

PRESSURE INJURIES IN OLDER ADULT ICU PATIENTS: HEMODIALYSIS

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Abstract

Intensive care unit (ICU) patients are at an increased risk of developing hospital acquired pressure injuries (HAPrI) due to various factors. Immobility, severity of illness, and various medical interventions place these patients at higher risk for developing a HAPrI. Patients in the ICU undergoing hemodialysis are at an increased risk of developing a HAPrI due to the severity of their illness and the toll hemodialysis takes on an individual's body. This study examined the characteristics of patients ≥ 60 years who received hemodialysis and developed a HAPrI during their ICU admission. A retrospective study of hemodialysis patients (N=457) was conducted using data from the Medical Information Mart for Intensive Care (MIMIC) database. Variables included in this study are age, length of hospital stay, minimum hemoglobin, minimum albumin, Braden total and subscale scores upon ICU admission. Bivariate statistical analysis was used to identify statistically significant variables that characterized hemodialysis patients who developed a HAPrI. Eighty-six (19%) ICU patients developed a HAPrI. Occurrence of HAPrIs among hemodialysis patients was influenced by length of hospital stay, minimum albumin, minimum hemoglobin, total Braden score, and some Braden subscale scores: activity, mobility, sensory perception, and moisture. Understanding these factors can guide healthcare professionals in creating effective preventive measures for HAPrIs in the ICU.

Introduction

Patients in the intensive care unit (ICU) are at an increased risk for developing pressure injuries (PrI) because of the severity of the individual's health needs, lack of mobility, and other factors that lead to the development of pressure injuries. In the intensive care unit (ICU), PrI that develop in the hospital occur in 3% to 24% of acutely ill patients (Alderden et al., 2017). The development of PrI is associated with longer hospital stays, deteriorating health, increased patient morbidity and increased patient suffering (Alderden et al., 2017). Hospital-acquired pressure injuries (HAPrIs) not only affect the health of patients and potentially cause suffering in patients, but also inflict a financial burden. It is the job of health care professionals to identify patients at risk for PrIs and implement various treatments and prevention techniques to prevent patients from developing a pressure injury. Patients in the ICU going through hemodialysis are at an increased risk for developing PrIs (Cox et al., 2020). Hospital acquired pressure injuries are a serious complication for many patients; and can be detrimental to the health of ICU patients undergoing hemodialysis.

Background

Pressure injuries are a serious complication that develop from a variety of different factors. Factors that increase a patient's risk for developing a PrI are included in the Braden Scale-For Predicting Pressure Sore Risk[®] (Braden Scale) (Bergstrom et al., 1987). These factors include: mobility, friction and shear, nutrition, moisture, activity, and sensory perception. There are many different types of PrIs and the stage/type is characterized by different features. The four stages of PrIs are: stage 1, stage 2, stage 3 and stage 4. An individual can progress in stages but cannot digress in stages. Stage 1 PrIs are categorized as redness of the skin, without visible loss of thickness. Stage 2 PrI is categorized as partial loss of thickness including the epidermis and

possibly the top layer of the dermis. Stage 3 PrI is categorized as a full thickness loss of the epidermis, dermis, and possible loss of subcutaneous fat. Stage 4 PrI is categorized as full thickness loss along with loss of muscle or bone; this is a severe stage and patients diagnosed with a stage 4 PrI are at a high risk for developing an infection (Aboud & Manna, 2023).

Hemodialysis patients are at a higher risk for developing PrIs because of low albumin levels, low hemoglobin levels, limited mobility and other issues including perfusion and length of stay in the ICU. Hemodialysis is a procedure that acts as an artificial kidney and filters blood. Hemodialysis is used in patients with End Stage Renal Disease, Kidney Failure, and other diseases that severely affect the function of a patient's kidneys and the ability of toxins to be filtered from the patient's body. Hemodialysis patients are at a higher risk for developing low albumin and low hemoglobin levels due to the hemolyzing effects the hemodialysis machine has on a patient's blood (Heidari et al., 2015). Treatment with hemodialysis is critical to the survival of patients with severe kidney disease or kidney failure. However, this treatment can also cause the hemolysis or breakdown of red blood cells and can lead to various other health problems including the development of PrIs. Hemoglobin is a measure of the amount of oxygenated blood cells present in an individual's blood, if patients present with a low hemoglobin this can cause many issues for patients including reduced perfusion and impaired tissue oxygenation.

