

**EXPLORATION OF PRE-SURGICAL RISK ASSESSMENT TOOLS TO IDENTIFY  
PRESSURE INJURY RISK  
IN CARDIAC SURGICAL PATIENTS**

by

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The following individuals certify that they have read, and recommend to the Faculty of Graduate and Nursing for acceptance, a thesis entitled:

Exploration of Pre-Surgical Risk Assessment Tools to Identify Pressure Injury Risk in Cardiac Surgical Patients

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## **Abstract**

**Background:** Cardiac surgical patients are at high risk for developing pressure injuries during their perioperative experience. These injuries may have significant impacts on morbidity, mortality, quality of life and health care system costs. One strategy to prevent pressure injuries is to identify high-risk patients prior to surgery that would allow for the implementation of prevention strategies. The majority of risk assessment tools in use today were developed in acute and long-term care settings and have been found ineffective in surgical populations. New pre-operative tools that are specific to surgical patients are now available.

**Purpose:** The aim of this research study was to explore the relative predictive capabilities of the three risk assessment tools.

**Methods:** This pilot study involved a retrospective chart review conducted at St. Paul's Hospital in Vancouver, British Columbia. Three risk assessment tools were retrospectively applied in a two arm comparison, to two groups of cardiac surgical patients where one group developed pressure injuries and the other had not. Descriptive statistics and logistic regression were then applied to analyse the data.

**Findings:** Insufficient cases were available to meet the inclusion criteria for the pressure injury arm therefore the focus of the study changed to a pilot study to test the methodology alone. A group of 13 cases were identified (that closely resembled the inclusion criteria) and were used to the pressure injury study arm. A group of 24 cases were identified in the control arm (non-pressure injury) that met the inclusion criteria. The study found that although the Braden Scale Score could statistically predict a pressure injury ( $p$ -value 0.04), when compared with the two other scales there was no statistically significant difference in predictive ability.

**Implications:** These results cannot be used to inform clinical practice due to limitations but testing the methodology may help inform future research. Recommendations for future research include diversification of the study sample across multiple sites. Alternatively, if possible performing prospective data collection would help ensure consistency in assessment and data collection, and help in standardizing the pressure injury prevention strategies to compensate for a confounding variable (nursing clinical judgement).

## **Lay Summary**

Patients undergoing surgery are at high risk of developing wounds or skin problems for many reasons. These include the anesthetic that makes it impossible to move or feel pain, and patient factors such as overall health and nutrition. The goal of this study was to test three questionnaires on people prior to their heart surgery to try to identify who may be at risk for developing a wound. There were several challenges with how the study was originally designed, and therefore the study became a “pilot study” with the goal to run the study for practice and a way to learn what could be done better in a future study. When completed, this practice study found several ways the methods could be improved in a future study, and help to find ways to improve the care of patients.

## **Preface**

This thesis is an original, unpublished, intellectual product of Pamela Turnbull. The research study was conducted under the supervision of committee members: Dr. Bernard Garrett, Dr. Fuchsia Howard and Laureen Sommerey. I conducted the literature review, collected the data, and wrote Chapters 1 to 5. Design of the study was completed in collaboration with the supervisory committee. Data analysis was completed in collaboration with Alexi Rodriguez-Arelis from the University Of British Columbia Department Of Statistics. All committee members reviewed and provided Feedback on Chapters 1 to 5. Ethics approval was received from the University of British Columbia Research Ethics Board (ethics approval number H18-02556).

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Lastly, I wish to thank my family and friends. I hope they will never need to hear me say "When my thesis is done I will do (*fill in the blank*)" again.

## CHAPTER 1

### INTRODUCTION

A pressure injury (PI), also known as a bed sore, decubitus ulcer or pressure ulcer, is “a localized injury to the skin and/ or underlying tissue, usually over a bony prominence, as a result of pressure or pressure in combination with shear” (National Pressure Ulcer Advisory Panel [NPUAP], 2014, p.286). A 2004 literature review estimated that 15-30% (overall estimate 26%) of individuals in various healthcare settings in Canada, have a PI at any given time, with 70% of these injuries determined to be preventable (Woodbury & Houghton, 2004). PI’s increase the length of stay in hospital, hinder functional recovery, and increase the risk of infections and mortality (NPUAP, 2014; Institute for Healthcare Improvement, 2018). They can also cause immeasurable pain, discomfort, mental health issues with lowered autonomy, independence and security for those affected (NPUAP, 2014; Institute for Healthcare Improvement, 2018). Pressure injuries can also be very costly to health care systems. Dealy, Posnett and Walker (2012) found that healing pressure injuries can cost £1064 - £10,551 (\$1,837- \$18,200 CAD) in the United Kingdom with overall costs to the National Health System (NHS) ranging between £1.4 -£2.1 billion(\$2.3- 3.4 billion CAD) annually. The Institute of Healthcare Improvement (IHI) also found that a single full thickness PI can cost as high as \$70,000 USD (IHI, 2011).

Undergoing surgery is a known risk factor for PI development with incidence rates as high as 45% (Aronovich, 1999; Feuchtinger, Halfens & Dassen, 2005; Fred, Ford, Wagner & Van Brackle, 2012; NPUAP, 2014; Primiano et al., 2011). However, historically the actual incidence of a PI developing in the operating room has been difficult to determine due to misidentification as burns or the inability to detect an injury until (sometimes) multiple days afterward (Aronovich, 1999; Engels et al., 2016; Gendron, 1988). Due to the postulated high

incidence of this problem, there has been much research recently focussing on the prevention of PI's through strategies to alter modifiable risk factors within the surgical environment. This includes evaluations using prophylactic dressings, different support surfaces and positioning devices, and risk assessment tools. The focus of this thesis will be the latter. Risk assessment tools have been used in the non-surgical populations for several decades but recent research has shown that the surgical environment has its own unique challenges that the traditional risk assessment tools were not designed to accommodate.

### **1.1 Problem Statement**

Patients undergoing surgery are vulnerable and at high risk for the development of PI's, and evidence of the efficacy of existing PI risk-assessment tools for this patient population remains unclear. Despite recent research findings identifying the possible ineffectiveness of the existing Braden Scale for Predicting Pressure Sore Risk for predicting the risk of PI development in the surgical patient, it remains the pre-operative risk assessment tool for the St. Paul's Hospital Cardiac Surgical Program in Vancouver, British Columbia. The Braden scale is applied in the Pre-Admission Clinic, however, the calculated results are not used to guide preventative strategies intraoperatively. Instead, nursing clinical judgement is used within the operating room (OR). Several new risk assessment tools are in development that are specific to surgical patients that, if validated, may improve PI prevention for this surgical population.

### **1.2 Significance of the Study**

Surgical patients are at very high risk of PI development intraoperatively. Up to 70% of all PI's are likely avoidable but research to identify prevention strategies for this type of injury is limited within the OR setting. The NPUAP (2014) states that "failing to provide appropriate prevention strategies when an individual has been identified to be at risk of pressure ulcer

development is failure of duty of care owed by the health professional and can be deemed as negligence” (p. 44). This study tests a specific methodology to explore the value of PI assessment tools in cardiac surgical patients with the hope of informing future research into decreasing the risk of PI’s in such patients.

### **1.3 Statement of Purpose**

The aim of this research study was to explore the relative predictive capabilities of the three different risk assessment tools. Due to their prominence in the literature, established widespread clinical use and ability to be applied retrospectively, the Braden Scale for Predicting Pressure Sore Risk, Scott Triggers Tool and the Perioperative Pressure Injury Risk Assessment Measure and Intervention Protocol were the risk tools chosen for exploration.

The choice to examine risk assessment tools in the cardiac surgical population for this pilot study (and not a more varied surgical population) was solely due to the accessibility of the data for both the control and affected groups. A recent educational initiative within the Cardiac Surgical Intensive Care Unit and the Cardiac Surgical Floor has increased electronic reporting of PI’s, which enabled easy electronic identification for the pressure injury sample of the study (M. Lesage, 2017) which made this group appropriate for a pilot study.

### **1.4 Research Questions**

1. Is the Braden Scale for Predicting Pressure Sore Risk (Braden) predictive of pressure injury development for cardiac surgical patients?
2. Is the Scott Triggers Tool (Scott Trigger) predictive of pressure injury development for cardiac surgical patients?
3. Is the Perioperative Pressure Injury Risk Assessment Measure and Intervention Protocol (PPIRA) predictive of pressure injury development for cardiac surgical patients?

4. Which tool (Scott Trigger, Braden, or PPIRA) has the most predictive validity for identifying patients at risk for pressure injuries in cardiac surgical patients?

### **1.5 Hypothesis**

1. The Braden will predict pressure injury development in cardiac surgical patients more effectively than the Scott Triggers or the PPIRA.
2. The Scott Triggers will predict pressure injury development in cardiac surgical patients more effectively than the Braden or the PPIRA.
3. The PPIRA will predict pressure injury development in cardiac surgical patients more effectively than the Braden or the Scott Triggers.

In order to understand the uniqueness of the surgical environment, the following chapter will briefly outline the etiology and evolution of pressure injuries in and outside surgical environment. Following this, current literature surrounding the development of PI's and PI risk assessment prevention tools will be examined.

