AMERICANUNIVERSITY OF BEIRUT

DEVELOPMENT OF AN EVIDENCE BASED CLINICAL PATHWAY FOR PATIENTS WITH ANEURYSMAL SUBARACHNOID HEMORRHAGE

by
ABED AL WAHAB HUSSEIN AL FIRIKH

A project
submitted in partial fulfillment of the requirements
for the degree of Master of Science in Nursing
to the Hariri School of Nursing
of the Faculty of Medicine
at the American University of Beirut

Beirut, Lebanon
March, 2016

AMERICAN UNIVERSITY OF BEIRUT

DEVELOPMENT OF AN EVIDENCE BASED CLINICAL PATHWAY FOR PATIENTS WITH ANEURYSMAL SUBARACHNOID HEMORRHAGE

by
ABED AL WAHAB HUSSEIN AL FIRIKH

Approved by:

Dr. Hala Darwish, Assistant Professor
Rafic Hariri School of Nursing
First Reader

Dr. Samar Noureddine, Professor
Rafic Hariri School of Nursing
Second Reader

Date of project presentation: April 11, 2016

AMERICAN UNIVERSITY OF BEIRUT

THESIS, DISSERTATION, PROJECT RELEASE FORM

Student Name: Al Firilch Abed Al Wahab Hussein.
Last First Middle

○ Master's Thesis ◐ Master's Project ○ Doctoral Dissertation

☑ I authorize the American University of Beirut to: (a) reproduce hard or electronic copies of my thesis, dissertation, or project; (b) include such copies in the archives and digital repositories of the University; and (c) make freely available such copies to third parties for research or educational purposes.

☐ I authorize the American University of Beirut, **three years after the date of submitting my thesis, dissertation, or project,** to: (a) reproduce hard or electronic copies of it; (b) include such copies in the archives and digital repositories of the University; and (c) make freely available such copies to third parties for research or educational purposes.

Signature 26/4/16
Date

This form is signed when submitting the thesis, dissertation, or project to the University Libraries

ACKNOWLEDGEMENTS

Acknowledgment to the Nursing Services Department at the American University of Beirut for sponsoring my education at Hariri School of Nursing.

Acknowledgment to Dr Hala Darwish and Dr Samar Noureddine for their wise advice and kind mentoring during my years of education.

AN ABSTRACT OF THE PROJECT OF

Abed Al Wahab Al Firikh for Master of Science
Major: Nursing

Title: Development of an evidence based clinical pathway for patients with aneurysmal subarachnoid hemorrhage

Clinical pathways are multidisciplinary care plans that are meant to provide practical clinical interventions, as well as timeframes, for a specific patient population based on the best available evidence.

Clinical pathways are meant to reduce patient length of hospital stay, number of mechanical ventilation days, improve hospital resources utilization and decrease the overall cost of health care. These care maps are also meant to improve patient outcomes by promoting evidence based practices and coordination between different hospital departments.

Aneurysmal subarachnoid hemorrhage is a catastrophic medical condition associated with high rates of mortality and complications despite expert medical and surgical management.

The aim of this project was to develop a clinical pathway for aneurysmal subarachnoid hemorrhage patients at the American University of Beirut Medical Center. This clinical pathway is based on the latest American Heart Association and European Stroke Organization guidelines, with consideration to the available resources at the targeted medical center.

This pathway will follow the patient from presentation in the emergency department to discharge from the hospital. Its implementation is meant to insure adherence to evidence based practice and smooth interdisciplinary coordination between healthcare team members.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABREVIATIONS

ADL	Activities of daily living
AHA	American Heart Association
APN	Advanced practice nurse
AROM	Active range of motion
aSAH	Aneurysmal subarachnoid hemorrhage
AUBMC	American University of Beirut Medical Center
AVERT	A Very Early Mobilization Trial
BP	Blood pressure
CBC	Complete Blood Count
CNS	Clinical Nurse Specialist
CP	Clinical pathway
CPP	Cerebral perfusion pressure
CSF	Cerebrospinal fluid
CT	Computed topography
CTA	Computed tomography angiogram
DCI	Delayed cerebral ischemia
ED	Emergency department
ESO	European Stroke Organization
EVD	Extra ventricular drain
GCS	Glasgow Coma Scale
ICF	International classification of functioning disability and health
ICP	Intracranial pressure
LP	Lumbar puncture
MAP	Mean arterial blood pressure
MCA	Middle cerebral artery
MRI	Magnetic resonance imaging
NCU	Neuro-Intensive Care Unit
PRBC	Packed red blood cells
PROM	Passive range of motion
PT	Prothrombin time
PTT	Partial thromboplastin time

TXA	Tranexamic acid
SAH	Subarachnoid hemorrhage
SCD	Sequential compression device

CHAPTER I

BACKGROUND AND SIGNIFICANCE

Aneurysmal subarachnoid hemorrhage (aSAH) is a catastrophic medical condition that is associated with an average case fatality rate of 30% to 50% (Behrouz & Sadat-Hosseiny, 2015). Close to one third of the survivors usually suffer from permanent neurologic deficits. (Young, et al., 2015). The American Heart Association (AHA) defined aSAH as Rapidly developing signs of neurological dysfunction and/or headache because of bleeding into the subarachnoid space (the space between the arachnoid membrane and the pia mater of the brain or spinal cord), which is not caused by trauma.(Sacco, et al., 2013).Even with expert surgical and medical management this condition is associated with devastating complications such as: vasospasm and delayed cerebral ischemia (DCI), hydrocephalus and electrolytes imbalances (Connolly, et al., 2012).

Misdiagnosis of patients suffering from aSAH ranges from 5 to 15% (Thomas, Edlow, & Goldstein, 2009). Misdiagnosis increases the likelihood of death or disability up to four times in patients who did not present with severe neurological deficits (Connolly, et al., Management of Aneurysmal Subarachnoid Hemorrhage, 2012).

The complexity of presentation of these critically ill patients requires adherence to evidence based practice, as well as efficient utilization of available resources in order to avoid delays in diagnosis and subsequent delivery of optimal treatment. Clinical pathways (CP) are document-based tools that provide a link between the best available

evidence and clinical practice. They provide recommendations, processes and time frames for the management of specific medical conditions or interventions (Bjurlin

g-Sjöberg et al, 2015). Clinical pathways integrate complex evidence based interventions as well as organize inter-professional teamwork to improve patient outcomes (Rotter, et al., 2010). Clinical pathways are used by health services to detail essential steps in the care of patients with a specific clinical problem. In 2015, it was stated that 80% of hospitals in the United States of America are already using clinical pathways to help hospital staff of all disciplines adhere to clinical guidelines (Bjurling-Sjöberg et al, 2015)..

Clinical pathways contribute to improved quality of care, increased adherence to best-practice guidelines, decreased time with mechanical ventilation, decreased length of stay in Intensive Care Units (ICU), and reduced hospital costs (Bjurling-Sjöberg et al., 2015). Clinical pathways are also associated with improved quality of care, more efficient utilization of hospital resources and reduced days of hospitalization and reduced cost of health care services (Curtis, et al., 2015; He, Bundorf, Gu, Zhou, & Di, 2015). He, et al. (2015), also linked the utilization of clinical pathways with improved patient and staff satisfaction.

The development of such clinical pathways for specific medical diagnoses falls in the scope of advanced nursing practice (McClelland, 2014). This project aims at developing a clinical pathway for patients suffering from ruptured aneurysmal SAH who are admitted to the emergency department (ED) of the American University of Beirut Medical Center (AUBMC). This CP will follow patients from the moment they present to the ED with signs and symptoms of aSAH, through their entire hospital stay until their discharge and re-integration into society. This document will serve as a guide for

physicians and registered nurses to offer optimum care for adult patients who suffer from SAH. It will be available online and accessed with an AUBMC valid user name and password.

The proposed aSAH clinical pathway is based on the American Heart Association (AHA) guidelines published in 2012 and the European Stroke Organization Guidelines (ESO) published in 2013. The table in Appendix1 summarizes and compares the recommendations of both guidelines. Aspects about the management of aSAH not covered by the guidelines (such as tools for headache evaluation in ED patients, limitations of diagnostic studies, physical rehabilitation and psychological screening) were covered by a critical appraisal of the literature published from the year 2005 to the year 20015. Through the databases: PubMed, Cochrane Library, and ClinicalKey for Nursing the following key terms were used for the research: cerebral aneurysm, subarachnoid hemorrhage, headache, cerebral vasospasm, and delayed cerebral ischemia, management and nursing care. The retrieved articles were also used as a background to retrieve references and citing articles. The best evidence available was incorporated in the development of this project.

CHAPTER II

REVIEW OF LITERATURE

This chapter includes a comprehensive literature review about all aspects of aSAH management; causes of aSAH, grading of severity, diagnostic studies will be reviewed. Clinical decision-making regarding evaluation and diagnosis will be analyzed. Furthermore, all aspects of medical-surgical nursing care will be discussed with special focus on the latest published international guidelines.