Albumin indicates nutritional status in patients and if a patient presents with low albumin this can indicate a nutritional deficit. This study investigated the relationship between low hemoglobin, low albumin levels, length of hospital stay, total Braden score, and subscale Braden scores to the development of HAPrIs among hemodialysis patients admitted to the ICU. Hospital-acquired pressure injuries are a serious complication that can cause multiple complications for patients and concurrently, have costly implications on any agency. Pressure

injuries put patients at a higher risk for infection which further complicates the patients' health status, potentially leading to a longer hospital stay and a host of additional problems.

Identification of characteristics of patients undergoing hemodialysis is important to understanding factors that put these individuals at a higher risk for developing PrIs. Advancing our knowledge in this area is foundational to being able to implement prevention techniques to reduce the occurrence of PrIs.

Literature Review

Patients in the ICU are at a high risk for the development of PrIs due to many factors that affect the patient's ability to move, maintain adequate nutrition and level of deteriorating health. Hemodialysis patients present with many common problems and many patients present with these problems in the ICU. The characteristics that can increase a patient's risk for developing a PrI include low hemoglobin levels, low albumin levels, decreased mobility/low Braden score, and an increased length of stay. Immobility is considered one of the most significant risk factors for the development of PrIs (Shibily, 2019). Many patients admitted to the ICU are not able to move around the room, are being given paralytic medications, or, in the case of hemodialysis, patients are required to stay stationary for about 5 hours a day multiple times a week to receive treatment. Mobility is a subscale section of the Braden Scale and is calculated to determine a patient's risk for developing a PrI. In a meta-analysis and systematic review, over 50 publications from various databases were analyzed to explore the relationship between PrI development and early mobilization in the intensive care unit (Shibily, 2019). Pressure injuries are multifactorial but a major cause of PrIs is prolonged pressure on the skin over a bony prominence. Immobility is a major cause of PrIs because patients cannot move resulting in prolonged pressure over a bony prominence. Patients in the ICU are at an increased risk for PrIs due to immobility, and

many ICU patients are on mechanical ventilation or require sedation due to the severity of their condition (Shibily, 2019). Patients undergoing hemodialysis are required to remain still for the course of their treatment which can be between 2.5 and 4.5 hours (Tandon et al., 2013). Patients undergoing hemodialysis in the ICU are more likely to suffer from PrIs because of their acute illness, especially for patients taking vasopressors (Cox et al., 2022). Due to lack of mobility and severe illness, muscle wasting occurs at the highest rate in the ICU and is the highest in the first two/three weeks of a patient's stay in the ICU (Gruther et al., 2008). Early mobility can help reduce the amount of muscle wasting and prevent PrIs by keeping patients moving and shifting weight evenly (Gruther et al., 2008). Mobility and a patient's ability to change position within the bed and shift their weight are important in preventing a patient from developing PrIs. Patients undergoing hemodialysis must remain still, but it is important to get patients up and moving if possible before and after treatment to help reduce the development of PrIs. It is critical to educate hemodialysis patients about the importance of changing positions while lying in bed or sitting in a chair to reduce prolonged pressure on a particular body part; thus, reducing the risk for PrIs.