## CHAPTER 2

### LITERATURE REVIEW

Risk factors, mechanisms of injury, and incidence rates of PI development have been extensively studied and published in research, however there continue to be gaps. The ability to identify a high-risk patient using a risk assessment tool is one of those gaps of current interest. The following will include be a brief overview PI etiology, followed by risk factors specific to the surgical environment, and then an overview research of pre-surgical risk assessment tools.

#### **2.1 Understanding Etiology and the Evolution of a Pressure Injury**

PI's can be caused by both extrinsic and intrinsic mechanisms of injury. Extrinsic factors are those that originate from outside of the body while intrinsic factors originate from within the body. A common cause to all PI's is obviously, pressure with or without shear or moisture. Pressure (an extrinsic factor) is the force applied perpendicularly onto a surface. The soft tissue lying between a bony prominence and a surface (ex. chair or mattress) is compressed causing occlusion of local blood flow leading to tissue ischemia and necrosis of skin and subcutaneous tissues (Walton-Geer, 2009). The amount of tissue damage that occurs is directly related to the magnitude of the mechanical load (pressure) that is applied to soft tissues and may be visible at a microscopic level within minutes (NPUAP, 2014). Research has found that there may be an inverse relationship between the duration of the pressure and its intensity where low pressure over a prolonged time can damage just as high pressure over a short time can (Walton-Geer, 2009; Armstrong & Bortz, 2001).

Damage caused by pressure can manifest in two different manners. Top down injuries occur when pressure from the outside (top) damages tissue, and then injury progresses downwards from the skin surface towards the bone. The wound may be superficial or deep. Stage 1 to 4 PI's

(Appendix A) can be caused by this mechanism and may be visible very quickly (Price, Whitney, King, & Doughty, 2005). The second process manifests from the muscle layer and progresses outwards (bottom up). This occurs when pressure is extensive enough to overcome a muscle cell's tolerance level, deform the cells and cause irreversible damage which will then inhibit the ability of blood vessels to deliver oxygen and nutrients to the skin and tissue lying above the muscle (Black, Brindle & Honiker, 2015). These PI's are called deep tissue injuries (DTI) and may initially present like a Stage 1 PI (non-blanchable erythema), blood filled blisters with purple/ maroon discoloration. Over time they often progress to be Stage IV PI as the ischemic/necrotic tissue (dead tissue) sloughs. This process can take up to 10 days (Doughty and McNicol, 2016; Sewchuk, Padula & Osborne, 2006. Schoonhoven, Defloor, & Grypdonck, 2002; Black et al., 2015).

Shearing force (also extrinsic) is another mechanism of injury which occurs when force is applied at the skin surface causing bone and tissue to slide in opposite directions leading to tearing of underlying tissue (NPUAP, 2014; Walton-Geer, 2009). This occurs during patient transfers, sliding, and positioning while in bed/stretchers. Lastly, Doughty and McNicol (2016) state that moisture alone is not enough to cause skin damage, but the overhydration of skin makes it even more vulnerable to pressure, shear and friction by decreasing tissue tolerance, changing the pH of the skin, weakening of the collagen or elasticity of the skin, and removal of protective oils (Armstrong & Bortz, 2001; Walton-Geer, 2009)..

The most common presentation of a PI that has occurred intraoperatively is a DTI (Sewchuck et al., 2006; Doughty & McNichol, 2016; Aronovich, 1999; Armstrong & Bortz, 2001). Pressure (causing muscle cell damage) and shear (causing tearing at deep tissue levels) and moisture (from pooled preparation solutions beneath the patient) contribute to these PI's.

Due to the delay in symptomatology, PI's that develop during surgery can be difficult to identify and are often, as previously mentioned, misdiagnosed as burns (NPUAP, 2014; Aronovich, 1999). Observable injury caused at a deep tissue level can be visible within hours or may not show for as long as three to five days after surgery (Price et al., 2005, Aronovich, 1999; Engels et al., 2016; Gendron, 1988, NPUAP, 2014). PI's that are identified within the first 72 hours after surgery in patients who have been following an expected course of recovery are often attributed to intraoperative causes (Papantonio, Wallop, & Kolodner, 1994).

## **2.2 Risk Factors Associated with Surgical Patients**

In addition to pressure, shear and moisture there are also numerous other known risk factors that place a surgical patient at risk for a pressure injury. The following section will focus on the most common risk factors that affect surgical patients that are considered significant and have recently been incorporated into the development of newer risk assessment tools. All risk factors will not be discussed in this document, see Table 1: Extrinsic and intrinsic risk factors for pressure injury development in the surgical environment for a summary of known risk factors within the surgical environment.

**Table 1: Extrinsic and Intrinsic Risk Factors for Pressure Injury Development in the Surgical Environment**

Extrinsic	Intrinsic
Pressure	Advanced Age
Shearing	Surgical Procedure
Friction	Comorbidity
Moisture	<ul style="list-style-type: none"> <li>e.g. diabetes, stroke, cancer, cognitive impairment, cardiopulmonary disease, peripheral vascular disease, renal impairment, malnutrition, and dehydration</li> </ul>
Type of anesthesia agents	Incontinence
Sedation	Weight
Vasoactive medications	Body Size
Use or continued use of vasopressors	Nutritional status
Intraoperative temperature	ASA Score
Temperature of operative devices	Hemoglobin and hematocrit
Time immobilized before surgery	Prealbumin/Albumin
Warming devices	Alterations in sensation
Length of surgery	Skin Integrity
Type of positioning devices	Previous skin breakdown
Standard OR foam mattress	Mobility status
Type of OR bed pad or overlay	Activity level
Periods of hypotension	Body Temperature
Periods of hypoxia	
Reduced mobility on the first day post-op	
Retractors	
OR Personnel	
Negativity	
Multiple surgeries in the same admission	

(Compiled from: Armstrong & Bortz, 2006, p.652; Primiano et al., 2011; Scott 2016, Engels et al., 2016; Rao, Preston, Strauss, Stamm & Zalman., 2016, Sewchuck. Padula & Osborne, 2006)

One of the most frequently identified risk factors in the literature exploring intraoperatively acquired PI development is the length of time of a surgical procedure, where surgeries that last greater than three to four hours increases the risk (Lumbley, Ali & Tchokouani, 2014; Armstrong & Bortz, 2001; Tschannen, Bates, Talsma & Guo, 2012). However, there is still debate about exactly how much time is a risk and what the critical time point for damage is with a variation of research support times anywhere from two to 10 hours (Armstrong & Bortz, 2001; Scott, 2016; Shen, Chen, Xu, Zhang & Wu, 2015; Lumbley et al., 2014). O'Connell (2006) states that surgeries that are greater than two hours in length place a person 35-50% more at risk of tissue damage while surgeries over four hours triple the risk.

Anesthesia and medications are also a major causative risk factors for PI development. Anesthesia or medications that cause the inability for a patient to move, feel pain or alter their position while lying on a relatively firm surface resulting in the loss of a person's innate ability

to relieve pressure by shifting. In addition, medication that cause hypotension or vasoconstriction may also contribute to PI development by decreasing perfusion to vulnerable tissue and muscle (Engels et al., 2016; Armstrong & Bortz, 2001).

Other extrinsic risk factors include the time admitted to hospital prior to surgery, time immobilized before surgery (preparation time in OR), hypotensive episodes during surgery, low core temperature and reduced mobility post-operatively (NPUAP, 2014, Lumbley et al., 2014). The position of the patient, type of support surfaces, positioning devices and linen are also important and may also contribute but will not be addressed in this thesis.

Intrinsic risk factors that may contribute to the development of a PI include low body mass index (BMI) and poor nutrition (Tschannen et al., 2012; Lindgren et al., 2005; Shultz, Bien, Dumond, Brown & Myers, 1999). A patient's general health, including their co-morbidities, place a patient at risk for PI development during a surgical procedure but it is hypothesized that co-morbidities that disrupt perfusion may be the most significant (Bliss, 1999; Lumbley et al., 2014). Diabetes, hypertension, nonspecific cardiac issues, respiratory disease, renal disease and smoking have been found to be significant (Lumbley et al., 2014; Feuchtinger et al., 2006; Larson, Hudak, Waring, Orr & Simonelic, 2012; Shultz et al., 1999; Liu, He & Chen, 2012). In fact, Lewicki, Mion, Splane, Samstag & Secic, (1997) predict that diabetics are three times as likely to develop PI's compared to non-diabetics. Co-morbidities are reflected in the American Society of Anaesthesiologists (ASA) status score which is calculated by the Anaesthesiologist pre-operatively. It is a subjective score based on patient condition and co-morbidities that is calculated on a scale of I to V where the lower the number the healthier the patient. (Daabis, 2011). The ASA Score has been found to strongly predict for greater intraoperative blood loss, post-operative resource utilization, morbidity and mortality (Daabis, 2011; Koo, Hyder,

Wanderer, Eikermann & Ramanchandran, 2015). During a literature search in 2005, Scott and Buckland found that the higher ASA score was associated with PI development and suggest that ASA score is more appropriate to predict PI's due to the perioperative environment.

There are numerous pre-surgical risk assessment tools in use worldwide with various amounts of identified validity (Braden, Waterlow, Norton, etc.). However, the most commonly used risk assessment tools (RAST's) were developed for use across a variety of health care settings and have not been developed considering factors unique to a surgical environment.

