or greater than one should receive anti-coagulation for treatment of AFF. Addition of anti-coagulants in these AFF patients has been well documented for the prevention of stroke or recurrent stroke, as it is shown to have a significant benefit in primary prevention trials.[87] Warfarin (Coumadin) is the most commonly prescribed drug in these patients; however, newer oral agents such as dabigatran (Pradax ^{TM}) are emerging and assuming larger shares of the market due to their ease of use and lack of mandated monitoring. Strokes in patients with AFF are generally more severe when compared to patients in sinus rhythm and are associated with a higher case-fatality, longer hospitalization, and increased disability.[88]

1.9.3 Tissue Plasminogen Activator (tPA)

In 1997 the Health Protection Branch of Canada gave conditional approval for the use of tPA for treatment of acute stroke. tPA is a serine protease that is involved in the breakdown of blood clots, specifically catalyzing the reaction of plasminogen to plasmin. It's clinically referred to as "thrombolytic" therapy and is generally administered intravenously for any disease that involves occlusion of a blood vessel by a blood clot, such as ischemic stroke, myocardial infarction, and pulmonary embolism. Although beneficial, thrombolytic drugs also have a potential for unwanted side effects; administration of tPA can cause serious bleeding, which can lead to disability, coma or death.

Current guidelines set the treatment window for patients with acute disabling strokes at 3 hours; however, recent evidence has expanded the window to 4.5 hours from a confirmed symptom onset.[28] The current eligibility rate for Canadian hospitals is approximately 5% of the 35000 annual strokes per year and approximately 31000 of these are due to an ischemic infarction. Thus the actual rate of tPA usage in an ED setting is quite low. This is in part due to the limited treatment window, coupled with the need for a known symptom onset, timely transport to a setting capable of thrombolysis treatment, and timely imaging and diagnosis confirming an actual stroke. There are also a set of exclusion criteria that prevent a large proportion of the population from

receiving the treatment (e.g., active bleeding, recent surgery, etc.) that further decreases those eligible for thrombolysis within the ED stroke population.

Even with the low rate of eligibility meta-analyses of randomized control trials of tPA use have shown that the risk for morbidity and mortality are reduced despite the increased intracranial bleeding risk.[89] There is a strong inverse relationship between treatment delay and beneficial clinical outcome; the current CSS recommendation suggests that eligible patients be treated without delay as long as the administration of the drug is within a 4.5 hour window from a known symptom onset and there are no contraindications to receive thrombolysis.[90]

There are dissimilarities of treatment between sexes for tPA; evidence shows that consistently women with ischemic stroke were 25% less likely to receive treatment than men. [91] While there are no definitive reasons for this observed disparity in tPA stroke treatment for women, there are some cogent theories. Compared to men women having a stroke tend to be older and widowed, therefore would have more non-witnessed events.[92] Also women presenting with acute ischemic stroke tend to have non-traditional neurological symptoms, complicating or delaying a confirmed diagnosis.[93] Currently there are still unresolved issues with respect to which patients are most likely to benefit from treatment: What is the latest time window; how large is the overall benefit for the patient outcome; which grades of stroke severity will be the most

responsive to treatment; and which patients with comorbidities or currently on medications that have contraindications?

1.10 Summary of Thesis

We undertook a retrospective chart review of medical records of TIA and stroke patients within the AHS Edmonton Zone and a prospective patient interview of stroke patients presenting to two tertiary care academic EDs. Data collection was separated into three distinct phases. The primary component was a retrospective chart review of a random selection of 7000 TIA and stroke patient charts presenting to any AHS Edmonton Zone ED between 2003 and 2009. The secondary component was a prospective interview of 330 patients presenting to either the UAH or RAH ED with a diagnosed TIA or stroke between June 2009 and May 2010. The third component was a chart review completed from each of the prospectively enrolled patients. This work was supported by a grant from Health Canada.

1.10.1 Thesis Study Design

This thesis will focus on two primary outcome measures. Firstly, analyzing chart review data with respect to AHS Edmonton Zone ED quality indicators,

specifically eligibility of stroke patients (e.g., observed event, < 4.5 hours), time to ED MD assessment, time to CT scan, and time to tPA administration. Secondly, the prospective research assistant administered questionnaire data will be compared to chart review data on key risk factor data. Basic quality indicator markers of tPA will be: proportion of eligible patients with acute stroke who received the drug within the 4.5 hour window and time to administration of drug, with stratification by sex, and site-specific trends over time. We will also explore the database for ED delays (time to ED MD assessment or time to CT) and sex differences. For secondary outcome measure, data from the RA administered patient interview will be compared to the prospective chart review.

Documentation within the RA administered patient interview is effectively 100% versus a medical record completed by an emergency physician administered +/- a consultant interview, which may not always be complete. Based on these comparisons, the analysis will focus on contrasting the collected history of (a) TIA or stroke event onset, (b) patient location at time of the event, and (c) patient's smoking history. Smoking history is notoriously poorly recorded or the information that is recorded is not representative of the patient's actual smoking status or history. These histories are of importance because smoking is a modifiable risk factor for stroke within this patient population.

The analysis will provide a broader understanding of how QoC standards are being met for ED patients with TIA or stroke and whether this is changing over time, as well how patient co-morbidities affect their outcomes. This information could be used to guide future policy development with respect to the creation of a standardized documentation procedure for stroke patients admitted to EDs.

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Figure 1.1: Diagrammatic representation of an Ischemic Stroke.

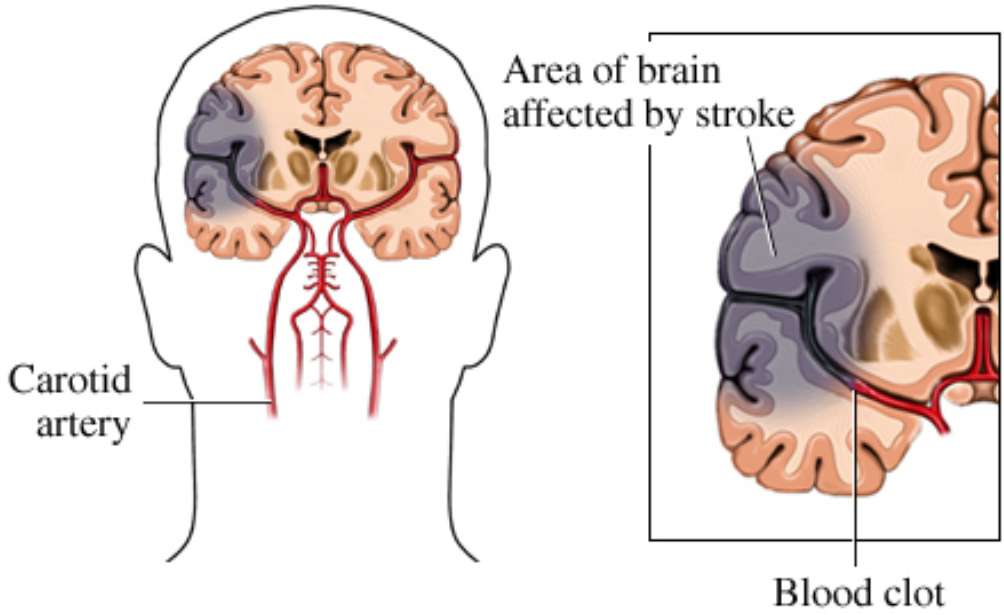

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Figure 1.2: CT showing infarct of MCA territory.

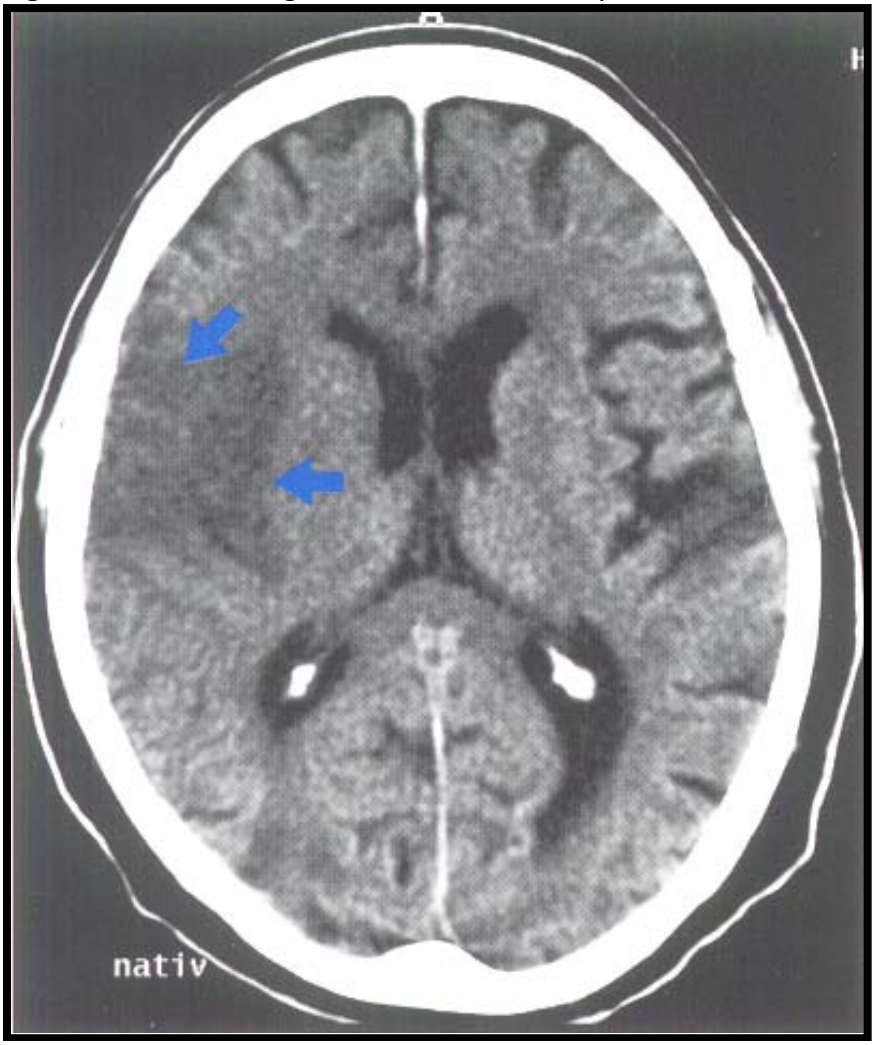
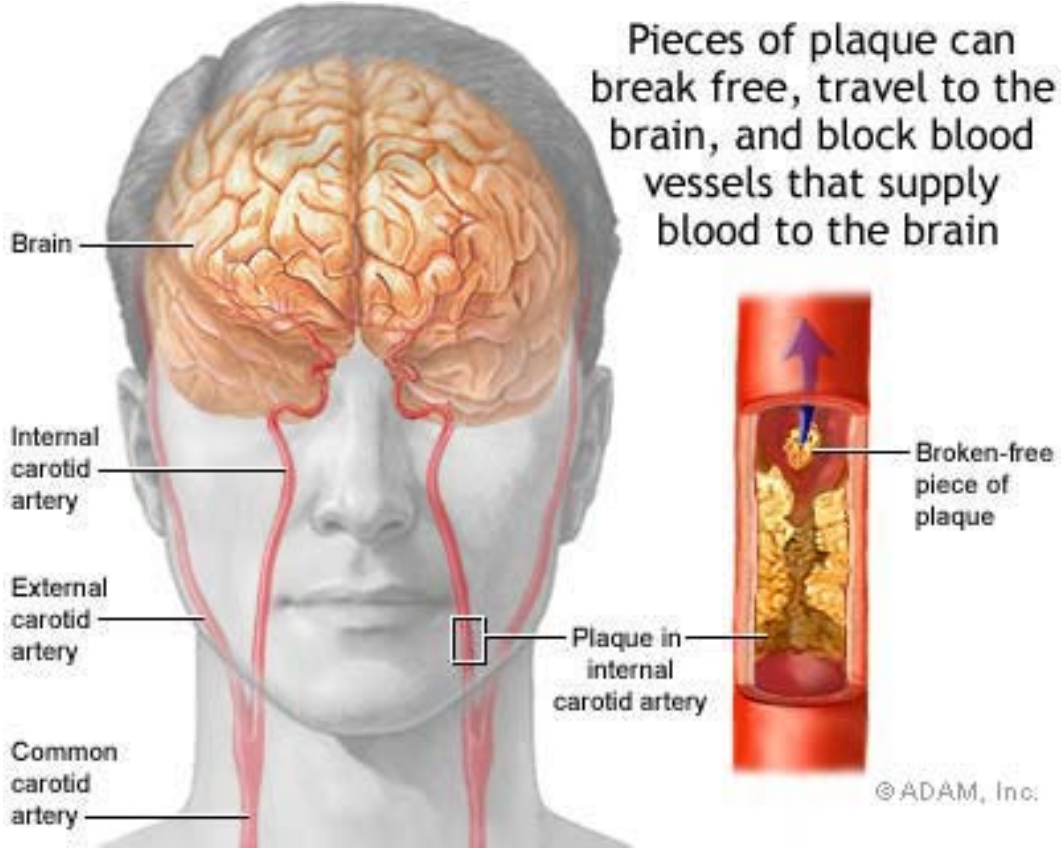
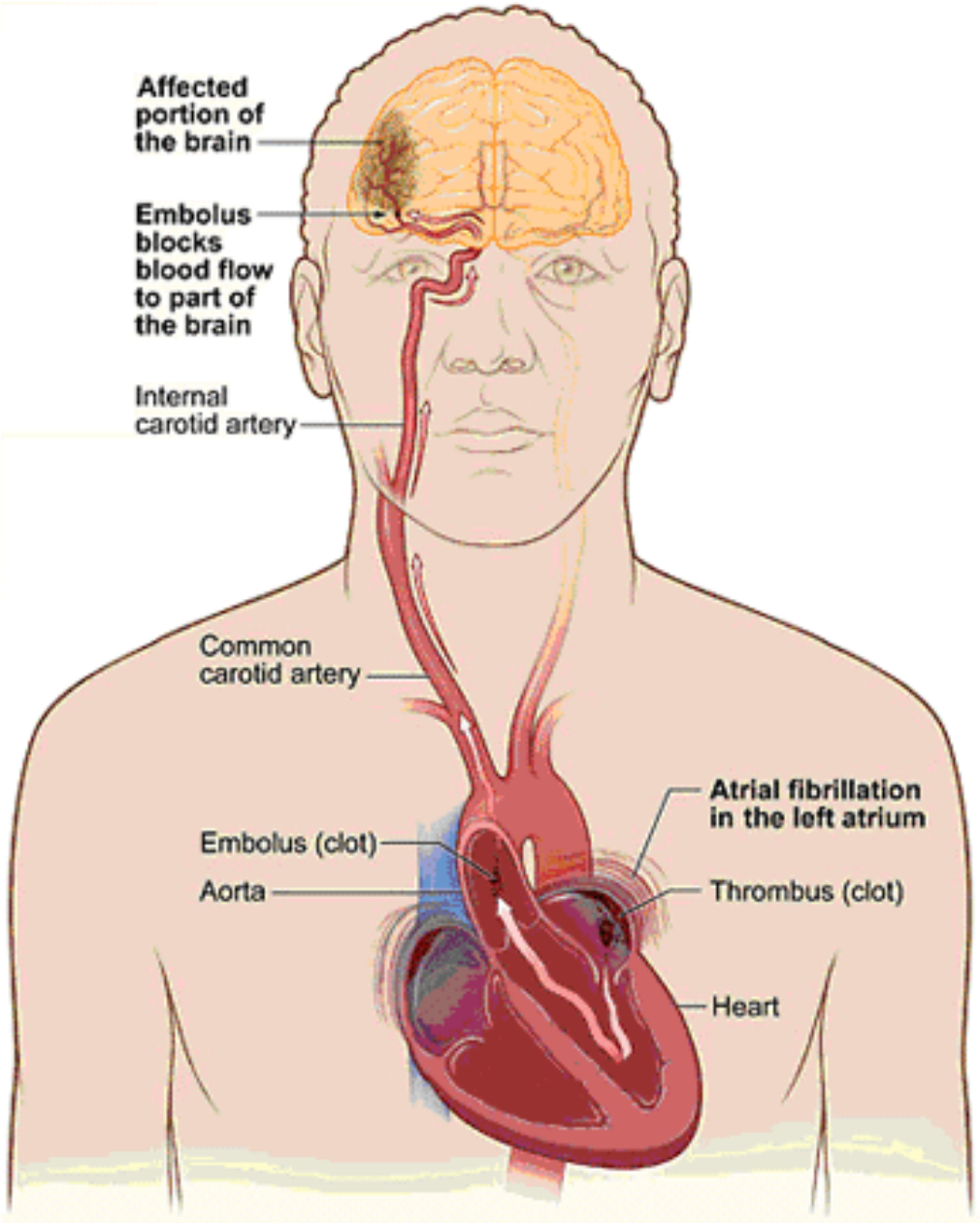


Figure 1.3: Diagrammatic representation of thrombotic stroke.



http://pennstatehershey.adam.com/graphics/images/en/18006.jpg

Figure 1.4: Diagrammatic representation of embolic stroke.



http://www.diattorney.com/wp-content/uploads/2010/06/stroke-disability-claim-attorney.jpg

Figure 1.5: CT scan showing inferior cerebellar cortical infarction.

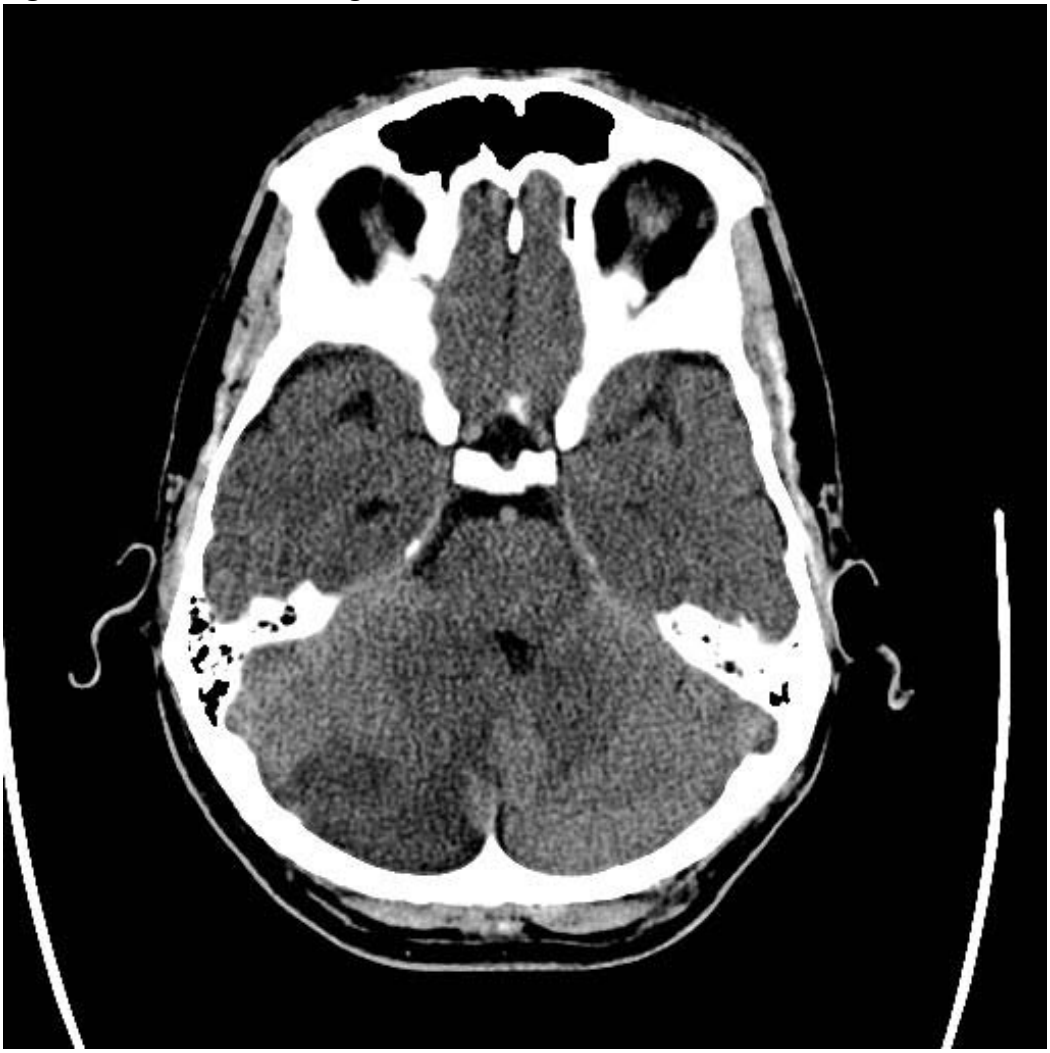
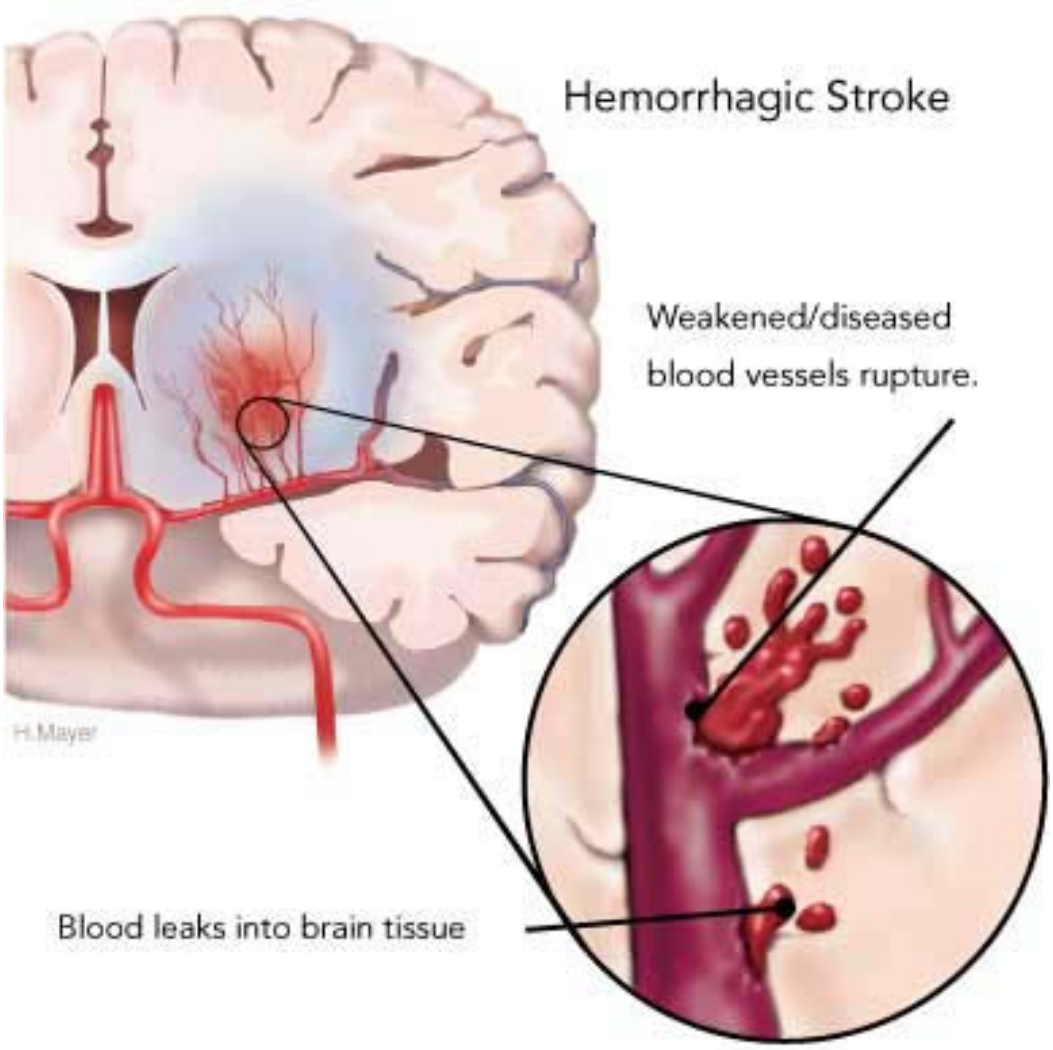


Figure 1.6: Diagrammatic representation of hemorrhagic stroke.



http://www.heartandstroke.com/atf/cf/%7B99452D8B-E7F1-4BD6-A57D-B136CE6C95BF%7D/stroke_hem_web_sm.jpg

Figure 1.7: CT scan showing of a small primary (hypertensive) hemorrhage.

