Pressure Ulcer Healing and the Impact of Nutritional Intervention

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Abstract

Pressure ulcers are a condition creating an epidemic of sorts within the healthcare system, both within the United States and Internationally (Doley, 2010). While there is a variety of research on mechanisms to prevent pressure ulcers, current pressure ulcer prevention strategies have proven insufficient, as pressure ulcers continue to lengthen patient hospital stays, complicate their health status, and cost the health-care industry copious amounts of money (Joseph & Davies, 2013). If pressure ulcers cannot be eradicated completely, it is imperative to find a way to lessen the severity of pressure ulcers and increase their healing times, thus creating fewer health-related complications and placing less of a burden on the health-care system. One way to do this is through the use of supplemental nutrition, a practice that has been seemingly neglected in regard to its’ effect on the healing of decubitus ulcers. Research indicates that certain nutrients, such as Vitamin A, Vitamin C, Zinc, Glutamine, and Arginine have proven beneficial in increasing the healing times of pressure ulcers. Such nutrients have the potential to create a profound impact on the physiological process of healing wounds. Thus, a visual aide known as the “Pressure Ulcer Tray for Healing” was created to guide patients, nurses, dieticians, and all health-care personnel in facilitating adequate intake of essential nutrients that will promote healing of ulcers. In theory, a poster of the tray would be displayed in every patient room, in order to assist patients in ordering foods conducive to expediting the healing process.
Introduction

A long-standing medical ailment, known as pressure ulcers, has been complicating nursing care and hospital budgets for multiple decades. Florence Nightingale once wrote, “If he has a bedsore, it’s generally not the fault of the disease, but of the nursing”. Others clinicians have even suggested that pressure ulcers are “caregiver sins”, or signs of negligent nursing care. While optimal nursing care undoubtedly contributes to decreased rates of pressure ulcers, the bedsore epidemic should be seen as a multidisciplinary issue, an epidemic demonstrating not the fault of nursing care, but rather a “failure of the entire health-care system through a breakdown in the cooperation and skill of the entire health care team, including physicians, nurses, physical therapists, dieticians, and all involved health care personnel” (Lyder & Ayello, 2008). Although pressure ulcer prevention should be considered a responsibility of all health-care members, nurses hold more responsibility for meeting this patient safety goal, as they are the foundation of patient care and advocacy. There is an array of literature regarding various interventions to prevent and assess for pressure ulcers, however, many of these interventions aim at prevention of pressure ulcers, and do not focus on measures to facilitate healing of ulcers. Risk assessment scales are simply not adequate to accurately predict a patient’s true risk of pressure ulcer formation, and do not suffice in promoting healing, especially when used incorrectly by nursing staff. Nurses’ values, knowledge, and competence can affect incidence and development of pressure ulcers”, thus placing nurses in a pivotal position to maintain education regarding pressure ulcer prevention and healing (Joseph & Davies, 2013). Furthermore, there is a deficit of
research pertaining to the effects of nutrition and healing of pressure ulcers. While it is acknowledged that proper nutrition can prevent multiple hospital complications, further emphasis must be placed on the value of nutrition, nutritional recommendations and teaching, and direct involvement with the patient regarding dietary choices.

**Review of Literature /Background**

Recent literature demonstrates profound need for pressure ulcer prevention and education among patient populations. The dramatic increase of pressure ulcers throughout the years is “placing a major burden on financial and labor resources in the U.S Healthcare system” (Doley, 2010). Furthermore, it is taking its toll on the patient population of the United States. Approximately 2.5 million patients are affected with pressure ulcer per year, amounting to a fiscal price tag between $9.1-$11.6 billion per year for the United States (Sernekos, 2013). The United States is not the only entity impacted, as financial implications are rampant internationally. The National Health Service (the publically funded healthcare system of the United Kingdom) spends $3.8 million per day, thus representing 4% of the total NHS expenditure (Jones, 2013).