A. Etiology of Subarachnoid hemorrhage

Aneurysmal rupture is the most common cause of spontaneous SAH, accounting for 75%-80% of the cases (Raya & Diringer, 2014). Other non-aneurysmal causes of SAH are: Arteria-venous malformations, tumors, coagulopathy, cerebral artery dissection, vasculitis, pituitary apoplexy, sickle cell disease and cocaine abuse (Thomas, Edlow, & Goldstein, 2009).

The factors associated with the highest risk for SAH are smoking, followed by excessive alcohol use and family history, among others, as shown in Table 2.1 below.

Table 2.1.The risk Factors for SAH with their respective relative risk and confidence interval.

Risk factor	Relative risk	Confidence interval
Female gender	1.24	1.09–1.42
Age greater than 50	1.6	1.2-2.1
Excessive alcohol use (> 150 grams/ week)	2.1	1.5-2.8
Smoking	2.2	1.3-3.6
Hypertension	2.5	2.0-3.1
Autosomal dominant polycystic kidney disease	4.4	2.7-7.2
Connective tissue disorders	No data	No data

Reference: (Connolly, et al., 2012; Thomas, Edlow, & Goldstein, 2009)

B. Severity Grading Scales

The American Heart Association (AHA) recommends using validated scales such as the Hunt and Hess Severity Scale and the World Federation Of Neurological Surgeons scale to assess the severity of SAH. It was reported that the scores of such scales are significantly associated with clinical outcome after the SAH episode (Connolly, et al., 2012).

Hunt and Hess scale: This is a scale to grade the severity of SAH based on the presenting signs and symptoms. The grades are delineated as follows: Grade1: asymptomatic; grade2: mild headache, slight nuchal rigidity, moderate to severe headache, no neurologic deficit other than cranial nerve palsy; grade 3: drowsiness / confusion, mild focal neurologic deficit; and grade 4: stupor, moderate-severe hemiparesis, coma, and decerebrate posturing (Rosen & Macdonald, 2005).

World Federation Of Neurological Surgeons: This scale grades the severity of SAH based on the patient's score on the Glasgow Coma Scale (GCS) upon presentation. Grade 1: GCS score of 15 without focal deficit; grade 2: GCS score of 13 or 14 without focal deficit; Grade 3: GCS score of 13 or 14 with focal deficit; and grade 4: GCS score of 7-12, grade 5: GCS score of 3-6(Rosen &Macdonald , 2005).

Both scales correlate positively with clinical outcomes of aSAH cases. The choice depends on the treating physician's preference.

C. Signs and Symptoms of Subarachnoid Hemorrhage

Cerebral aneurysms may rupture during physical activity or emotional stress, but it is more common for aneurysms to rupture at rest. The most common presenting sign and symptom is severe headache; 70% of patients report to the ED only with headache without any associated abnormality. Conscious patients often describe it as the worst

pain he or she ever experienced. Other signs and symptoms are: seizures, neurological abnormalities, photophobia, nausea and vomiting (Grimm, 2015).

1. Emergency department evaluation

Considering any type of intracranial bleed as a potential diagnosis is straightforward in a patient who suffers from any neurologic deficit along with headache, but it becomes challenging when a patient reports headache with no associated neurologic abnormalities. Headache is reported by 2% of patients who visit the emergency department. SAH is a life threatening diagnosis; however it accounts for only 1% to 3% of these patients (Perry, et al., 2013). The AHA recommends a high index of SAH suspicion for any patient suffering from headache (Connolly et al., 2012), but it is still challenging to pinpoint which patients should be screened for SAH in the emergency department (ED) especially if the patient is not suffering from neurological deficits.

2. Clinical rules for headache evaluation

Several clinical decision algorithms were designed to identify which patients presenting with headache should be screened for aSAH. A study done by Perry et al. in 2013 assessed the sensitivity and specificity of three different processes to rule out aSAH in patients reporting to the ED with headache. Each processes based on a set of different risk factors. If patient has more than one of the mentioned risk factors, aSAH is to be considered a potential cause of the headache. The authors tested the sensitivity of these three processes or rules for use in diagnosing SAH. Rule one: Age greater than or equal to 40 years with neck pain or stiffness, witnessed loss of consciousness, onset of headache during exertion, instantly peaking headache, and limited neck flexion on exertion. Rule two: Age greater than or equal to 45 years, arrival with the help of

emergency transport personnel, vomiting, diastolic blood pressure greater than or equal to 100 mmHg. Rule three: Age 45 to 55 years with neck pain, arrival with the help of emergency transport personnel, systolic blood pressure greater than or equal to 160 mmHg. The authors conducted this cohort study in 10 different Canadian hospitals over 4 years and included 2131 patients who came to the ED with headache. This study concluded that the first rule, which was named the Ottawa SAH Rule, has a very high sensitivity of100% (95 CI 97.2% to 100%). The sensitivity for rule two was 95.5% and 96% for rule three (Perry, et al., 2013). So rule one was considered the best and was adopted as has been followed when evaluating patients with headache coming to the ED.

D. Diagnostic studies

The AHA recommends a non-contrast CT of brain to confirm diagnosis. If the CT result is negative and there is clinical suspicion, it should be followed by a lumbar puncture (Connolly et al., 2012). The European Stroke Organization (ESO) considers CT/CTA and MRI as equally important for the diagnosis of SAH in the first 24 hours (Steiner et al. 2013) The ESO did not specify which diagnostic test to perform first.

1. Non-contrast Head CT

A CT scan is the main diagnostic tool for the detection of SAH. Its sensitivity is high (approximately 100%) during the first 12 hours after the bleed. The diagnostic value of the CT scan is time dependent because the accumulated blood in the subarachnoid space becomes isodense as the CSF circulates (Suarez, 2015).

However, the use of CT scans has some limitations related to ; the time of doing the CT, the volume of the bleed, the expertise of those reading the CT, the type of equipment used and the patient's clinical condition. In terms of time, the sensitivity of

the CT scan decreases as the time since the onset of symptoms passes. Moreover a CT scan may fail to detect small volumes of blood in the subarachnoid space**.** The clinical experience of the interpreter of the CT can also influence the sensitivity of the diagnostic study. In addition, modern third generation CT scans are more likely to detect SAH when compared to older machines. Finally, **a** hematocrit less than 30% can cause a false negative result Anemic patients might have isodence blood due to low hemoglobin levels, and CT scans cannot detect isodence blood (Suarez, 2015).

2. Lumbar puncture

Both the AHA and ESO recommend performing a lumbar puncture (LP) if the CT scan is negative when there is clinical suspicion for SAH (Connolly, et al., 2012). The LP is can detect a small volume of blood that is not detectable by CT. An LP should be done within 6 to 12 hours with caution to differentiate blood due to SAH from a traumatic LP (Steiner et al., 2013). The presence of RBCs in the first and the fourth CSF tube indicates SAH. Xanthochromia (yellowish discoloration) due to the breakdown of hemoglobin in the collected CSF is an evidence of SAH starting from six hours after the onset of bleed up to two weeks (Suarez, 2015). A traumatic tap may interfere with the detection of SAH bleeding and xanthochromia may not be present before 12 hours since the time of SAH onset (Suarez, 2015).

Recent articles have shown that the sensitivity of a CT scan can reach 100% in detecting SAH. This sensitivity is particularly close to 100% within the first six hours after the bleed. LP can be uncomfortable for the patients, and is associated with some complications. It is reasonable to consider the utility of LP if the CT scan performed within six hours is negative for bleed with clinical suspicion indicating SAH. Recent studies have concluded that it is reasonable to modify the current practice and depend

on the CT scan results alone to rule out SAH without performing an LP in patients who present to the ED with headache; provided that the CT scan is performed within six hours after onset of symptoms using a modern third generation CT machine, and the radiologist reading the image has enough experience. (Blok et al., 2015; Claveau & Dankoff, 2014).

3. Magnetic resonance imaging (MRI)

According to the ESO, an MRI is as useful as a CT scan for the diagnosis of SAH within the first 24 hours. However, according to the AHA, the role of magnetic resonance imaging in acute aneurysmal SAH is limited due to the following reasons: it is not routinely available, it is challenging to perform this imaging modality in a critically ill patient, the patient has to be cooperative for this imaging to be useful (risk of motion artifacts), it needs a long duration of time to complete and get the results, and is expensive (Connolly et al., 2012).

4. Cerebral angiography

Cerebral angiography is considered the golden standard for the detection of SAH and the exact location of the aneurysm (Connolly et al., 2012; Steiner et al., 2013). According to the AHA, cerebral angiography should be performed if the source of the bleeding cannot be determined noninvasively; it can detect the ruptured aneurysm and help decide whether to coil or surgically obliterate the aneurysm. The ESO also recommends cerebral angiography when the aneurysm cannot be detected by other means (Steiner et al., 2013).

On the other hand, CT angiography (CTA) is a less invasive method that can detect the source of bleeding; it has a sensitivity of 0.77–0.97 and specificity of 0.87–1.00. The sensitivity of CTA decreases significantly with small aneurysms that are

harder to detect (Steiner et al., 2013)

5. Laboratory studies

A chemistry panel, complete blood count (CBC), prothrombin time/partial thromboplastin time (PT/PTT), blood typing and screening, and troponin are recommended in the case of suspected SAH (Grimm, 2015). A CBC panel helps detect anemia, which could lead to false negative CT scan results. A Chemistry panel is to detect any electrolyte imbalances. The coagulation studies are needed to understand the initial cause of the bleed and to clear the patient for any surgical intervention. Troponin correlates with cardiac as well as neurologic complications.