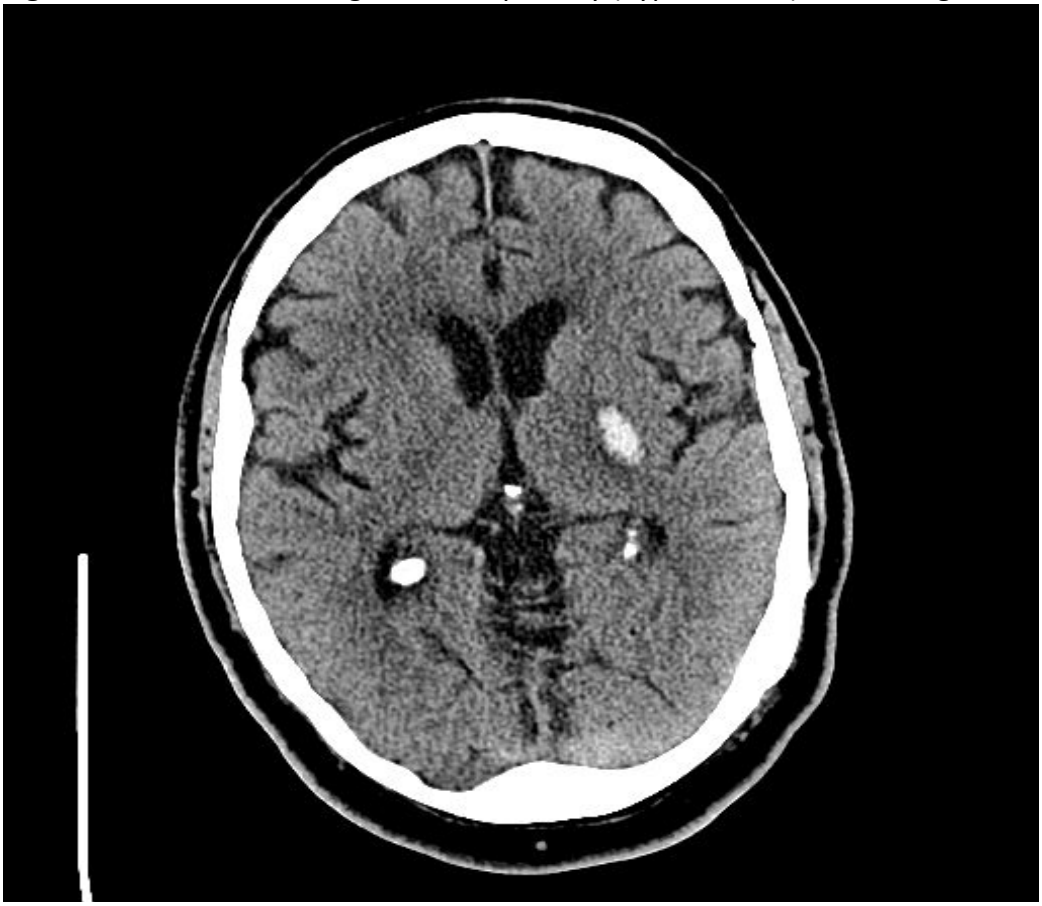


Figure 1.8: CT scan of a Circle of Willis vessel aneurysm rupture.

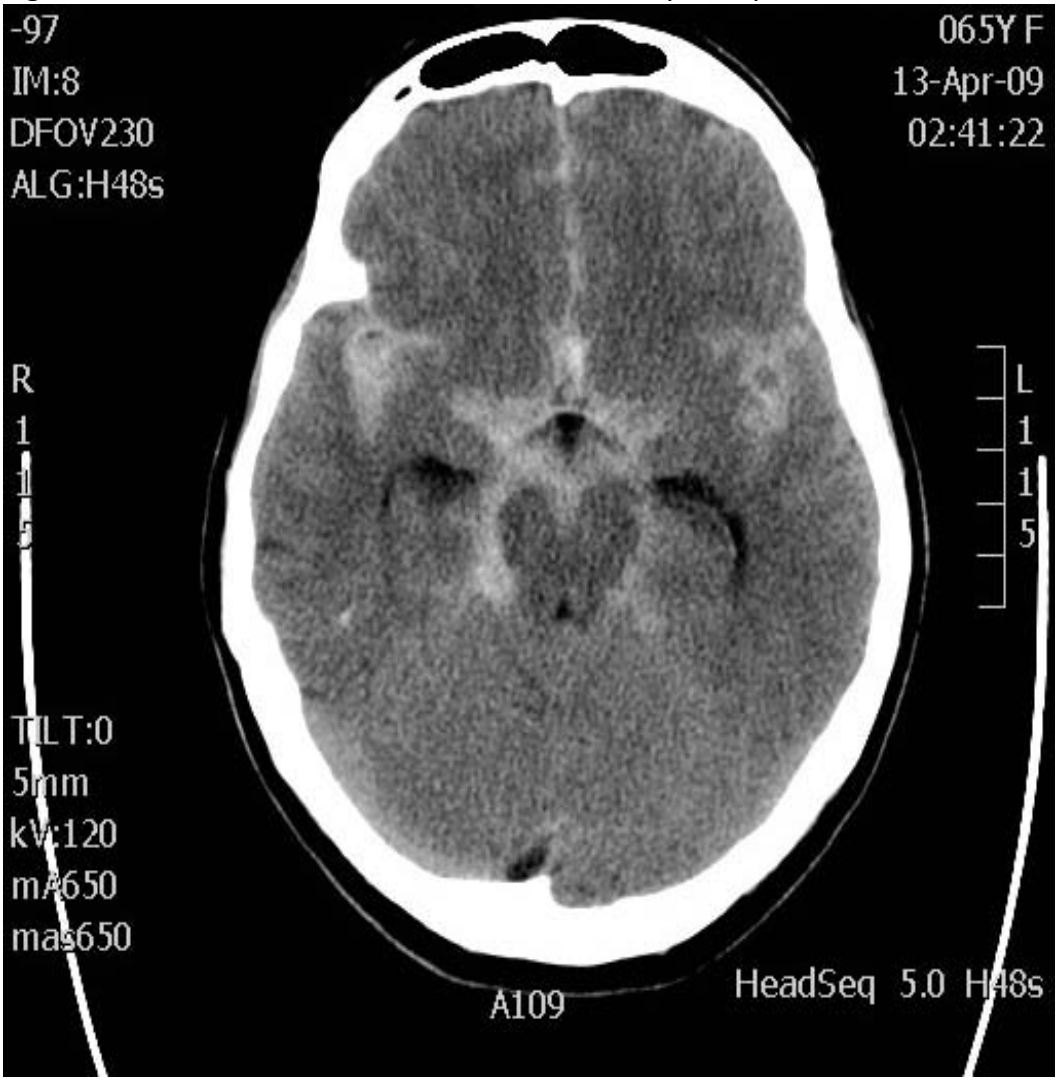
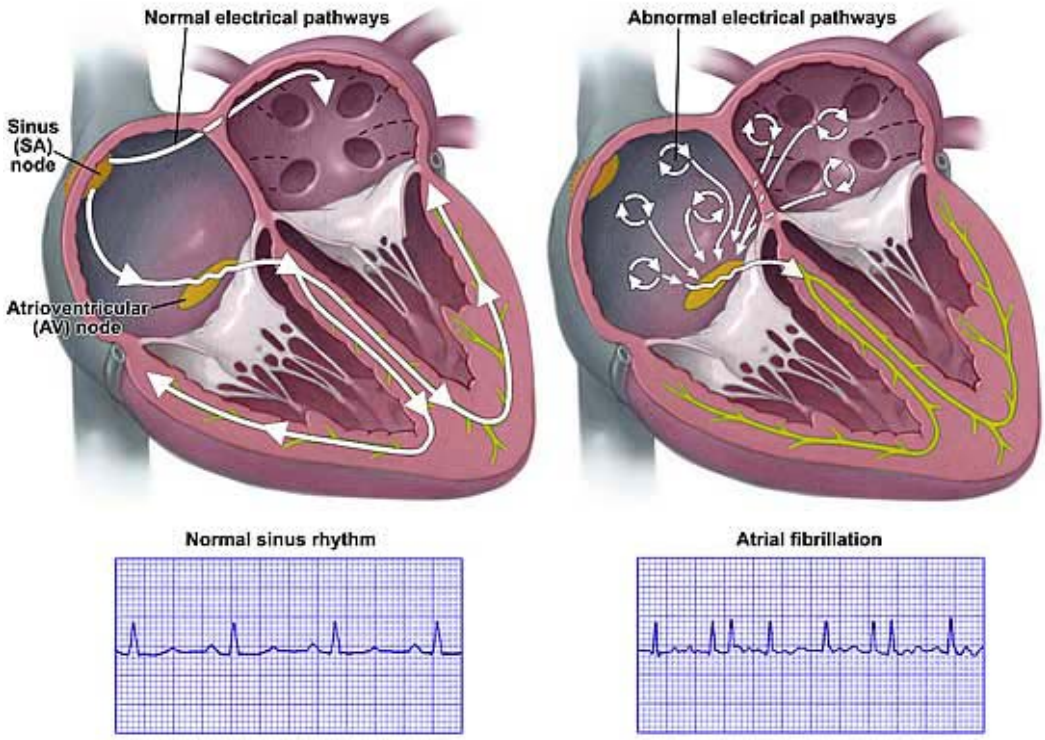


Figure 1.9: Diagrammatic representation of atrial fibrillation.



http://www.strokesurvivors.ca/new/images/atrial-fibrillation-lg.jpg

Chapter 2

Prospective Medical Record Reviews of Stroke Patients Presenting to AHS Edmonton Zone Emergency Departments

2.1 Introduction

Quality of medical record reviews in epidemiological research has long been debated in the medical literature. Data that has been collected prospectively is generally considered to be more accurate and representative of the truth.[1] Data collected retrospectively is fraught with missing or incorrectly recorded entries, illegible writing, and missing data. Extraction of this data by researchers is further complicated by inter-observer variability or reproducibility which affects precision and hence accuracy. When comparing a medical record review to standardized patient interview data, degradation can occur due to non-random bias or lack of reliability at any step where information is recorded or obtained. Very few comparisons have been made in epidemiologic literature between data that has been collected retrospectively and prospectively. In the few cases where it has been performed, the information is far less complete or accurate when compared to prospective data.[2;3]

2.1.1 Medical Record Fidelity

The difference between what patients tell interviewers in real time versus the availability of that data within the medical record has not been studied in sufficient depth, especially in stroke research, and thus its validity has been called into question.[4] Kothari et al. found that for recorded symptom onset in 151 stroke patients, only 79% of the event times were accurate when actual times were compared against the written emergency department (ED) medical record information.[5] When examining the postponement from symptom onset to ED presentation, Evenson et al. examined 583 patients presenting with stroke symptoms. They compared information obtained from direct interview with the information that was recorded in the medical record. [6] Stroke patients who arrived more than six hours from the onset of their symptoms had their actual onset time recorded accurately only 30% of the time. Other studies have focused on determining how representative medical records are for quality of care measures. Two studies by Luck et al. used actor-patients; they found that all elements of the clinical encounter including histories were significantly less accurately recorded when compared to standardized patient checklists.[7;8]

2.1.2 Medical Record Information Flow

Information flows through three connected participants when encoding patient histories: the subject, the clinician, and the medical records coder. Validity and reliability affect each of these participants in unique ways. There multiple interfaces where information can be lost through data degradation; the absence of precision can usually be accounted for whereas censoring and bias cannot.[9;10] Subject reproducibility was found to be poor in the study performed by Nagurney et al. on 143 adult patients presenting to the ED with a chief complaint of chest pain. When interviewed, they found that 30% of these patients would give different answers when questioned a second time one hour after the initial interview and up to 8% were unable to recall historical events at all.[1] This type of data degradation would be present in both prospective and retrospective studies due to patient recall bias. Prospectively gathered information may also be incorrect because patients poorly recall their medical history even when verified by other sources; in fact, patients have been shown to censor, over-report, and under-report historical data.[11;12] The next factor in the chain of information flow is the clinician. Nagurney et al. noted that within a single ED medical record illegibility and contradictory data are present and occur frequently. Clinicians suffer from both false-positive and false-negative results, as well omission of data in their notes. This is due to the errors from the patient encounter as well as errors on part of how they recorded or recalled the

information they acquired. This may be even more problematic in the chaos surrounding a stroke presentation in the ED.

The last participant in the information flow is the medical record nosologist or the researcher. Encoding accurate information may also be subject to similar biases as with patients and clinicians through non-reproducibility bias. The methodological issues of retrospective data collection are discussed in further detail in Chapter Three of this thesis. When comparing to a prospective criterion, historical data reproducibility tends to be affected by the type of variable being collected, weather it is nominal or continuous. The greater the number of potential responses to a variable the greater chance of incongruence between the actual patient history and the information recorded in the medical record.[13]

2.1.3 Validity and Reliability within Medical Records

Variability in the validity and reliability of medical information has also been observed. For example, Paganini-Hill found good agreement for certain variables, such as prescription medications, but poor agreement for others, such as history of myocardial infarctions. It is unclear as to why patients exhibit such poor recall with regards to their health information. Coughlin et al. noted that upon evaluating the literature a distinction should be made: the inaccuracy

between recall that was biased and recall that is non-reproducible is based on the exposure of interest and the disposition of the respondents.[13] It appears that the nature of the question being asked and to whom it was being asked plays a part in recall. This is where bias on part of the subject comes into play. One possible explanation is the "social desirability bias" where by the subject feels the need to give a desired response to a question about an acceptable health behavior.[14] This explanation has been used to describe why under-reporting occurs with respect to cigarette smoking rates from health surveys.[15]

2.1.4 Special Case in Medical Record Reviews: Smoking Documentation

This study used smoking histories with a specific subset of the ED patient population to examine the quality of medical record coding. Smoking is an especially relevant risk factor as it exacerbates the risk of stroke through increasing the probability of detrimental vascular events occurring in this population. Smith recently published a study looking at tobacco use among emergency department patients in urban Ontario hospitals and found that current use was found to be approximately 26 percent within this population.[16] The age stratified rates were almost double when compared to the general population across all age groups, showing that the ED population has especially high risk smoking behaviors. Documentation within these groups has been shown to be poorly performed. Self et al. looked at 13 studies over the last decade and found that for patients with cardiovascular disorders and respiratory

disorders their smoking histories were not documented on average 40% of the time. Even worse, only two studies recorded second hand smoke exposure less than 10% of the time.[17] Former smokers were found in only one study and were recorded 60% of the time. Failure to document co-morbidities in these patients compounds the potential for poor management or improper treatment that reduces the possibility for a positive patient outcome.

2.2 Methods

2.2.1 Study design

A prospective cohort study was conducted to examine the management of patients with an ED diagnosis of “stroke” or “TIA” between January 1, 2009 and May 19, 2010.

2.2.2 Study setting

The study was conducted primarily at the University of Alberta Hospital (UAH); the Royal Alexandra Hospital (RAH) ED was also used. The UAH is an academic teaching hospital, is a designated stroke and neurosciences hospital, and is one of two regional trauma centers. UAH patient volume in 2009 was approximately 54,000 visits over the age of 17. The RAH is a clinical teaching

hospital and a regional trauma center; both hospitals are staffed by neurosurgical and neurological consultants. RAH patient volume in 2009 was approximately 65,000 visits over the age of 17.

2.2.3 Inclusion/Exclusion Criteria

Inclusion was defined by ED physician diagnosed patients with stroke or TIA that resided within the AHS-Edmonton Zone where a valid postal code could be obtained. Patients were excluded when the following conditions were present: traumatic head injury, out of region (i.e. the patient lived outside of the Greater Edmonton Area), hemorrhagic events due to aneurysm or anticoagulant-associated ICH, the patient was confused or the patient was unable to respond. A **R**efused, **M**issed and **O**therwise excluded (RMO) database was maintained throughout the study to examine generalizability of the cohort.

2.2.4 Study Protocol

Research assistants were available from 07:00-23:00 Monday-Friday and 08:00-18:00 most weekend days at the UAH and 08:00-17:00 Monday-Friday at the RAH. Patients were approached after the assessment and investigation by the most responsible emergency physician. Once a diagnosis of TIA/stroke was

confirmed by the emergency physician, a study research assistant provided the study information sheet and consent form to TIA/stroke patients or their family members. The purpose of this protocol was to ensure that under no circumstance could a research assistant inform the patient of their TIA/stroke diagnosis prior to a physician discussing the case with the patient or family. Following informed consent, trained research assistants completed a research form (Appendix A). This questionnaire gathered information regarding the timing, location, and knowledge of the patient's event. As well, information regarding occupational and smoking history was gathered. Documentation within the RA administered patient interview is effectively 100% versus a medical record completed by an emergency physician administered +/- a consultant interview, which may not always be complete or accurate. Based on these comparisons, analyses will focus on contrasting the collected history of (i) TIA or stroke event onset, (ii) patient location at time of the event, and (iii) patient's smoking history (current, ever, never, and pack year history) or occupational exposure. Smoking history is notoriously poorly recorded or the information that is recorded is not representative of the patient's actual smoking status or history.

2.2.5 Data Collection

Following completion of the visit encounter, trained Emergency Medicine research staff completed a formal chart review using a structured form (Appendix C: In Chapter 3) following the same protocol outlined in the retrospective chart review. The chart review obtained additional data on risk factors, such as hypertension, previous stroke, heart disease, diabetes, and smoking, as well as selected baseline vital statistics that indicate greater susceptibility to stroke.

2.2.6 Sample Size

Sample size calculations required a minimum of 330 patients to be enrolled to yield accurate estimates between successive patient interview and chart review questions. These estimates were based on the following assumptions: 1.) Some factors would be documented in 20-30% of charts and 40-50% in others; 2.) Not all patients enrolled would have a definite stroke upon a confirmed diagnosis: we assumed 10% of interviewed patients would not have a confirmed stroke upon discharge; 3.) A sample size of 330 would provide a margin of error of 8.98% and confidence intervals around the point estimates of +/- 5.35% for factors with 20-30% reporting and point estimates of +/- 5.35% for factors with 40-50% reporting; 4.) A sample size of 330 would achieve power of

1.0; assuming that the difference between a research assistant administered interview would be a minimum of 35% detection error (established from a previous literature review[17]) for smoking histories.