Hemodialysis patients are also at risk for developing low albumin levels, which can increase a patient's risk for developing PrIs. Albumin is a protein in the blood that helps the healthcare team evaluate a patient's nutritional status. Albumin levels below 3.5 g/dL have been linked with an increased risk for the development of PrIs in ICU patients (Huang et al., 2023). In a study conducted by Huang et al., patients with a white blood cell count less than 12,000, 75/83 of these patients had an albumin less than 3.5 which is considered low (2023). These two coinciding lab values were statistically significant and led to an increased risk for the development of PrIs. According to another study, around 70% of ICU patients with

hypoalbuminemia developed a PrI (Chang & Weng, 2023). Albumin is a marker for the nutritional status of a patient, but also helps regulate oncotic pressure in the body, thus low albumin causes more water to move from blood to tissue causing edema and increasing risk for PrIs (Chang & Weng, 2023, pg. 7). Edema can cause the development of PrIs because it weakens the skin and with the addition of pressure applied to the skin from immobility and lack of movement can lead to easily damaged skin and PrIs (Chang & Weng, 2023). A retrospective study completed by Chang & Weng, showed that low albumin levels related to an increased risk for developing stage 2, stage 3, and stage 4 PrIs (2023). A patient's risk for developing a Stage 2 to Stage 4 PrI decreased by 50% for every 1g/dL increase in a patients' albumin level (Chang & Weng, 2023, pg. 4). Patients in the ICU with low hemoglobin and albumin levels were found to be more susceptible to developing deep tissue injuries (DTIs) or unstageable pressure injuries compared to patients with normal levels of hemoglobin and albumin (Chang & Weng, 2023, pg. 4). Older adult hemodialysis patients are at risk for developing low albumin levels because these patients experience increased protein catabolism and the loss of albumin during hemodialysis due to how the treatment and technology functions (Kalantar-Zadeh et al., 2021). It is imperative that nurses and members of the health care team monitor the albumin levels of hemodialysis patients to help identify patients at risk for developing PrIs. Hence, the health care team can implement different interventions for the patient, possibly administering albumin, to decrease the chance of developing a PrI. Studies show that an intravenous injection of albumin can help reduce a patient's risk for developing a PrI (Chang & Weng, 2023, pg. 7). Concurrently, albumin is important for patients who have developed a PrI because albumin helps patients heal from PrIs by keeping the skin strong. It is important to treat patients with low albumin to prevent PrIs and treat patients that have already developed a PrI with albumin to help the healing process.

Pressure injuries cause serious issues for patients; thus, it is important for healthcare professionals to identify patients at risk for PrIs and treat them accordingly in order to reduce their risk of developing PrIs.

Furthermore, hemodialysis patients are at risk for developing low hemoglobin levels, which increases the patient's risk for developing a PrI. Hemoglobin is a protein that binds with oxygen on a red blood cell and carries oxygen throughout the body. If a patient has low hemoglobin, this can lead to decreased perfusion and a decrease in the amount of oxygenated blood being sent to tissue, making skin more vulnerable to damage (Chang & Weng, 2023). Hemoglobin levels less than 12 g/dL in women and below 13g/dL in men constitute low hemoglobin/anemia (Chang & Weng, 2023). Because low hemoglobin makes skin more vulnerable to damage, this leads to an increased risk for developing PrIs. For older adult individuals a drop in hemoglobin can increase their risk for PrIs substantially because of the current fragile state of their skin due to old age (Chang & Weng, 2023, pg. 7). Patients on hemodialysis are at a higher risk of developing low hemoglobin because the kidneys produce a hormone called erythropoietin which signals to body to make red blood cells. If a patient's kidney is not functioning appropriately or failing, this can lead to a decreased production of erythropoietin therefore leading to low hemoglobin levels. Hemodialysis and blood testing in the ICU can lead to low hemoglobin levels and anemia (Sagheb et al., 2016). Low hemoglobin levels not only increase a patient's risk for developing a PrI, but can lead to increased fatigue and decreased physical functioning (Sagheb et al., 2016). According to a study conducted by Chang & Weng, a significant biomarker for predicting an increased risk of PrIs is a combination of a Waterlow score, albumin, hemoglobin, CRP, age, and gender showed moderate predictive ability (2023). Both a low hemoglobin and low albumin can increase a patient's risk of developing PrIs.