E. Supportive management of Aneurysmal Subarachnoid hemorrhage

The AHA recommends urgent treatment of patients with SAH based on the fact that the risk of aneurysmal re-bleeding is high and associated with worse outcomes (Connolly et al., 2012). The ESO recommends that the patient receive treatment in an intensive care unit where continuous hemodynamic monitoring is available. It is also recommended that a patient receive hourly neurologic exams and vital signs monitoring (Steiner et al., 2013).

The initial management of a patient with SAH should follow the A-B-C (Airway, Breathing, and Circulation) sequence; as such a patient might need intubation and mechanical ventilation prior to any other intervention, especially if he/she has a GCS score less than 8. The vital signs' monitoring and neurologic assessment will guide the rest of the management (Grimm, 2015).

After initial stabilization the treatment goals of the patient will focus on; symptom management, prevention of re-bleed, repair of the aneurysm, and management of complications.

1. Pain management

The ESO recommends the use of Paracetamol 500mg every four hours as a first line treatment of pain in SAH patients. If needed the use of Codeine or Tramadol can be considered (Steiner et al., 2013).

2. Prevention of re-bleed prior to aneurysm obliteration

Re-bleeding is a very important complication of SAH. The highest risk for re-bleeding is during the first 72 hours after the initial event. The cause of this complication is hypothesized to be the lysis of the thrombus found at the core of the aneurysm (Behrouz & Sadat-Hosseiny, 2015).

In order to prevent the re-bleeding of the aneurysm, it is recommended to control the patient's blood pressure (BP). According to the AHA guidelines, it is recommended to control BP with an antihypertensive drug that can be titrated according to need. Titration of the dose should be done to reduce the risk of re-bleeding secondary to hypertension while maintaining adequate cerebral perfusion pressure. Calcium channel blockers; such as, Nicardipine, or beta-blockers; such as, Labetalol are recommended for this purpose; however there is not enough evidence regarding clinical outcomes that favors one over the other. In addition no consensus on the BP parameters has been reached; however it is acceptable to keep the systolic BP below 160mmHg the lower border of blood pressure was not specified (Connolly et al., 2012). In order to maintain a stable mean arterial pressure; hence a cerebral perfusion pressure within normal limits.

For the purpose of preventing re-bleeding, the ESO acknowledges that it is difficult to determine a clear-cut BP limit, thus it should be customized to each patient. The ESO recommends the reduction of systolic BP to less than 180mm Hg; it should

also be reduced by 25% compared to patient's baseline. It is recommended to use Labetalol for this purpose (Steiner et al., 2013).

3. Treatment of the ruptured cerebral aneurysm: the endovascular and surgical approach

Surgical clipping or endovascular coiling of ruptured cerebral aneurysms is necessary to prevent new episodes of SAH. During surgical clipping, a clip is secured around the neck of the aneurysm through a craniotomy. Endovascular coiling is a procedure where platinum coils are deployed in the fundus of the aneurysm to induce thrombosis through intra-arterial angiography.

Endovascular coiling has become the preferred treatment whenever both modalities are possible as it is less invasive. Stenting of the aneurysm, which is another option is often associated with increased morbidity and mortality and should be considered only if other approaches have been excluded. Intra-operative induction of hypothermia is not recommended for routine care and should be considered only in specific cases based on the clinical judgment of the practicing neurosurgeon. Long-term follow up with endovascular cerebral angiogram is recommended (Connolly et al., 2012).

The ESO recommends that the aneurysm should be treated as early as possible to prevent re-bleed. It is reasonable for the intervention to be done within the first 72 hours after the initial bleed. The ESO prefers endovascular coiling as well, however certain clinical conditions are highlighted where invasive clipping of the aneurysm through a craniotomy is preferred. These conditions are illustrated in appendix 1 (Steiner et al., 2013).

Evidence published in the 1960s suggested that anti-fibrinolytics decrease the risk of

re-bleed in SAH patients by preventing the disintegration of the thrombus at the core of the aneurysm. Drugs that inhibit plasminogen activation such as Tranexamic acid (TXA) and ε-Aminocaproic acid (eACA) were very popular back then. Recently the associated risk of vasospasm and the risk of delayed cerebral ischemia became of particular concern. A Cochrane review published in 2013 concluded that the routine use of anti-fibrinolytics is not recommended anymore(Behrouz & Sadat-Hosseiny, 2015). The AHA recommends the use of Tranexamic acid or Aminocaproic acid only if endovascular intervention is to be delayed more than three days (Connolly et al., 2012).

F. Management of complications

The main complications associated with SAH include vasospasm and delayed cerebral ischemia, hydrocephalus and seizures**.**

1. Vasospasm and DCI

Vasospasm is defined as the narrowing of the cerebral arteries. It is a common complication after SAH that is associated with dreaded outcomes; such as, disability and death that are related to delayed cerebral ischemia (DCI). Vasospasm occurs 7 to 10 days after the initial hemorrhage and spontaneously resolves after 21 days. Although studies associate large artery vasospasm with symptoms of DCI, some patients with angiographically evident vasospasm might not develop symptoms of DCI (Balanzar & Guinto-Nishimura, 2014).

The precise pathophysiology of cerebral vasospasm after SAH is completely understood. Three mechanisms are implicated: First, the oxidative stress associated with SAH is hypothesized to lead to protein kinase and Rho kinase activation; this in turn causes the smooth muscle cells in the cerebral arteries to contract. Second, the

extravagation of oxy-hemoglobin causes the endothelial cells to release Endothelin-1, which is a potent vasoconstrictor; and the third, SAH is associated with reduced nitric oxide levels, which is a strong vasodilator (Balanzar & Guinto-Nishimura, 2014).

Serial neurologic assessments are required to detect the onset of vasospasm and the associated DCI. The AHA recommends the use of transcranial Doppler that, non-invasively, measures cerebral blood flow (Connolly et al., 2012). Also according to a study by Kumar & Alexandrov in 2015, the monitoring of vasospasm using trans-cranial Doppler as a daily routine was found to be associated with improved clinical outcomes (Kumar & Alexandrov, 2015).

There are two approaches to treat cerebral vasospasm after SAH: Nimodipine and triple H therapy. Nimodipine is a calcium channel blocker that relaxes the vascular smooth muscles, thus relieving cerebral vasospasm. The AHA recommends 60 mgs of Nimodipine every four hours for 21 days for SAH patients. It is associated with improved neurologic outcomes and reduced mortality (Behrouz& Sadat-Hosseiny, 2015). The ESO recommends the same dose and duration of treatment with Nimodipine, and also recommends the IV administration of the drug when the enteral route is not possible to use (Steiner et al., 2013).

Triple H therapy is described as Hypertension, Hemodilution, Hypervolemia; these are means for hemodynamic augmentation to increase the cerebral perfusion through narrowed arteries. Complications of this therapy include: pulmonary edema, cerebral edema, cardio-pulmonary failure and rupture of unsecured aneurysms. New evidence suggests that there is no benefit for hypervolemia induction when compared to euvolemia (Connolly, et al., 2012). This is why the AHA recommends: first, to maintain euvolemia and avoid hypervolemia. Second, the recommendation is to induce

hypertension unless the patient is hypertensive prior to admission or his cardiac status is compromised. Third, cerebral angioplasty with intra-arterial vasodilators is recommended if patients are not responsive to induced hypertension (Connolly, et al., 2012).

Triple H therapy is referred to as the "hemodynamic management of DCI" by ESO. The ESO also found no evidence that hypertension or hypervolemia improves patient outcomes as a treatment of vasospasm and that the therapy is associated with cardiopulmonary complications (Steiner et al., 2013).

Other studies have examined the use of statins in the treatment of SAH. Statins, also known as HMG-CoA (3-hydroxy-3-methyl-glutaryl coenzyme A) reductase inhibitors, are a class of drugs that are indicated in ischemic stroke and ischemic heart disease. Statins are associated with: Neuro-protection, improvement of vascular vasomotor tone, reduction of inflammation and reduction of vasospasm. However, in a phase III randomized clinical trial, STASH (Simvastatin in Aneurysmal Subarachnoid Hemorrhage), the role of statin in SAH patients was studied and concluded that this pharmacological category did not improve patient outcomes. Therefore, statins are not considered part of the routine management of SAH at this point in time till further studies show the opposite (Behrouz & Sadat-Hosseiny, 2015). According to the ESO, further evidence is needed to recommend the routine use of statins (Steiner, Juvela, Unterberg, Jung, Forsting, &Rinkel, 2013)**.**

Intravenous magnesium sulfate has also been studied for its efficacy in treating vasospasm. The ESO and AHA do not recommend the use of magnesium sulfate for the prevention of DCI.(Connolly, et al., 2012; Steiner et al., 2013)

2. Hydrocephalus

Around 7% – 65% of patients suffering from SAH develop acute hydrocephalus, while 8% –63% develop chronic hydrocephalus. Hydrocephalus occurs when cerebrospinal fluid (CSF) drainage is obstructed as the arachnoid villi become obstructed by accumulation of blood products (Lewis & Kimberly, 2014). According to both the AHA and ESO, acute hydrocephalus should be managed by extra-ventricular drain (EVD) (Class I; Level of Evidence B). Chronic hydrocephalus should be managed by ventriculo-peritoneal shunting (VPS)(Connolly, et al., 2012; Steiner et al., 2013). VPS is a procedure during which CSF is shunted through a catheter into the peritoneal cavity to control a patient's ICP (Lewis & Kimberly, 2014).