2.2.7 Statistical analysis

Data analyses were performed using Stata Statistical Software® Release 11.1 (College Station, TX, Stata Corporation). Descriptive analyses included proportions for categorical variables which were reported with 95% confidence intervals (CI). For continuous data, means and standard deviations (SD) are reported; data that did not follow a normal distribution are reported as medians with interquartile ranges (IQR). Tests for one-sample proportions with binary outcomes were done by using a binomial probability test with respective 95% confidence intervals (CI). For comparing proportions of 2 independent groups with binary outcomes, p-values are reported using Fisher's exact test. For comparing binary outcomes for matched pair samples, McNemar's test. Wilcoxon Signed Rank Test was used to determine the differences between groups with repeated measures and continuous outcomes. Mann-Whitney U tests were performed to compare continuous variables to determine whether the included and excluded populations (independent groups) significantly differed. All tests were employed a $\alpha < 0.05$ to signify significance and reported with respective 95% CI when applicable.

2.2.8 Ethics

This work was supported by a restricted grant from Health Canada. The study was approved by the University of Alberta Human Ethics Research Board. The Northern Alberta Clinical Trials and Research Center provided operational approval before accessing any Capital Health or Caritas Resources or Facilities. Following the first three months of the study several issues were identified that required a revision in the protocol. Inclusion criteria for the prospective study was initially limited to stroke victims only, subsequently TIA, ICH, and SAH patients were included to clarify the inclusion criteria. These amendments were approved by each respective ethics board.

2.3 Results (Prospective Study)

2.3.1 Sample

A total of 759 patients were approached following confirmatory diagnoses; 12 refused, 94 were missed and 317 had other exclusions (Figure 2.1). We enrolled approximately 30 patients per month during the peak periods and the number of missed patients declined over the study period (Chart 2.1). Overall, three hundred and thirty six patients were enrolled in this study, 300 coming from the UAH and 36 from the RAH. Reviews of all 336 chart reviews have been completed and corresponding databases been created. Patients

found to be out of region are still included in the database and have been labeled as such ensuring completeness. Of the 336 charts reviewed, 34 were found to have a final diagnosis (upon further inspection by medical staff outside the Emergency setting) other than TIA/stroke. Diagnoses included various central and peripheral nervous system disorders, demyelination diseases (i.e., MS), migraines, and delirium/dementia and brain tumors. The ED diagnoses along with the actual diagnoses have been included in the database.

2.3.2 Sample Demographics

Of the 336 patients enrolled in this study the median age was 74; 52% were female and the severity at presentation was most often CTAS 2: 176 (52%) or CTAS 3: 154 (46%) (Table 2.1). Physicians saw patients relatively rapidly with a median time from triage to physician assessment of 40 minutes (IQR: 14, 124): these patients had a known symptom onset in 50% of the cases and 74% arrived by ambulance. The median difference between onset knowledge was 56 minutes; patients with a known symptom onset were assessed by an emergency physician more quickly when compared to an unknown symptom onset at 22 (IQR: 10, 68.4) and 78 (IQR: 26,143) minutes, respectively ($p < 0.0001$) A total of 48 (14%) of these patients were transferred in from other hospitals within the AHS-Edmonton Zone.

2.3.3 Co-morbidities

Previous smoking was documented in the chart for 19% of patients and only 21% of patients denied ever smoking. The median number of pack years from chart review was 27.5 (IQR: 20, 35). Heart disease was documented in 102 (30.2%), hypertension in 242 (71.8%), diabetes in 72 (21.4%) and previous stroke and TIA in 114 (33.8%). Overall, 146 (43.3%) charts had no smoking status recorded; 58 (17.2%) were reportedly current smokers (Table 2.1).

2.3.4 Treatment

At the time of arrival, 147 (43.6%) patients were on ASA, Plavix or Aggrenox and 37 (11.0%) were on oral anticoagulants such as Coumadin. The median time from triage to CT was 77 (IQR: 38, 164) minutes, with all but one patient receiving imaging 335 (99%). The median time to CT for known and unknown onset was 47 (IQR 30.5, 125.5) and 109 (IQR: 51.5, 177.5) minutes respectively ($p = < 0.0001$). Thrombolysis was administered to 36 (10.7%) patients with a median time of 75 (IQR 57, 99) minutes from triage (Table 2.2). We did not identify a difference between males and females with respect to the timing of thrombolysis ($p = 0.1798$).

2.3.5 Outcomes

Most patients 227 (68%) had a cerebral infarction (ischemic stroke) or a transient ischemic attack 67 (20%). The large majority of patients were admitted 272 (81%) and a small proportion 22 (6.5%) died (Table 2.3).

2.3.6 Location of Event

In the chart review, we assumed that most patients came from home; however, in the prospective study we gathered more detailed information regarding the location at symptom onset. Overall, 248 (74%) of patients were awake at the time of the stroke. Exertion of any kind was documented in 8% of the cases; most patients were sitting or resting at the time of the event 167 (50%). The majority of patients were inside 302 (90%); however, 16 (5%) were in a vehicle at the time of the event. Overall, 228 (68%) of patients recalled when the stroke started (Table 2.4).

2.3.7 Residence

The majority of patients suffering from a stroke/TIA event were within 15 minutes of their home on the day of, the day before, and 2 or 3 days prior (range: 79.4 to 84.5%). Approximately 1 in 6 patients were more than 15 minute

drive from home and still within the Edmonton area; only a small number of patients were outside the Edmonton region in the 3 days prior to their stroke (range: 1.5 to 2.7%) (Table 2.5).

2.3.8 Congruence with Chart Review

There was a significant difference between the information obtained from direct interview compared to blinded chart review (Table 2.6). For example, known symptom onset was reported by 70.5% of patients in the prospective study compared to only 50% where information was documented on the chart ($p = < 0.0001$). Location of the event was assumed to be 100% in the neighborhood of their postal code; however, this only occurred in 84.5% of patients in the prospective study ($p = < 0.0001$). Parenthetically, patients who were < 65 years of age were less likely to be at their home or in close proximity to their home compared to those > 65 years of age (23.3% vs. 76.7%; $p < 0.0001$). In addition, smoking history was collected prospectively and compared to retrospective documentation; status “not documented” occurred in 43% of the chart reviews and none of the prospective studies (Table 2.6).

Comparing smoking status on the chart review, approximately 121 (36%) had been documented as “ever smoking” whereas in the prospective studies 205 (61%) had been documented as “ever smoking” ($p = < 0.0001$). Current smoking

status was underestimated in the chart review 58 (17.2%) versus the prospective study 78 (35.1%) (p = 0.0679). Pack year history was documented in only 50 (15%) of the cases in the chart review whereas 336 (100%) of the cases were available in the prospective study. The estimated pack year history was not significantly different 30 (18, 40) vs. 27.5 (20, 35) for median pack years (p = 0.8229). Exposure to second hand smoke was never documented in the chart review; however, 136 (41%) of patients described exposure to second hand cigarette smoke. Occupational exposure was documented in 78 (23%) of the prospective cases.

2.4 Discussion

This prospective cohort study examined 336 consecutive patients with acute stroke and TIA symptoms presenting to two university-affiliated EDs in the Edmonton area as part of the Health Canada stroke environmental study. The study focused on ischemic cerebrovascular disease and excluded patients who were known to have stroke-like problems (e.g., migraine headache, seizure, demyelinating disease, psychiatric disorders, etc.), trauma, and referred from non-Edmonton zone hospitals. Moreover, the study attempted to restrict enrollment to patients who were potential candidates for thrombolytic therapy. In this cohort, a small percentage of patients refused enrolment and several were missed; however, this population appears to be comprehensive and

representative of the sample of patients presenting to tertiary care EDs with symptoms compatible with ischemic stroke.

Overall, this population was elderly, equally female and male, and arrived via ambulance in an urgent or critical state. These stroke/TIA patients demonstrated impressive co-morbidities and approximately one-third reported a previous stroke or TIA. Importantly, a large majority of these patients were already receiving an anti-platelet or anticoagulant agent prior to their ED presentation. The majority of these patients were admitted after being diagnosed. It is the interaction of these multiple co-morbidities that poses the greatest ongoing threat to this patient population.[18]

Time to assessment suggests that the UAH ED is meeting the current guidelines for acute assessment of stroke patients.[19;20] The current recommendation by the Canadian Stroke Strategy and Alberta Provincial Stroke Strategy suggests time to CT interpretation and time to tPA should be no more than 45 and 60 minutes, respectively. When considering a known onset, time to ED MD assessment and time to CT more closely matches the suggested guidelines.

Comparing the retrospective chart review to the prospective data collection, patients presenting to the ED are most often in the postal code of their residence at the time of the event or immediately prior to the event. Approximately 85% of the patients were near or in their home at the time of the event. Overall, 14% were at least a 15 minute drive from their home and only 2%

were out of the Edmonton region on the day of the stroke. These findings did not vary on the 1-3 days before the stroke/TIA event; however, there was an age difference with younger patients more frequently residing away from their home on the day of and prior to the stroke/TIA event. This suggests that postal code is generally accurate for correlations to environmental exposure. While it may need to be adjusted for younger stroke victims most acute strokes occur in and around the home. A search of relevant literature failed to find any other primary research that focuses on these onset location facts and this should be considered a novel result.

With regards to the smoking status, the prospective study provides an interesting comparison of the detail required to adequately adjust for important co-morbid factors. For example, the chart review identified only 17% current smokers whereas the prospective study identified 35% current smokers. This is a 50% detection failure in the ED chart review and for an important stroke risk factor, this is an important finding. Moreover, exposure to occupational smoke and second hand cigarette smoke are known risk factors for atherosclerosis and they would be under-detected if chart review methodology was relied upon. Although inpatient services and charting tend to provide a more comprehensive patient history and comorbidity summary, it is still important for ED physicians to attempt to capture these data. Considering these findings, this study suggests that the implementation of standard smoking history documentation needs to

be implemented to accurately detect smokers (for interventions) and risk factor documentation.

2.5 Limitations

This study has several limitations. First, the study was only conducted in the Edmonton area: socioeconomic, work, and travel factors would be different in other regions. Second, the subjects were interviewed by a physician and a researcher after their presentation, which could introduce subject recall bias or Hawthorne effect. In either case, biases generated will skew the true result reducing the validity of presented data. Unfortunately, quantification of the bias would be very difficult to verify, due to the nature of retrospective data collection. Third, missing or conflicting data within the medical record could result in further bias. Again, determining the consequence of either of these possibilities would be very difficult in this study. These biases can have the potential to either over or under estimate the quality of care each patient is receiving. Fourth, UAH is the main quaternary care stroke referral center in the Edmonton Zone and is subject to referral bias and dominates the use of thrombolytics. Clearly, this referral bias must be considered in extrapolating these results to other centers. Fourth, not all presenting patients were enrolled; however, the comprehensive documentation of the enrollment (Figure 2.1) should not have resulted in biased results. Fifth, the physicians in these two sites are affiliated with an academic, university-based Department of Emergency

Medicine and are not representative of all Canadian emergency physicians. It is likely that these physicians document more and are exposed to more evidence-based management education than other non-academic EDs. Therefore, these results cannot be extrapolated outside the academic setting. Finally, the sample size was only 336; despite the use of a quaternary care stroke referral center and a tertiary care active academic ED, we only collected 336 patients over approximately 11 months of surveying.

2.6 Conclusions

In conclusion, the prospective study provides comprehensive information regarding symptom onset, location at the time of stroke, smoking history and exposure to occupational and second hand smoke. Using a “gold-standard” patient interview is a relatively effective way to verify data from medical records as well has the ability to show gaps in data flow from a patient encounter to written medical records. These findings are important when considering stroke patients and adjusting for exposure effects and co-morbidities.

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Figure 2.1: Prospective Patient Flow

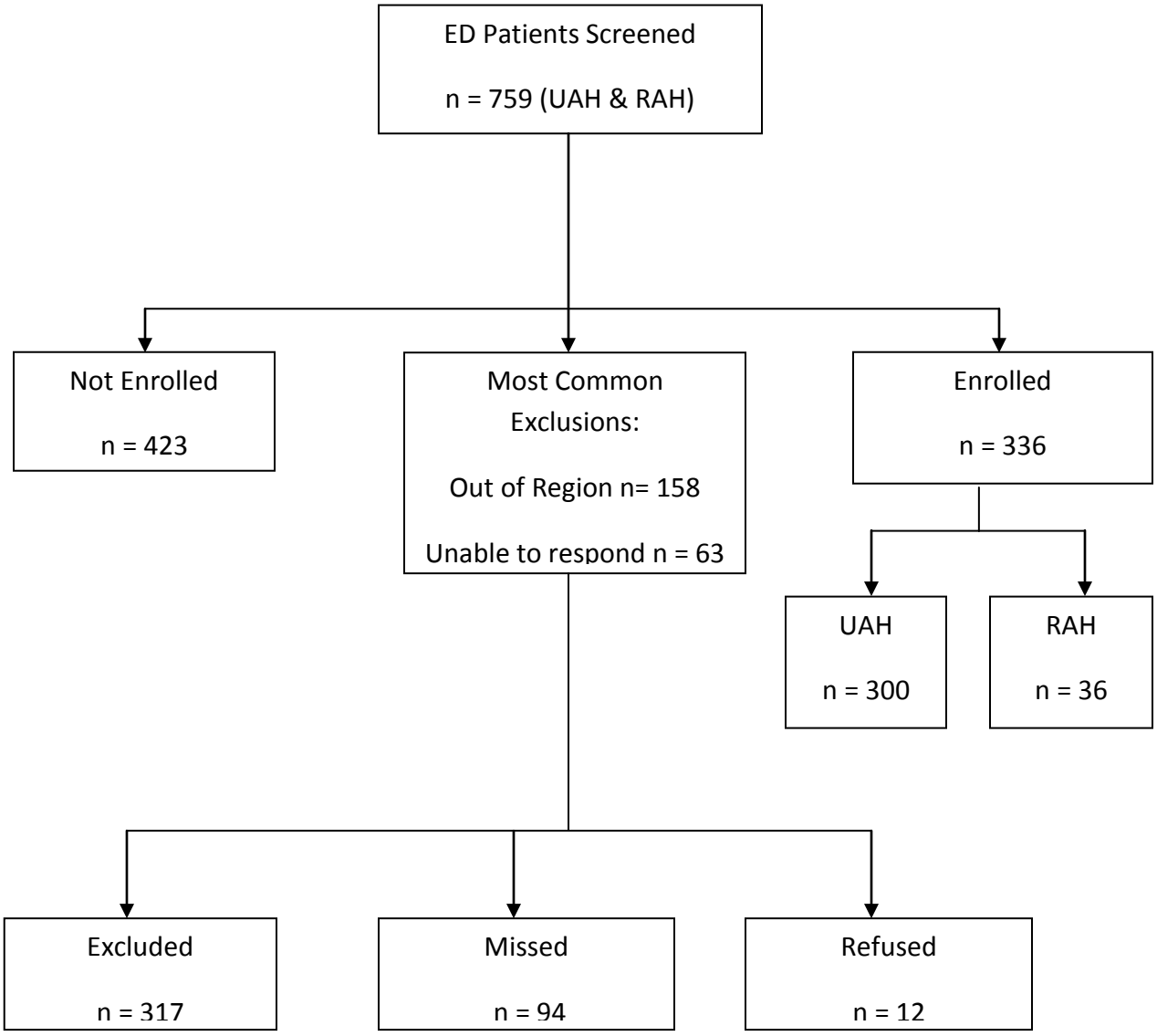

Figure 2.2: Prospective study questionnaire form

Triage Date:	___ / ___ / ___ dd mm yy	Initials			Patient Study ID
Triage Time	__ __ : __ __ (00:00-24:00)	Enroll Date:	___ / ___ / ___ dd mm yy		Postal Code

Questionnaire Appendix: A

Associations between air pollution exposure and stroke events reported at emergency departments in Edmonton,

You have been diagnosed with a stroke. Please answer the following (circle responses):

Were you awake when this stroke occurred?	**Yes**	**No**	**Unsure**		
What were you doing when this stroke happened?	**Sleeping**	**Exercising**	**Sitting/ resting**	**Exerting at work**	**Other**
Where were you when this stroke happened?	**Inside**	**Outside**	**In vehicle**	**Other**	
Do you recall when your stroke started?[1]	**Yes**	**No**	**Unsure**		

	Date (dd/mm/yy)	Time (hh:mm)
If you answered yes to the previous question, about what time and day did it start?[2]	__ __/__ __/__ __	__ __ : __ __

Please check (√) one of the 3 boxes in each column of this table.	Where were you:			
	on the day of your stroke? [3]	**on the day before your stroke? [4]**	**in the two (2) days before your stroke? [5]**	**in the three (3) days before your stroke? [6]**
Most of the time I was at home, or within a 15 minute drive from home				
Most of the time I was more than a 15 minute drive from home, but still in the Edmonton area				
Most of the time I was outside of the Edmonton area				

				Yes		No
Have you ever been a regular smoker (smoked more than 1 cigarette per day)? [7]						
If you have been a regular smoker, have you stopped smoking more than 12 months ago? [8]						
If you have been a regular smoker, have you smoked regularly in the past 12 months? [9]						
If you have been a regular smoker, about how many cigarettes per day did you, or do you, smoke? [10]				___ ___ cigarettes/day		
How long have you smoked in your life?				___ ___ years		
Are you regularly exposed to second-hand cigarette smoke?				**Yes**		**No**
Do you work in an occupation where you are regularly exposed to smoke or fumes? If yes, _____	**Retired**			**Yes**		**No**
ICD 10 Code:						

Signature of Data Collector:_____

Figure 2.3: Number of Monthly Enrollments for Prospective Patient Interviews (UAH&RAH)

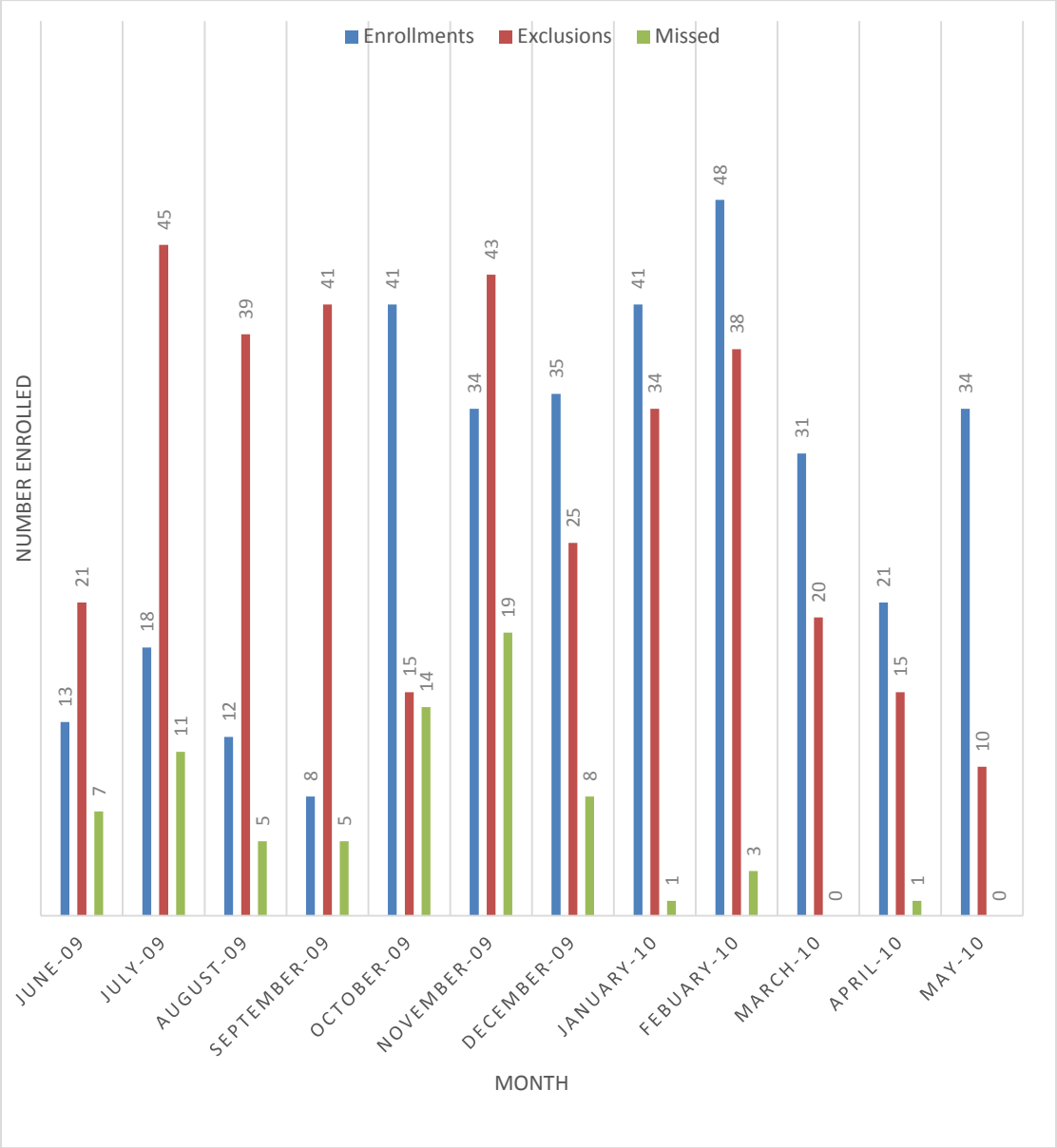

Table 2.1: Descriptive statistics of prospective patients presenting to UAH or RAH ED with acute TIA or stroke symptoms.