### **2.3 Risk Assessment Tools in the Surgical Environment**

Many PI prevention guidelines now recommend the use of RAST's to predict PI development (ex. National Pressure Ulcer Advisory Panel, European Panel Ulcer Advisory Panel, National Institute for Health and Care Excellence, etc.) however research has not been able to conclude that the use of RAST's actually decrease PI incidence (Moore & Cowman, 2014; Pancarbo-Hidalgo, Garcia-Fernandez, Lopez-Medina & Alvarez-Nieto, 2006). A 2019 Cochrane Review found only two studies that met the specified criteria for review. With low or very low certainty of evidence, neither of these studies could support the use of structured and systematic use of RAST's (Moore & Cowman, 2019). Another systematic review did not find any studies assessing pre-operative interventions (like RAST's) that could be initiated in the Pre-Admission Clinic to decrease the risk of PI's in older cardiac surgical patients (Ettema, Van Koeven, Peelen, Kalkman and Schuurman, 2014).

Overwhelmingly, research has identified the need for the development of effective RAST's that are specific to the surgical environment (NPUAP, 2014, Ettema et al. 2014; Aloweni et al., 2018; Defloor & Grypdonck, 2004). Having surgery alone is now an acknowledged risk factor for PI development. There are many factors that are unique to the surgical environment that are

not considered or accounted for when applying the more traditionally accepted RAsT's (e.g. the Braden). Although some widely used RAsT's are still applied pre-operatively, there are several new ones under development.

Interestingly, despite lack of research supporting the use of RAsT's in the surgical area, The Association for periOperative Registered Nurses (AORN) has stated in a 2016 position paper that a collaborative relationship for PI prevention, with risk assessment and communication strategies, must be in place across all surgical phases to prevent injuries for all surgical patients (AORN, 2016). This includes PI education yearly, and notification of PI's to surgical staff upon occurrence (AORN, 2016). AORN has now dedicated a page on its website to PI prevention and recommends two pre-surgical risk assessment tools (Scott Triggers Tool and the Munro Pressure Ulcer Risk Assessment for Perioperative Patients for Adults) that are currently being developed.

For the purpose of this thesis, three RAsT's were applied retrospectively to a specific study population. The RAsT's included the Braden, The Scott Triggers, and the Perioperative Pressure Injury Risk Assessment and Prevention Protocol. See Table 2: Summary of risk factor variables in three risk assessment tools for a summary of the risk factors included within each tool.

**Table 2: Summary of risk factor variables in three risk assessment tools**

<b>The Braden</b>	<b>Scott Triggers</b>	<b>PPIRA</b>
Sensory Perception	Age 62 or older	Previous Surgery
Moisture	Albumin level < 3.5g/L or BMI <19 or > 40	Diabetes
Activity	ASA score 3 or greater	Braden Score ≤ 16
Nutrition	Surgical time over 3 hours or 180 minutes	Age ≥ 70
Friction and Shear		Pre-existing pressure injury
		Surgical time greater than 5 hours

### **2.3.1 Braden Scale for Predicting Pressure Sore Risk**

The Braden (Appendix B) was developed in 1987 for individuals in acute and long-term care settings (He, Liu & Chen, 2012). Globally, it is one of the most widely used RAsT's due to its ease of use (few questions and minimum time to complete), however, its sensitivity and specificity vary greatly depending on the care setting and characteristics of the patients (Park, Choi & Kang, 2015). The Braden assesses and assigns a score for six areas of risk including mobility, activity, sensory perception, moisture, nutrition, friction and shear (Lewicki, Mion, Secic, 2000). The total score identifies the level of risk that a patient may have for PI development ranked from no risk to high risk. The Braden does not include a care plan or communication tool as some other risk assessment tools do.

A systematic review by Pancarbo-Hidalgo et al. (2006) found that although PI incidence did not go down with the use of any RAsT (Braden, Norton Scale, or Waterlow Scale and clinical judgement), the use of the Braden brought up the intensity and effectiveness of other interventions when compared to other RAsT's. Defloor and Grypdonck (2005) found that the effectiveness of the Braden was very low and its use increased workload and had financial implications (80% of patients were receiving unnecessary preventative interventions). However, they also felt that although the effectiveness of the RAsT was poor, it was better than nursing clinical judgement alone (Defloor & Grypdonck, 2005).

Although the Braden Scale is one of the most common RAsT's used worldwide, it was not developed to predict PI development in surgical patients and has been shown to have minimal predictive value for this population (Price et al., 2005; Scott, 2005; Lewicki et al, 1997; He et al., 2012). In a study in Turkey, 84 patients, who were greater than 20 years old and undergoing elective surgery that would be over two hours in length, were found to be at no risk

of developing a PI based on a pre-operative Braden Scale screening but 54.8% went on to develop a PI (Karadag & Gümüşkaya, 2006).

### **2.3.2 Scott Triggers Tool**

Unlike the Braden, the Scott Triggers (Appendix C) was developed to specifically target the surgical population. This tool was first published in 2015. It was developed based on a secondary analysis of a study the author performed in 2005 called “Perioperative Pressure Ulcer (PPU) Assessment and Prevention Efficacy Study of a Multilayer Pressure Re-distribution Pad in the Operating Room” (Scott, 2015). It incorporates 4 risk factors found to be significant for surgical patients including age greater than 62 years, an ASA greater than 3, low albumin, and surgery time over 180 minutes (Scott, 2015). Although the tool has not been validated, with promising results it has been incorporated into several research studies and quality improvement projects with positive results (Scott, 2015). It was also added to the AORN toolkit in 2016. Unlike the RAsT that is discussed next, the Scott Triggers (or the Braden) do not incorporate a communication tool or preventative bundle but simply assigns a risk score. However, although not patient specific, the author suggests implementation of operating room specific “skin bundles” that would include interventions such as assessment of the skin pre- and post-operatively, safe patient handling, standardized high quality operating room surfaces and redistribution/ offloading devices, use of protective dressings, maintenance of normothermia and microclimate, and handoff communication (Scott, 2016).

### **2.3.3 Perioperative Pressure Injury Risk Assessment and Prevention Protocol**

And lastly, another promising tool in development is the Perioperative Pressure Injury Risk Assessment and Prevention Protocol (PPIRA) by Meehan, Beinlich and Hammonds (2016) (Appendix D). This RAsT was developed by nurses as a quality improvement project within

their own hospital. The protocol consists of a six-item risk indicator assessment which includes previous surgery during this admission, history of diabetes mellitus, Braden less than 16, age greater than 70 years, existing PI and surgical time over five hours (Meehan et al., 2016). The nurses found that this tool reduced PI's by 60% reduction within their facility when comparing a retrospective sample using standard PI prevention measures to a prospective sample which underwent evaluation with the PPIRA tool (Meehan et al., 2016). Although this study identified several limitations, their significant reduction in PI's has led to further investigations of the tool at other sites (Meehan et al., 2016).

## **2.4 Summary**

Although RAsT's in general do not have a large and conclusive body of research to support their effectiveness when used alone, their use in combination with PI prevention strategies may still have clinical benefits. Overall, in the surgical environment, the Braden has been shown to have low predictive value, however, its use is better than using nursing clinical judgement alone (He et al., 2012, Karadag & Gümüşkaya, 2006; Defloor & Grypdonck, 2005). Newer RAsT's, such as the Scott Triggers and PPIRA are promising due to their surgical population specificity, and in the case of the PPIRA, inclusion of PI prevention planning.

The next chapter will describe the research methodology employed in this thesis. This will include the description of the theoretical framework, research design, study setting, sampling plan, inclusion and exclusion criteria, and access to records, data collection, data analysis and ethical considerations.

## CHAPTER 3

### METHODS

#### 3.1 Theoretical Framework

The primary theoretical framework for this research is an evidence-based practice (EBP) approach. Garrett (2018) states that EBP:

Represents the collection, interpretation, and integration of valid, applied empirical experience from research- derived, clinician-observed and patient reported evidence. The aim being that the best available evidence, cost-effectiveness, practical patient circumstances and preferences are all considered decisions to maximize the care delivered. (p. 119).

An EBP approach was adopted to establish evidence to identify the value of specific RAsT's in predicting the formation of PI's during the perioperative period for surgical patients. These RAsT's tools use previously established risk factors for PI development (age, mobility, nutrition, pre-existing conditions, surgical time, overall health, etc.) theorizing that the likelihood of PI development can be predicted and therefore prevented (He et al., 2012; Pancarbo-Hidalgo, et al., 2006). Having the ability to prevent injuries, based on evidence, will improve overall care for patients and prevent more health-related complications and decrease the costs to the healthcare system

#### 3.2 Research Design

In this study, a quantitative retrospective chart review was completed to compare the ability of the Braden, Scott Triggers, and PPIRA RAsT's to predict PI development in cardiac surgical patients. Each RAsT was retrospectively applied to a group of patients who had developed a PI in the perioperative period (symptomatology developed within 72 hours post-

surgically) and compared to a similar group of patients who had not. The purpose of the study was to assess whether one RAsT could more accurately predict PI development than the others.