The management of EVDs varies according to the institution, with no evidence to support one protocol over the other. One option involves keeping the EVD closed and opening it when intracranial pressure (ICP) exceeds 20mmHg. The rationale behind this approach is to allow CSF to drain through the arachnoid villi, thus minimizing the risk of occlusion of the villi with blood clots. In option two, the EVD is unclamped for 4 to 5 days after the aneurysmal repair, then it gets clamped if there is no evidence of: hydrocephalus, pseudomeningocele, presence of RBCs in the CSF, or vasospasm. In the third option, the EVD drainage level is raised over several days gradually until it is clamped, provided that there is no evidence of clinical or radiologic deterioration; this approach is known as stepwise weaning or gradual weaning (Lewis & Kimberly, 2014).

Weaning failure is defined in the literature as the presence of clinical or radiologic deterioration: Clinical deterioration is evident by: headache, changes in the level of consciousness, nausea and/or vomiting, ICP above 20 mmHg sustained for more than 5 minutes, or leakage of CSF from the EVD insertion site. Radiologic deterioration is evident by: exacerbation of hydrocephalus based on CT scan results. If

two attempts to wean from the EVD failed, then the patient is a candidate for VPS. VPS is an invasive procedure by which CSF is shunted from the ventricular system into the patient's peritoneum through a surgically inserted catheter to control ICP

3. Seizures

According to the ESO, seizures occur at the onset of SAH in 7% of patients, and within weeks after presentation in 10% of the patients. Subclinical seizures in comatose patients have been estimated to occur in 8% of the patients and 0.2% of patients will progress into a state of status epilepticus (Steiner et al., 2013). A recent population based longitudinal study estimated that epilepsy occurs in 12% of patients at 5 years (Huttunen et al., 2015).

The AHA recommends the short-term use of anti-epileptic drugs prophylactically immediately after SAH. Long-term prophylactic use of anti-epileptic drugs is only recommended in patients with other risk factors for epilepsy(Connolly, et al., 2012).The ESO, on the other hand, found lacking evidence to consider the routine prophylactic administration of anti-epileptic drugs, thus treatment with these medications should only be considered when the patient suffers from a seizure(Steiner et al., 2013).

4. Management of other medical complications

In addition to the above, other complications were reported in SAH patients and must be managed. These include malnutrition, fever, glycemic abnormalities, anemia, hyponatremia and deep vein thrombosis

Malnutrition is linked to increased incidence of hospital-acquired infections and with worse clinical outcomes in SAH patients, thus routine screening of patients, and provision of adequate nutrition is recommended (Badjatia et al., 2015).

Regarding fever, it is recommended by the AHA to treat it. Clinicians should target normothermia rather than hypothermia (Connolly et al., 2012).

In addition, he AHA recommends the management of blood glucose levels. Special focus should be considered to avoid hypoglycemia (Connolly et al., 2012). The ESO recommends keeping blood glucose level less than 10 mmol/l (or less than 180 mg/dl) (Steiner et al., 2013).

Anemia is also a common complication, especially in patients who are critically ill. No evidence is conclusive regarding hemoglobin target ranges. However, the AHA recommends the treatment of anemia using packed red blood cells in patients with SAH since it compromises cerebral tissue oxygenation (Connolly et al., 2012).

Imbalances in blood Sodium levels can lead to neurologic complications. The AHA recommends the treatment or prevention of hyponatremia with hypertonic saline or fludrocortisone acetate (Connolly et al., 2012).

Deep vein thrombosis (DVT) is a complication among patients suffering from SAH, especially those who are kept in complete bed-rest (Connolly et al., 2012). The ESO recommends the use of sequential compression devises (SCD) for thrombo-prophylaxis. In cases of identified DVT, low molecular weight heparin can be administered provided that the aneurysm has been surgically secured for more than 12 hours (Steiner et al., 2013).

G. Physical Rehabilitation

Studies estimate that 50% of patients who survive aneurysmal SAH are left with long-term cognitive and physical injuries. Patients who survive the complications of SAH struggle with the psychological and neuromuscular complications associated with critical care and prolonged immobility (Olkowski et al., 2013).

In 2011, A Very Early Rehabilitation Trial (AVERT) concluded that early mobilization is safe for patients suffering from various types of stroke who did not receive intensive care. This study also showed that early mobilization helped patients walk faster and was associated with faster recovery, less depression, and reduced cost of care (Cumming et al., 2011).

The care of patients suffering from SAH is quite different from the care of patients who present with ischemic stroke. It is a common belief that patients with SAH should be completely bedridden in order to prevent complications. Studies showed that changes in head of bed elevation did not increase the incidence of DCI. Furthermore, ICP and cerebral perfusion pressure (CPP) were not affected by passive or active range of motion exercises (Olkowski, et al., 2013).

Olkowski, et al. (2013) concluded that early mobilization exercise was both feasible and safe for patients who suffer from SAH. In this project, the proposed clinical pathway will utilize the early mobilization program proposed by Olkowski and colleagues to promote early mobility of SAH patients because it was specifically studied in this patient population. It focuses on: Therapeutic exercise, functional training, as well as patient and family education as shown in table 2.2. The inclusion criteria for the mobilization program are: patient has a secured aneurysm, able to open eyes and move at least one extremity to command, normal cerebral blood flow evident by tanscranial Doppler studies (MCA flow rate ≤ 120/second), MAP ≥80 and ≤110 mm Hg, Heart rate >40 and <130 beat per minute, Respiratory rate < 40 breaths/min, Pulse oximetry>88% measured ICP ≤15 (Olkowski, et al., 2013). Any fluctuation in the above criteria outside the mentioned parameters is considered deterioration and requires that the mobilization trial be stopped. Patients are assessed on daily basis by a registered

nurse against these inclusion criteria to start the mobilization trials. A physiotherapist will perform the exercises, and help the patient progress through different levels mentioned in the table below.

Table 2.2 Early mobilization program proposed by Olkowski, et al. (2013).

Intervention	Position			
	Supine	Sitting	Standing	Walking
Positioning	Pressure ulcer prevention Edema reduction Joint protection Pain reduction	Pressure ulcer prevention Joint protection Pain reduction	Joint protection	Joint protection
Education	Positioning Safety Family training	Positioning Safety Family training	Safety Assistive device Family training	Safety Assistive device Family training
Functional training	Bed mobility Transfer	Transfer Weight shifting Balance ADL Posture	Balance ADL Posture Weight shifting	Gait Posture Balance ADL
Therapeutic exercise	PROM AROM Breathing	PROM AROM Breathing Reaching Weight shifting	AROM Breathing Reaching Weight shifting	Breathing Endurance Balance

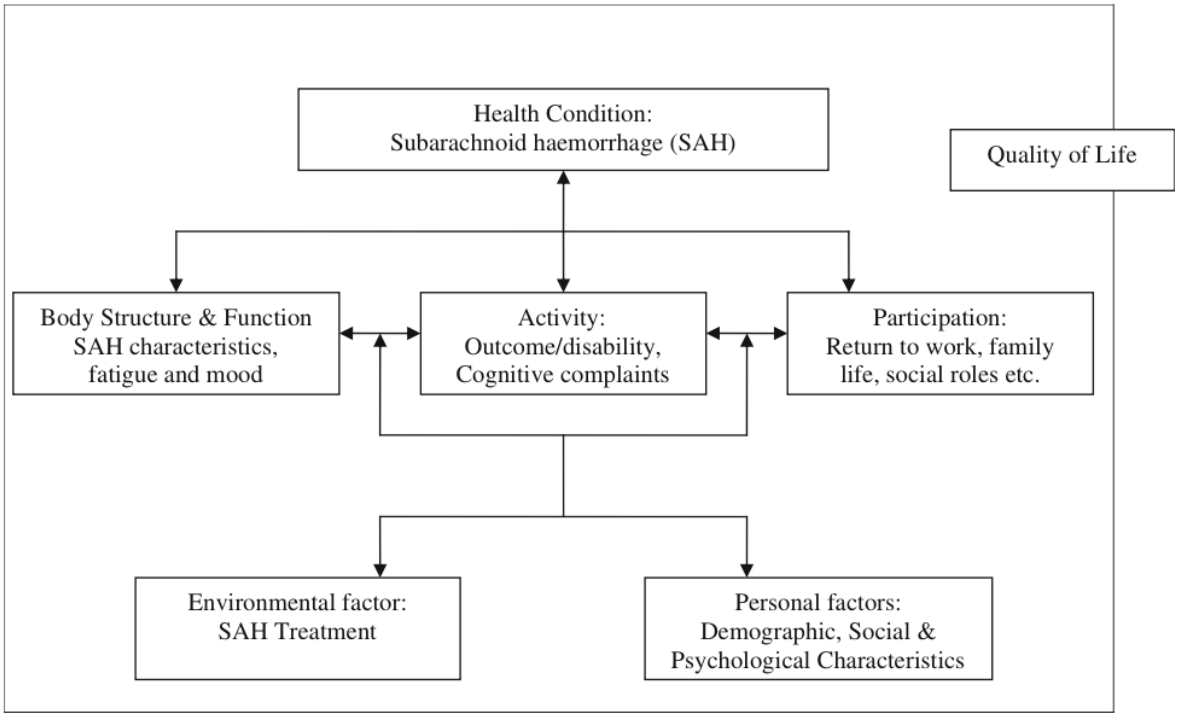
Legend: ADL: activities of daily living, AROM: active range of motion, PROM: passive range of motion.