Individual patients are perhaps the most severely affected, as 60,000 patients die each year as a direct result of pressure ulcers, with the remaining facing an individual hospital bill of $20,900 to $151,700 per pressure ulcer (Berlowitz, Lukas, Parker, Niederhauser, Silver, Logan, Ayello & Zulkowski, 2011). Pressure ulcers place great demand on nursing and hospital resources, as pressure ulcer related complications average 13 - 14 days, as compared with 5 days and $10,000 for patients without bedsores (Doley, 2010). However, with 95% of pressure ulcers being preventable, the Department
of Health has announced that “improved pressure ulcer prevention is a priority” (Berlowitz et al., 2011). The reduction and treatment of pressure ulcers are increasingly being viewed as benchmarks of nursing care, thus making it imperative that such quality measures are addressed (Choo, Hayter & Watson, 2013).

Despite the availability of risk assessment tools to predict pressure ulcer development and severity, complications from pressure ulcers continue to occur. Findings from literature represent a lack of evidence regarding the effectiveness of risk assessment tools in preventing or promoting healing of pressure ulcers (Joseph & Davies, 2013). An audit examined by Joseph & Davies found that risk assessment was conducted within 24 hours for only 54% of patients, with 16% of assessments completed, but undated, and 18% uncompleted. Only 12% of assessments charted were considered “satisfactory”, and such were completed after 24 hours (Joseph & Davies, 2013). Because nurses have differing attitudes towards pressure ulcer assessment tools, Joseph and Davies (2013) claim such tools to be “unreliable” and suggest that educational training regarding pressure ulcer risk factors “may be more useful than reliance on assessment scales, which may be open to individual interpretation” (Joseph & Davies, 2013).

In their review of risk assessment tools, Joseph & Davies (2013) found that nurses tended to overrate patient’s risk of developing pressure ulcers, with only 13 of 110 nurses surveyed correctly identifying patients on the Waterlow scale. Studies suggested that some nurses consider risk assessment tools as a “paper exercise” rather than an opportunity for prevention (Joseph & Davies, 2013). Furthermore, because risk assessment tools focus on elements of quantitative scoring, some nurses may neglect the holistic and qualitative aspects of their patient’s care. Risk assessment tools, such as the
Braden scale, will allow the nurse to see that a patient has dehydration, poor appetite, and poor mobility. However, such assessment tools may also influence the nurse to view each of these categories individually, thus failing to analyze data, make conclusions, and improvise interventions appropriate for a patient at risk for pressure ulcers (Joseph & Davies, 2013). Clearly, nurses’ understanding of pressure ulcer related factors are reflected in their “decisions to initiate preventative interventions, and the time and appropriateness of such interventions” (Joseph & Davies, 2013). However, these decisions should not be based off risk assessment tools alone, and nurses must improvise interventions which are beyond the scope of such tools. Ultimately, holistic assessment and detail-oriented clinical judgment provide a greater service to the patient.

To incorporate a holistic view of patient care, nurses must place a greater emphasis on nutrition, without reliance on risk assessment tools as predictive measures (Joseph & Davies, 2013). While the precise mechanisms of assessing nutritional status is controversial, there is much evidence to support that nutritional counseling in itself can add numerous benefits to the prevention and healing of pressure ulcers (Joseph & Davies, 2013).

Data from the National Database of Nursing Quality Indicators (NDNQI) at a New England Community Hospital exhibited that “improvement was needed in the provision of nutritional support to patients at risk for pressure ulcers” (Barrett, Tuttle, Whalen, Gatchell & Dawe, 2010). Such data was collected after an inventory of 13 international pressure ulcer guidelines revealed that providers often failed to include nutritional factors in their assessments of those at risk for decubitus ulcers, and rarely advised dietary consults (Barrett et al., 2010). In an attempt to research the nutritional
needs of patients with pressure ulcers, an evidence-based practice project was implemented. The group was composed of register dieticians, nurses specializing in informatics, wound care, and research, as well as nurses on Medical-Surgical and Intensive Care units.