### **3.2.1 Study Setting**

St. Paul's Hospital (SPH) is a 450-bed urban tertiary teaching hospital located in Vancouver, British Columbia. It is affiliated with the University of British Columbia and participates in research in order to ensure best practice. SPH is a centre for excellence and is the designated Heart Centre for British Columbia where it works in collaboration with local and provincial partners to improve heart health for all British Columbia residents (Providence Health Care, 2018). SPH performs over 1100 emergent or planned cardiac procedures per year (Providence Health Care, 2018). Due to recent quality improvement initiative (involving extensive education), the SPH Cardiac Surgical Intensive Care Unit (CSICU) and Cardiac Surgical Floor (5B) had the highest compliance rates for health care professionals to complete British Columbia Patient Safety Learning System (BCPSLS) reports for PI occurrence. The BCPSLS reports are voluntary reports completed by health care professionals to report patient safety events, near misses and hazards including pressure injury development (BC PSLs, 2018). At time there is no accurate data reflecting PI incidence at St. Paul's Hospital due to the lack of a mandatory reporting system. Some PI's may be reported in physician discharge summary dictation but most are not reported. Although heavily encouraged, the BCPSLS is a voluntary reporting system dependent on front line staff.

### **3.2.2 Access to Records and Ethical Considerations**

- Ethics approval was obtained from the University of British Columbia and Providence Health Care Research Ethics Boards (REB) for Human Ethics. Due to the nature of retrospective chart reviews, there are minimal risks to the patient's under evaluation.

Following REB approval, permission was also obtained from the following:

- Barbara Hall, Patient Care Manager, Cardiac Surgery (Temporary Director)
- Providence Health Care – Health Information Management. Sharon Penney

All personal information was removed from data collection and each patient was given a non-identifying code for analysis purposes. The data was kept on a password protected, PHC computer in a locked office. Data will be kept for five years by Dr. Bernie Garrett and then destroyed as per Research Ethics Board policy.

### **3.2.3 Sampling Plan**

A retrospective, non-probability, convenience sample was obtained from patient medical records. Data was collected comparing two groups who had undergone cardiac surgery. The groups compared were those who developed PI's within 72 hours after surgery and those who did not between the dates of January 1, 2016 – October 31, 2018.

After REB approval had been obtained, 69 BCPSLS potential PI reports were identified by the PHC Quality and Patient Safety Team using the following search criteria:

- Clinical Unit: CSICU or 5B
- Reports categorized as “wound/skin injury”

A hundred non-PI cases were then randomly generated by the Providence Health Care Advanced Analytics and Decision Support Team through the Patient Care Information System (PCIS) for the following surgeries that are in the supine position and greater than two hours at length.

- Aortic valve replacement
- Aortic valve replacement REDO (repeat)
- Aortic valve replacement & CABG (coronary artery bypass graft)

- Aortic valve replacement & CABG REDO
- Mitral valve replacement & CABG
- Mitral valve replacement & CABG REDO
- Aortic & mitral valve replacement REDO
- Ascending aortic replacement
- Aortic arch replacement
- Aortic/mitral/ tricuspid valve replacement
- Aortic/ mitral/ tricuspid valve replacement REDO
- Aortic root replacement (Bentalls)
- Aortic root replacement REDO – (Bentalls)
- Aortic valve replacement & mitral valve repair
- CABG x 3 & LIMA (Left Internal Mammary Artery) / RIMA (Right Internal Mammary Artery)
- CABG x 3 LIMA/ RIMA REDO

All cases were then entered into PCIS for data collection by the researcher. After access was granted, all charts were reviewed to determine which would meet the study criteria.

**Inclusion Criteria:**

The inclusion criteria for this pilot study will include patients who:

- Underwent cardiac surgeries between January 1, 2016 to October 31, 2018
- Had charts containing documentation of all required data outlined in data collection/appendix E
- Underwent a cardiac surgical procedure in the supine position
- Had elective surgery with same day admission

- Required general anesthetic
- 18 years or older
- Apart from the PI, experienced an uncomplicated post-surgical recovery

**Exclusion Criteria:**

Charts that have the following characteristics will be excluded from the study:

- Deviation from expected post-surgical trajectory (unable to reposition/turn within three hours, hemodynamic instability, open chest, etc.)
- PI has developed greater than 72 hours after surgery
- Pre-existing PI

**3.2.4 Data Collection**

All data collection was completed by the Pam Turnbull (co-investigator). All data was collected onto an excel spreadsheet and records given unique identifiers to prevent patient identification during the analysis. The “data key” and the raw data are kept on a PHC desktop, password protected compute on a personal drive within the system that is only accessible by the researcher. Once all data was collected, a copy was made where all identifying variables were removed. This was provided to the statistician for data analysis. Please see Appendix E for Data Collection Tool that outlines all variables collected within the study.

After the study completion, all data was transferred to Dr. Bernie Garrett (primary investigator) at the University of British Columbia and will be kept for 5 years. Data collected and currently stored on the PHC password protected personal computer hard-drive will be deleted.

### 3.2.5 Data Analysis

Data analysis began by cleaning and screening the spreadsheet data. All variables were complete for the 37 cases with no missing data. With the assistance of Alexi Rodriguez-Arelis from the UBC Department of Statistics, descriptive statistics were completed to describe the sample characteristics.

Initially, contingency tables were completed for each of the three RAsT's (Braden, Scott Triggers, and the PPIRA) to compare whether there was an association between the risk tool's ability to predict a PI or not. The next step was to use software R to run Fisher's exact tests or Pearson's Chi-squared tests on the data to determine if there was a statistical association between a PI condition and the predictive test or not.

Finally, it was determined that logistic regression would be the appropriate method for modelling and prediction assessment due to the discrete and binary type of categorical response related to PI condition. Logistic regression was used to predict the probability of occurrence of PI given estimated parameters associated to one or more covariates, e.g., one of the aforementioned RAsT's. Confusion matrices were then used to compute the sensitivity (true positive) and specificity (true negatives) of the tools which were then used to formulate receiver operating characteristic (ROC) curves. The ROC curves are used to determine which tool has the best predictive performance based on which has the larger value under the curve (Rodriguez-Arelis, 2019).

## **CHAPTER 4**

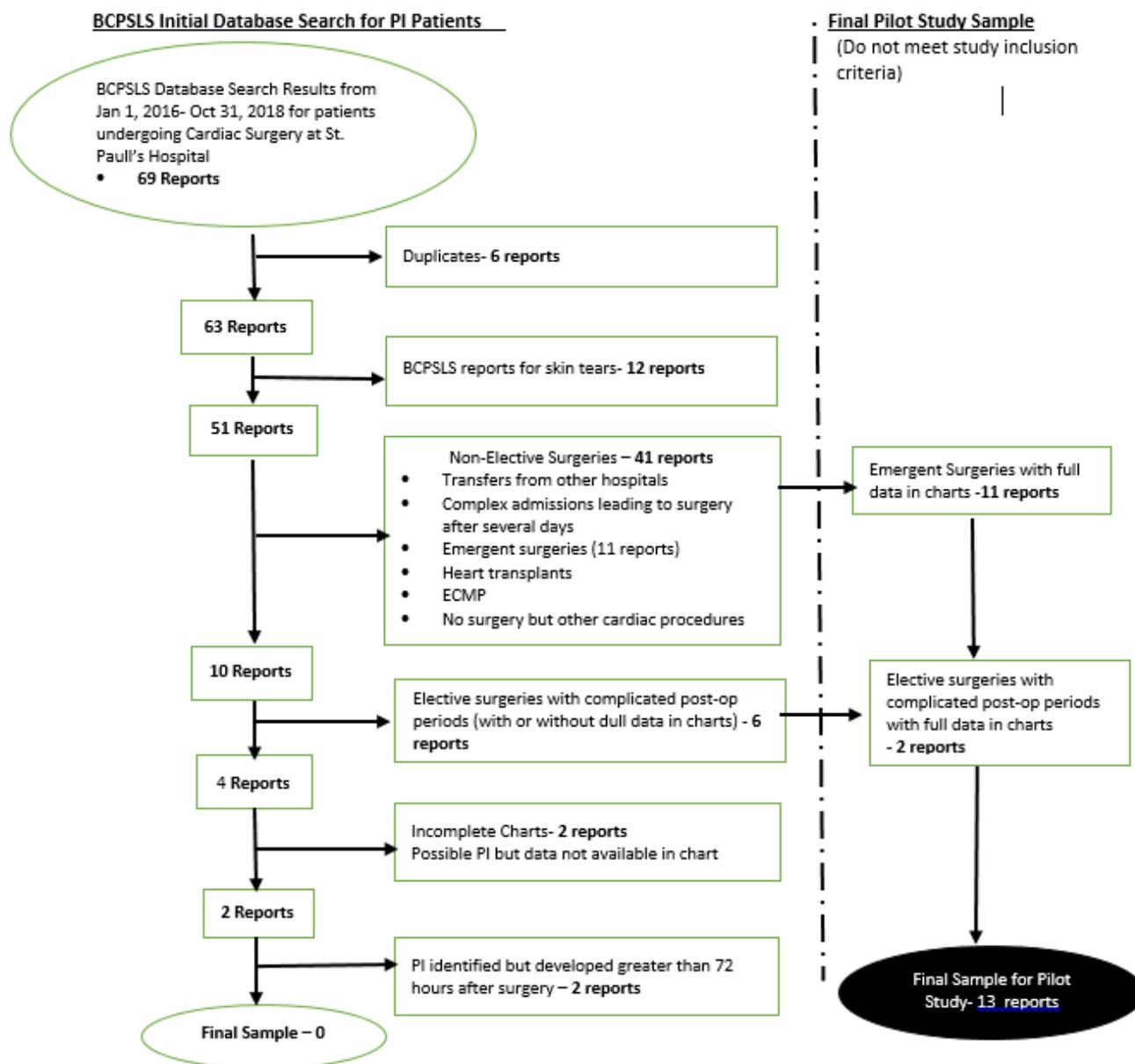
### **RESULTS**

Unfortunately, the research questions for this study were not completely answerable due to a lack of cases that met the inclusion criteria for the PI group. However, as a pilot study, this work was completed by adapting the selection criteria to use excluded cases in order to test the methodology as this would still help inform future research. Therefore, as a pilot study and methodological test, the results are described as follows.