H. Supporting the Patient's Psychological Status and Enhancing his Quality of Life

Many patients who survive aneurysmal subarachnoid hemorrhage suffer from diminished quality of life. These patients often suffer from mood disorders and cognitive disturbances after their discharge. A systematic review published in 2013 studied all the factors that are related to the reduced quality of life and proposed a model named: "The International Classification of Functioning, Disability, and Health

(ICF) model for SAH" (Passier, Visser-Meily, Rinkel, Lindeman, & Post, 2013). The model is shown in Figure 1 below

Figure 2.1.The ICF model for SAH. Passier et al. (2013)



Passier et al. (2013) analyzed the published research and the factors related to the quality of life in SAH patients. The factors that were weakly related to reduced quality of life were: the patterns of the bleed and the treatment options. On the other hand, the factors that were moderately to strongly related to reduced quality of life were: fatigue, cognitive abnormalities, depression, and a passive coping mechanism. It is vital for the healthcare team to consider the impact of psychological factors on the quality of life of patients recovering from SAH. The standardized screening by professional clinicians of patients for psychological complaints is important and has great influence on the patients' rehabilitation process (Passier et al., 2013).

In conclusion the published literature covers all aspects of care including: assessment, diagnosis, supportive care, surgical management, nursing care, and prevention of complications. The best evidence published regarding the care of aSAH was illustrated. It is now possible to synthesize a care map that governs the care of patients throughout their hospital stay.

CHAPTER III

DEVELOPMENT OF A CLINICAL PATHWAY AT AUBMC

Clinical pathways are tools that are based on the latest available guidelines for specific diseases. These tools offer more than just recommendations for practice; they provide specific clinical interventions in a specific sequence, and within an appropriate time frame. In other words, these pathways integrate the best available evidence into practice, with special consideration to the available resources. This is why clinical pathways offer more practical information for healthcare professionals.

Based on the evidence provided earlier, the tool in Table3.1is proposed to represent a guide for clinicians at AUBMC caring for patient suffering from aSAH. The clinical pathway was organized in a table format for ease of use and convenience (Table 3.1). Seven main goals were set which are: (1) Urgent evaluation of patients with suspected a SAH in the emergency department, (2) Support of the patient's hemodynamic status, (3) Early treatment of the aneurysm, (4) Promotion of adequate nutritional intake, (5) Management of complications, (6) Patient rehabilitation, and (7) Advanced psychological screening prior to discharge. To achieve each goal, a set of evidence based interventions are listed in a checklist format. These interventions are grouped into bundles that respect the scope of practice of each member of the healthcare team. Time frames to achieve each of the main goals are also specified in order to optimize the overall clinical outcome.

Table 3.1. Clinical pathway for SAH: treatment goals, levels of evidence with proposed interventions

Emergency department			
Treatment Goal	Scope of practice	Interventions	Time frame
Urgent evaluation of patients with suspected a SAH in emergency department	Registered Nurse	• Assess Vital signs • Assess admission GCS • Use the Ottawa SAH rule to screen patients with headache (Appendix 2) • Blood tests for: CBCD, Chem9, PT, PTT, INR	Immediately upon reporting to ED
	Physician and Radiology technician	• Early CT brain	Within 6 hours of suspected bleed onset Within1hourfromreporting to ED
	Physician	• Classify the severity of the bleed based on: Hunt And Hess Scale, World Federation Of Neurological Surgeons (Appendix 3) • Consider LP if CT is negative when there is clinical suspension for SAH *within 6 to 12 hours, look for RBCs in 1st and fourth tube.*	Immediately when CT image is out Perform LP as soon as logistically possible
	Physician, registered nurse and radiology technician	• CTA to detect the source of bleeding • Cerebral angiogram when required if CTA did not detect the source of bleed	

Table 3.2. Clinical pathway for SAH: treatment goals, levels of evidence with proposed interventions (cont'd)

Neuro intensive care unit (NCU)			
Treatment Goal	Scope of practice	Intervention	Time frame
Support patient's hemodynamic status	Registered Nurse	• Initiate hourly vital signs monitoring • Initiate hourly neurological examination by a *trained* registered nurse • Report changes in neurological status accordingly • Assess pain severity using verbal descriptive scale or numeric rating scale	Continuous
	Physician and registered nurse	• Manage pain with Paracetamol as a first line treatment and morphine as a secondary alternative	
	Physician	Goal: 120mmHg < SBP< 160 mmHg or reduce by 25% from baseline blood pressure. • Labetalol 10mg IV Push PRN every 15 min Withhold if HR is < 50 beats per minute. Do not exceed a cumulative dose of 300 mg in 24 hours. • Nicardipine IV drip: 500mg in a total of 1000 ml NSS; start at a rate of 5mg per hour and titrate by 2.5mg per hour every 15 minutes to achieve target blood pressure. • Maximum dose is 15mg per hour.	Continuous
	Registered Nurse	• Administer Labetalol PRN according to blood pressure • Titrate Nicardipine to keep 120mmHg < SBP< 160 mmHg or reduce by 25% from baseline blood pressure. • Prepare patient for surgical intervention	Continuous

Table 3.3. Clinical pathway for SAH: treatment goals, levels of evidence with proposed interventions (cont'd)

Intra procedure			
Early treatment of the aneurysm	Physician	• Insert Arterial line for Blood pressure monitoring • Insert central venous catheter • Insert Foley catheter	Prior to the Procedure
	Physician	• Clipping is preferred if: o the patient is young, o the aneurysm is a middle cerebral artery aneurysm, o The aneurysm has one of the following characteristics: a wide diameter, arterial branches in the fundus, and/or an unusual shape. • Coiling is preferred if: o the patient is over 70 years o The aneurysm has one of the following characteristics: present in the posterior circulation, has a small neck and/or unilobar configuration. • When both are technically appropriate, coiling can be beneficial	As soon as logistically possible Within three days of the suspected time of bleed to reduce the risk of re-bleed.

Table 3.4. Clinical pathway for SAH: treatment goals, levels of evidence with proposed interventions (cont'd)

Post-operative management of complications Activate aSAH order-set			
Promotion of adequate nutritional intake	Physician	• Initiate feeding orally or using an enteral tube as soon as possible after endovascular coiling.	Once tolerated by the patient
	Dietitian	• Advance feeding as tolerated by patient after consulting a dietitian	Advance feeding if tolerated by patient
Management of Complications: vasospasm	Vascular technician	• Monitor the incidence and progress of vasospasm daily using a trans-cranial Doppler	Start on day 7 after the bleed
	Physician	• Nimodipine 60mg every four hours for 21 days, hold if MAP is less than 80 mmHg • Blood pressure control of secured aneurysm • Initiate Levophed protocol for induction of hypertension • Start albumin 20% 50ml vial IV Drip every 12 hours to maintain intravascular volume.	Start on day 7 and continue treatment for 21 days
Management of Complications: Hydrocephalus	Physician	• Insertion of EVD for CSF drainage	Once there is evidence of hydrocephalus
	Registered nurse	• Maintain ICP <20mm Hg • Maintain CPP>60mm Hg	Monitored on hourly basis
	Physician	• Mannitol 20% 1 g per Kg IV Drip over 15 min • Hypertonic saline NaCl 3% 250 ml IV Drip over 20 min	As needed based on serum osmolality studies
Management of Seizures	Physician	• Phenytoin 200mg IV drip every 12 hours • Consider the need for long term AED	Immediately when aSAH is diagnosed
Management of Complications: hyponatremia, and hypovolemia	Physician	• Insert a Central venous catheter	Post operatively
	Registered nurse	• Monitor CVP at least every 4 hours • Weigh patient daily • IV NSS at a rate of 1 to 1.5 ml per KG per hour • Maintain euvolemia: 5mmHg <CVP< 12 mmHg • Maintain grand total balance less than 700 ml in case of hyponatremia (to account for insensible losses)	Starting day 7 till day 21 after initial bleed
	Physician	• Consider fludrocortisone acetate to treat hyponatremia • Consider Hypertonic saline NaCl 3% 250 ml IV Drip over 20 min	