The group began with editing their electronically charted risk assessment tools. Criteria for dietary consults was revised so that nutritional screening was linked with the Braden scale, requiring that a score less than or equal to 18 mandated a dietary consult (Barrett et al., 2010). Next, a wound care nurse presented an educational poster providing information regarding the importance of nutritional assessment in reducing patient risk for pressure ulcer development. Education focused on increased protein and carbohydrates during wound healing (Barrett et al., 2010). Brightly colored, cup-shaped visual aides were developed to remind nurses to offer nutritional supplements during hourly rounds, and to document accordingly. Education about the importance of supplemental nutrition was a key component, and “critical to the success of the project” (Barrett et al., 2010).

The effectiveness of the project was measured by the number of nutritional consults ordered, pre- and post competency exams (regarding risks for pressure ulcers and assessment skills), and the number receiving nutritional support. Within one year, results found that the total number of dietary consults increased from 303 to 810 --an increase of 167% (Barrett et al., 2010). After education was provided to 175 nurses over 3 months, post- test scores also improved. Such improvement suggests the educational sessions “served as a reminder to focus on patients nutritional status more closely and intervene when indicated by requesting a nutrition consult” (Barrett et al., 2010). It
should be noted that one question—regarding how often nutritional screening should be conducted—remained the lowest scoring item on both pre and post exams. Many nurses incorrectly responded that nutritional assessment should be performed on admission. The correct answer is that nutritional assessment should be performed *with each Braden scale*. EPUAP and NPUAP guidelines recommend that a nutritional assessment be performed on admission, at any time when pressure ulcers are failing to heal, and with every change of patient condition (Sernekos, 2013). This information was later clarified for all staff. Lastly, the NDNQI data regarding use of supplemental nutrition exhibited a “slow but consistent increase in the use of nutrition support and intervention for patients at risk for pressure ulcers” on 3 out of 4 units examined (Barrett et al., 2010). As evidenced by this study, he implemented visual aides and educational programs advocated consistent nutritional assessments and interventions, while simultaneously increasing staff’s knowledge and allowing them to be more invested in prevention of pressure ulcers. Studies such as these exemplify the importance placed on nutrition in relation to pressure ulcers.

However, opinions regarding nutritional interventions for pressure ulcers “vary from advocating the assessment of serum albumin levels, dietary protein intake, BMI or recent weight loss, to the patient’s ability to chew and swallow” (Jones, 2013). The need for increased research in this area stems from the fact that literature is “unclear about the relationship between protein energy malnutrition and pressure ulcer formation”, most likely debatable due to the lack of randomized control trials on the subject (Jones, 2013). Yet, despite inconsistent evidence, numerous studies have found a linkage between
nutrition and bedsores, and it is generally agreed upon that “maintaining optimum nutrition is essential to maximize skin health” (Jones, 2013).

However, much of the literature regarding pressure ulcers focuses on the influence of nutrition in preventing pressure ulcers, as opposed to healing them (Sernekos, 2013). A study of one Veteran’s Administration nursing home found that 13 of 23 (56.5%) older male residents with pressure ulcers were malnourished, with an additional 7 (30.4%) being at risk for malnutrition (Sernekos, 2013). A 2010 study of 290 patients in German nursing homes and hospitals found that 14% experienced an undesired weight loss of 5-10%, whereas 3.7% experienced a weight loss of greater than 10%. Sixteen percent of patients were clinically underweight, with body mass index of less than 18.5 (Sernekos, 2013). Research clearly shows that “significant weight loss was associated with a greater likelihood of developing a pressure ulcer” (Sernekos, 2013).

However, what can be done to facilitate healing of that ulcer once it has occurred? Evidence is sparse, and there is an urgent need to identify factors to promote healing in order to reduce ulcer-related costs and complications.