#### **4.1 Sample Selection Adjustment**

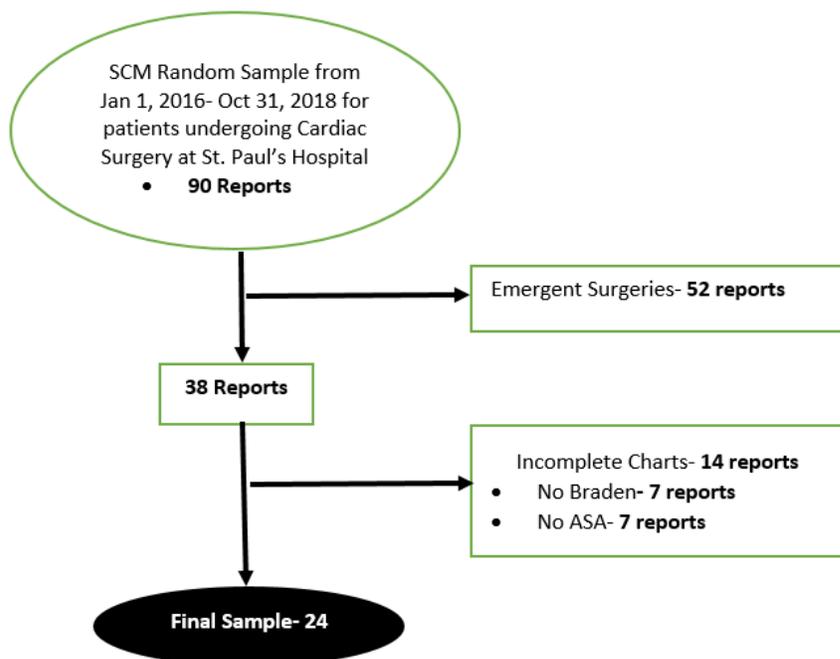
After review of the charts identified in the potential PI development group from BCPSLS data, it was found that no cases met the inclusion criteria. However, for the purposes of this study, 13 cases were identified that met the majority (but not all) of the inclusion criteria, and were used to test the methodology. Of the 13 cases, 11 were included despite being of emergent nature and 2 were included despite the patients having complicated post-operative periods making it difficult to determine when a PI could have developed (Figure 1). The “control” or “non-PI development” sample did meet the selection criteria and consisted of 24 of the 100 reviewed cases.

**Figure 1: Pressure injury development arm: Sample selection**



**Figure 2: Non- pressure injury development arm: Sample selection**

**Sunrise Clinical Manager (SCM) Database Search for Non-PI Patients**



#### 4.2 Descriptive Statistical Analysis

The first step of data analysis completed was the calculation of descriptive statistics or contingency tables for the two groups (PI and Non-PI patients). See Table 3 for overall, combined sample statistics. Table 4 displays results comparing the PI group to the non-PI group. When comparing the groups, the PI group was slightly older with a mean of 72.62 years compared to 68.50 (Figure 3). They also had slightly lower BMI's (Figure 4) and pre-operative Braden Scores (Figure 5) than the non-PI group. The PI group also had a longer surgical times (Figure 6) and higher ASA scores (Table 5). Interestingly, and likely expected, the PI group had higher ASA scores (all IV or higher) indicating severe systemic disease that is a constant threat

to life while the non-PI group had several patients that were not as ill prior to surgery with scores of III.

**Table 3: Overall descriptive statistics for the total sample of PI and non-PI patients (N = 37)**

	Mean	Median	Std. Dev.	Range
Age (years)	69.95	71	7.67	56-83
BMI	26.59	26.4	5.82	17.90-46.85
Pre-op Braden	19.32	20	3.82	9-23
Surgical Time (min)	315.16	289	111.54	174-714

**Table 4: Summary statistics by pressure injury development**

Covariate	Mean		Median		Std. Dev.		Range	
	PI	Non-PI	PI	Non-PI	PI	Non-PI	PI	Non-PI
Age (years)	72.62	68.5	74	68	8.09	7.2	57-82	56-83
BMI	24.12	27.93	23.04	27.35	4.11	6.23	17.9-31.07	19.27-46.85
Pre-op Braden	17.08	20.54	18	20.5	5.33	1.89	9.23	17.23
Surgical Time (min)	341.54	300.88	296	271	141.31	91.91	174-714	179-550

**Table 5: Summary of ASA scores by pressure injury development**

ASA Score	Pressure Injury Group	Non-Pressure Injury Group
I	0	0
II	0	0
III	0	5
IV	4+ 8*	19
V	1*	0
VI	0	0

ASA I: normal healthy person

ASA II: mild systemic disease

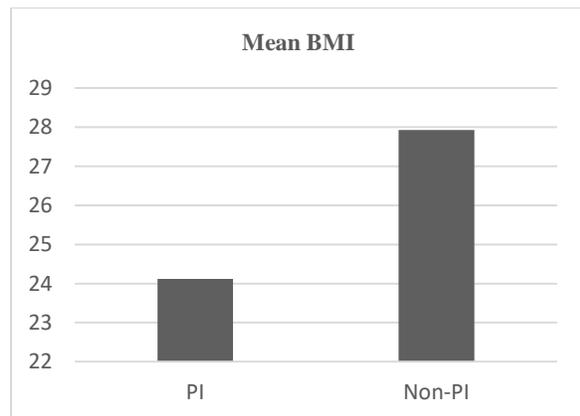
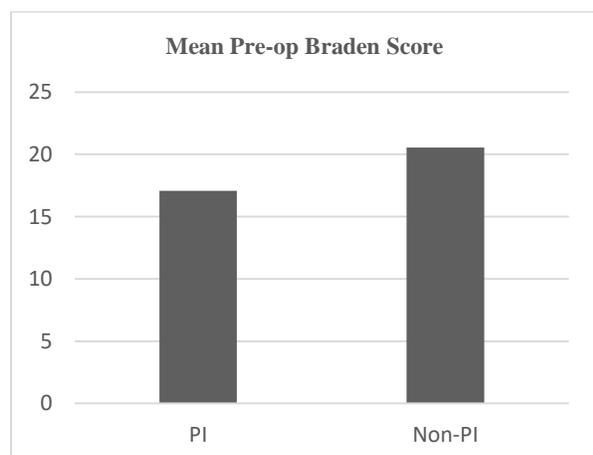
ASA III: systemic disease

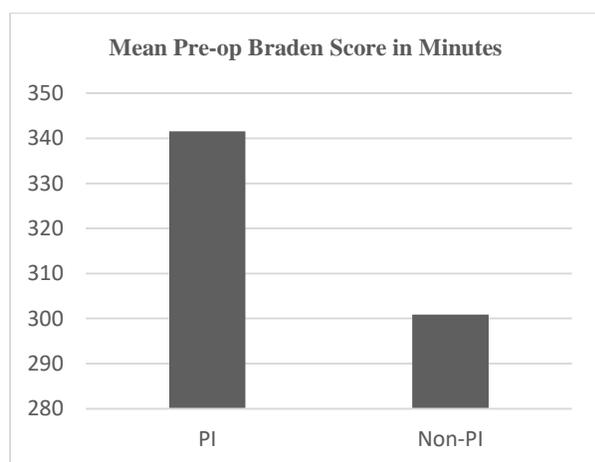
ASA IV: severe systemic disease that is a constant threat to life

ASA V: not expected to survive surgery

ASA VI- brain dead organ donor

\* addition of "E" denotes Emergency surgery

**Figure 3: Comparison of mean age****Figure 4: Comparison of mean BMI****Figure 5: Comparison of mean pre-operative Braden Score**

**Figure 6: Comparison of mean total surgical time**

Overall, although inferential testing was not carried out, it appears that those that developed a PI were older, had lower BMI, lower pre-operative Braden scores, and longer surgical times than those who did not. There was also a higher percentage of patients in the PI groups who had diabetes and were smokers compared to the non-PI groups. Overall, less women had cardiac surgery with 85% of those developing a PI being male (see Tables 6-8).