Table 3.5. Clinical pathway for SAH: treatment goals, levels of evidence with proposed interventions (cont'd)

Supportive care			
Patient rehabilitation	Registered nurse	• Screen the patient daily for inclusion in the early mobilization program based on the following criteria: o Patient has a secured aneurysm o Patient is able to open eyes and move at least one extremity to command, o Patient has normal cerebral blood flow evident by TCD studies (MCA flow rate ≤ 120/second o Patients vital signs are within acceptable range: MAP ≥80 and ≤110 mm Hg, Heart rate >40 and <130 beat per minute, Respiratory rate < 40 breaths/min, Pulse oximetry>88% o measured ICP ≤15 o Activate the early mobilization tool (appendix 3) when criteria are met as validated by a trained physiotherapist	Once tolerated by the patient
	Physio-therapist	• Start exercising the patient progressively as tolerated	
Advanced psychological screening prior to discharge	Psychiatric APN	• A psychiatric advanced practice nurse will screen all patients once the rehabilitation phase has started. • Results of the assessment will be documented and communicated with the patient's primary team	Prior to patient discharge

A. Documentation of interventions

One of main goals of the implementation of a clinical pathway is the facilitation and improvement of documentation (Bjurling-Sjöberg et al, 2015). For that purpose a separate documentation tool (Appendix 4) and an order-set (Appendix 5) will be proposed. The documentation tool is presented to document important milestones in the care of the aSAH patient. This documentation tool requires the documentation of a brief history of the case, estimated time of bleed, time of ED arrival, admission GCS; it also provides a space for multi-disciplinary notes.

The tool allows the documentation of the time each of the seven main goals of treatment is initiated so that the time frames of the pathway are respected, as well as the documentation of all the requested diagnostic studies with their results. Documentations of the interventions will be in the form of a checklist to promote ease of use.

The order set for patients after aneurysmal coiling is proposed as an official patient record document in AUBMC. It will be initiated by the physician post operatively and carried by the modular registered nurse.

B. Measurement of quality indicators

The quality indicators for this project implementation will be measured at two levels: process quality indicators and outcome quality indicators. These indicators will measure the success of the implementation of the clinical pathway and the way it influenced patient care.

The proposed process quality indicators are: percent of patients whose first CT scan of brain is delayed for more than 1hour in the ED, percent of patients who receive coiling or clipping of the aneurysm after three days since the estimated time of bleed, and percent of patients who receive early rehabilitation. Another indicator is

measurement of the rate of compliance with the pathway and description of any variances, which means what were the characteristics of patients who were not treated, based on the pathway or why were they not treated accordingly.

Outcome quality indicators will be: aSAH patient mortality rates, patient average length of hospitalization, and patient length of stay in Neuro-critical care.

C. The role of the clinical nurse specialist

There is accumulating evidence that the clinical nurse specialist (CNS) improves the quality of health care services (Gordon, Lorilla, & Lehman, 2012). Part of the role of the CNS is to promote evidence based practice, education of nursing staff and quality improvement (Gordon, Lorilla, & Lehman, 2012). The role of the CNS is central in the introduction of the aSAH clinical pathway, and the monitoring of the specified quality indicators.

This project will be proposed for implementation at AUBMC. The following process will be followed to secure approval. The CNS will write a comprehensive proposal that describes the importance of CPs and the rationale for their use; in addition to the guidelines, order sets and the documentation tool. The proposal will be submitted the neuro- collaborative practice council. This council includes nursing and medical representatives; as well as a senior pharmacist and a critical care dietitian. Once the neuro- collaborative practice council reviews and approves the proposed project, it will be submitted to the pharmacy and therapeutic council to determine if the proposed medications are properly indicated and utilized. Later the CNS will present the proposal to the head of the neurosurgery department. Finally, the approval of the medical center administration will be sought. Once all concerned departments at AUBMC approve the project the piloting phase will start.

During the piloting phase, the role of the CNS becomes more central. In fact, the role of the CNS has two major parts: The direct education of the nursing staff, and acting as a leader and a consultant to promote the collaboration between all the involved healthcare professionals (Gordon, Lorilla, & Lehman, 2012).

The education of the nurses will be formally conducted; the CNS contacts the career professional development center to address the learning needs of the nursing staff. Then the CNS will deliver unit level series of presentations targeting the ED nurses and neurologic units health care providers.

Once the education sessions are completed, the CNS will start the piloting phase of the CP. The piloting will take place through the implementation of the CP gradually. First the diagnostic algorithm will be introduced in the ED. After four months, the postoperative order sets will be introduced to the NCU nurses. During this phase the CNS will meet with the neuro-collaborative practice council to address the concerns of the staff on monthly basis. Any modifications will be voted on by all the members of the council and addressed accordingly.

The role of the CNS will also involve the monitoring of quality indicators (Gordon, Lorilla, & Lehman, 2012). A baseline data collection of the quality indicators will be done prior to the introduction of the CP, and every four months after the implementation starts, which is the standard protocol for the nursing department at AUBMC.

CHAPTER IV

CONCLUSION

This project highlighted the importance of CPs utilization for promotion of evidence based practice and improving the quality of healthcare services. It also proposed a CP for the clinical management of aSAH patients, and highlighted the role of the CNS in its implementation. This chapter will discuss the limitations of the project and propose adequate solutions to address them.

A. Limitations

The implementation of the aSAH clinical pathway at AUBMC will be faced by a main challenge, which is the acceptance and compliance of healthcare professionals. Physicians might think that clinical pathways limit their decision-making authorities.

Clinical pathways might also not be customizable enough to suit individual patient characteristics. Furthermore, it might be simple to implement a pathway for simple medical diagnosis, but difficult for complex ones such as SAH. SAH patients require multiple diagnostic studies, medical as well surgical interventions. Thus a patient might have an unexpected change that might not be covered by the pathway. These aspects will be addressed by a variance analysis whereby documentation will be made of all eligible patients who were not treated based on the pathway with reasons for that.

The introduction aSAH clinical pathway will take time to be accepted and will require the commitment of all the members of the healthcare team and in multiple departments. However the benefits for patients outweigh any inconvenience to the health team.

B. Recommendations

In order to address the above problem, the pathway will be introduced gradually. The first part to be introduced will be the diagnostic algorithm to be utilized in the ED for all patients with suspected SAH. At a later stage, and once the diagnostic algorithm is accepted by the ED staff, the post-operative SAH order-set will be introduced for patients admitted to NCU after coiling. Order-sets are already a routine part of the practice at AUBMC. Finally, the early mobilization of patients will be implemented with the coordination with the physical therapy department. During this stage the CNS will be meeting with neuro-collaborative practice council on monthly basis to address all the concerns of the staff. The final stage of introduction will be the complete clinical pathway implementation. By this stage the change would have been gradually accepted and healthcare members will be used to implement the standardized care for SAH patients.

In conclusion, the acceptance of change can be difficult. Hospital staff of all disciplines might resist the implementation of standardized care. The success of this project will depend greatly on the support and coordination of all members of the healthcare team in AUBMC, as well as the hospital administration. In time the perceived benefits of clinical pathways will be evident and clear to administrators and clinicians. Other clinical pathways for different diagnoses will be looked into and the healthcare system in Lebanon will start to follow the global trends in healthcare.

APPENDICES

APPENDIX I

GUIDELINES SUMMARY

Table comparing the American Heart Association and the European Stroke Organization guidelines for the treatment of aneurysmal subarachnoid hemorrhage

Aspect	AHA	ESO
Prophylactic screening	Screen patients with 1st degree family member affected by aneurysmal SAH.	Screen in case of two or more affected 1st degree relatives.
Initial assessment	Use GCS-based scales to assess patients and to grade their clinical condition	Scales to assess patient: Hunt and Hess, World Federation of Neurological Surgeons and the PAASH scales
Urgency of treatment	Evaluate and treat patients urgently because the risk of re-bleeding is high and it drastically affects the outcome. Coiling or clipping should not be delayed	Treat the aneurysm within 72 hours to decrease re-bleeding risk regardless of SAH grading.
Clinical suspicion	SAH should be highly suspected in patients reporting acute severe headache. The risk of misdiagnosing SAH is high	
CT scan	Recommended initially for diagnosis	Recommended initially for diagnosis
MRI	Recommended if CT was negative	Equally important as the CT
Lumbar puncture	Recommended if CT and MRI are negative	Recommended if CT and MRI are negative Consider the risk of false positive result due to a traumatic tap
CTA	Recommended to diagnose and plan treatment	Recommended to pinpoint the source of bleeding
Angiogram	Recommended to diagnose and to decide if coiling or clipping is more suitable	Recommended if CTA is negative
BP	BP should be controlled with a drug that can be titrated to reduce the risk of re-bleeding Target blood pressure is controversial but should be kept below 160mmHg	Home anti-hypertensive should be stopped Blood pressure target should be individual used and should be kept below 180mmHg Consider Nimodipine and analgesics prior to starting antihypertensive