While “nutrition status has a significant effect on the rate of wound healing”, little research has been done on the supplementation of specific nutrients to prevent pressure ulcers” (Doley, 2010). It is acknowledged, however, that malnutrition can extend the inflammatory phase of healing, while decreasing collagen formation and fibroblast proliferation—essentials involved in wound healing (Doley, 2010). An article in the Ostomy Wound Management Journal reports that malnutrition results in a reduction of lean body mass, which can directly affect a wound’s ability to heal (Harris & Fraser, 2004). While a 10% loss of lean tissue decreases immune function, a 20% loss can
“inhibit healing of existing ulcers and increase risk for developing new wounds” (Harris & Fraser, 2004). Malnutrition also negatively impacts *wound quality during* healing, as several studies have demonstrated a reduction in wound strength in the presence of nutrient deficits (Doley, 2010). Thus, as nurses, it is imperative to identify patients’ nutritional needs in order to facilitate optimal wound healing.

To facilitate this need, The Institute for Healthcare Improvement has recommended that, “in hospitalized patients, pressure ulcer risk assessment, including nutritional concerns, [are] addressed every 24 hours rather than the previous suggestion of every 48 hours” (Hughes, 2008). In obtaining a daily representation of a patient’s nutritional status and micronutrient intake, there is a decreased opportunity for nutritional deficits and thus, less likelihood of pressure ulcer related complications.

A 2011 meta-analysis of studies performed indicates that patients with pressure ulcers have “significantly higher resting energy expenditure” than patients without (Senerkos, 2013). Literature shows that certain nutritional variables may compensate for these increased energy demands, and are particularly beneficial to wound healing. Included in these are increased caloric intake, Vitamin A, Vitamin C (ascorbic acid), protein (with a particular emphasis on arginine), zinc, glutamine, adequate intake of fluids, and glycemic control (Senerkos, 2013).

Maintenance of adequate hydration is essential to maximize pressure ulcer healing, as dehydration results in reduced blood volume, consequently decreasing the delivery of blood containing nutrients, oxygen, and immune cell to the damaged wound bed (Harris & Fraser, 2004). To promote fluid management, it is also recommended that patient’s diet demonstrate glycemic control, as hyperglycemia often leads to osmotic
diuresis. Furthermore, hyperglycemia has a negative effect on the immune system, and has been correlated with “reduced granulocyte function and decreased production of phagocytes and other immune cells” (Harris & Fraser, 2004). Patients in the hospital with hyperglycemia are at increased risk for wound infections, and thus glycemic control and monitoring should be practiced regularly.

Increased caloric intake can prevent weight loss in hospitalized patients, and thus may help decrease severity of pressure ulcers (Sernekos, 2013). However, few studies have researched the effect of increased caloric intake alone, and such studies were complicated by the fact that calories were administered in supplement form, with the addition of vitamins and trace elements (Sernekos, 2013). In 2011, a Japanese study of 60 tube fed patients (mean age 81.4) with Stage III or IV pressure ulcers received additional calories through parenteral nutrition. The caloric intake for the control group remained the same as before the study. Results showed that patients receiving the higher calorie feedings demonstrated “significantly greater reductions in wound surface size and depth” (Sernekos, 2013).

Adequate protein intake is another essential element to promote the healing of pressure ulcers. All immune system cells involved in the initiation of the inflammatory process are composed of proteins, thus making protein a crucial element in wound healing (Choo, Hayter & Watson, 2013). Dietary protein is of special concern in older adults with pressure ulcers, as the demands of wound healing may accelerate sarcopenia (Sernekos, 2013). Multiple studies have examined the influence of protein supplementation and its relation to pressure ulcer healing, but few have determined the effect of protein alone, when in isolation from other nutrients. Breslow and his
colleagues were one of the few researchers who analyzed the outcome of protein alone in the healing of pressure ulcers. The study involved 28 malnourished nursing home residents with Stage II-IV pressure ulcers, thirteen of whom received a 14% protein oral supplement, and fifteen who received a 25% protein oral supplement. Results found there was a “significant decrease in the total pressure ulcer surface area of the residents taking a supplement with 24% protein as opposed to those taking a supplement with 14% protein” (Sernekos, 2013).