**Table 6: Contingency table for sex**

Gender	PI	Non-PI	Total
Female	2	8	10
Male	11	16	27
Total	13	24	37

**Table 7: Contingency table for smokers**

Smoker	PI	Non-PI	Total
No	7	17	24
Yes	6	7	13
Total	13	24	37

**Table 8: Contingency table for diabetics**

Diabetes	PI	Non-PI	Total
No	6	14	20
Yes	7	10	17
Total	13	24	37

### 4.3 Inferential Statistical Analysis

#### 4.3.1. Cross- Tabulations (Pearson's Chi-Squared or Fisher's Exact Tests)

In order to answer the research questions for this study, statistical testing was required in a step-wise approach. The research questions that were being attempted to answer were again as follows:

1. Is the Braden Scale for Predicting Pressure Sore Risk (Braden) predictive of pressure injury development for cardiac surgical patients?
2. Is the Scott Triggers Tool (Scott Trigger) predictive of pressure injury development for cardiac surgical patients?
3. Is the Perioperative Pressure Injury Risk Assessment Measure and Intervention Protocol (PPIRA) predictive of pressure injury development for cardiac surgical patients?
4. Which tool (Scott Trigger, Braden, or PPIRA) has the most predictive validity for identifying patients at risk for pressure injuries in cardiac surgical patients?

First, contingency tables were completed for each risk assessment tool (see Tables 9-11). Each of these tools was then evaluated using Pearson's Chi-squared or Fisher's exact tests (see Table 11). Of the three tools, only the Braden Scale Score showed a statistically significant ability to predict a PI with a  $p$ -value of 0.04.

**Table 9: Contingency table for Braden**

Covariate\ Response	PI (1)	Non- PI (0)	Total
Predicted PI (1)	3	0	3
Non-Predicted PI (0)	10	24	34
Total	13	24	37

**Table 10: Contingency table for Scott Triggers Risk Assessment Tool**

Covariate\ Response	PI (1)	Non- PI (0)	Total
Predicted PI (1)	13	24	37
Non-Predicted PI (0)	0	0	0
Total	13	24	37

**Table 11: Contingency table for PPIRA**

<b>Covariate\ Response</b>	<b>PI (1)</b>	<b>Non- PI (0)</b>	<b>Total</b>
Predicted PI (1)	13	19	32
Non-Predicted PI (0)	0	5	5
Total	13	24	37

**Table 12: Statistical tests by risk assessment tools**

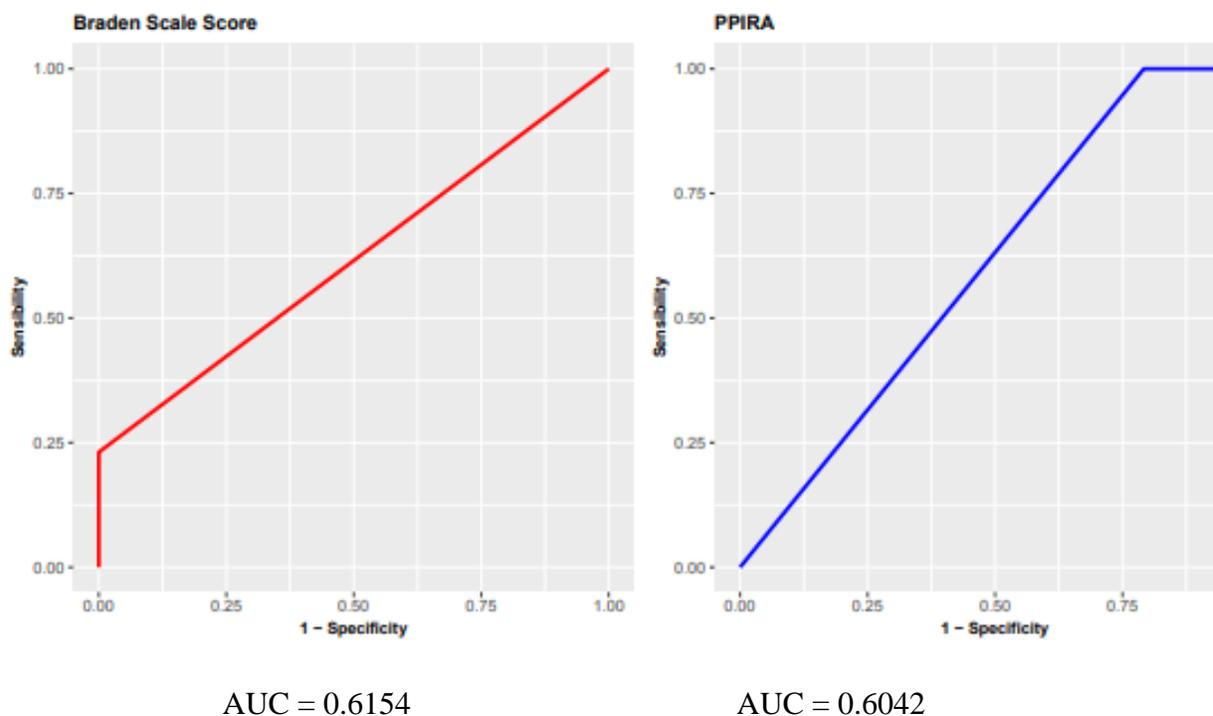
<b>Risk Assessment Tool</b>	<b>Test</b>	<b>p-value</b>	<b>Conclusion</b>
<i>Braden Scale Score</i>	<i>Fisher's exact test</i>	0.04	Reject the null hypothesis
<i>Scott Triggers Risk Assessment Tool</i>	<i>Pearson's chi-squared test</i>	0.07	Fail to reject the null hypothesis
<i>PPIRA Measure and Intervention Protocol</i>	<i>Fisher's exact test</i>	0.014	Fail to reject the null hypothesis

### 4.3.2 Logistic Regression

The next step of statistical evaluation of the data was to use logistic regression to predict the probability of occurrence of PI given estimated parameters associated to each one of the risk assessment tools. Unfortunately, the Scott Triggers Tool did not predict any cases of PI, and therefore this testing could not be applied.

Confusion matrices were then used for each risk tool in order to determine their sensitivity (True Positive Rate) and specificity (True Negative rate) which were then plotted in a receiver operating characteristic (ROC) curve (Figure 2). The larger value of the area under the curve (AUC) reflects better predictive performance of the tool (Rodriguez- Arelis, 2019, page 3). To compare the two RAsT's, the Delong Statistical Test is used to determine significance. In this case, there was no statistical significance that one risk assessment tool was better than the other.

Figure 7: ROC Curves by risk assessment tools



AUC = 0.6154

AUC = 0.6042

DeLong test  $p=0.88$

When the data analysis was complete it was evident that there were many ways a new study could be designed in order to explore this subject further. Not only could the design be improved, but the limitations of the study are now better understood. The next chapter will discuss these issues further.

## CHAPTER 5

### DISCUSSION

#### 5.1 The Findings

As a pilot study, although the results must be examined with extreme caution, some findings are of interest and may be significant if replicated using a more robust methodology. The findings also assist in informing the development of future work.

The first point of interest from this study relates to the choice of surgical population to study. The cardiac surgical population at SPH enabled easier data collection but unfortunately an inadequate sample was obtained for the PI group. This surgical population is very homogenous and narrow therefore had little variability and identified an insufficient sample. In order to allow the study to move forward, some PI group cases needed to be included in order to provide a sufficient sample.

When reviewing the ability of each RAsT's individual ability to predict a PI using inferential statistics it is interesting to note that the Braden was found to have the highest predictive ability ( $p=0.04$ ), followed by the Scott Triggers ( $p=0.07$ ) and then the PPIRA ( $p=0.14$ ), despite being the only tool that was not designed specifically for cardiac surgery patients. When logistic regression was applied to compare the Braden with the PPIRA, despite the Braden appearing to be the better tool after the initial inferential statistics were applied, it appeared there was actually no statistical difference in the predictive ability of all of the RAsT's tested.

The Scott Triggers, in particular, is interesting to review because it over-predicted the development of PI's (all 37 cases were considered high risk- see Table 9), therefore leading it to not be statistically testable with logistic regression against the other RAsT's. When trying to

understand why this tool could have over predicted the development of PI's it could be for several reasons. Firstly, perhaps the variables within the study require some revision in order to not over predict PI development. For example, the age specified for high risk is over 62 compared in the Scott Triggers compared to greater than 70 in the PPIRA (Braden does not use age as a variable). The Scott Triggers also identifies those with an ASA score of III (systemic disease) or surgery lasting over 180 minutes as at risk but these may be too strict. In comparison to this tool, the Braden does not have any surgically specific factors but was able to correctly predict that 24 of 37 cases would not develop a PI while the Scott Triggers conversely predicted that 24 of 37 cases would develop a PI that in fact did not.

The second issue relates to the perceived over prediction of PI's in this study may not be related to the tool but the choice of study population. Cardiac surgical patients by nature are sicker and have more co-morbidities than many other surgical patients. In fact, all cases in the PI arm had an ASA score of IV or above and the Non-PI arm were III and above. At best, all of these individuals had systemic disease but the majority of cases had severe systemic disease that was a constant threat to life. This may support the recommendation to study a more diverse surgical population with varying pre-surgical health status where the study population is not the sickest of the sick.