Thromboxane	Consider Thromboxane within 3 days if coiling is to be delayed	
Multidisciplinary decision	Multi-disciplinary approach is recommended	Multi-disciplinary approach is recommended Include the patient in the plan of care even if elderly
Aneurysm treatment options	Endovascular coiling is preferred.	Endovascular coiling is preferred
Factors affecting choice of intervention		Clipping is preferred if: the patient is young, the aneurysm is a middle cerebral artery aneurysm, and the aneurysm has one of the following characteristics: a wide diameter, arterial branches in the fundus, and/or an unusual shape. Coiling is preferred if: the patient is over 70 years and the aneurysm has one of the following characteristics: present in the posterior circulation, has a small neck and/or unilobar configuration.
Follow up imaging after coiling	Routine follow up imaging is recommended after coiling or clipping to assess for the need of retreatment.	
Stenting	Stenting is associated with higher risk of complications Only to be considered if other options are not possible	
Hospital volume	Hospitals that treat more than 35 aSAH patients per year, have well-trained Neurosurgery team and neuro-critical care unit are recommended.	
Certification of hospitals	A hospital with certification process for physicians treating aneurysm is recommended.	
Patient Monitoring		A critical care unit with heart rate and rhythm monitoring is recommended
Serial assessment		GCS, motor or sensory deficits, temperature and blood pressure should be assessed hourly.
Fluid therapy	Maintain euvolemia to prevent DCI. Hypervolemia is not recommended Monitor: CVP, PWP, fluid balance Crystalloid or colloid fluids can be	Maintain euvolemia Administer 3 liter per day of normal saline. Readjust IV hydration after

	used	considering enteral fluid intake Consider fluid lost due to fever

Blood pressure management	Hypertension (HTN) should be induced except if the patient suffers from history of HTN or other cardiac problems	HTN is not recommended due to lack of evidence
	Selective infusion of vasodilators in cerebral arteries is to be considered only if vasospasm is symptomatic despite induction of HTN	
Monitoring of vasospasm	TCD can be used to monitor the vasospasm of cerebral arteries	Use non-invasive perfusion imaging (MRI and CT scan) to detect regional delayed cerebral ischemia
Labs		Take labs at least every other day to monitor: WBCs, electrolyte imbalances, blood glucose level
High ICP management		To avoid further elevation in ICP consider treating: pain, nausea/vomiting, constipation prior to aneurysm coiling or clipping. Consider bed rest prior to occlusion of the aneurysm
Pain management		First option: Paracetamol 500mg every 4 hours as needed Second option: Codeine or Tramadol intravenously Manage patients pain before blood pressure control
DVT prophylaxis		Ted stocking and SCDs are recommended In case of DVT, consider Lovenox only 12 hours after aneurysm is secured
Nimodipine	Recommended for all patients with aneurysmal SAH	Consider intravenous form if enteral form is contraindicated
Short term prophylactic anti-epileptic drugs	May be considered	Not indicated
Long term prophylactic anti-epileptic drugs	May be beneficial if other risk factors of seizure are concurrent	Not indicated

Anti-epileptics in case of new seizure onset	Recommended	Recommended
Magnesium Sulfate	Not recommended	Not recommended
Statins	Under study	Under study
Steroids	Fludrocortisone can be considered to treat hyponatremia	Not recommended
EVD	Recommended in acute hydrocephalus	Recommended if blood is present on 3rd and 4th ventricle
Lumbar drain	Recommended in acute hydrocephalus (choice depends on physician preference)	Recommended if bleeding did not reach 3rd and 4th ventricles provided that patient is sedated
V/P shunting	Recommended in case of chronic hydrocephalus	Recommended in case of chronic hydrocephalus
Glycemic management	Glucose management with strict avoidance of hypoglycemia	Hyperglycemia over 180 mg/dl should be treated
Temperature management	Control fever aggressively Target normothermia	Control fever
PRBC	Packed RBCs can be used to manage anemia and reduce risk of DCI Target Hgb not determined yet	
Hyponatremia management	Fludrocortisone acetate and/or hypertonic saline is recommended	
Psychological screening	Patients should be referred to receive psychological, cognitive, behavioral evaluation after discharge.	

APPENDIX II

THE OTTAWA SUBARACHNOID HEMORRHAGE RULE

Screen the patient coming to the Emergency department with headache if he has at least two of the following:

The Ottawa SAH Rule
Age greater than or equal to 40 years
Neck pain or stiffness
Witnessed loss of consciousness
Onset of headache during exertion
Instantly peeking headache
Limited neck flexion on exertion

APPENDIX III

SUBARACHNOID HEMORRHAGE SEVERITY ASSESSMENT TOOLS

Hunt And Hess Scale(Rosen &Macdonald , 2005).

Grade1: asymptomatic
Grade2: mild headache, slight nuchal rigidity, moderate to severe headache, nuchal rigidity, no neurologic deficit other than cranial nerve palsy
Grade 3: drowsiness / confusion, mild focal neurologic deficit
Grade 4: stupor, moderate-severe hemiparesis; coma, decerebrate posturing

World Federation Of Neurological Surgeons. (Rosen &Macdonald , 2005).

Grade 1: GCS score of 15 without focal deficit
Grade 2: GCS score of 13 or 14 without focal deficit
Grade 3: GCS score of 13 or 14 with focal deficit Grade 4: GCS score of 7-12
Grade 5: GCS score of 3-6

APPENDIX IV

CLINICAL PATHWAY DOCUMENTATION TOOL

Last Name: _____ **First & Middle Name:** _____ **Patient Number:** _____ **Date of Birth:** _____ **Age:** _____ **Gender:** □ **Male** □ **Female** **Admission Date:** _____ **Admitting Physician:** _____	Identification label	**Clinical Pathway: Aneurysmal Subarachnoid Hemorrhage**

Emergency department		
Focus		Interventions
Urgent evaluation of patients with suspected a SAH in emergency department	Estimated time of bleed:_____ Time of arrival to ED:_____ Admission GCS: _____	
		Results
	□SAH Ottawa screening	
	□CT scan done, Time:	
	□LP done if needed	
	□CTA	
	□Cerebral Angiogram	
	Notes:	
	Page 2	
Admission to intensive care	□Initiate hourly vital signs monitoring □Initiate hourly neurological examination by a registered nurse □Report changes in neurological status accordingly Time and Initials:_____	
	□ Pain management order initiated Time and Initials:_____	
Support patient's hemodynamic status	□ Labetalol according to protocol □Nicardipine according to protocol Time and Initials:_____	
Early treatment of the aneurysm	□ Insert Arterial line for Blood pressure monitoring □ Insert Foley catheter □ Insert Central line Time and Initials:_____	
Post operative management of complications		
□ Initiate Aneurysmal Subarachnoid Hemorrhage–Order Set		
Early patient rehabilitation	□ Screen the patient daily for inclusion in the early mobilization program □ Activate the early mobilization program whenever patient is ready	
Advanced psychological screening	□ Screen all patients once the rehabilitation phase has started □Communicate the results with the patient's primary team Time and Initials:_____	

APPENDIX V

ANEURYSMAL SUBARACHNOID HEMORRHAGE COILING ORDER SET

AUBMC
AMERICAN UNIVERSITY of BEIRUT MEDICAL CENTER

Identification label

Aneurysmal Subarachnoid Hemorrhage–Order Set

Last Name: _____
First & Middle Name: _____
Patient Number: _____
Date of Birth: _____ **Age:** _____
Gender: ☐ **Male** ☐ **Female**
Admission Date: _____
Admitting Physician: _____

Unit: _____
Weight: _____ **Height:** _____
Expanded Precautions: ☐ None ☐ Airborne ☐ Droplet ☐ Contact ☐ Contact Plus
Other Precautions: _____
Allergy (specify reaction):

The following abbreviations may not be used to document patient care: U IU QD QOD .X mg X.0 mg MS MSO_4 $MgSO_4$ CC µg mcg

☑ **Check the Applicable Order**

	Nurse's Name & Signature	**Time Noted**
Condition ☑Critical Activity ☑CBR Diet ☑NPO pending Dysphagia Screen ☐If dysphagia screening is passed: ☐Allow medications with sips of water ☐Start patient diet: _____		
Treatments		
☑Neurological examination and vital signs every 15 minutes for 2 hours, then every 30 minutes for 6 hours, then every 1 hour for 24 hours, then every 2 hours thereafter. ☑Head of bed: ☐30°- 45° ☐Flat in bed for 4 hours ☑Inform physician if patient manifests: - Change in level of consciousness - Decrease in motor power - Nonreactive or non equal pupils - Onset of sever headache - Heart rate greater than 110 beats/minute or less than 50 beats/minute - Systolic blood pressure more than ___ mmHg or less than ___ mmHg - Diastolic blood pressure greater than ___ mmHg or less than ___ mmHg - □ CVP less than 5mmHg or greater than 8mmHg - □ CVP less than 8mmHg or greater than 12mmHg **in case of vasospasm** - Temperature greater than 38 degrees Celsius - ☑Assess inguinal area dressing every 30 min for two hours then every one hour for 4 hours and notify physician on call in case of any changes. - ☑Assess _____ Dorsalispedis pulse in lower every 15 minutes for the first hour then every 30 minute for second hour then every 1 hour for 3 hours and notify physician on call in case of any changes ☐ Keep _____ arterial line ☐ keep _____ central line ☑ IV hydration normal saline at a rate of ____ ml per hour		

MD Name: _____ **Signature:** _____
Date: _____ **Time:** _____ **Pager Number:** _____

Original: Medical Record
Copy: Pharmacy

~~ FAX OR SCAN TO PHARMACY ~~

February 2015 1/2 Stock #?????