Variables	Included (Prospective) (n=336)
Demographic Details	
Age in years (median [IQR])	74 (61, 84)
Female Sex n (%)	114 (52%)
ED Presentation	
CTAS n (%)	
1	3 (0.9%)
2	176 (52.23%)
3	154 (45.6%)
4	4 (1.2%)
5	0
Not documented	0
Time from triage to physician assessment in minutes (median [IQR])	40 (14, 115)
Known symptom onset (n {%})	169 (50.1%)
Mode of arrival n (n {%})	
Emergency Medical Services	248 (73.6%)
Without medical assistance	89 (26.4%)
Not documented	0
Transferred patient (n {%})	48 (14.2%)
Smoking (n {%})	
Never	70 (20.8%)
Previous	63 (18.7%)
Current	58 (17.2%)
Not documented	146 (43.3%)
Number of pack years (median [IQR])*	27.5 (20, 35)
Heart Disease (n {%})	102 (30.2%)
Not documented	0
Use of Anti-hypertensive medications (n {%})	242 (71.8%)
Not documented	0
Use of insulin/oral hypoglycemic medications (n {%})	72 (21.4%)
Not documented	0
Previous Stroke/TIA (n {%})	114 (33.8%)
Not documented	0

* = Only documented in 50 (14.8%) of subjects; CTAS = Canadian Triage & Acuity Scale; ED = emergency department n = number subjects; [IQR] = interquartile range; TIA = transient ischemic attack

Table 2.2: Treatments and current therapies of prospective patients in the ED with TIA/Stroke in UAH/RAH ED.

Variables	Included Prospective (n=336)
Time to CT in minutes (median [IQR])	77 (38.5, 164)
CT received (n{%})	335 (99.9)
Time to CT in minutes for known onset (n = 168) (median [IQR])	47 (30.5, 125.5)
Time to CT in minutes for unknown onset (n = 168) (median [IQR])	109 (51.5, 177.5)
Thrombolysis given (n {%})	36 (10.7%)
Time to Thrombolysis in minutes (median [IQR])	75 (57, 99)
Time to Thrombolysis for females in minutes (n = 16) (median [IQR])	65.5 (50, 80)
Time to Thrombolysis for males in minutes (n = 19) (median [IQR])	78 (61, 106)
Use of Antiplatelet Pre-ED (n {%})	147 (43.6%)
ASA (aspirin)	117 (80.0%)
Plavix	23 (15.6%)
Aggrenox	7 (4.8%)
Not documented	0
Use of Anticoagulant Pre-ED (n {%})	37 (11.0%)
Coumadin/Warfarin	37 (100%)
Low Molecular Weight Heparin	0

CT = computerized tomography; CTAS = Canadian Triage & Acuity Scale; ED = emergency department n = number subjects; [IQR] = interquartile range; TIA = transient ischemic attack

Table 2.3: Outcomes and final disposition of prospective patients seen in the UAH/RAH ED with TIA/stroke.

Variables	Included Prospective (n=336)
Stroke sub-type (n {%})	
Subarachnoid hemorrhage (SAH)	8 (2.4%)
Intra-cerebral hemorrhage (ICH)	26 (7.8%)
Non-traumatic hemorrhage	6 (1.8%)
Cerebral infarction (stroke)	227 (68.0%)
Transient cerebral ischemic attacks (TIA)	67 (20.1%)
Other	2 (0.6%)
Outcome (n {%})	
Admitted	272 (80.7%)
Discharged	41 (12.2%)
Died	22 (6.5%)
Transferred out	2 (0.6%)
Site if transferred out (n {%})	
Tertiary care hospital (UAH)	1 (50%)
In-region hospital (non-UAH)	1 (50%)

ICH = intracranial hemorrhage; ED = emergency department n = number subjects; [IQR] = interquartile range; SAH = subarachnoid hemorrhage; TIA = transient ischemic attack; UAH = University of Alberta Hospital

Table 2.4: Events related to acute TIA or stroke in 336 patients included in prospective study of patients presenting to UAH/RAH EDs.					
Interview Questions:	**TOTAL INCLUDED (n=336) n (%)**				
Were you awake when this stroke occurred?	Yes 248 (73.8%)	No 51 (15.2%)	Unsure 37 (11.0%)		
What were you doing when this stroke happened?	Sleeping 79 (23.5%)	Exercising 15 (4.5%)	Sitting/resting 167 (49.7%)	Exerting at work 11 (3.3%)	Other 64 (19.1%)
Where were you when this stroke happened?	Inside 302 (90.0%)	Outside 15 (4.5%)	In vehicle 16 (4.8%)	Other 3 (0.9%)	
Do you recall when your stroke started?	Yes 228 (67.9%)	No 31 (9.2%)	Unsure 77 (23.0%)		

Table 2.5: Location related to acute TIA or stroke in 336 patients included in prospective study of patients presenting to UAH/RAH EDs.

Interview Questions:	TOTAL INCLUDED (n=336) n (%)			
	On the day of your stroke?	**On the day <u>before</u> your stroke?**	**In the <u>two (2) days before</u> your stroke?**	**In the <u>three (3) days before</u> your stroke?**
Most of the time I was at home, or within a 15 minute drive from home	283 (84.5%)	266 (79.4%)	273 (81.5%)	280 (83.6%)
Most of the time I was more than a 15 minute drive from home, but still in the Edmonton area	47 (14.0%)	64 (19.1%)	55 (16.4%)	46 (13.7%)
Most of the time I was outside of the Edmonton area	6 (1.5%)	6 (1.5%)	8 (2.1%)	10 (2.7%)

Table 2.6: Detailed smoking history of 336 patients included in prospective study of patients presenting to UAH/RAH EDs with an acute TIA/stroke.

Interview Questions:	**Yes n (%)**
Have you ever been a regular smoker (smoked more than 1 cigarette per day)?	205 (61.0%)
If you have been a regular smoker, have you stopped smoking more than 12 months ago?	113 (49.3%)
If you have been a regular smoker, have you smoked regularly in the past 12 months?	78 (23.2%)
If you have been a regular smoker, about how many cigarettes per day did you, or do you, smoke? Median (IQR)	13 (10, 25)
How long have you smoked in your life? Median (IQR)	30 (18, 40)
Are you regularly exposed to second-hand cigarette smoke?	136 (40.6%)
Do you work in an occupation where you are regularly exposed to smoke or fumes?	78 (23.2%)

Table 2.7: Comparison of patient interview and chart review for patients presenting to UAH/RAH EDs with TIA/stroke.			
Question:	**Prospective Interview (n = 336)**	**Prospective Chart Review (n = 336)**	**P Value (α = 0.05)**
Time onset yes (n {%})			
Time onset known	206 (61.4%)	169 (50.3%)	**0.0051***
Location day of event? yes (n {%})			
Home	283 (84.2%)	assumed 100%	**0.0001***
<65	66 (23.3%)	N/A	N/A
≥65	217 (76.7%)	N/A	N/A
Within 15 minute drive	47 (14.0%)	assumed 0%	**0.0001***
Out of region	6 (1.8%)	assumed 0%	N/A
Home location before event? yes (n {%})			
Day before	283 (84.5%)	assumed 100%	N/A
Two days before	266 (79.4%)	assumed 100%	N/A
Three days before	280 (83.6%)	assumed 100%	N/A
Smoking History yes (n {%})			
Status not documented	0%	146 (43.3%)	**0.0001***
Ever smoked regularly	205 (61.0%)	121 (35.9%)	**0.0001***
Current smoker	78 (35.1%)	58 (17.2%)	0.0679
Pack-year history documented	336 (100%)	50 (14.8%)	**0.0001***
Estimated pack-year history	30 (18, 40)	27.5 (20, 35)	0.8229
Second hand cigarette exposure	136 (40.6%)	0%	N/A
Occupational Exposure	78 (23.2%)	0%	N/A
Retired	176 (52.4%)	0%	NA

Chapter Three

Retrospective Medical Record Reviews for Stroke Patients Presenting to AHS Edmonton Zone Emergency Departments

3.1 Introduction

Much of the original research in Emergency Medicine is driven by information extracted from routine medical records.[1] The data are collected by doctors, nurses, and paramedics through the course of each patient's medical encounter. These records contain important clinical information; however, their production is not intended for research purposes.[2] This information is gathered at the point of care and subsequently research accesses it at a later date. The logistics revolving around these collection processes defines a set of issues that are inherent to the actual process itself, in that they are a reflection of the illness experience. Each record can provide information in several important areas such as, history of past illnesses, disease descriptions of patient illness, diagnostic results, and clinical-pathological correlations.

3.1.1 Medical Records and Primary Research

These data afford researchers the opportunity to develop hypotheses regarding treatment, prognostic factors, and complications that can be tested in prospective studies.[3] These chart reviews allow researchers to use an already existing dataset to conduct practice-based clinically relevant research. The foremost weakness associated with medical record reviews is that there is no unifying protocol for patient care, recording chief complaints, defining diseases, or assessing outcomes. This issue is then compounded by a lack of protocols for committing any of the above information to paper. The data are recorded by any number of health care providers and contain personal interpretations of symptoms, diagnostic results, diagnoses, and outcomes.[4] Inherently, clinicians have differing methods on how they observe, measure, and report their findings; couple this with the high likelihood of illegible, conflicting, missing, or otherwise un-codable information and the reliability and validity of the extracted data can come into question. Schwartz et al. looked at emergency physician records of trauma patients and found they lose one third of the available data about the history of their presenting illness because they never write it down.[5] When they compared medical records to directly observed or videotaped medical encounters, the written records were often found to be incorrect.[6]

3.1.2 Medical Record Review Methodology

It has been reported that approximately 25% of published peer reviewed emergency medicine studies use this chart review methodology.[7;8] Due to the high likelihood of errors, omissions, and idiosyncrasies in the recording process and subsequent abstraction process, Gilbert et al. proposed eight strategies in an attempt to standardize the method of collection and improve the quality of medical record review.[4] This checklist was then further revised by Worster et al and Badcock et al to include four additional items.[9;10] These authors created a set of publishing standards that should be required for conducting and reporting medical reviews. At the very minimum every published medical record review should provide information on seven key methodological areas: 1) explicit protocols for case selection and exclusion, 2) abstractor training, 3) precise definitions of key variables, 4) use of standardized abstraction and coding forms, 5) monitoring of abstractor performance, 6) blinding of abstractors to study hypotheses, and 7) testing of inter-rater agreement. The first standard is required for readers to comprehend the sampling methodology, source population, and exclusion/inclusion criteria. Standards two to five increase the validity and reproducibility of the data by establishing a priori protocols for data abstraction. The sixth standard attempts to counter bias that are incurred during data collection from the abstractor's predisposition regarding their hopes or theories of potential outcomes. Lastly, the seventh standard provides a measure

for how reproducible the data are. If any of these key standards are missing the conclusions resulting from the medical record review should be questioned.

In the original article from Gilbert et al which screened 986 original articles, most medical record reviews described inclusion and exclusion criteria (98%); however, most did not report on abstractor training (18%), use of standardized abstraction forms (11%), monitoring of abstractors (4%), blinding of abstractors (3%), or testing of inter-rater reliability (0.4%). A decade later Worster et al. and Badcock et al. re-assessed the level to which these standards were being met. Unfortunately, they only found marginal improvements in adherence of 4 areas: abstractor performance monitoring, standardized abstraction forms, blinding, and inter-rater reliability. They also suggested additional standards be applied to medical record reviews, sample size calculation, human ethics board approval, sampling methodology, and disclosure of funding sources. For most journals these are normally required for any submission to be accepted. The lack of methodological rigor is reflected in the absence of quality control procedures for manuscript preparation, review, and publication. Adherence to the standards first recommended by Gilbert et al., would ensure that the data presented and conclusions drawn were accurate and reproducible.[3]

3.2 Methods

3.2.1 Study Design

A retrospective chart review of medical records of TIA and stroke patients was conducted within the Alberta Health Services (AHS) – Edmonton Zone (formerly known as the Capital Health Authority [CHA]). Outlined below, the retrospective chart review methodology employed appropriate techniques to enhance validity and reliability using guidelines outlined by Worster, Gilbert and Badcock.[4;9]

3.2.2 Data Sources

Emergency Department Information Systems (EDIS): provides triage information (time of arrival, patient demographics, current vitals, and description of presenting illness), manages patient flow & tracks patient movement through the emergency department.[11]

3.2.2a Emergency Department charts (ED MD charts)

A paper document in which patient encounter information is recorded by the attending physician. Relevant information is recorded with respects to patient demographics, history of presenting illness, patient co-morbidities,

current and previous medical history, differential diagnoses, treatment progress and if applicable discharge or transfer information.

3.2.2b Nurses Note

These are paper documents that provide information regarding the status of the patient, the actions of the nurse, and the final disposition of the patient. It also clearly describes an assessment of the patient's health status, nursing interventions carried out, and the impact of these interventions on patient outcomes.[12]

3.2.2c Consultant Notes

These are paper documents written by medical specialists. These doctors are requested by an emergency physician to perform assessments for specific illnesses, create suggestions for patient management, and design decision pathways for further investigations or treatments. These documents also contain information on relevant patient demographics, medical histories, and co-morbidities.

3.2.2d Emergency Medical Services Records (EMS)

These are paper documents written by first line medical care specialists. EMS provides advanced life support and emergency medical care during patient transport until arrival at a tertiary care center. The documents contain information regarding patient demographics, current physiological condition, past medical histories and any relevant information regarding the history of their presenting illness.[13]

3.2.3 Setting

Data on ED visits was supplied by the AHS – Edmonton Zone for all Edmonton area hospitals and covered the period between April 1, 2003 and December 31, 2007. There were a total of 11 sites included in the study: (01 - {UAH} University of Alberta, 02 - {RAH} Royal Alexandra Hospital, 03 – {GNH} Grey Nuns Community Hospital, 04 – {MCH} Misericordia Community Hospital, 05 – {NECHC} Northeast Community Health Centre, 06 – {SCH} Sturgeon Community Hospital, 07 – {DGH} Devon General Hospital, 08 – {FSHC} Fort Saskatchewan Health Centre, 09 – {LCH} Leduc Community Hospital, 10 – {RHC} Redwater Health Centre, and 11 – {WHC} Westview Health Centre). Due to a considerable proportion of microfilmed charts and the difficulty accessing these records, data from 2008 and 2009 was added post-hoc. All AHS Edmonton Zone EDs are linked by a joint academic and teaching program at the University of

Alberta. These hospitals have full service emergency departments with in-patient beds, operate 24-hour service EDs, and are staffed by full-time emergency physicians. The overall catchment size covered by the hospitals is estimated at approximately 1.5 million individuals.

3.2.4 Clinical Data

Each ED chart has been coded by an experienced medical record nosologist using triage information, nursing notes, ED records and consultation notes. ED department visits were classified according to the International Classification for diseases 10th revision (ICD-10) and based on the physician's discharge diagnosis. Time and date of presentation were extracted from ED records. Analyses were restricted to visits for stroke from 2003-2009 data (ICD-10: I60-I69). Further analyses of stroke subtypes will use ICD-10 codes for stroke, not specified as hemorrhage or infarction (ICD-10: I61), subarachnoid hemorrhage (ICD10:I60), and transient cerebral ischemic attacks and related syndromes (ICD10:G45).

3.2.5 Data Abstraction Form

Retrospective data collection form was initially created to collect a core set of variables from our patient population and was then revised to a

standardized form after an initial pilot extraction. Key variables were defined by a code book with descriptions of clinical syndromes and drug types (Appendix C).

3.2.6 Data Collection

Chart reviews examined data for stroke/TIA patients admitted to any AHS-Edmonton Zone ED between April 1 2003 and September 30 2009. A master list was obtained from the Data, Management and Information Repository (DMIR) which contained every stroke patient that presented to an AHS-Edmonton Zone ED within the study period. It consisted of 14014 presentations and was randomized by a blinded third party methodologist to create a sample size of 7330 patients.

Using a standardized form, the data collected include age, sex, date of ED presentation, time of ED registration, time of ED MD assessment, and discharge diagnosis. In addition, co-morbid conditions (e.g., hypertension, heart disease, previous TIA/stroke and diabetes mellitus), current anti-platelet or anticoagulant therapies, smoking status, ED-treatments investigations (e.g., CT scan) and treatments (e.g., thrombolysis) were recorded on each patient, where applicable. A priori exclusion / inclusion protocols were defined: upon a confirmed most responsible diagnosis any non -stroke or TIA, or out of region

patient would be excluded from the retrospective collection. These excluded patients were then recorded in a Retrospective Exclusion Database.

3.2.7 Abstractor training

Training was completed on a random pilot set of 50 charts. These extractions were then compared between the Primary Investigator (BHR) and the research coordinator (DP); differences were adjudicated until a consensus was reached. The research coordinator trained two additional abstractors (SK and JL), and subsequently reviewed a random selection of 100 charts between the 2 reviewers to ensure agreement was being met. Consensus was defined for collected variables by outlining preferred extraction locations. We standardized a method for dealing with conflicting or missing entries (i.e., using preferred chart data locations for where key variables should be extracted as well a standardized hierarchy established for what to do with missing data or conflicting values). Data regarding times (time seen by ED MD or time to CT for example) could potentially have been recorded differently by separate health care workers; therefore, ED MD's notes were preferred over nurses' notes in cases where the values differed. If information was missing on the ED chart, other locations were searched (e.g., EDIS, consultant's notes, EMS chart, and nurse's notes). This was especially relevant for smoking histories. Often specialty consult notes were used to source patient co-morbidity or drug use history in cases where the

information was not recorded in the ED chart. Final diagnoses were confirmed by discharge summary when patient was admitted to an inpatient service and if the documents were available.

3.2.8 Statistical analysis

Data analyses were performed using Stata Statistical Software® Release 11.0 (College Station, TX, Stata Corporation). Reviewing approximately 7000 charts provided an effective power of 1.0 to detect population frequencies of relevant patient characteristics and stroke patient outcome variables while in the ED. These estimates are based on the following assumptions: 15-25% of charts would not contain the diagnosis of interest; some factors would be present or documented in 20-30% of charts and 40-50% in others. A sample size of approximately 7000 would provide confidence intervals (CI) around the point estimates of +/- 0.94% for factors with 10% reporting, +/- 0.94% for factors with 20-30% reporting and point estimates of +/- 0.94% for factors with 40-50% reporting. Descriptive analyses included proportions for categorical variables which were reported with 95% (CIs). For continuous data, means and standard deviations (SD) are reported; data that did not follow a normal distribution are reported as medians with interquartile ranges (IQR). Tests for one-sample proportions with binary outcomes were done by using a binomial probability test with respective 95% confidence intervals. Matched pair groups with binary

outcomes were analyzed using a McNemar's test. Wilcoxon Signed Rank Test was used to determine the differences between groups with repeated measures and continuous outcomes. Mann-Whitney U tests were performed to compare continuous variables to determine whether the included and excluded populations (independent groups) significantly differed. All tests were employed a $\alpha < 0.05$ to signify significance and reported with respective 95% CI when applicable.

Kappa statistics were used to assess inter-rater reliability and agreement between data extractors. Kappa is a more robust measure than simple percent agreement calculations since it takes into account the agreement occurring by chance. The chance adjustment of kappa statistics assumes that, when not completely certain, raters could guess. Landis and Koch characterized values < 0 as indicating no agreement, 0.0–0.20 as slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial, and 0.81–1 as almost perfect agreement.[14] All tests were used at at $\alpha=0.05$ and reported with respective 95% CI when applicable.

3.2.9 Ethics

This work was supported by a restricted grant from Health Canada. The study was approved by the University of Alberta Human Ethics Research Board. The Northern Alberta Clinical Trials and Research Center provided operational

approval before accessing any Capital Health or Caritas Resources or Facilities. Following the first three months of the study several issues were identified that required a revision in the protocol. Inclusion criteria for the retrospective study was initially limited to stroke victims only, subsequently TIA, ICH, and SAH patients were included to clarify the inclusion criteria. As well, due to the time consuming nature of reviewing microfilm charts, inclusion of the calendar years 2008 and 2009 were added. These amendments were also approved by each respective ethics board.

3.3 Results

3.3.1 Sample

From 14,014 patients identified with stroke/TIA in AHS Edmonton zone over the study period, we randomly selected 7330 charts for review. Both paper 4079 (55.6%) and microfilm 3251 (44.3%) charts were reviewed (Figure 3.1). There were 124 patient charts that could not be located which represent approximately 1.7% of the overall sample. There were a large number 1260 (17.2%) excluded after a confirmed diagnosis was determined for each chart. The unknown diagnosis of “not yet diagnosed” (NYD) occurred in 402 (2%) patients and other causes of stroke like symptoms that were not CVA were excluded and they amounted to 667 (53.7%). Overall, other exclusions occurred due to:

trauma 90 (7.1%), seizure 51 (4%), migraine 61 (5%), aneurysm 26 (2.1%), stenosis 25 (2.0%), and cancer 60 (4.8%). Following these exclusions and losses of chart availability, 5945 charts were completely reviewed.

3.3.2 Demographics

The median age was 73 (IQR: 60, 82). There were 3016 (50.7%) patients who were female and the large majority of these patients presented with a CTAS score of (2) 2729 (45.9%) or (3) 2731 (46.0%). The mode of arrival was evenly distributed between EMS 3106 (52.5%) and other modes of transportation 2834 (47.8%); p = 0.5224 (Table 3.1).

3.3.3 Current Therapies and Co-morbidities

The use of anti-platelets and anticoagulants in patients before arriving to the ED was observed in 2281 (38.4%) and 670 (11.3%) of the sample, respectively. The most common drugs used were aspirin in 1858 (81.4%) and coumadin/warfarin in 655 (97.8%) from each group respectively. Smoking status was poorly documented; 2854 (48%) were not available and only 912 (15.3%) were recorded as current smokers. Median number of pack years for patients with any smoking history was 30 (IQR: 20, 45). Comorbidities were common;

many patients were documented to have heart disease 1566 (26.3%), hypertension 3536 (59.5%), diabetes 1219 (20.5%), and previous stroke or TIA 1747 (29.4%) (Table 3.2).