## **5.2 Gaps in Research: Risk Assessment Tools**

There are several challenges in investigating the effectiveness of RAsT's. The first is that nursing clinical judgement and subsequent actions may be a confounding variable. Moore and Cowman (2019) found that many studies did not include or control for preventative interventions that had been initiated by nurses based on their judgement, rather than on the basis of RAsT's. These interventions could influence an assessment of the predictive ability of a tool. In fact,

several studies have found that when nurse's clinical judgement was used to determine preventative strategies, as high as 80% of patients had unnecessary preventative measures initiated, or conversely may have had insufficient preventative measures implemented (Defloor & Grypdonck, 2005; Garcia-Fernandez, Pancorbo-Hidalgo, & Soldevilla Agreda, 2014; Moore & Cowan, 2019). Numerous studies also agree and recommend, that although RAsT's are not perfect, the use of validated tools should be used instead of clinical judgement alone, especially for inexperienced staff (Garcia-Fernandez et al., 2014; Defloor & Grypdonck, 2005; Pancorbo-Hidalgo et al., 2006). Pancorbo-Hidalgo et al. (2006) found that although the use of RAsT's alone do not decrease the incidence of PI's, their use "increases the intensity and effectiveness of prevention interventions" (p.94).

Another element that may confound research into RAsT's use and effectiveness is the lack of established PI prevention care plans that can be implemented based upon the RAsT results (Johansen, Moore, van Eten & Strapp, 2014). Many RAsT's may identify a patient as high risk but, unfortunately, in many cases there is no corresponding standardized prevention plan/protocol to guide the development of an individualized care plan. Prevention measures are often left up to the nurse's clinical judgement. For example, the widely used Braden score provides only a risk score with no prevention however, although not standardized, a nurse could make a care plan based on the Braden sub scores (Tescher, Branda, Byrne & Naessens, 2012).

### **5.3 Limitations**

There were many limitations to this study. One limitation of the study was the choice of study population. Cardiac surgical patients, by nature, are essentially homogenous when it comes to pre-operative risk factors including high pre-operative ASA Scores, age and co-morbidities. Essentially, all patients in this study were found to be at high risk for PI development for both

the Scott Triggers Tool and the PPIRA, while none of them were found to be at risk pre-operatively when assessed with the Braden. In addition, although emergency surgery or pre-operative admission to hospital should remain an exclusion due to the increased risk of PI development, the majority of cases used for evaluation in this study were admitted for emergent procedures which should have been excluded from this study.

Furthermore, the nature of a retrospective chart review also presented a limitation in terms of data access, because many important data variables were not available for data collection. Most frequently, this included variables such as pre-operative Braden and the ASA scores. Charts with incomplete data were excluded from this study.

Another limitation of this study was the sample size and selection, and although this was a pilot study, there were challenges finding an adequately-sized sample population to study due to the nature of the selected study population, inclusion and exclusion criteria, and missing data in the charts reviewed. Lastly, it is unknown what other factors might have contributed to the prevention or the development of PI's in the perioperative setting due to the lack of a standard pressure injury prevention program and the reliance of nurse's individual clinical judgement. For example, current practice by OR nurses is to use clinical judgement to decide on the appropriate support surface and PI prevention devices. These devices or interventions were not documented in the chart and could not be collected in this study therefore no data analysis could be completed and the variability of practice is unknown. This would seem to indicate significant issues in the standardization of PI assessment processes and protocols and in their documentation in practice.

## CHAPTER 6

### CONCLUSION

The purpose of this study was to examine and potentially identify which of three RAsT's could most accurately predict the development of a pressure injury during cardiac surgery. Unfortunately, due to the insufficient cases identified that met the inclusion criteria, I was unable to fully test the hypothesis of this study. However, when re-visiting the research questions and analyzing the data, only the Braden Scale Score showed a statistically significant ability to predict a PI when looked at individually. When the three tools were compared to each other no significant differences were identified between them regarding their accuracy to predict PI development.

From the outset of data collection, methodology issues were identified but despite this, many valuable insights were obtained from the study that could inform future research into pre-surgical risk assessment tools. In addition, although the results cannot be used to actually evaluate the RAsT's selected here or recommend changes to current practice, they do suggest that the predictive ability of RAsT's is worth evaluating further, in order to potentially improve clinical practice and decrease negative outcomes associated with PI development.

#### **Implications/ Recommendations for Future Research**

The first implication for future research would be to identify a larger sample, possibly by using multiple sites, or a more diverse population. This study was unable to acquire sufficient cases to examine, which was predominantly a result of the specific inclusion and exclusion criteria of the design. A more diverse study population with varied pre-surgical health status would allow the RAsT's to be applied on a wider range of individuals. The cardiac population chosen were, by nature, very ill and often underwent surgery for an emergent and not elective

reason. Unfortunately, this meant that PIs that developed during the perioperative setting remained difficult to identify. By continuing to exclude factors that may promote a PI (pre-surgical “down-time”, CPR, prolonged waiting in the hospital unit for investigations or OR time, etc.) it would also be easier to determine if a PI developed during surgery compared to pre or postoperatively.

The second recommendation for future research into RAsT’s would be to design a prospective study. A prospective trial would be beneficial for two reasons. The first reason a prospective trial would be beneficial is that a pressure injury prevention plan/ bundle could be developed and implemented that could be triggered when a high-risk patient has been identified through a RAsT. This prevention plan/ bundle could also decrease the variability that occurs in current practice that generally results from the implementation of individual nurse’s clinical judgement. We know completing a RAsT alone would not change the outcome of a PI developing without a corresponding preventative action to assist with practice therefore a prospective trial would enable the development and implementation of a standardized pressure injury prevention plan. Not only would this decrease the variability of current practice that is based on nursing judgement, it would enable the researchers to ensure the protocols being studied were as homogenous as possible and limit the confounding variables.

The second reason is that in a prospective trial, standardized data collection tools and trained evaluators could be used, to enable for more complete data collection and therefore increase the sample by ensuring each case was viable for inclusion. During data collection, it was noted that many of the charts were incomplete with critical data missing including ASA and Braden Scores. Unlike more concrete data such as lab results, age, surgical times etc. the ASA and Braden Scores are dependent on health professional assessment and participation. A retrospective trial

could be feasible if policy was implemented to make and enforce the documentation of all necessary risk factors/ completion. At this time, whether it is mandated or not, the documentation is not complete therefore a retrospective trial could continue to have the same challenges as this study. However, if the results of a prospective trial showed significant benefits of the RAsT's it could provide ammunition for policy development and enforcement in the future.

Lastly, another area that could be considered for future work is examining the combining of tools. It could be hypothesized that using more than one tool could increase the predictive ability overall for pressure injury prevention, however there are some issues with this idea, namely that using multiple assessment tools is more time consuming, complicated, and staff compliance may be difficult to achieve. Anecdotal observations of the writer observe that nurses are already reluctant to complete the existing RAsT's due to high workload volume. Adding another tool could lead to more compliance issues than already exist, despite the potential benefit.

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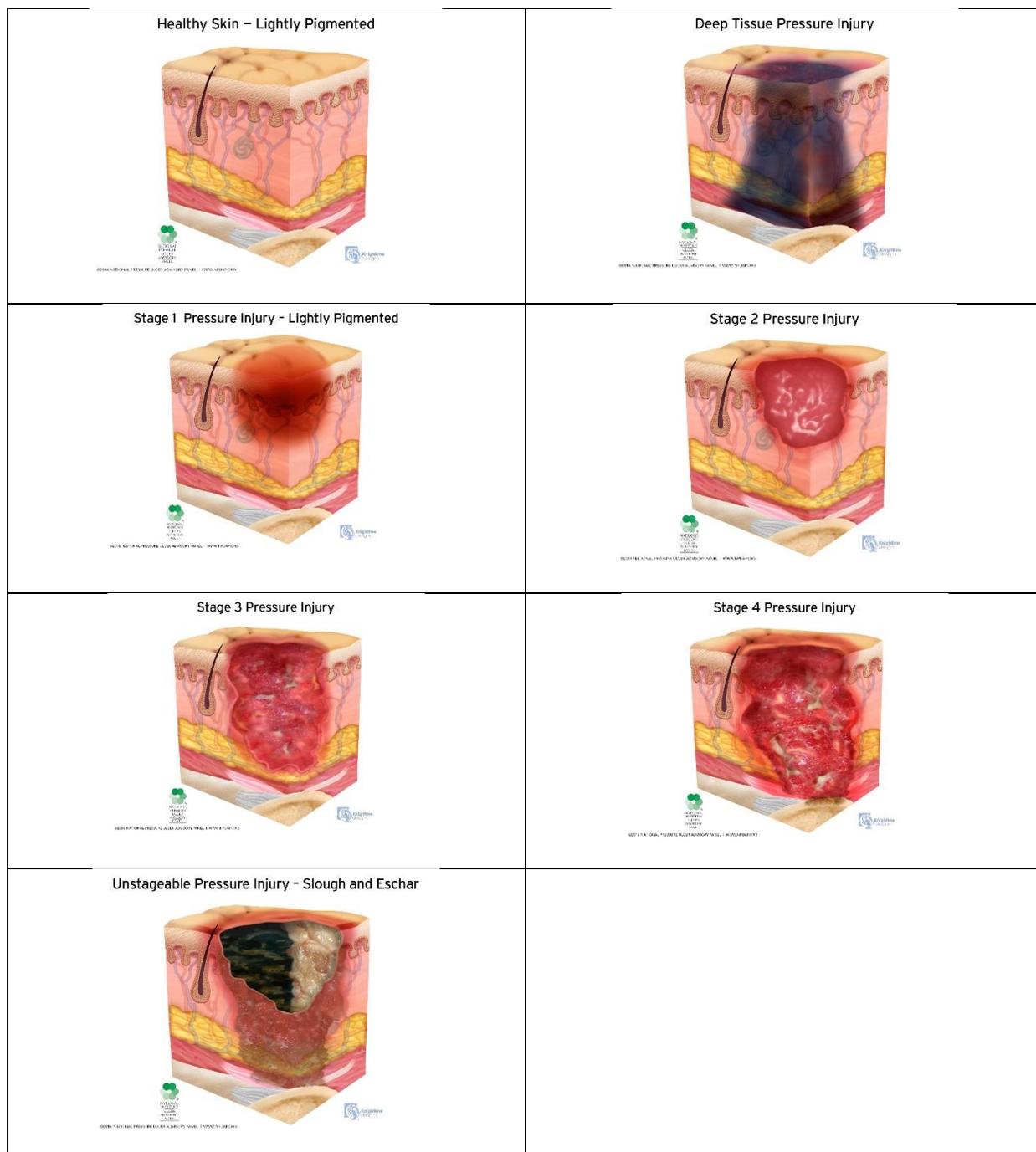
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## Appendix A