Furthermore, it is imperative that patients undergoing hemodialysis are monitored closely for signs of low hemoglobin and low albumin because of the hemolyzing properties of hemodialysis and the toll this treatment takes on the human body.

The longer a patient stays in the intensive care unit, the higher the risk for PrI becomes. The length of a patient's stay extends due to the negative implications that PrIs can have on the health of patients. Furthermore, in the study conducted by Labeau et al., data showed that patients who resided in the ICU greater than 12 days had a 7.5 times more increased risk of developing a PrI compared to patients who stayed in the ICU less than 3 days (2021). Patients who develop a HAPrI not only suffer because of the pressure injury, but it costs the hospital a great deal. In a recent published systematic review, the treatment of patients with PrIs ranges between \$2.03 and \$558.68 per patient, while the cost to prevent PrI ranges between \$14.87 and \$103.27 (Demarré et al., 2015). Along with the increased cost associated with patients who develop a HAPrI, the longer a patient is admitted in the hospital the more it costs the hospital.

Research Questions

This study explores the various characteristics associated with hemodialysis patients that put these patients at an increased risk for developing PrIs. Patients receiving hemodialysis are at an increased risk for developing low albumin and low hemoglobin which increases their risk for developing PrIs. Furthermore, a hemodialysis patient's length of stay on the intensive care unit also correlates with an increased risk for developing PrIs. Pressure injuries are a serious medical complication that cause patients to deteriorate in health, prolong their hospital stay and cost the hospital money. This research answers the questions:

Research Question 1: What are the differences in characteristics of older adult hemodialysis patients who developed a HAPrI?

Research Question 2: What are the stages of PrIs and their locations for hemodialysis patients who developed a PrI in the ICU?

The population for this research project is the older adult patients in the ICU receiving hemodialysis. It is important to identify characteristics that put hemodialysis patients at risk for developing PrIs in order to recognize these patients early and protect them from developing PrIs. Pressure injuries affect many ICU patients and hemodialysis patients, so by identifying key characteristics that put these patients at a higher risk for PrIs helps nurses and other healthcare professionals to recognize these patients and implement the correct prevention techniques in order to prevent patients from developing PrIs. Findings from this study will address the current health care issue surrounding patients developing PrIs while in the ICU to help nurses and the medical team identify characteristics that put their patients at risk so that patients can be closely monitored and prevention techniques can be implemented.

Methods

A retrospective descriptive design was used to examine characteristics of hemodialysis patients and their PrI occurrence using data extracted from the MIMIC database. The MIMIC database is a de-identified dataset that includes data from the electronic health record from hospitalized ICU patients. The MIMIC database is a nationwide database that allows researchers to use information from patients that is de-identified to protect the privacy of patients while allowing individuals to use the data for research.

Sample/Setting

The population of interest for this study was a subset identified from the MIMIC database of patients undergoing hemodialysis and who developed a PrI during their ICU stay were . This group of patients was selected to comprise the effective sample (N=457). Inclusion criteria in addition to being a hemodialysis patient are: patient in the ICU for the first time on this admission, older adult patients who were ≥ 60 years of age, and who had as ICU stay > 48 hours. Using this dataset, characteristics thought to place hemodialysis patients at an increased risk for developing PrIs will be examined. These characteristics include: length of hospital stay, minimum albumin, minimum hemoglobin, total Braden scale and Braden mobility.

Measurement

Braden Scale. The Braden scale (Bergstrom et al., 1987) is used to help nurses and other members of the health care team predict a patient's risk for developing a PrI. There are six subscales that make up the Braden scale, these include: activity, mobility, sensory perception, friction/shear, moisture, and nutrition (Bergstrom et al., 1987). Each subscale is scored from 1 to 4, with 1 being the worst and leading to the most risk for developing a PrI and 4 being the best with little to no risk for the development of PrIs. Each patient is given a Braden score at least once every shift and it is updated as needed to evaluate the patients risk for developing a PrI. In this study, each subscale of the Braden Scale was evaluated and the total score upon admission to the ICU. These scores were used to determine a patient's risk for developing a PrI. Scores and subscale scores were used to determine if a particular subscale score is more indicative of an increased for developing PrIs versus the others.