3.3.4 ED Treatment

The median time to physician assessment from triage was 62 minutes (IQR: 26, 152). It was assumed that all patients in the Emergency Department received a CT scan. Overall, 5023 (84.5%) patients received CT imaging, unfortunately 191 (3.2%) of the CT times were unavailable due to lack of recorded information in either the paper or electronic record. Patients transferred inform other locations most likely had a CT scan done at the referring hospital and most of these records were unobtainable due to accessibility of this information post-hoc. The time to CT scan for those seen in one for the AHS-Edmonton Zone EDs (not transferred), was a median of 117 minutes (IQR: 56, 200). Use of tPA occurred in 247 (4.2%) of the cases and a median time from triage to administration of tPA was 81 minutes (IQR: 60, 98). When considering patients that fell into the newly expanded 4.5 hour tPA administration window, 66 (26.7%) of this population were treated beyond 3 hours (Table 3.3).

3.3.5 Outcomes and Final Patient Disposition

The large majority patients presenting with stroke symptoms to the ED were diagnosed with either a cerebral infarction 2809 (47.3%) or TIA 2217 (37.3%). Approximately equal proportions of these patients were either admitted 2501 (42.1%) or discharged 2580 (43.4%). Lastly, a small number of patients were transferred out of site to another tertiary care hospital 343 (90.9%) (Table 3.4).

3.3.6 Differences Between Included and Excluded Patient Population

With respects to the excluded population, on average they were 6.9 years younger, 3.7% more female, and had CTAS's that showed significantly less severe presentation dispositions. This was evident when comparing the proportions of the included versus excluded populations presenting with a CTAS 2 or 3, which were 45.9% versus 36.5% ($p = 0.01$) and 46.0% versus 52.1% ($p < 0.001$) respectively (Table 3.5).

3.3.7 Agreement

Kappa statistics for the initial inter-rater reliability between the principle investigator and research coordinator showed a high level of agreement for all

variables collected. The lower values (symptom onset and previous stroke - below 0.90) are most likely due to artifacts inherent in the medical chart recording process. Kappa statistics for the subsequent inter-rater reliability between the research coordinator and both research assistants also showed high levels of agreement (Table 3.6).

3.4 Discussion

This retrospective chart review study examined patient information, as collected on the ED and inpatient charts, for patients presenting over a 7-year period to EDs in the AHS – Edmonton Zone. First and foremost, this study identified approximately 17% of the charts were removed due to inaccurate coding upon a confirmed diagnosis by either a consultant note or discharge summary. A large proportion of these excluded patients had a diagnosis with an unclear etiology even at discharge or had diagnoses that were stroke mimics (e.g., seizures, weakness, syncope, migraine, and space occupying lesions). This is an important observation and a source of potential bias, since the excluded charts tended to be younger, more commonly female and present with less severe symptoms. In theory this could explain why an initial presentation could be misinterpreted as a stroke since females can present with more complex pathologies and younger patients are less likely to suffer from strokes.[15] The influence of this exclusion and misclassification is unclear; however, further

research through a more granular analysis of this subpopulation's characteristics and co-morbidities does seem warranted to determine if this is a bias or some imprecision in the results.

The chart review has identified a number of important factors that may be used in adjusting this analysis: including the preexisting use of anti-platelet, anti-coagulants, or anti-hypertensive medications in 38.4%, 11.3%, and 59.5% of all patients, respectively. As well, this population carries a considerable burden of co-morbidities: a considerable proportion had previous diagnoses of heart disease, diabetes, or stroke/TIA's in 26.3 %, 20.5%, and 29.4% of all patients, respectively. These rates tend to be much higher than found in the average population, albeit a specific subset, this data shows that stroke victims tend to suffer from these events due probable numerous longstanding and complicated health issues. This is readily apparent when looking at the rates of hypertension in this population, since hypertension is the most important prognostic factor for determining the risk of stroke.[16]

As a secondary corollary, current smoking is a risk factor for thrombotic events and the current smoking rates, while lower than reported in the literature, are probably the result of coding errors or lack of standardized smoking history taking. Data from the prospective study demonstrated low and inaccurate smoking documentation within medical records. The prospective study identified 50% of charts where smoking histories were not documented,

thus it is highly likely that only a fraction of the actual population is being captured via this method. Perhaps a better approach would be to add the current and previous smokers together since they represent patients with considerable risks. For example, if these groups were combined, this population would have an adjusted prevalence 29.5%. This would more closely approximate the smoking prevalence Smith found in their study of ED patients in Ontario.[17] Considering stroke victims are the population being studied; it would be advantageous to integrate a standardized questionnaire or checklist into the medical record itself. A concisely worded question regarding the patient's status and pack year history would be required, as "current" or "previous" smoking can be readily interchangeable depending on the disposition of the patient at the time of arrival (i.e., after a stroke the patient could have "quit" that day). This integrated question box may cue the emergency physician to ask about this potential risk factor, and as well as identify potential patients who could benefit from tobacco cessation counseling and therapy.

One of the criticisms of previous research in this field has been the lack of high quality chart review methodology. In this chart review we have used an: 1) explicit protocol for case selection and exclusion; 2) abstractor training; 3) precise definitions of key variables; 4) standardized abstraction and coding forms; 5) monitoring of abstractor performance; and 6) testing of inter-rater agreement. Reliability between the principle investigator (BHR) and the senior research coordinator (DP) was verified, then subsequently between the senior

coordinator and the two research assistants. Overall the interclass correlation coefficients and kappa statistics are all excellent except for pre-ED anticoagulant use and previous stroke. The simple agreements are all above 80% and this same is true for research assistant assessment. As per the criteria set out by the original paper by Landis and Koch, agreements above 0.8 are considered near perfect.

Potential explanations for this incongruence between variables are likely due to the data extraction protocol. Information was sourced via a priority algorithm, whereby certain data sources were given priority over others. Neurologist consultant notes and discharge summaries were generally considered the final decision for any of the extracted variables with ED MD notes followed by Nurses Notes and EMS notes. Within these records there was commonly “disagreement” or “incongruence”. For example, the most commonly inconsistently documented information would be a patient’s pack year history of smoking; often differing years or status would be found between data sources, this would especially be relevant for patients with long or complicated medical histories. A reasonable explanation for this incongruence would likely be due to either recall or a social desirability bias on part of the patient being questioned numerous times by differing allied health care staff.

Due to the issues of feasibility, cost – effectiveness, and rare event incidence, retrospective studies will continue to be performed. There are

however, protocols that can be implemented to enhance data collection. Limiting the complexity or variability around each question being asked will therefore limit deviation from the true answer that is being researched. I.e. limiting questions to “yes” or “no”, or asking for a specific number or disposition will decrease the potential for erroneous responses. Lastly, implementing check lists for common issues like stroke would ensure that negative co-morbidities are checked off rather than appearing missing. Overall, due to a meticulous protocol this study has demonstrated high levels of reproducibility between data extractors and can be deemed representative of the actual conditions within the population.

3.5 Limitations

This study has several limitations. First, the study was only conducted in the AHS-Edmonton area: socioeconomic, work, and travel factors would be different here compared to other regions. Second, the subjects were interviewed by a physician after the stroke event, which could introduce subject recall bias. This bias could distort the actual patient history, resulting in reduced validity of the chart review data. Unfortunately quantification of the presence or absence of this bias would be very difficult to verify, due to the inherent issues of retrospective data collection. Third, missing or conflicting data within the medical record could result in bias. If non-recording reflects failure to question,

then the data is an under-estimation of the factor; if non-recording reflects absence of factor, then the data represents an over-estimation. Again, estimating the consequence of either of these possibilities would be very difficult from this study. These biases can have the potential to either over or under estimate the quality of care each patient is receiving. Third, the main quaternary care stroke referral center is subject to referral bias and dominates the use of thrombolytics and this referral bias should be considered in interpreting these results. Despite this, we collected stroke/TIA patients from all AHS-Edmonton Zone hospitals. Finally, caution must be taken when drawing conclusions, especially for subsets of patients; none of these subgroups were randomized, nor were the diagnostic assessments or interventions standardized among groups.

3.6 Conclusions

This chart review identifies several issues that are important in future studies examining the correlation between patient co-morbidities, ED treatments and presentations of stroke/TIA. First, 17% of the stroke charts are misclassified and this is an important consideration that needs to be further examined. It appears that the initial ED presentation coded as a stroke event is not always valid. Confirmation following further investigation shows that not all "stroke patients" presenting to an ED actually have stroke. Similarly, not all TIA

patients seen in the ED have a TIA.[15] This should be considered when examining administrative data, since these sources may over-estimate stroke rates and prevalence. Second, the data collected from chart review is more comprehensive for inpatients but overall relatively poorly documented in the ED. Chart reviews performed here demonstrate a particularly poor documentation of smoking whether it is previous, current, or second hand exposure. Finally, the results indicate that a very small proportion of patients presenting to stroke centers and Emergency Departments receive thrombolytic therapy and needs to be examined in a more robust manner.

3.7 References

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Figure 3.1: Flow diagram for the retrospective chart review of stroke/TIA patients in the AHS region.

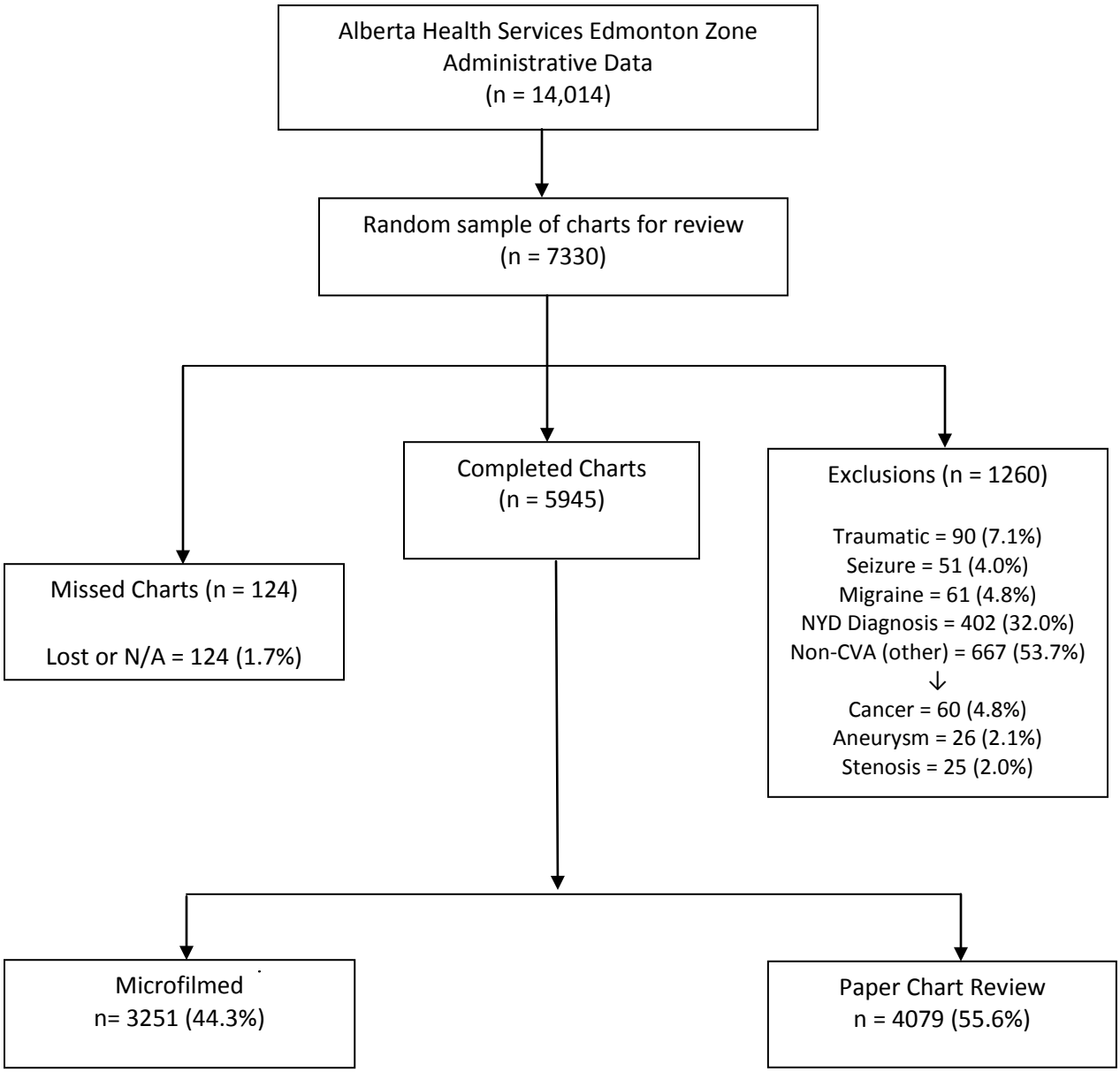
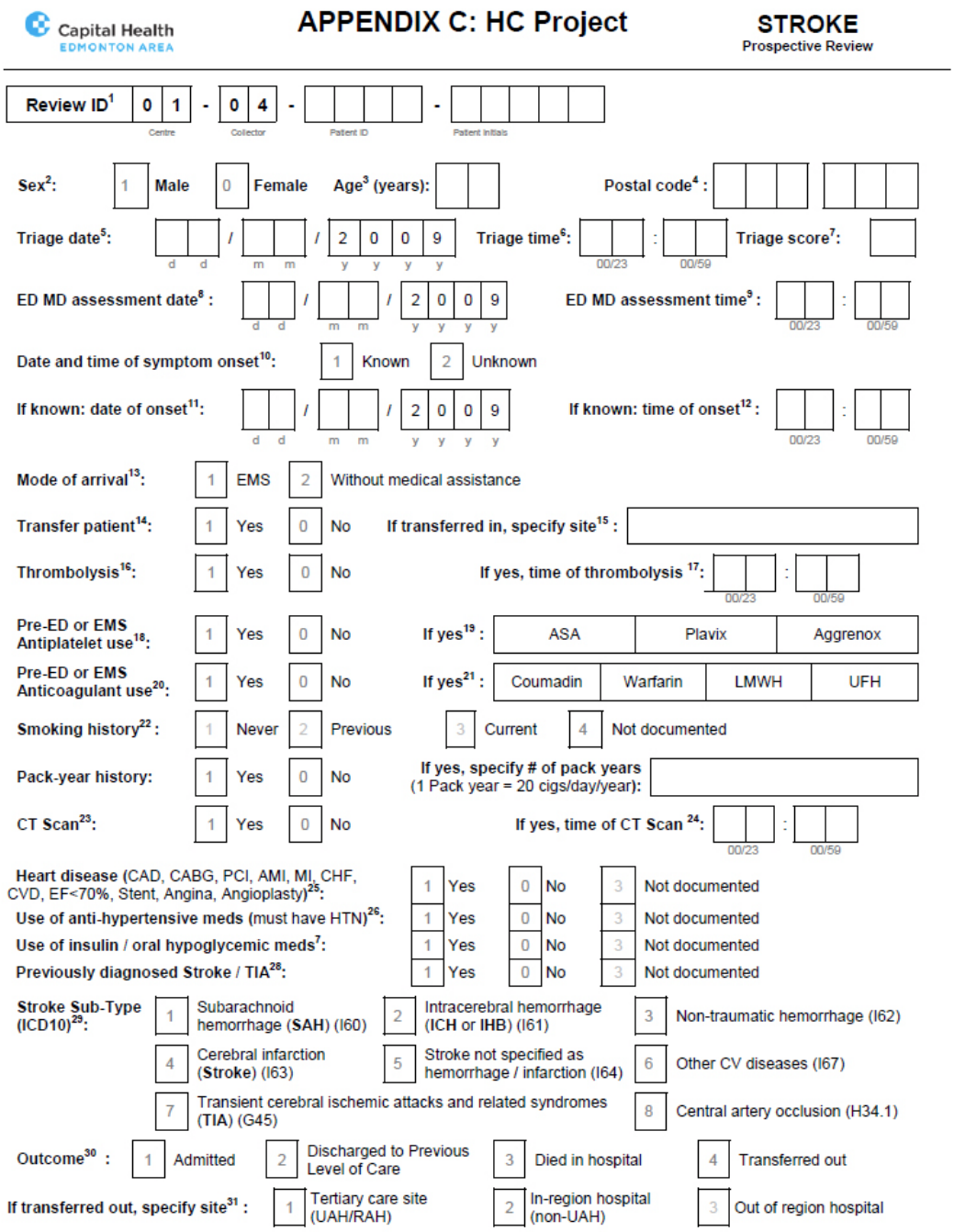


Figure 3.2: Retrospective Chart Review Form



Capital Health
EDMONTON AREA

APPENDIX C: HC Project

STROKE
Prospective Review

Review ID[1] 0 1 - 0 4 - ____ - _____
(Centre - Collector - Patient ID - Patient Initials)

Sex[2]: 1 Male 0 Female **Age**[3] **(years):** __ **Postal code**[4]: ___ ___

Triage date[5]: __ / __ / 2009 (d d / m m / y y y y) **Triage time**[6]: __ : __ (00/23 : 00/59) **Triage score**[7]: __

ED MD assessment date[8]: __ / __ / 2009 (d d / m m / y y y y) **ED MD assessment time**[9]: __ : __ (00/23 : 00/59)

Date and time of symptom onset[10]: 1 Known 2 Unknown

If known: date of onset[11]: __ / __ / 2009 (d d / m m / y y y y) **If known: time of onset**[12]: __ : __ (00/23 : 00/59)

Mode of arrival[13]: 1 EMS 2 Without medical assistance

Transfer patient[14]: 1 Yes 0 No **If transferred in, specify site**[15]: _____

Thrombolysis[16]: 1 Yes 0 No **If yes, time of thrombolysis**[17]: __ : __ (00/23 : 00/59)

Pre-ED or EMS Antiplatelet use[18]: 1 Yes 0 No **If yes**[19]: ASA | Plavix | Aggrenox

Pre-ED or EMS Anticoagulant use[20]: 1 Yes 0 No **If yes**[21]: Coumadin | Warfarin | LMWH | UFH

Smoking history[22]: 1 Never 2 Previous 3 Current 4 Not documented

Pack-year history: 1 Yes 0 No **If yes, specify # of pack years (1 Pack year = 20 cigs/day/year):** _____

CT Scan[23]: 1 Yes 0 No **If yes, time of CT Scan**[24]: __ : __ (00/23 : 00/59)

Heart disease (CAD, CABG, PCI, AMI, MI, CHF, CVD, EF<70%, Stent, Angina, Angioplasty)[25]: 1 Yes 0 No 3 Not documented

Use of anti-hypertensive meds (must have HTN)[26]: 1 Yes 0 No 3 Not documented

Use of insulin / oral hypoglycemic meds[7]: 1 Yes 0 No 3 Not documented

Previously diagnosed Stroke / TIA[28]: 1 Yes 0 No 3 Not documented

Stroke Sub-Type (ICD10)[29]:
1 Subarachnoid hemorrhage (**SAH**) (I60)
2 Intracerebral hemorrhage (**ICH** or **IHB**) (I61)
3 Non-traumatic hemorrhage (I62)
4 Cerebral infarction (**Stroke**) (I63)
5 Stroke not specified as hemorrhage / infarction (I64)
6 Other CV diseases (I67)
7 Transient cerebral ischemic attacks and related syndromes (**TIA**) (G45)
8 Central artery occlusion (H34.1)

Outcome[30]: 1 Admitted 2 Discharged to Previous Level of Care 3 Died in hospital 4 Transferred out

If transferred out, specify site[31]: 1 Tertiary care site (UAH/RAH) 2 In-region hospital (non-UAH) 3 Out of region hospital

Table 3.1: Patient demographics of stroke/TIA patients presenting to an AHS ED (2003-09)

Variables	Included (Retrospective) (n=5945)
Age in years (median [IQR])	73 (60, 82)
Female Sex (n {%})	3016 (50.7%)
CTAS (n {%})	
1	208 (3.5%)
2	2729 (45.9%)
3	2731 (46.0%)
4	246 (4.1%)
5	20 (0.3%)
Not documented	11 (0.2%)
Known symptom onset (n {%})	2788 (46.9%)
Mode of arrival n (n {%})	
Emergency Medical Services (EMS)	3106 (52.5%)
Without medical assistance	2834 (47.7%)
Not documented	5 (0.1%)
Transferred patient (n {%})	309 (5.2%)

CTAS = Canadian triage and acuity scale; ED = emergency department; EMS = emergency medical services; IQR = interquartile range; n = number.

Table 3.2: Pre-ED therapy and co-morbidities of stroke/TIA patients presenting to an AHS ED (2003-09).