### National Pressure Ulcer Advisory Panel Pressure Injury Staging



Retrieved from: <https://npuap.org/page/PressureInjuryStages>

## Appendix B

<b>Braden Scale - For Predicting Pressure Sore Risk</b>					
RISK FACTOR	DESCRIPTION				SCORE
<b>SENSORY PERCEPTION</b> <sup>7</sup> Ability to respond meaningfully to pressure-related discomfort	<b>1. COMPLETELY LIMITED</b> Unresponsive (does not moan, flinch, or grasp) to painful stimuli, due to diminished level of consciousness or sedation, OR Limited ability to feel pain over most of body.	<b>2. VERY LIMITED</b> Responds only to painful stimuli. Cannot communicate discomfort except by moaning or restlessness. OR Has a sensory impairment which limits the ability to feel pain or discomfort over half of body.	<b>3. SLIGHTLY LIMITED</b> Responds to verbal commands but cannot always communicate discomfort or need to be turned, OR Has some sensory impairment which limits ability to feel pain or discomfort in 1 or 2 extremities.	<b>4. NO IMPAIRMENT</b> Responds to verbal commands. Has no sensory deficit which would limit ability to feel or voice pain or discomfort.	
<b>MOISTURE</b> Degree to which skin is exposed to moisture	<b>1. CONSTANTLY MOIST</b> Skin is kept moist almost constantly by perspiration, urine, etc. Dampness is detected every time patient is moved or turned.	<b>2. VERY MOIST</b> Skin is often but not always moist. Linen/ incontinent briefs must be changed at least once a shift.	<b>3. OCCASIONALLY MOIST</b> Skin is occasionally moist, requiring an extra linen / incontinent brief change approximately once a day.	<b>4. RARELY MOIST</b> Skin is usually dry; linen only requires changing at routine intervals.	
<b>ACTIVITY</b> Degree of physical activity	<b>1. BEDFAST</b> Confined to bed.	<b>2. CHAIRFAST</b> Ability to walk severely limited or non-existent. Cannot bear own weight and/or must be assisted into chair or wheelchair.	<b>3. WALKS OCCASIONALLY</b> Walks occasionally during day, but for very short distances, with or without assistance. Spends majority of each shift in bed or chair.	<b>4. WALKS FREQUENTLY</b> Walks outside room at least twice a day and inside room at least once every two hours during waking hours.	
<b>MOBILITY</b> Ability to change and control body position	<b>1. COMPLETELY IMMOBILE</b> Does not make even slight changes in body or extremity position without assistance	<b>2. VERY LIMITED</b> Makes occasional slight changes in body or extremity position but unable to make frequent or significant changes independently.	<b>3. SLIGHTLY LIMITED</b> Makes frequent though slight changes in body or extremity position independently.	<b>4. NO LIMITATIONS</b> Makes major and frequent changes in position without assistance.	
<b>NUTRITION</b> Usual food intake pattern. <sup>1</sup> NPO: Nothing by mouth. <sup>2</sup> IV: Intravenously. <sup>3</sup> TPN: Total parenteral nutrition.	<b>1. VERY POOR</b> Never eats a complete meal. Rarely eats more than one-third of any food offered. Eats two servings or less of protein (meat or dairy products) per day. Takes fluid poorly. Does not take a liquid dietary supplement, OR Is NPO <sup>1</sup> and/or maintained on clear liquids or IV <sup>2</sup> for more than five days.	<b>2. PROBABLY INADEQUATE</b> Rarely eats a complete meal and currently eats only about one-half of any food offered. Protein intake includes only three servings of meat or dairy products per day. Occasionally will take a dietary supplement, OR Receives less than optimum amount of liquid diet or tube feeding.	<b>3. ADEQUATE</b> Eats over half of most meals. Eats a total of four servings of protein (meat, dairy products) each day. Occasionally will refuse a meal, but will usually take a supplement when offered. OR Is on a feeding tube or TPN <sup>3</sup> regimen, which probably meets most of nutritional needs.	<b>4. EXCELLENT</b> Eats most of every meal. Never refuses a meal. Usually eats a total of 4 or more servings of meat and dairy products. Occasionally eats between meals. Does not require supplementation.	
<b>FRICTION AND SHEAR</b>	<b>1. PROBLEM</b> Requires moderate to maximum assistance in moving. Complete lifting without sliding against sheets is impossible. Frequently slides down in bed or chair, requiring frequent repositioning with maximum assistance. Spasticity, contractures, or agitation leads	<b>2. OCCUPATIONAL THERAPISTENTIAL PROBLEM</b> Moves freely or requires minimum assistance. During a move, skin probably slides to some extent against sheets, chair, restraints, or other devices. Maintains relatively good position in chair or bed most of the time but occasionally slides down.	<b>3. NO APPARENT PROBLEM</b> Moves in bed and in chair independently and has sufficient muscle strength to lift up completely during move. Maintains good position in bed or chair.		
<b>RISK SCORES: AT RISK = 15 – 18    MODERATE RISK = 13 – 14    HIGH RISK = 10 – 12    VERY HIGH RISK = ≤ 9</b>					<b>Total Score</b>

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## Appendix C



Review patient record and complete data in left column. Place a check in the right column if the answer is YES. If two or more YES answers are present, this may indicate an increase risk of perioperative pressure ulcers. Use Perioperative Pressure Injury Prevention Plan (PIPP) of care.

SCOTT TRIGGERS*	Does it meet these qualifications?	If YES, please check here.
Age _____	Age 62 or Older	
Serum Albumin _____ g/L or BMI	Albumin level <3.5 g/L or BMI <19 or >40	
ASA score (circle) 1 2 3 4 5	ASA score 3 or greater	
Estimated surgery time in hours/minutes _____	Surgery time over 3 hours or 180 minutes**	
Two or more YESES = HIGH RISK SURGICAL PATIENT		
Assessment Comments:		

Retrieved from: <https://www.aorn.org/guidelines/clinical-resources/tool-kits/prevention-of-perioperative-pressure-injury-tool-kit>

## Appendix D

### Perioperative Pressure Injury Risk Assessment Measure and Intervention Protocol

All patients with physician consent, excluding those undergoing local anesthesia, will be assessed for the following risk factors:	YES	NO
Previous surgery this admission		
Diabetes		
Braden score $\leq 16$		
Age $\geq 70$		
Preexisting pressure injury		
Surgical time $\geq 5$ hours		

If you answered "yes" to any one of the above risk factors, please implement and document the following interventions:

1. Request patient position themselves cff dependent OR site in preoperative unit whenever possible.
2. Reposition pt q 2 hours while in the preoperative unit and postanesthesia care unit (PACU) areas when able.
3. Confirm pressure relieving surface; 4-inch OR mattress or gel pad.
4. Complete Postoperative Peek Tool form and place on the patient's chart.
5. Provide heel relief in preoperative unit with foam boots for patients who will be in the supine position during surgery (preoperative nurse). No foam boot on operative foot (use pillow to off-load heel). The OR nurse will send foam boots with patient to PACU.

For patients with a **Braden Score of  $\geq 16$**  or an anticipated **surgery  $\geq 5$  hours** in the supine or lateral decubitus position, please implement these additional interventions:

1. Apply a multilayer silicone foam border dressing to sacrum for patients in the supine or lithotomy positions, or nonoperative greater trochanter for those in the lateral decubitus position (preoperative nurse). Turn form over and document!
2. Apply a multilayer silicone foam border dressing to sacrum for patients with preexisting stage 1 or stage 2 pressure injuries.
3. Place a static air seat cushion under patient's sacrum beneath the OR table sheet if in the supine position and not on a 4-inch OR mattress or gel pad unless contraindicated by nature of patient condition or surgery.
4. Maintain continuous awareness of pressure points and ongoing communication among the surgical team related to need for repositioning according to nursing policy.
5. Use donut to relieve occipital pressure in the OR.

A few reminders:

1. Do not massage bony prominences. Relieve pressure as soon as possible.
2. Clean and dry any areas that are moist from urine, feces, diaphoresis, or skin prep.
3. Avoid placing warming blankets under the patient if possible.
4. Report any concerns to the receiving nurse on turnover.

Tell patient: "Your surgeon is aware that we are applying a little extra padding to your bottom/hip which may help it from getting sore. It will stay on until you are up and about. There are no adhesives, and it is hypoallergenic and easily removed."

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