Patient Name: _____ Patient Number:_____

The following abbreviations may not be used to document patient care: U IU QD QOD .X mg X.0 mg MS MSO_4 $MgSO_4$ CC µg mcg ☑ **Check the Applicable Order**	Nurse's Name & Signature	Time Noted
Treatments continued		
☐ Keep indwelling foley catheter ☐ keep nasogastric tube ☐ Apply sequential compression device (if venous duplex scan is negative for thrombosis) ☐ Keep external ventricular drain: ☐ Opened at _____ or ☐ closed and attached to continuous ICP monitor ☐ Oxygen _____ _____ Liters per minute ☐ Keep patient Intubated with the following settings: _____ ☐ Blood sugar finger sticks every __ hours. ☐Discontinue after 24 hours if patient is not diabetic ☐ Activate Adult Hypoglycemia Management Protocol		
Diagnostic Studies		
☐CT brain without contrast ☐TrascranialDopler: ☐daily☐every other day ☐start monitoring on: _____ ☐Chest X-ray ☐12 lead EKG ☐CBC, Chemistry 9, PT/PTT/INR, troponin, CK, fasting lipid profile, AST, ALT, GGT ☐Daily CBC and Chemistry 9☐☐ PT/PTT/INR every_____ hours		
Pharmacological management		
☐ Paracetamol (Perfalgan) 1 gram IV Drip every 6 hours PRN for pain ☐Pantaprazpl 40mg _____ daily ☐ Codiene ___ mg IV push every ___ hours PRN for pain ☐ Metoclopramide 10mg IV drip every 8 hours for PRN for nausea ☐phenytoin 200mg IV Drip every 12 hours ☐Depakene 400mg every 8 hours IV Drip ☐Nimpdipine (Nimotop) 60mg _____ every 4 hours ☐ Labetalol 10mg IV push over two minutes PRN every ___ min to keep ____< SBP < ____ (suggested140 to160 mmHg) ☐Nicaripine (Loxen) 50mg in a total of 500ml NSS start at a rate of 5mg per hour and titrate by 2.5mg per hour every 15 minute to keep ____< SBP <____ (suggested 140 to 160 ☐ Levophed 8mg in a total of 250ml D5W, start at a rate of 2 mcg/minute and titrate every 10 minute to keep: ☐ ____< SBP <____ (20mmHg greater than pre-op baseline) or ☐ ___<MAP <____		

Original: Medical Record
Copy: Pharmacy
January 2015

~~ FAX OR SCAN TO PHARMACY ~~

2/2

Stock # ?????

REFERENCES

Badjatia, N., Monahan, A., Carpenter, A., Zimmerman, J., Schmidt, J. M., Claassen, J., et al. (2015). Inflammation, negative nitrogen balance, and outcome after aneurysmal subarachnoid hemorrhage. *American Academy of Neurology, 84*, 680-687.

Balanzar, G. G., &Guinto-Nishimura, Y. (2014).Vasospasm in Subarachnoid Hemorrhage. *World Neurosurgery , 82* (6), 677-678.

Behrouz, R., & Sadat-Hosseiny, Z. (2015). Pharmacological Agents in Aneurysmal Subarachnoid Hemorrhage: Successes and Failures. *Clinical Neurophrmacology, 38* (3).

Blok, K., Marjorie, C. B., Hendrikse, J., Braaksma, M., Tijssen, C. C., Wong, Y., et al. (2015). CT Within 6 Hours of Headache Onset to Rule Out Subarachnoid Hemorrhage in Nonacademic Hospitals. *Neurology, 84*, 1927–1932.

Breen, D., Duncan, C., Pope, A., Al Shahi Salman, R., & Salman, R. A. (2008).Emergency department evaluation of sudden, severe headache. *Quarterly Journal of Medicine, 101*, 435-434.

Claveau, D., &Dankoff, J. (2014). Is lumbar puncture still needed in suspected subarachnoid hemorrhage after a negative head computed tomographic scan .*Canadian Journal of Emergency Medicine, 16* (3), 226-228.

Connolly, E. S., Rabinstein, A. A., Carhuapoma, R. J., Derdeyn, C. P., Dion, J., Naidech, A. M., et al. (2012, june). Guidelines for the Management of Aneurysmal Subarachnoid Hemorrhage. *Stroke*, 1-27.

Cumming, T. B., Thrift, A. G., Collier, J. M., Churilov , L., Dewey, H. M., Donnan, G. A., et al. (2011). Very Early Mobilization After Stroke Fast-Tracks Return to Walking Further Results From the Phase II AVERT Randomized Controlled Trial. *Stroke, 42*, 153-158.

Curtis, C., Balint, C., Al Hamarneh, Y. N., Donald, M., Tsuyuki, R. T., McBrien, K., et al. (2015). Online clinical pathway for managing adults with chronic kidney disease. *Canadian Pharmacists Journal*, 148(5), 257-262.

Gordon, J. M., Lorilla, J. D., & Lehman, C. A. (2012). The Role of the Clinical Nurse Specialist in the Future of Health Care in the United States. *Perioperative Nursing Clinics* , 343–353.

Grimm, J. W. (2015). Aneurysmal Subarachnoid hemorrhage: A Potentially Lethal Neurologic Disease. *Journal of Emergency Nursing, 41* (4), 281-284.

He, X. Y., Bundorf, M. K., Gu, J. J., Zhou, P., & Xue, D. (2015). Compliance with clinical pathways for inpatient care in Chinese public hospitals. *Bio Med Central Health Service Research,* 15, 459-468.

Hunt, W., & Hess, R. (1968). Surgical risk as related to time of intervention in the repair of intracranial aneurysms. *Journal of Neurosurgery, 28* (1), 14-20.

Lewis, A., & Kimberly, W. T. (2014).Prediction of ventriculoperitoneal shunt placement based on type of failure during external ventricular drain wean. *Clinical Neurology and Neurosurgery, 125*, 109-113.

McClelland, M. (2014). A Guide to Advanced Practice Registered Nurse Roles. *Med-Surg Matters.23* (4), 10-14.

Olkowski, B. F., Devine, M., Slotnick, L. E., Veznedaroglu, E., Liebman, K. M., Arcaro, M. L., et al. (2013). Safety and Feasibility of an Early Mobilization Program for Patients With Aneurysmal Subarachnoid Hemorrhage. *Physical Therapy, 93* (2), 208-2015.

Passier, P., Visser-Meily, J., Rinkel, G., Lindeman, E., & Post, M. (2013). Determinants of health-related quality of life after aneurysmal subarachnoid hemorrhage: a systematic review. *Quality of Life Research, 22*, 1027–1043.

Perry, J. J., Stiell, I. G., Sivilotti, M. L., Bullard, M. J., Hohl, C. M., Sutherland, J., et al. (2013). Clinical Decision Rules to Rule Out Subarachnoid Hemorrhage for Acute Headache. *The Journal of The American Medical Association, 310* (12), 1248-1255.

Sacco , R. L., Kasner, S. E., Broderick, J. P., Caplan, L. R., Connors , J., Culebras, A., et al. (2013). An Updated Definition of Stroke for the 21st Century A Statement for Healthcare Professionals From the American Heart Association/American Stroke Association .*Stroke, 44*, 2064-2089.

Sjöberg, P. B., Wadensten, B., Pöder, U., Nordgren, L., &Jansson, I. (2015). Factors affecting the implementation process of clinical pathways: a mixed method study within the context of Swedish intensive care. *Journal of Evaluation in Clinical Practice*, 255–261.

Steiner, T., Juvela, S., Unterberg, A., Jung, C., Forsting, M., &Rinkel, G. (2013).European Stroke Organization Guidelines for the Management of Intracranial Aneurysms and Subarachnoid Haemorrhage. *Cerebrovascular Disease, 35*, 93-112.

Rosen, D. S., &Macdonald, R. (2005). Subarachnoid Hemorrhage Grading Scales A Systematic Review .*Neurocritical Care, 2*, 110–118.

Rotter, T., Kinsman, L., James, E., Machotta, A., Gothe, H., Willis, J., et al. (2010). Clinical pathways: effects on professional practice, patient outcomes, length of stay and hospital costs. *Cochrane Database of Systematic Reviews* (3).

Thomas , L. E., Edlow , J., & Goldstein, J. N. (2009). Evidence-Based Approach To Diagnosis And Management Of Aneurysmal Subarachnoid Hemorrhage In The Emergency Department .*Emergency Medicine Practice, 11* (7), 1-28.

Young, A. H., Karri, S. K., Helmy, A., Budohoski, K. P., Kirollos, R. W., Bulters, D. O., et al. (2015). Pharmacologic Management of Subarachnoid Hemorrhage. *World Neurosurgery, 84*, 28-35.