Variables	Included (Retrospective) (n=5945)
Use of antiplatelet Pre-ED (n {%})	2281 (38.4%)
Aspirin	1858 (81.4%)
Plavix	323 (14.2%)
Aggrenox	88 (3.8%)
Not documented	12 (0.5%)
Use of anticoagulant Pre-ED (n {%})	670 (11.3%)
Coumadin/warfarin	655 (97.8%)
Low Molecular Weight Heparin	15 (2.2%)
Smoking Status (n {%})	
Never	1333 (22.4%)
Previous	846 (14.2%)
Current	912 (15.3%)
Not documented	2854 (48.0%)
Number of pack years (median [IQR])*	30 (20, 45)
Heart Disease (n {%})	1566 (26.3%)
Not documented	164 (2.8%)
Use of Anti-hypertensive medications (n {%})	3536 (59.5%)
Not documented	123 (2.1%)
Use of insulin/oral hypoglycemic medications (n {%})	1219 (20.5%)
Not documented	130 (2.2%)
Previous Stroke/TIA (n {%})	1747 (29.4%)
Not documented	186 (3.1%)

Note: * = Only documented in 723 (12.2%) subjects; IQR = interquartile range; ED = Emergency Department; n = number; TIA = transient ischemic attack.

Table 3.3: Treatments given to stroke/TIA patients presenting to an AHS ED (2003-09)

Variables	Included (Retrospective) (n=5945)
Time from triage to ED MD assessment in minutes (median [IQR])	62 (26, 151)
CT received (n{%})	5023 (84.5%)
CT Times Not Documented/Missing (n{%})	191 (3.2%)
Time to CT in minutes (median [IQR])	114 (54, 196)
TPA given (n {%})	247 (4.2%)
Time to TPA in minutes (median [IQR])	81 (60, 98)

CT = computerized tomography; ED = emergency department; IQR = interquartile range; MD = medical doctor; n = number; TPA = thrombolysis

Table 3.4: Outcomes and final disposition of patients presenting to an AHS ED (2003-2009)

Variables	Included (Retrospective) (n=5945)
Stroke sub-type (n {%})	
Subarachnoid hemorrhage (SAH)	208 (3.5%)
Intra-cerebral hemorrhage (ICH)	495 (8.3%)
Non-traumatic hemorrhage	216 (3.6%)
Cerebral infarction (Stroke)	2809 (47.3%)
Transient Ischemic Attack (TIA)	2217 (37.3%)
Other	3 (0.02%)
Outcome (n {%})	
Admitted	2501 (42.1%)
Discharged	2580 (43.4%)
Died	485 (8.1%)
Transferred out	377 (6.3%)
Not documented	2 (0.03%)
Site if transferred out (n {%})	
Tertiary care hospital (UAH)	343 (90.9%))
In-region hospital (non-UAH)	21 (5.6%)
Out of region hospital	5 (1.3%)

ICH = intracranial hemorrhage; SAH = subarachnoid hemorrhage; TIA = transient ischemic attack; UAH = University of Alberta Hospital; ED = emergency department; AHS = Alberta Health Services

Table 3.5: Comparison of included and excluded patients in the retrospective chart review study.

Variables	Included (Retrospective) (n=5945)	Excluded (Retrospective) (N = 1260)	T-Test (p-value)
Age in years (median [IQR])	73 (60, 82)	68 (51, 79)	**0.0000***
Female Sex (n {%})	3016 (50.7%)	686 (54.4%)	**0.0169***
CTAS (n {%})			
1	208 (3.5%)	27 (2.1%)	**0.0142***
2	2729 (45.9%)	460 (36.5%)	**0.0000***
3	2731 (46.0%)	657 (52.1%)	**0.0001***
4	246 (4.1%)	92 (7.3%)	**0.0000***
5	20 (0.3%)	9 (0.7%)	0.0805
Not documented	11 (0.2%)	15 (1.2%)	**0.0000***

Note: CTAS = Canadian Triage & Acuity Scale, *= denotes a significant difference

Table 3.6: Inter-rater reliability testing between

Variables	% Agreement (kappa) PI to RC Reliability (n=50)	% Agreement (kappa) RC to RAs Reliability (n=99)
Sex, age, triage-time, CTAS	100% (1.0)	95.9% (0.92)
ED MD assessment time	N/A (0.99)	N/A (0.92)
Symptom onset	93.9% (0.87)	89.9% (0.79)
Thrombolysis	100% (1.0)	100% (1.0)
Pre-ED antiplatelet use	95.9% (0.90)	91.9% (0.82)
Pre-ED anticoagulant use	97.9% (0.66)	98.9% (0.93)
Smoking history	91.8% (0.85)	92.9% (0.90)
Heart disease	95.9% (0.85)	95.9% (0.91)
Previous stroke	89.8% (0.70)	96.9% (0.92)
Stroke type	93.9% (0.89)	95.9% (0.94)
Outcome	91.7% (0.78)	94.9% (0.91)

Note: PI = Principle Investigator (Brian Rowe); RA = Research Assistant (Justin Lowes and Scott Kirkland); RC = Research Coordinator (Dion Pasichnyk

Table 3.7: Charts Screened through AHS - Edmonton Zone hospital EDs.

Site	2003	2004	2005	2006	2007	2008	2009	Totals
UAH	53	52	638	670	735	736	434	**3318**
RAH			290	277	276	306	150	**1299**
GNH		89	188	159	235	262	184	**1117**
MCH			166	158	172	186	82	**764**
NECHC	59	59	60	60	60	51	52	**401**
SGH			70	70	70	70	70	**350**
FSHC/DGH / LCH	11	11	11	11	11	11	15	**81**
Charts Screened:								**7330**

UAH = University of Alberta Hospital; RAH = Royal Alexandria Hospital; GNH = Grey Nuns Hospital; MCH = Misericordia Community Hospital; NECHC = Northeast Community Health Centre; SCH = Sturgeon Community Hospital; FSHC/DGH/LCH = Fort Saskatchewan, Devon, Leduc.

Chapter Four

Quality of Care Indicators for Stroke Patients within AHS Edmonton Zone Emergency Departments

4.1 Introduction

4.1.1 Quality of Care Indicators

Quality of care indicators are a way of measuring the degree to which care is delivered; in accordance with established standards and optimal outcomes, it is one of the key dimensions of value within healthcare.[1] These indicators cover key patient health care requirements, all major health care logistics, and encompass most major disease areas. While several coverage gaps remain, such as patient safety, patient experiences, and comparability across health authorities, these indicators allow policy makers and other stakeholders to draw inferences about relative health care system performance in key areas.[2] Examples include time to treatment of sepsis, time to antibiotics for community acquired pneumonia, and time to thrombolysis for acute myocardial infarction and strokes.[3-6]

Recent evidence supports quality of care monitoring as a method of improving accountability in healthcare delivery.[7] Unfortunately, evaluation of ED care in Canada is hindered due to the lack of unifying consensus regarding what

constitutes appropriate measures of quality ED care and patient safety measures. Over the last decade emergency medicine literature has demonstrated that increasing patient wait times and subsequent ED overcrowding is a continuing issue that has been plaguing the Canadian health care system.[8] In an effort to reduce waiting times and improve ED care the Institute for Clinical Evaluative Sciences (ICES) released a report of Quality of Care Indicators (QCI) for emergency departments (ED).[9] A process of developing a consensus began in Canada in January 2008 with a goal of defining evidence based and parsimonious set of QCI's for ED's. An expert panel used a modified Delphi survey technique to generate evidence-based QCI's for Canadian Emergency Departments showing that management of stroke was the fifth most important QCI on the compiled list of 48 final indicators. Relevant to this thesis, time to computerized tomography (CT) scan and time to thrombolysis with tissue plasminogen activator (tPA) were secondary measures within this indicator category. These markers are of considerable interest because they reflect both the availability of timely access to emergency care and the relative efficiency of EDs in meeting an accepted standard of care.

4.1.2 Emergency Departments and Overcrowding

ED overcrowding is defined by CAEP (Canadian Association of Emergency Physicians) and NENA (National Emergency Nurses Affiliation) as: a condition

whereby EDs are unable to provide timely emergency care within established time frames.[10] Concerns regarding timely access and quality of ED care have long been debated in Canada.[11] In 2001, a community survey was conducted from 1,400 adults residing Canada, Australia, United Kingdom, New Zealand, and the United States; Canadians ranked their EDs the lowest at providing "good or excellent" care and stated that they were most likely to wait longer than two hours in an ED.[12] ED patient flow is limited by a combination of factors: input (how patients enter the ED), throughput (time spent in the ED from being triaged to being assessed and receiving therapy) and output (where patients go after leaving the ED, weather admitted or discharged).[11] A report commissioned by the Canadian Agency for Drugs and Technologies in Health (CADTH) identified the top five causes of ED overcrowding as: 1) lack of admitting beds; 2) lack of acute care beds; 3) ED length of stay for admitted patients; 4) increasing complexity or acuity over time; and 5) occupancy rates of ED stretchers caused by output failure.[13] The report also found that 62% of Canadian ED directors surveyed in 2006-7 considered overcrowding as a major problem in cities with populations greater than 150,000 residents when compared with the previous year.

The primary cause of ED overcrowding is "access block", whereby admitted patients remain in the ED for prolonged periods due to insufficient inpatient bed capacity.[14] The net result is overcrowding in EDs, overcapacity waiting rooms, and emergency medical service (EMS) patient offloads being

forced to wait or ambulances being diverted to other hospitals.[15] EMS diversion occurs when patients undergoing transport are ineligible for admission to an ED; this leaves paramedics and their patients in an untenable position, they no longer have an ability to serve other patients requiring pre-emergency care. Also relevant, albeit geographically separate, is the consequence of ED overcrowding on rural hospitals. Access block affects these rural settings as well, when overcrowding occurs these centers are unable to transfer patients that are in need of a higher level of care. The immediate result is a system that is being taxed beyond a sustainable limit for prolonged periods of time; this is a direct impediment to access of emergency care, delaying delivery of time-sensitive treatments, increasing rates of patient departure prior to completion of care, and overall dissatisfaction for both patients and staff. Long-term consequences further complicate the issue of stroke care when considering overcrowding; patients with ED appropriate conditions may elect to defer treatment or seek care in sub optimal venues. This ultimately causes a negative impact on both patient health status and treatment costs for a now more complex or acute condition.

Canada currently has 3 hospital beds per 1000 people, ranking 26th out of the 30 Organization for Economic Co-operation and Development (OECD) countries.[16] Therefore hospitals are forced to frequently operate at occupancy rates higher than 90%. When this system is stressed by an additional community health crisis (e.g. an influenza outbreak), it is unable to cope with the extra

patient load.[17-19] The prevalent method to dealing with hospital overcrowding involves inappropriate use of ED's to "warehouse" admitted patients until an inpatient bed becomes available. Patients are referred to in some jurisdictions as emergency in-patients (EIPs), because they have been admitted by an inpatient service but still remain in the ED due to a lack of bed availability on the wards. This results in a blockage of admitted patients to the wards, which in turn leads to problems further backlogging ED throughput.[15] More than 50% of newly admitted patients are Canadian Triage and Acuity Scale (CTAS) level 2 or 3 and require critical or acute care beds, which are the same beds occupied by most EIPs.[20] This environment of increased patient volume with more severe acuity is associated with limited ED treatment spaces, therefore lends to the end result of increased wait times with overall patient and staff dissatisfaction.

4.1.3 Stroke Patient Flow and Emergency Departments

Patient flow through an ED is impacted by of four distinct factors; 1) community factors (e.g., where the patients arrive from and what mode of transportation they employ); 2) patient factors (e.g., complexity and acuity of presenting illness); 3) emergency department factors (e.g., capacity, availability of staffing or equipment); and 4) Health care system factors (e.g., in-patient resources, rehab services, homecare abilities, primary care networks and long term care facilities) all of which could be considered confounders that can

potentially interrupt treatment.[21] Strokes and EDs are closely linked. For example, most acute strokes present to the ED via EMS transport or private vehicle rather than through other care providers such as general practitioner offices. Approximately fifty percent of patients seeking acute care for stroke arrive via ambulance.[22] Upon arrival to the ED, patients are triaged based on the acuity of their presenting illness and subsequently assigned a CTAS score defining urgency to which they require assessment. The retrospective section of this study has demonstrated that most suspected stroke patients present with a CTAS score of 2 or 3. In some EDs, Stroke Teams or Triage Liaison Physicians (TLP) may perform an initial assessment; however, in most North American EDs, all of the patient's subsequent treatment is dependent on the availability of a bed within the ED.

Once the patient is transferred from the waiting room or an EMS stretcher to a suitable bed, diagnostic evaluations and an emergency physician assessment are completed. A diagnosis by the most responsible physician is made, laboratory assessment, and immediate CT scan are required to determine the etiology of the stroke symptoms (e.g., hemorrhagic, ischemic, secondary to tumor or other). Following these etiological investigations, suitable treatment is undertaken with antiplatelet, anticoagulants and/or thrombolytic agents. Most patients are admitted to an inpatient hospital unit following a CVA diagnosis; however, this will depend on the stroke severity, timing, treatments given acutely and home supports available to patients. Each of these distinct phases

could have potential “bottlenecks” that would hamper the delivery of the recommended standard of care; stroke related events are time sensitive, patients need to move through these phases as quickly as possible to ensure that as much damage as possible can be averted. Stroke expert Jeff Saver provides the following quote that summarizes the importance of timely treatment: “The typical patient loses 1.9 million neurons each minute in which stroke is untreated, therefore - time is brain”.

4.1.4 Stroke Care and Emergency Departments

Hyper-acute Stroke Care is defined as the health care activities that occur between first contact with a potential stroke patient and admission to hospital. Two guidelines have been established by the Canadian Stroke Strategy (CSS) to provide expedited acute stroke management medical services in Canada within the 4.5 hour window from symptom onset to administration of tPA therapy.[22] Firstly, a pre-hospital phase that begins with symptom onset with on-scene management and transport time, which should be 3 hours or less. Secondly, an ED phase that consists of a diagnostic evaluation and treatment option evaluation, which should be 60 minutes or less. To minimize negative outcomes for these patients requires a coordinated system of care in order to ensure rapid access to time sensitive treatments.[23] Delays in treatment of stroke patients including lack of pre-hospital identification of appropriate patients,

inappropriate transport of CVA patients to primary care facilities non-stroke facilities , and non-expedited triage of CVA patients represent potentially preventable obstacles for delivering high-quality stroke care.[24] Delays by patients seeking care after experiencing stroke symptoms, however, are still the most important barrier to timely treatment following a stroke event.[25]

Patients presenting to an ED with a suspected stroke or TIA must have an immediate clinical evaluation that accurately as possible establishes time of onset, confirms the diagnosis, and rules out any stroke mimics; the goal of an ED is to complete assessment and initiate treatment, potentially with tPA, within 90 minutes of stroke symptom onset based on CSS best practice recommendations. These patients often have multiple comorbidities that can complicate management of their stroke; for example, intracranial bleeding, recurrent stroke, hypertension, and the presence of a coagulopathy will impact subsequent treatment decisions. Since it is impossible to differentiate a cerebral infarct from a hemorrhage through clinical examination alone, neurovascular brain imaging is absolutely necessary to guide management. Timely access to neuro-imaging (e.g., CT or MRI) is important to facilitate the diagnosis decision and appropriate treatments. The diagnosis of stroke differs in approximately 20 percent of patients, and many management decisions follow the differential diagnosis post imaging.[26] Even though there is a lack of randomized control trials, it is accepted from various clinical practice guidelines, that a non-contrast (CT) should be performed as is the initial imaging modality of choice; a performance measure

defined by the CSS suggests that these patients should receive brain imaging within 60 minutes of being triaged.[27]

4.1.5 Regional Stroke Care Guidelines

For a regional perspective the Alberta Provincial Stroke Strategy (APSS) has established a set of recommendations, protocols, and algorithms to ensure the rapid identification and treatment of stroke patients. Their mandate is to ensure optimal outcomes for all stroke patients within the province. They have adapted a similar strategy as the CSS with recommendations based on graded peer reviewed evidence. The APSS uses designated specific EDs are that directly linked as tertiary stroke centers; they service most large metropolitan centers and are operational 24 hours a day, 7 days a week, and 365 days a year. Access to neurovascular imaging (CT) and expert interpretation is set to 60 minutes within a tertiary stroke center and have mandated that; all patients with a suspected stroke or TIA should undergo immediate neuro-imaging. Acute thrombolytic treatment is set to 4.5 hours from a known symptom onset; evaluation upon arrival should be without delay, thus determining the eligibility of tPA, with a “door to needle” time less than 60 minutes. The APSS has also designed a set of 3 algorithms for the treatment of stroke; they are designed as practice guidelines to assist physician assessment and diagnosis of stroke. Each algorithm uses a Boolean logic diagram to carry each patient case though a

clinical evaluation and differential diagnosis, and acute stroke management. The APSS time targets are: onset to hospital < 60 minutes (EMS and patient issues), triage to CT scan (ideally < 10 minutes but 10-30 minutes), triage to decision of tPA (60 minutes).[28]

In Alberta there are two comprehensive stroke programs, one at Calgary Foothills Hospital and one at the University of Alberta Hospital. Each center offers comprehensive care through access to a full complement of diagnostic tools as well a full staff of stroke specialists, neurovascular surgeons, interventional neuroradiologists, and sub-specialized nursing staff. Due to Alberta's large geographical size 40% of the province's residents do not have access to this level of stroke care. Most regional health authorities in Alberta do not have dedicated stroke programs and have limited access to tPA treatments, this is reflected in the fact that though multiple practice guidelines have been established, there is still no provincial standard of stroke care. A partial solution to this problem has been the implementation of a Telemedicine link from primary stroke treatments sites to tertiary stroke centers. The system allows for a virtual assessment and CT scan of the patient by a stroke specialist. This grants timely access for evaluation and potential treatment of an acute ischemic stroke with tPA, which would otherwise be logistically impossible due to the prolonged transport these patients often require.[29]

4.2 Rationale

This chapter set out to create a representative synthesis of the current body of literature with respects to quality of care standards. Contrasting Canadian provincial standards with multinational benchmarks set by various health authorities we can explore gaps that exist between evidence based recommendations and actual practice measures. Using representative data collected from tertiary care centers within the Alberta Health Services (AHS) - Edmonton Zone we can show how regional performance compares internally to Canadian standards as well as others. The review methodology was chosen as a synopsis of relevant literature with a similar protocol to the systematic review set by the Cochrane Library. A comprehensive systematic review was not completed for this study, instead a rapid review methodology was chosen when considering the scope of the data that was required; comparing all available health authorities and stroke associations would not likely provide significant resolution or robustness of comparative data versus looking at how other G8 nations manage stroke. Representativeness of our data should be compared to other facilities with similar resources, facilities, and demographics, hence why only comparable infrastructures were chosen. This review instead focused varying levels of administration, i.e. Provincial to Federal, to show regional trends and guidelines; the subsequent searches then focused on national to multinational levels to contrast how Canada compares to other countries when examining how other's set their quality of care guidelines.

4.3 Methods

4.3.1 Search Protocol

A search of health evidence literature databases was examined from 2000 to 2011. Specifically PUBMED, SCOPUS, EMBASE, MEDLINE, and GOOGLE SCHOLAR were used followed by a more in depth search of filtered evidence databases, specifically NGC (National Guideline Clearinghouse), NICE (National Institute for Health and Clinical Excellence), NLM (National Library of Medicine), and Cochrane. The search used Medical Subject Heading Terms (MeSH), refer to (Table 4.1). Study design criteria included: meta-analyses, systematic reviews, randomized control trials, quasi randomized trials, guidelines, reports, and consensus statements. Study design exclusion criteria: any study reporting a recommendation or guideline with respects to treatment for acute stroke/TIA patients that is not evidence based, grey literature, and manuscripts not in English. The population of interest contained any patient presenting to an emergency department with symptoms of an acute stroke/TIA. The intervention of interest was administration of thrombolysis, while the comparison was normal standard of care. The primary outcome for this review is time to thrombolysis with secondary outcomes of time to ED MD assessment and time to CT for patients with a known or witnessed symptom onset. Since this review is focusing on accepted times to tPA that were agreed upon by evidence and consensus there was no a priori time point cut offs set.

4.3.2 Statistical analysis

Data analyses were performed using Stata Statistical Software® Release 11.0 (College Station, TX, Stata Corporation). Descriptive analyses included proportions for categorical variables which were reported with 95% confidence intervals (CI). For continuous data, means and standard deviations (SD) are reported; data that did not follow a normal distribution are reported as medians with interquartile ranges (IQR). Tests for one-sample proportions with binary outcomes were done by using a binomial probability test with respective 95% confidence intervals. Tests to determine the differences between included and excluded groups with continuous variables used a Wilcoxon Signed Rank. Two sample T-Tests with unequal variance (confirmed by F-Tests) were performed on continuous variables to determine whether the included and excluded groups differed significantly between variables. This determined the mean percentage difference between the 2 groups.

4.3.3 Multivariate Analysis

Multivariate regression modeling was completed using a purposeful selection method.[30] Univariate analysis tests each covariate at an alpha of $p < 0.10$. Significant variables are retained within the model. In the iterative process of variable selection, covariates were removed from the model if they were non-

significant or identified for interaction. Significance was evaluated at an alpha level of 0.10, while confounding was evaluated as a change in any remaining parameter estimate greater than 15% when compared to the full model. Changes in parameter estimates above the specified level indicates that the removed variable is important in providing adjustment for one or more of the variables retained in the model. Any variable not selected from the original multivariate model was added back, with significant covariates retained earlier. This identifies variables that, by themselves, were not significantly related to the outcome but make an important contribution in the presence of other variables. Any variables that were significant from 0.1 to 0.15 alpha level are put in the model, and then iteratively reduced as before. At the end of this final step, the preliminary main effects model is defined.[31]

4.4 Results

4.4.1 Quality of Care Standard Review

A comprehensive search using the outlined MeSH key words with in the specified databases identified 16 evidence based practice guidelines In order of number of recommendations for each time point measure 5, 6, 7, and 15 out of 16 documents reported a time to ED assessment, time to CT, time to tPA, and time limit for tPA, respectively (Table 4.2). The median time recommended in all of the guidelines is as follows: 10 minutes to ED assessment, 25 minutes to CT

scan was, 60 minutes to tPA administration, and 4.5 hours maximum safety time for tPA administration. Only the Australian document failed to make a recommendation to limit the maximum therapeutic window of tPA. Approximately half of the documents recommended a 3 hour time limit and the other half recommended a 4.5 hour time limit for tPA administration. This was most likely due to the increased expansion of the tPA administration window after recent evidence was published from the ECASS III clinical trials.[23] Documents that recommend this 4.5 hour window use new evidence from ECASS III while other older documents did not and the shorter timed guidelines reflect this emerging data. Documents that did not recommend any specific time limits on treatment measures tended to denote a level of urgency and preface their guideline with an "as soon as possible" type protocol based on the urgency of the stroke symptoms. Unifying themes between documents show that most regulatory bodies use a specific set of clinical trials to ground their practice recommendations. The most common trials cited are: CASES [32], ECASS [23], NINDS [33], ATLANTIS [34], and EPITHET [35] all which were phase 3 or 4 clinical trials studying the efficacy of thrombolytics for the treatment of stroke in the emergency setting.