Lee & colleagues also performed research on the effect of isolated protein through a double-blinded study of 89 residents in a long-term care facility with Stage II-IV pressure ulcers. This group received a commercially concentrated collagen protein supplement while control groups received a placebo supplement. Using the Pressure Ulcer Scale for Healing (PUSH scale) for evaluation, (a tool developed by the National Pressure Ulcer Advisory Panel as a fast and valid measure to assess changes in pressure ulcers over time), the treatment group showed a significantly higher rate of healing at 2, 6, and 8 weeks (Sernekos, 2013). The AHRQ suggests that up to 2 g/kg/day of protein is needed for healing (Doley, 2010).

Deseneves & colleagues performed a similar experiment to Lee, in which protein was isolated, and also combined with micronutrients, to determine the effects on wound healing. In this Australian trial, 16 hospitalized patients with stage II-IV pressure ulcers were placed on three sample diets: 1) standard hospital diet; 2) a standard diet plus two high-calorie/high-protein supplements per day, and 3) a standard diet plus two high protein/high-energy supplements fortified with arginine, vitamin C, and zinc (Desneves, Todorovic, Cassar & Crowe, 2005). Patient ages ranged from 37-92 years. All patients
presented with elevated C-reactive protein levels and insufficient zinc and albumin serum levels prior to the trial. Nutritional status, size, and severity and size of pressure ulcers were documented for three weeks by a clinical nurse consultant who was unaware of the patient’s dietary modifications (Desneves et al., 2005). Pressure ulcers were monitored using the PUSH scale, which included sub-scores for wound length and depth, tissue time, and amount of exudate present. These scores are then added together to give a PUSH score of 0 (completely healed) to 17 (most severe). By comparing scores over time, this study provided “an indication of the improvement or deterioration in pressure ulcer healing” (Desneves et al., 2005). After 4 weeks, the arginine-supplemented group revealed significantly lower PUSH scores and improvements in healing that were 2.5 times greater when compared to the other two groups (Desneves et al., 2005). Interestingly, this study revealed that the supplements containing solely high protein produced no significant changes in pressure ulcer healing (Choo, Hayter & Watson, 2013). However when the same high protein supplement was enriched with arginine, zinc, and vitamin C, “significant healing was observed compared with other diet groups” (Choo, Hayter & Watson, 2013). Desneves’ study raised an important question regarding the effect of protein on other nutrients. It is currently unknown if protein has a “promoter effect” on other nutrients, or if these nutrients (arginine, zinc, vitamin C) would produce the same healing effect on their own (Choo, Hayter & Watson, 2013). While there are currently no randomized control trials that have studied arginine in isolation from other nutrients, Langer et al. examined the effect of vitamin C and zinc isolation in healing. The results did not support positive healing outcomes with either the use of vitamin C or zinc (Choo, Hayter & Watson, 2013). Thus, “it is only reasonable to conclude that only
the use of the mixture of these supplements (arginine, vitamin c, and zinc) improved the healing outcome of patients with pressure ulcers” (Choo, Hayter & Watson, 2013).

There is an array of research which advocates for the supplementation of the specific amino acid protein known as arginine. Physiologically, arginine aids in the formation of polyamines, a cationic compound crucial to the development of new tissue in wound healing (Doley, 2010). Furthermore, arginine is essential for the formation of nitric oxide synthetase, which once metabolized, produces nitric oxide. Nitric oxide then assists in wound healing, as it is toxic to bacteria, inhibits platelet aggregation, and functions as a neurotransmitter and vasodilator (Doley, 2010). Arginine is known as a semi essential amino acid that the body is capable of producing independently; however, in times of physiological distress, arginine production may be deficient. In such cases, additional sources of arginine must be supplied through the diet. Arginine is also available commercially as a powdered supplement for clinical purposes. While average dietary intake of arginine is 5-6g/day, reports of older adults living in nursing homes reveal insufficient arginine intake, in the range of 2.4- 3.3-g/ day (Sernekos, 2013).