Albumin. Albumin is a protein found in the blood that measures a patient's nutritional status, liver function, and contributes to the body's homeostasis (Moman et al., 2022). Albumin is

measured in grams per deciliter and the normal albumin levels are 3.5g/dL – 5.5g/dL (Moman et al., 2022). Hypoalbuminemia is an albumin level less than 2.5g/dL and can indicate an impaired liver function, renal failure, malnutrition, and can indicate an accumulation of fluid in the body (Moman et al., 2022). Albumin is an important protein in the body because it helps maintain homeostasis in the body and keeps the fluid from shifting and causing too much fluid accumulation (Moman et al., 2022). Patients with low albumin are at a higher risk for developing PrIs because of the increased fluid which can lead to edema (Chang & Weng, 2023). Albumin levels less than 3.5g/dL are shown to increase a patients risk for developing a surgical site infection, which is why it is important to monitor a patients albumin levels in order to identify patients at risk for PrIs and infection (Moman et al., 2022).

Hemoglobin. Hemoglobin transports oxygen from the lungs to tissues and is measured using a blood test (Ahmed et al., 2020). Patients with low hemoglobin levels are at an increased risk of anemia, leading to insufficient oxygen delivery to body tissues. Anemia frequently manifests in patients initiating hemodialysis, partly due to the hemolytic effects of the dialysis process (Karaboyas et al., 2019). Additionally, kidney disease often contributes to anemia by causing deficiencies in iron and erythropoietin, essential for red blood cell production. Consequently, individuals with kidney disease are more susceptible to anemia and reduced hemoglobin levels post initiation of hemodialysis. To mitigate these risks, many patients undergoing hemodialysis receive intravenous iron supplements and erythropoiesis-stimulating agents (Karaboyas et al., 2019). Hemoglobin concentrations are assessed with reference to sex-specific norms. For females, the acceptable range is 12-16 g/dL, while for males, it is 14-18 g/dL (Murphy, 2014). Hemoglobin is measured in grams per deciliter and a hemoglobin less than 12 for women and 14 for men is considered low.

Analysis

The statistical significance of differences in characteristics of older adult hemodialysis patients admitted to the ICU at Beth Israel Deaconess Medical Center was determined using t tests, Mann-Whitney U tests, and χ^2 test. The t test was used to compare two separate groups. In this study, the two groups that were compared are: hemodialysis patients admitted to the ICU and of those hemodialysis patients the individuals that developed a hospital-acquired pressure injury (HAPrI). The t test helps determine the significance of each variable and if it was significant in causing patients to develop a pressure injury. The Mann-Whitney U tests was used to test if PrIs have similar medians or if a particular variable leads to a higher occurrence of PrIs in hemodialysis patients. The χ^2 test was used to determine if the variables are related or if they occur due to chance. Descriptive statistics were calculated to describe patient characteristics and summarize information about variables that are found to significantly impact a patient's chance of developing a HAPrI. The variables examined in this study were: age in years, sex, length of stay(days), minimum albumin, minimum hemoglobin, total Braden score upon admission, and Braden subscales (activity, mobility, sensory perception, friction and shear, moisture, and nutrition).

Results

Research Question 1: What are the differences in characteristics of older adult hemodialysis patients who developed a HAPrI?