4.4.2 Regional Performance

Evaluating unified QoC time benchmark standards as a guideline, the AHS Edmonton zone showed that it did not meet any of the cut-point times in any category. Median time to ED MD assessment was 47.5 minutes (IQR: 19, 108; n=2361), time to CT was 91 minutes (IQR: 40, 167; n=2361), and time to tPA administration was 81 minutes (IQR: 60, 98; n=247). These times were all greater than the suggested time limits set by the unified standards as well both of the Canadian Stroke Society and Alberta Provincial Stroke Strategy. The UAH as a whole performed better than the other AHS Edmonton zone hospitals for time to ED MD assessment and time to CT. This would be intuitive, as the UAH is the designated "stroke center" for the AHS - Edmonton Zone and has the most dedicated and sophisticated infrastructure in place for dealing with these types of patients. The UAH was virtually always the only acute care center that administered tPA (n=224), with 20 patients given tPA at the GNH and 2 patients given tPA at MCH accounting for approximately 10% of all administered thrombolytics (Table 4.3).

4.4.3 Stratified Symptom Onset

A stratified analyses, based on known or unknown time of presentation, demonstrated a significant difference in patient flow between the 2 groups (both have p-values <0.0001). The difference in median time to ED MD assessment was

23.5 minutes, while the difference in median time to CT was 42 minutes. On the whole, patients with a known onset were assessed more quickly and received CT imaging sooner than those with unknown onset times (Table 4.4).

4.4.4 Stratified Time to Event by Sex

Time to ED MD assessment was stratified by sex men were evaluated by an emergency physician a median of 8 minutes sooner than women; this difference was statistically significant ($p = 0.0028$). When time to CT was stratified by sex, men received imaging a median of 10 minutes sooner than women ($p=0.0014$). Lastly, when time to tPA was stratified by sex, there is no difference in the time to administration of the drug between men and women. Both males and females received the drug a median time of 81 minutes from triage ($p = 0.87$) (Table 4.5).

4.4.5 Stratified Time to Event by Age

Time to ED MD assessment, time to CT, and time to tPA were evaluated on the basis of the patient's age being either greater or less than 65 (Table 4.6). The only statistically significant difference was found in time to tPA, where

patients less than the age of 65 received treatment 13 minutes earlier than their over 65 counterparts (p=0.01).

4.4.6 Stratified Time to Event by Year

Symptom onset to ED arrival, time to ED MD assessment, time to CT, and time to tPA were stratified for each year the retrospective chart review covered (Table 4.7 & Chart 4.1). There were no discernable patterns with respect to an overall improvement for the time to event. It did appear, however, that time to CT imaging was improving in the last two years of the study, while onset to door and time to ED MD assessment was slightly increasing, while time to tPA was remaining relatively consistent over the study period.

4.4.7 Multivariate Analysis

Using a purposeful selection method, outcomes variables were defined as time to events: specifically, onset to door, time to EDMD, time to CT, time to TPA, and onset to TPA. Significant covariates were checked for interactions and then retained within the final model (Table 4.8). For onset to door times, sex has no significant impact within the model, but once the patient enters the ED, patient sex becomes a significant outcome variable for time to EDMD and CT

metrics. Knowledge of symptom onset is the main predictor for time sensitive therapies, as it is the one consistent variable that is retained in every model. Arrival by EMS is more difficult to explain as it is a positive predictor for reduction in time metrics for all outcomes except time to tPA. Stratified age groups (<65 or >65) and sex both had significant effects on time to EDMD and CT times; these data correspond to the results from the independent stratified analyses from Tables 4.6 and 4.7 respectively.

4.5 Discussion

The present study offers a comprehensive overview of how stroke has been managed within the AHS-Edmonton Zone from 2003 to 2010. When data from each study component are integrated, they offer insight into how stroke patients have been managed in the past, how they are being managed currently, and parenthetically the trends that have occurred over time. This study has demonstrated that provincial and federal standards for stroke management are not being achieved within AHS-Edmonton Zone EDs. Review of the most relevant literature has shown that there are considerable similarities amongst quality of care standards for most G8 nations for ischemic stroke management. When these internationally accepted standards are applied to quality of care for stroke patients within the AHS-Edmonton zone, we again fail to meet any of the critical time requirements.

4.5.1 AHS Edmonton Zone Emergency Department Performance

The news is not all bad. For example, Northern Alberta's designated tertiary stroke center at the UAH performed significantly better than the other AHS-Edmonton Zone hospitals when managing stroke and this is reflected in the more rapid patient flow though it's ED. While this may be expected, since the UAH has the most developed infrastructure for managing stroke patients in the Northern region of Alberta, it is reassuring that this expectation can be validated. Moreover, times to ED assessment and CT scans have decreased over time. This demonstrates that the implementation and revision of current stroke management and triage protocols are having some impact. This is especially promising considering ED patient volumes have steadily been rising over the last decade as have wait times within the ED.[15] It is unclear, however, if these decreased throughput times are due improvements in actual ED patient flow efficiency or as a byproduct of increased health care spending in hospital infrastructure.

4.5.2 Factors Influencing Stroke Quality of Care Delivery

When examining the flow of stroke patients through ED, it becomes apparent that 4 subgroups have a significant impact. First, knowledge of symptom onset plays an important role in how quickly assessment and treatment is received. Patients tend to be assessed by an emergency physician

and have a subsequent CT scan much more rapidly than patients who do not have accurate knowledge of their time of onset. Patients with a known onset time that are potentially within the tPA administration window are streamlined though the ED significantly more quickly. This ensures they have the highest probability of receiving thrombolysis, since lack of onset knowledge is a contraindication for this therapy. Second, sex of the patient also plays a role in patient flow. These data indicate that male patients are assessed by an emergency physician and have CT imaging performed more quickly than their female counterparts. The probable reasons for this disparity is due to the non-traditional presentation characteristics of women suffering stroke, thus causing delays in their diagnosis.[36] Women are 25% less likely to receive tPA for ischemic stroke than men, which could be explained by this delayed assessment and treatment.[37]

Unfortunately, these suppositions are not definitive and it is beyond the scope of this study to draw specific conclusions. It is clear, however, that special considerations should be in place when managing female stroke victims in an attempt to ensure that this specific population has the same likelihood of receiving tPA as a male, since the evidence does not support a sex-related response. Third, expansion of the tPA window in this population has a significant effect, approximately one quarter of the population fell beyond the three hour window. These patients account for 66 out of 247 of the total population that received tPA. Expansion of the administration window allows for treatment of a

broader group of the total stroke population, thus allowing access to a potentially lifesaving therapy, that would otherwise be unavailable. Lastly, age of the patient appears to have an effect on how quickly tPA is administered. In our population, patients under the age of 65 received tPA significantly sooner than their older counterparts. This delay could be due to more complex patient histories that are associated with older populations. Our results are not unique in this regard, similar results have been found in other settings where acute stroke has been examined and similar delays have been shown to be caused by older patients.[38]

4.5.3 Data Collection in Medical Record Reviews

The feasibility of data collection is always a necessary consideration when undertaking a study of this magnitude. Unique issues arose for both the retrospective and prospective data collection phases. The retrospective data extraction took 3 separate reviewers approximately 18 months while the concurrent prospective enrollment took a team of ED-based researchers approximately 11 months to complete. The major barrier to retrospective data collection was the large proportion of microfilmed charts and the lack of a standard data collection form for suspected stroke patients. The microfilmed charts posed a unique issue because it prolonged the duration of extracting more than 40% of all the retrospective charts. Each microfilmed chart extraction

usually took at least two to three times as long to extract. Initially, issues were encountered that slowed recruitment of new stroke patients; this was resolved for the prospective study by expediting patient enrollment though expanding the inclusion criteria to include TIA patients as well as stroke patients. Moreover, the broadest possible coverage was implemented by having staff present during the weekends as well as 24 hour coverage during the weekdays. This allowed for the target sample size to be met much more quickly and also allowed for a more diverse patient population with varying degrees of severity to be examined.

Overall, studies on this size tend to be time-consuming and potentially costly; however, the acquired data from these efforts are able to justify these costs. The collected information on stroke patients within the AHS-Edmonton Zone provide an invaluable picture of how stroke is managed within the region, as well as demonstrating how well this region performs with respects to meeting quality of care standards.

4.5.4 Gap Analysis

Gap analysis for our study can be broken down into three major aspects that parallel the components of the overall study: performance of the retrospective chart review, performance of the prospective interview, and performance of the AHS-Edmonton Zone with respect to the treatment of

stroke. First, data from the retrospective chart review, through its rigorous methodology, can be considered a representative and comprehensive cross section of the urban stroke population for the AHS-Edmonton Zone. These data have been shown to be reliable and valid. The variables within the data collection form sufficiently answered the questions revolving around descriptive characteristics, co-morbidities, and outcomes for stroke patients. Second, data from the prospective chart review can also be considered a representative and comprehensive cross section of the newly admitted stroke and TIA patients within the AHS-Edmonton Zone. The prospective study was able to demonstrate that a structured "gold-standard" data collection form will always provide more reliable and valid information than a retrospectively collected data set. As well, the prospective study found that key patient variables such as smoking history can be very poorly documented. Lastly, our data has demonstrated that the AHS-Edmonton Zone, either by individual site or as an entire region, has failed to achieve widely accepted quality of care markers for stroke treatment.

4.6 Limitations

This study has several limitations. First, the study was only conducted in the Edmonton area: socioeconomic, work, and travel factors would likely be different in other regions. Second the limited scope of the literature review could have missed potentially important articles, or reports on stroke

management in other jurisdictions; however, the guideline that was compiled from the literature search should encompass a significant spectrum of varying health authority protocols to provide a representative comparison to the AHS regional performance as a whole. Third, the study only examined stroke patients as metrics for quality of care standards, other illnesses and patient populations may yield other insights into how well the AHS-Edmonton Zone EDs function.

4.7 Conclusions

It is apparent that quality of care involves examining indicators of ED performance that can assist in quantifying how quickly a patient moves through an ED. In one way, length of stay is a reflection of the efficiency of the system as a whole; however, it is important to sub-classify times that examine the ability of the ED to meet certain national and international quality indicators. While an ED that admits a stroke patient quickly to the floor may have a short length of stay, if it fails to meet CT and thrombolytic time benchmarks the ED would not be considered to provide high quality stroke care.

Monitoring of these indicators is of paramount importance, as they are required for accountability and furthering quality improvement within the ED and specifically for stroke care. Suggestions arising from this study include, but are not limited to: 1) inclusion of an electronic data collection form for both

clinicians and researchers encompassing suspected stroke and similar etiologies (e.g., suspected acute myocardial infarction); 2) Electronic forms that are standardized for a multitude of common presenting illnesses could streamline information gathered from any patient population. This would ensure that the data collected is comprehensive and accurately represents the current status and history of each patient. Key variables such as symptom onset or other important co-morbidities such as smoking history should be included. This would effectively eliminate false negatives patient histories, thus providing a clearer picture of the patient's current condition and need for alternative services (e.g., smoking cessation); 3.) As well for researchers, electronic data collection forms would also streamline the chart review process. This would eliminate the necessity for a secondary data entry phase from a paper collection form, while also eliminating the potential for errors from the coding of this information.

This study demonstrates that the AHS-Edmonton Zone performs variably when treating stroke, and there is room for considerable improvement. This is, in part, a reflection of the current status of the EDs within the AHS-Edmonton Zone, in that, overcrowding and subsequent access to timely care are directly impacted by a multitude of external and internal factors. Pre-hospital factors could be targeted through the implementation of a pre-arrival notification system. The ED would be notified before arrival of a possible stroke patient within the 4.5 hour window, thus pre-notifying the CT scanner and stroke team. Bottlenecks within each ED that should be targeted would include, improved

time to emergency physician assessment or increasing the availability of CT imaging. Thrombolysis also is an important consideration, as it is an example of the cumulative time required for any patient to move through an emergency department. Multivariate analyses confirm there are complex interactions occurring within the specific patient characteristics within a stroke population. Certain covariates impart significant reductions for time specific outcomes; specifically onset knowledge and arrival by EMS impart significant reductions in meeting time sensitive treatments more quickly for stroke patients. Interestingly, in our population, sex did not impart a significant difference in time to receiving thrombolytics as it has been demonstrated in other studies.[37] A key consideration when examining this stroke population would be educating "at risk" populations and informing them of the importance of seeking immediate medical care when suffering these events. This would likely yield a marked improvement for a beneficial outcome and reduce the overall morbidity and mortality from stroke. Stroke patients must still be considered an important population when considering emergency department efficiency, as they represent an example of how well or poor a patient can enter, move through, and depart this system.

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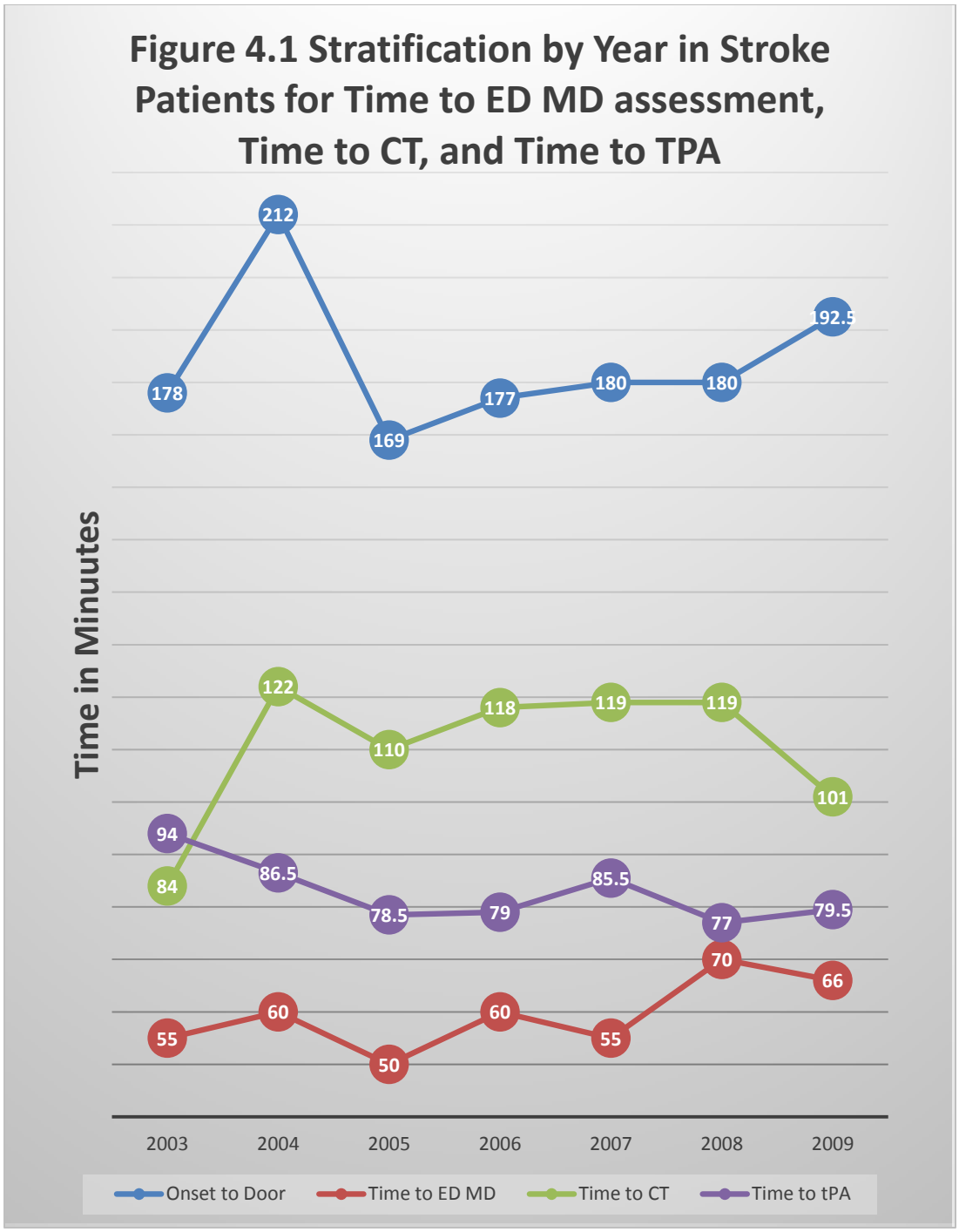
Figure 4.1 Stratification by Year in Stroke Patients for Time to ED MD assessment, Time to CT, and Time to TPA
Time in Minuutes
212
178
169
177
180
180
192.5
122
84
110
118
119
119
101
94
86.5
78.5
79
85.5
77
79.5
55
60
50
60
55
70
66
2003
2004
2005
2006
2007
2008
2009
Onset to Door
Time to ED MD
Time to CT
Time to tPA

Table 4.1 Medical Subject Heading Terms Used				
Key Term 1	Key Term 2	Key Term 3	Key Term 4	Key Term 5
Stroke	*Guideline*	*Computerized Tomography*	*Thrombolysis*	*Time*
Cerebrovascular Accident (CVA)	Recommendation	Imaging	Tissue Plasminogen Activator (tPA)	Event
Infarction	Standard of Care	CAT	Alteplase	Onset
Transient Ischemic Attack (TIA)	Management	CT		
Ischemic	Practice	Scan		
Acute	Treatment			

Table 4.2: Summary of Relevant Literature Outlining Standard of Care Practices for G8 Nation Health Authorities

Citation	Year	Time to ED MD Assess	Time to CT	Time to Interpret	Time to tPA	tPA Eligibility Window	Ref
Canadian Stroke Strategy CSS Best Practice Recommendations	2010	n/s	25 min	45 min	60 min	4.5 hours	39
American Stroke Association ASA Guidelines for Stroke Prevention	2003	10 min	25 min	45 min	60 min	3.0 hours	40
National Institute of Neurological Disorders and Stroke NINDS Guidelines for Acute Stroke Treatment	1997	10 min	25 min	45 min	60 min	3.0 hours	41
British Columbia Stroke and TIA: Management & Prevention	2009	n/s	As soon as possible (less than 24 hr)	n/s	n/s	4.5 hours	42
Thrombolysis Interest Group of Canada	2007	n/s	n/s	n/s	n/s	3.0 hours	43
National Guideline Clearinghouse (NGC) and the Institute for Clinical Systems Improvement (ICSI):	2010	10 min	25 min	45 min	60 min	4.5 hours	44
ASA/AHA Guidelines for Stroke Prevention	2007	10 min	25 min	45 min	60 min	3.0 hours	45
American Collage of Chest Physicians: thrombolytic therapy for stroke: EBCPG	2008	n/s	n/s	n/s	n/s	4.5 hours	46
National Stroke Foundation (Australia): NSF: assessment & diagnosis	2010	n/s	As soon as possible (less than 24 hr)	n/s	n/s	4.5 hours	47
Scottish Intercollegiate Guidelines Network (SIGN): management and treatment of TIA and Stroke	2008	n/s	As soon as possible (less than 24 hr)	n/s	n/s	4.5 hours	48
Singapore Ministry of Health: Stroke and TIA management	2009	n/s	n/s	n/s	n/s	3 hours	49
American Association of Neuroscience Nurses: Guide to the care of the hospitalized patient with ischemic stroke	2008	10 min	25 min	45 min	60 min	4.5 hours	50
National Institute of Clinical Excellence NICE: Stroke Full Guideline	2008	n/s	As soon as possible (less than 24 hr)	60 min	n/s	3.0 hours	51
National Health and Medical Research Council NHMRC (Australia): Stroke Guideline	2009	n/s	As soon as possible (less than 24 hr)	n/s	n/s	n/s	52
APSS: Alberta Provincial Stroke Strategy	2010	n/s	25 min	45 min	60 min	4.5 hours	53
European Stroke Organization: Acute Stroke Management	2009	n/s	As soon as possible (less than 24 hr)	n/s	n/s	3.0 hours	54

Table 4.3: Unified Quality of Care Time-point Benchmarks versus AHS Region and Individual Centers for Known Onset Strokes								
Time (minutes)	Unified Times	AHS	UAH	RAH	GNH	MCH	NECHC	SGH
Time to ED MD Assessment	10	**47.5** (19,108) (n=2361)	**27** (11,76) (n=1381)	**69** (29,174) (n=355)	**72** (37,139) (n=470)	**68.5** (42,126) (n=242)	**52** (34,92) (n=205)	**59** (37,103) (n=109)
Time to CT	25	**91** (40,167) (n=2361)	**53** (32,133) (n=1311)	**119** (67,206) (n=337)	**129** (77,200) (n=418)	**143** (102,205) (n=203)	N/A	**131** (94,201) (n=89)
Time to CT Interpretation	45	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Time to tPA	60	**81** (60,98) (n=247)	**81.5** (61,96.5) (n=224)	N/A	**76** (56,107) (n=20)	**78.5** (59,98) (n=2)	N/A	N/A
Administration Window Limit	270	**147**$^{\alpha}$ (126,183) (n=247)	N/A	N/A	N/A	N/A	N/A	N/A

*Note: No CT times available for the NECHC due to lack of access; No tPA administered at RAH / NECHC / SGH in the study period; Values are reported as median number of minutes with 75 and 25% interquartile ranges (IQR) in **Bold**; N = number of subjects; N/A = not applicable; α = time from onset to administration of tPA. [*Note for all tables: "n=" values do not always total the actual number of patients in the retrospective database. This was due to incomplete/unavailable data in the original data base.