A group of 457 ICU patients who were receiving hemodialysis were pulled using information from the MIMIC database and analyzed to determine what characteristics led to the development of HAPrIs. Eighty-six of the 457 patients undergoing hemodialysis developed a HAPrI. The mean length of hospital stay in days (SD) for all the patients was 18(14) days, but in

patients that developed a HAPrI the length of stay was 22(14) days. The mean minimum hemoglobin (SD) for all 457 patients was 8.02mg/dL (1.57) and for patients that developed a HAPrI the minimum hemoglobin was 7.52mg/dL (1.46). The mean minimum albumin (SD) for all 457 patients was 2.56mg/dL (0.66) and the mean minimum albumin (SD) for patients that developed a HAPrI was 2,4mg/dL (0.56). Additionally, data was collected regarding the patients total Braden score and each subset score to determine which aspects helped predict the development of HAPrIs in patients undergoing hemodialysis. The mean total Braden score (SD) for all 457 patients was 13.84(2.89) while the mean total Braden score for patients that developed a HAPrI is 12.93(2.56). The mean Braden activity score (SD) for all 457 patients was 1.71(0.51) while the mean Braden activity score (SD) for patients the developed a HAPrI was 1.06(0.28). The mean Braden mobility score (SD) for all 457 patients was 2.35(0.82), but for patients who developed a HAPrI the mean Braden mobility score (SD) was 2.10(0.85). The mean Braden sensory perception score (SD) for all 457 patients was 2.68(1.02), but for patients who developed a HAPrI the mean Braden sensory perception score (SD) was 2.34(1.08). The mean Braden moisture score (SD) for all 457 patients was 3.53(0.62) while the mean Braden moisture score (SD) for patients that developed a HAPrI was 3.37(0.69).

Research Question 2: What are the stages of PrIs and their locations for hemodialysis patients who developed a PrI in the ICU?

An analysis was conducted on the different stages and locations of HAPrIs that hemodialysis patients developed in the ICU. The differences examined between the stages and locations of HAPrIs showed that 2/86 developed a PrI on their back, 4/86 patients developed a PrI on their head/neck, 24/86 patients developed a PrI on their heel/limb, 53/86 patients developed a PrI on their sacral coccygeal, 3/86 patients developed a PrI on their trunk. In the

sample, 17/86 patients developed a Stage 1 PrI, 7/86 patients developed a Stage 2 PrI, 2/86 patients developed a Stage 3 PrI, 0/86 patients developed at Stage 4 PrI, 8/86 patients developed an unstageable PrI and 22/86 patients developed a deep tissue injury. Most of the patients that developed a HAPrI in the ICU developed a PrI on their sacral coccygeal and the most common stage of PrI among the patients that developed a HAPrI was a stage 2 PrI.

Discussion

Patients receiving hemodialysis, as well as healthcare professionals overseeing their care in any context, must recognize the critical importance of monitoring for PrIs. It is essential to employ diverse preventive strategies to reduce the risk of these patients developing PrIs.. Patients undergoing hemodialysis in the intensive care unit are at an increased risk for developing HAPrIs because of the severity of their illness and the toll hemodialysis puts on the human body, which leaves these patients vulnerable to PrIs. Through this study various characteristics were identified that are statistically significant in patients undergoing hemodialysis that developed a PrI versus those who did not. In hemodialysis patients who developed a PrI, these patients had a longer stay in the ICU, lower minimum hemoglobin levels, lower minimum albumin levels, lower total Braden scores and some subscale Braden scores: activity, mobility, sensory perception, and moisture.

Limitations

The data for this study were extracted from the nationwide MIMIC database of hospitalized ICU patients. The MIMIC database was compiled from existing EHR records. Thus, researchers in this study did not have control over characteristics of those included in the parent database. Use of data from another population could lead to different findings. Study replication

with data collection from a larger sample of ICU patients experiencing HAPRIs may be indicated.

Conclusion

Pressure injury is a serious complication that can prolong a patient's admission and lead to a host of medical problems. Preventing the development of PrIs is at the forefront of health care and prevention is a critical part in the daily care of patients in the hospital. Hemodialysis patients are at an increased risk of developing PrIs due to decreased hemoglobin due to the hemolyzing properties of hemodialysis. These patients are also at an increased risk due to longer hospital stays and low total Braden scores and subscale scores. It is imperative that health care professionals recognize these characteristics in hemodialysis patients and implement preventative measures to decrease the chances of these patients developing PrIs.

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