Table 4.4: Stratification by Known versus Unknown Symptom Onset in Stroke Patients for Time to ED MD assessment and Time to CT

Time (minutes)	All	Known	Unknown	P-Value
Time to ED MD assessment	**59** (25,135) (n=5907)	**47.5** (19,108) (n=2772)	**71** (34,162) (n=3135)	**>0.0001*** (96.63, 102.18)
Time to CT	**114** (54,196) (n=5023)	**91** (40,167) (n=2361)	**133** (74,218) (n=2662)	**>0.0000*** (134.71, 140.34)

*Note: Values are reported as median number of minutes with 75 and 25% interquartile ranges (IOR) in **Bold**; N = number of subjects; N/A = not applicable; * = a significant result; p-values are at α = 0.05 level of significance with 95% confidence intervals reported. [*Note for all tables: "n=" values do not always total the actual number of patients in the retrospective database.

Table 4.5: Stratification by Sex in Stroke Patients for Time to ED MD assessment, Time to CT, and Time to TPA

Time (minutes)	All	Male	Female	P-Value
Time to ED MD assessment	**59** (25,135) (n=5907)	**55** (25,128) (n=2995)	**63** (27, 141) (n=2912)	**0.0028*** (96.46, 102.01)
Time to CT	**114** (54,196) (n=5023)	**109** (51, 189) (n=2542)	**119** (51, 205) (n=2481)	**0.0014*** (134.84, 140.47)
Time to tPA	**81** (126,183) (n=247)	**81** (60,98) (n=134)	**81** (61, 96) (n=113)	0.8651
Onset to tPA	**147** (126, 183) (n=247)	**145** (120, 180) (n=134)	**149** (132, 184) (n=113)	0.3600

*Note: No Values are reported as median number of minutes with 75 and 25% Interquartile ranges (IQRs) in **Bold**; n = number of subjects;
* = a significant result; p-values are at $\alpha = 0.05$ level of significance with 95% confidence intervals reported for significant outcomes. [*Note for all tables: "n=" values do not total the actual number of patients in the retrospective database.

Table 4.6: Stratification by Age in Stroke Patients for Time to ED MD assessment, Time to CT, and Time to TPA

Time (minutes)	All	<65	>65	P-Value
Time to ED MD assessment	**59** (25,135) (n=5907)	**56** (26, 131) (n=1934)	**60** (25, 136) (n=3879)	0.2880
Time to CT	**114** (54,196) (n=5023)	**113** (55,188) (n=1563)	**115** (53, 136) (n=3381)	0.2891
Time to tPA	**81** (126,183) (n=247)	**70** (52, 92.5) (n=72)	**83** (64, 98) (n=171)	**0.0112*** (86.54, 93.36).
Onset to tPA	**147** (126, 183) (n=247)	**145.5** (121.5, 196.5) (n=72)	**147** (128, 177) (n= 171)	0.9103

*Note: No Values are reported as median number of minutes with 75 and 25% Interquartile ranges (IQRs) in **Bold**; n = number of subjects; * = a significant result; p-values are at $\alpha = 0.05$ level of significance with 95% confidence intervals reported for significant outcomes. [*Note for all tables: "n=" values do not total the actual number of patients in the retrospective database.

Table 4.7: Stratification by Year in Stroke Patients for Time to ED MD assessment, Time to CT, and Time to TPA

Time (minutes)	All	2003	2004	2005	2006	2007	2008	2009
Onset to Door	**180** (95, 375) (n=2787)	**178** (95,353) (n=87)	**212** (150,345) (n=59)	**169** (95, 334) (n=456)	**177.5** (93, 365) (n=580)	**180** (94, 363) (n=632)	**180** (96, 409) (n=627)	**192.5** (105, 420) (n=346)
Time to ED MD assessment	**59** (25,135) (n=5907)	**55** (33, 96) (n=147)	**60** (32.5, 96) (n=124)	**50** (24, 103) (n=1064)	**60** (28, 125) (n=1184)	**55** (28, 132) (n=1296)	**70** (25, 169) (n=1349)	**66** (22, 168) (n=743)
Time to CT	**114** (54,196) (n=5023)	**84** (32, 167) (n=67)	**122** (89, 171) (n=41)	**110** (54, 185) (n=925)	**118** (57, 199) (n=1018)	**119** (58, 195) (n=1137)	**119** (54, 207) (n=1158)	**101** (46, 199) (n=677)
Time to tPA	**81** (126,183) (n=247)	**94** (82, 94) (n=5)	N/A	**78.5** (59, 93.5) (n=32)	**79** (59.5, 95.5) (n=44)	**85.5** (66, 112.5) (n=68)	**77** (64, 89.5) (n=56)	**79.5** (58, 98) (n=42)

*Note: No Values are reported as median number of minutes with 75 and 25% Interquartile ranges (IQRs) in **Bold**; n = number of subjects. [*Note for all tables: "n=" values do not total the actual number of patients in the retrospective database.

Table 4.8 Multivariate Model Building Matrix

DEPENDANT VARIABLES	Univariate Predictors (p < 0.10)									FINAL MODEL
ONSET TO DOOR	SEX	Onset +/-	EMS	CTAS	α-plat	α-coag	AGEbi	Smoker	CAD	EMS, ONSET, smoker
TIME TO EDMD	SEX	Onset +/-	EMS	CTAS	α-plat	α-coag	AGEbi	2008-09	CAD	SEX, ONSET, EMS, α-plat, AGEbi
TIME TO CT	Sex	Onset +/-	EMS	CTAS	α-plat	α-coag	AGEbi		DM	SEX, ONSET, EMS, DM, AGEbi
TIME TO TPA	SEX	Onset +/-		CTAS						ONSET
ONSET TO TPA	SEX	Onset +/-	EMS					2009		ONSET, EMS, 2009

*Note covariates added at alpha level p < 0.10, and tested for interaction before being retained in the final model; α-coag = anticoagulant usage pre-ED arrival; AGEbi = age of patient < or > 65; α-plat = antiplatelet usage pre-ED arrival; CAD = coronary artery disease; CTAS = Canadian Triage and Acuity Score categorical score of 1-5; DM = diabetes mellitus; EMS = arrival by Emergency Medical Service; Onset +/- = knowledge of stroke onset time; SEX = male or female; Smoker = current tobacco usage; 2008/2009 = chart review year.

Chapter 5

Future Directions

5.1 Introduction

This thesis set out to quantify stroke management in the Alberta Health Services (AHS)-Edmonton Zone region. We examined patient flow within AHS Edmonton zone emergency departments (ED) to evaluate if specific performance measures were being achieved. These performance measures represent quality of care indicators (QCI) that create a methodological approach to evaluate how well accepted standards of care have been implemented. Chapters two, three, and four presented data that was intended to create a representative analysis of how the AHS-Edmonton Zone EDs performed with respect to the clinical management of stroke. Consequently, these three chapters will generate specific discussions regarding future directions. The introduction, however, can be viewed as a compilation of existing clinical and epidemiological data that exists in the literature.

5.2 Chapter One Summary and Continuing Directions

The first chapter discussed etiology and epidemiology of stroke and transient ischemic attacks (TIA) with a goal of creating a representative clinical

picture of the stroke syndrome; a synthesis of the current body of clinical literature was presented on stroke classifications, clinical presentations and pathology, risk factors, and current therapies administered within the ED setting. This introductory chapter attempted to inform the reader and bridge any gaps in knowledge before examining the main thesis study. Due to the changing landscape of scientific literature, this background chapter should be revised by updating the previous literature searches. Annual searches should be implemented by provincial and federal healthcare governing bodies to ensure the most relevant data is present, this is especially important with respects to treatment regiments for stroke patients. Important issues to consider from this chapter are the aging nature of the population and the need to prepare for the "tsunami" associated with older person's care.

5.3 Medical Record Review Summary and Continuing Directions

The retrospective component of this thesis comprised the bulk of data collected; this phase of the study posed a unique set of issues that required specific management protocols to ensure their successful completion. Lessons learned from this study can be used to guide new, more efficient efforts to update this study or other retrospective data collection studies in general. Exploration of retrospective studies through a medical record review requires a specialized set of methodological protocols and infrastructure to successfully

accomplish each study.[1] Overall, we found the sheer volume of data that was collected required considerable investment of time due to the large proportion of charts formatted in microfilm. Microfilm extraction considerably increased original estimates required for collection; therefore, due to these limitations, special considerations should be implemented with respect to the data source, and its subsequent availability and legibility. Difficulties often arise for extractors to discern, with any reasonable amount of reliability, the writing legibility and jargon within each medical record. This is due to the inherent design of a paper based system itself; paper based charts will always suffer from illegibility, omitted information, and availability from their respective repositories.[2]

A coordinated and elegant approach to solve issues associated with retrospective chart reviews can be found with the recent inception of electronic medical records (EMR). EMRs have the potential to improve data integration by directly affecting the efficiency, accuracy, and access to patient information collected; specifically, EMRs can standardize data collection and allow for simultaneous real-time access to information by multidisciplinary teams, resulting in improved resource allocation and availability.[3] EDs with fully functional EMRs have lower length of stay (LOS) and treatment times when compared to EDs that are paper based.[4] Creation of an interactive electronic database that is created in real-time during a physician patient encounter eliminates the need for data classification or recoding. A quick search of the literature shows that EMRs have not been implemented in many tertiary care

EDs; however, the systems that have are showing promise.[5-7] In theory a fully functional, ubiquitous, and interactive EMR has the potential to eliminate most of the issues with retrospective chart reviews that have previously been discussed. A relevant example a successfully implemented EMR system is in Ontario: their EMR system includes data in tPA in the Canadian Institute for Health Information (CIHI) database.[8]

A comprehensive discussion of the implementation of EMR's within an ED setting is beyond the scope of this thesis; however, discussion of the three most relevant aspects should provide some insight in to these difficulties: patient information and data usage, data access, and data integration. The most profound effect an EMR could elicit would be at the initial patient-physician contact phase. This point of contact is the most important as it is the critical phase of data collection where all pertinent patient history, therapies, and diagnoses are recorded. Considering the recent widespread availability of tablet-based portable devices, integration of a standardized and interactive charting tool could be implemented within an ED. When considering stroke management, implementation of the "Get With the Guidelines" (GWTG) standardized stroke management program in the US, showed immediate improvements in key performance indicators.[9] Integrating a quality improvement registry program like GWTG with an EMR could have a profound effect on the overall management of stroke.

Such a system would have important impacts on QCI and surveillance activities.[10] First and foremost, an EMR would effectively eliminate issues with legibility, missing data and failure to document important information. For stroke patients, every encounter would have a standardized charting form with standardized entry requirements. Using a tablet based data collection tool could mimic the currently implemented ED chart but with adaptive pull-down menus that embedded within the form to prevent entry errors. A "Disease Guidance System" would queue the physician to record relevant variables such as: history of presenting illness, time of onset, co-morbidities, current medications, and smoking status. It could go even further to recommend, via interactive alerts, specific treatment pathways that have been guided by evidence. In the retrospective chart review we commonly found that smoking history was not recorded or there was conflicting information between observers with respect to patient history or medication usage; in these cases an EMR has the potential to effectively eliminate erroneous entries.

Secondly, EMR would eliminate data extraction for retrospective studies. The initial physician-patient encounter would be encoded electronically and accessible on a centralized server in real-time with the current ED information system demographic and time-based data recording. Accessing this information would be incredibly simple and efficient once a data repository was created. When considering the scope of the data collection undertaken within this thesis, integration of a standardized stroke EMR would effectively eliminate the

necessity for any retrospective data collection. Instead all pertinent data could be accessed from existing databases. This also has a secondary advantage of eliminating any errors in extraction, interpretation, and re-coding of information, as the data can simply be merged into a new database. When evaluating cost effectiveness, an EMR eliminates paper medical record repositories, loss of data fidelity through recoding of information, or secondary data extraction; an EMR system, once established, is self-sustaining even when factoring high upfront costs.[11] The subsequent automation over time is when the initial cost would be recovered and no need for continual investment to gather data or funding support.[12] Although one rate limiting factor still remains for EMR implementation, primarily data entry by busy clinical personnel, EMR systems should attempt to streamline this process as effectively as possible; therefore the main drawback is the increased work load on ED physicians and nurses to record data. If every group approached the EDs with a similar registry, ED overcrowding would likely increase in the short-term. Consequently, the role of EMR implementation on ED efficiency must not be overlooked.

Lastly, EMRs have the ability to address the issue of incorrectly coded stroke events and follow patients over time. The retrospective study found that, upon confirming actual diagnoses through discharge summaries, a large proportion of coded “strokes” that were gathered from the Data Information Management Repository (DIMR) were not actual strokes. This accounted for approximately 17% of the total number of charts that were reviewed. Other

studies have shown that stroke mimics are found in approximately 4-13% of acute ED stroke presentations.[13] In an electronically formatted database, these coding errors would be effectively removed, as the updated discharge summaries are added to the original patient record automatically. If taken a step further, creation of a "Disease Registry" would automate collection of disease characteristics, burden, and patterns of care. Registries could be utilized for evaluation of intervention effectiveness or "hospital report cards".[14]

5.4 Quality of Care Performance Summary and Continuing Directions

Performance and efficiency within EDs are unifying themes in this thesis. The primary measures that were analyzed, time to triage, time to assessment, time to CT, and time to tPA, were all used as representative benchmarks of patient flow within an ED. For acute stroke management the ultimate indicator of ED efficiency is represented by door-to-needle time (DTN); it is the culmination of all the processes within the ED leading to a definitive treatment. Moreover, the results from this thesis suggest that biases exist (e.g., patients who are male, with known symptom onsets, and under the age of 65, receive assessment, diagnostic imaging and intervention sooner than their counterparts) in the treatment of patients, which requires immediate educational interventions.

The ultimate goal of this thesis is to yield insight into the overall efficiency of managing stroke within the AHS-Edmonton Zone EDs; specifically, these data should be used to guide the implementation of innovative protocols to augment treatment in a manner that delivers care which is timely and effective. As a corollary, the question that needs to be answered is: which protocols are most effective in reducing stroke morbidity and mortality? This thesis examined hyper-acute stroke management, as it is the critical period for management strategies. To further an overall clinical picture and quality of care with in stroke, we must look beyond the indicators outlined in this thesis. Pre-hospital care (e.g., EMS pre-screening stroke tools), telestroke, triage liaison physicians, and most importantly ED overcrowding, all potentially influence the delivery of stroke care.

An overarching topic that is discussed within this thesis, which is closely linked to stroke management, is ED overcrowding. The two are closely linked because of the acute nature of stroke pathophysiology and the time sensitive resource competition within an ED. When examining overcrowding effects on stroke, Chatterjee et. al. retrospectively examined 1342 stroke patients presenting to academic and community hospitals. They found that with onset times under 3 hours the DTN time was not significantly affected by ED overcrowding; however, patients who arrived outside this window experienced significantly longer wait times for CT imaging and assessment.[15] Another research group examined DTN time of 246 TPA patients and found that there is

an inverse correlation between temporal proximity to tTPA administration windows and patient arrival times; specifically, the earlier a patient arrives within the 3 hour window, the longer the Stroke Team takes to initiate tPA.[16] The authors called this inverse correlation the "3 Hour Effect", and it is primarily attributed to a psychological disposition on the part of the ED MD. There is a feeling that there should be "no rush" for tPA administration if the patient is well within the window; however, this effect could also be attributed to overcrowding where internal resource competition delays tPA administration.[17;18] Whether the patient is outside the TPA window or arrives early within the window, treatment should be initiated as soon as possible as results from pooled trial data indicate that the benefit decreases with increased treatment delay.[19] The "3 Hour Effect", could also potentially become more prevalent once the newer 4.5 hour treatment window becomes standard practice across jurisdictions.

Considering the data presented in this thesis, coupled with overcrowding effects, what effective measures should be implemented to alleviate these treatment delays? This thesis identified quality of care indicators that do not meet currently accepted standards and subsequently suggested areas for improvement. Looking beyond these indicators, other efforts to expedite patient throughput may be beneficial, including a dedicated "stroke team" outside the main University site or the implementation of the triage liaison physician (TLP) to rapidly identify patients with strokes and assume care until specialist arrival. A

recent systematic review demonstrated that the implementation of TLPs reduced ED inpatient length of stay, time physician initial assessment, and leaving without being seen (LWBS).[20] If the TLP intervention included acute stroke management, a new hypothesis and study can be envisioned. Expansion of the data encompassed by this thesis would be included, but in addition, collecting data on how TLP inclusion influences the efficiency of ED stroke care delivery could be measured. Evaluation of time to ED MD assessment, CT imaging, and finally TPA delivery would be critical metrics examined: additionally, ED LOS, and rates of LWBS could be evaluated.

Addressing the "3 Hour Effect/No Rush" phenomenon may be more difficult to combat. Reports from the Registry of the Canadian Stroke Network (RCSN) were used by the Emergency Stroke Care Quality Improvement Team (ESCQIT) to provide real-time prospective review of performance measures.[21] They demonstrated that through coordinated care, continuing education, and development of a performance feedback mechanism, Ontario EDs were able to meet nationally accepted quality of care indicators. Implementations of similar protocols, within AHS ED's, have the potential to achieve similar improvements. Quantifying the effects of these procedural changes could be evaluated in a study that would only need to be slightly expanded from the current inception cohort within this thesis, as most of the metrics have already been collected. Collecting outcome measures such as, TLP presence, ED patient volume, and

stroke patient length of stay, would provide sufficient robustness to determine whether these programs have a positive effect.

In 2005 the Alberta government created the Alberta Provincial Stroke Strategy (APSS) as a coordinated approach to manage stroke across Alberta; subsequently, in 2007 the APSS initiated a multifaceted approach to evaluate and improve quality of care for stroke within AHS ED's. A province wide public awareness campaign, increased number of primary stroke centers, EMS stroke transport protocols, EMS stroke screening forms, and increased imaging availability were established as methods to improve stroke care in Alberta. The effectiveness of the program was evaluated in their 2010 report.[22] Relevant highlights that relate to this thesis of the province wide quality of care changes were: significant reductions in onset to door time, increased proportions of arrivals within 2.5 hours, and decreased time to tTPA. The data collection times from this thesis encompass the same periods of data collection from the APSS report. When results from the APSS report are contrasted to this thesis, the APSS data confirms some of the conclusions that were drawn. The APSS program had an effect on a provincial level, but when stratified by Edmonton Zone EDs only, the changes disappeared; specifically, there was no change in onset to door times, or proportion of patients arriving within 2.5 hours from onset within the Edmonton Zone. One conflicting conclusion between the 2 reports, the APSS showed a significant reduction in time to tPA within the Edmonton Zone, while the data analyzed in this thesis does not. The reason for this disparity is unclear

but could be due to a different sample size used by the APSS. The APSS report did not examine ED MD assessment, CT times, sex, or age effects in stroke care; this is where the data contained in this thesis differs by providing more granular resolution in the complete ED management picture.

Why the APSS program functions more effectively on a province wide level versus the Edmonton Zone is unclear. A potential explanation may be that large improvements were observed in outlying areas that were previously devoid of a coordinated stroke management program. In these regions the implementation of telestroke, increased imaging access, and EMS transfer protocols resulted in large benefits, compared to urban centers that have an effective stroke infrastructure in place. If the results from this thesis and from the APSS report are used, a refined approach can be created to evaluate and improve stroke management. It appears that through public awareness campaigns, EMS transfer protocols, and EMS screening tools, delays in patient arrival times can be mitigated.[23] Perhaps, a different approach can be taken, since there seems to be no change in urban areas for onset to door times with the APSS changes; the concept of a 'mobile stroke unit' could alleviate delays in this area by bringing treatment to the patient either through telemedicine or a EMS delivery system that has the ability to administer tPA on-site.[24] Evaluation of such a system could be completed with similar protocols that were used by this thesis and has the potential to provide thrombolytics to remote populations that normally do not have access to such therapies. This may represent a more

effective method to improve care delivery as EMS protocols and public awareness campaigns do not seem to have a very substantive impact in an urban setting.

5.5 Conclusions

In summary, the overall complexity within the delivery of stroke care poses many challenges. Mitigating these issues requires a multifaceted and innovative approach that has the utility to elucidate effective solutions to the problems EDs face. QCIs are merely a mechanism to evaluate performance and stimulate change within EDs; however, they also have the potential to generate new ideas and directions regarding how stroke should be treated. Evaluating performance is a critical feedback mechanism that shows how well or how poorly an ED or network of EDs is functioning. Continuing and expanding this type of research will likely improve care for stroke patients, and subsequently improve their overall quality of life.

5.6 References

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