According to Doley, “use of arginine-supplemented formulations should be considered in patients with pressure ulcers who are critically ill or undergoing major surgery, as reduced infectious complications and a decreased duration of mechanical ventilation have been observed in patients fed an immune enhancing formula containing arginine” (Doley, 2010). Because many patients with pressure sores experience low mobility, loss of appetite, and nutritional deficits, the addition of arginine in one’s meal plan could stimulate one’s immune system and thus promote healing (Doley, 2010).
The *Journal of the American Association of Nurse Practitioners* and the *International Journal of Nursing* both contain meta-analyses, which review multiple studies indicating the positive influence of arginine on pressure ulcer healing. Cereda, Gini, Pedrolli and Vanotti conducted a study with 28 residents (mean age 82.1 years) in a long term care facility, who were fed a hospital diet in addition to 400mL of an oral supplement containing 34g of total protein, 6g of arginine, 500 mg of vitamin C, and 18 mg of zinc (Sernekos, 2013). Primary outcomes in the treatment group resulted in reduction of ulcer healing area in addition to a decreased PUSH score. Secondary outcomes showed lower rates of infection and shorter duration of antibiotic treatment when compared with the control group (Sernekos, 2013).

In 2010, Van Anholt et al. conducted a similar study with pressure ulcer patients (mean age 72 years) in a European long-term care facility. The treatment group with Stage III and IV pressure ulcers received a 200ml supplement containing 20g of total protein, 3 g arginine, 238g vitamin A, 250mg vitamin C, 38mg vitamin E, 9mg zinc, in addition to carotenoids, selenium, copper, and folic acid (Sernekos, 2013). Supplements were received three times per day. Control groups received a flavored supplement containing no calories. Over an 8 week period, results showed a reduction in pressure ulcer surface area and a significant decline in PUSH scores (Sernekos, 2013). When compared to the control group, secondary outcomes revealed a significantly smaller amount of dressing changes required per week, in addition to less time spent on dressing changes performed by nurses (Choo, Hayter & Watson 2013).

In 2012, Leigh et al. performed a randomized study of 23 Australian hospital and rehabilitation patients with Stage II-IV ulcers, with average age being 69.8 years. Patients
received 1 of 2 supplements: (a) a supplement containing 4.5g arginine, 155mg vitamin C, and 40.5mg vitamin E, or (b) a supplement containing 9g arginine, with doubled amounts of vitamins C and E (Sernekos, 2013). After 3 weeks, both groups showed statistically significant reduction in PUSH scores and increased healing times. However, there was no significant difference in the rates of healing between the groups receiving lower and higher doses of arginine. Thus, it was concluded that lower doses of arginine are equally affective as higher doses (Sernekos, 2013).

Vitamin A, with a long-standing reputation for its function in wound healing, stimulates the immune system by ”maintaining mucosal and epithelial integrity, increasing collagen formation, and enhancing epithelization” (Doley, 2010). The NIH sets the “upper safe limit” for Vitamin A at 10,000 IU for adults 19 years and older (National Institute of Health, 2013). When given within two to four days within the time of injury, Vitamin A has shown benefits in healing. Research suggests 10,000 to 15,000 IU per day for up to 7 days to enhance this effect (Doley, 2010). Nurses should note that Vitamin A should be supplemented cautiously in those with renal and liver failure.

Vitamin C, with a longstanding reputation for maintaining skin integrity since the 1930’s, is also considered helpful in the healing of pressure ulcers, as ascorbic acid aids in “fibroblast maturation, collagen formation, and critical functions in the wound healing process” (Doley, 2010). Vitamin C is also required for “immune response, cell mitosis, and monocyte migration into wound tissue, in addition to its role as an antioxidant” (Doley, 2010). Although simple to obtain, many hospitalized patients experience deficits, and this could delay healing times of decubitus ulcers. In a randomized controlled trial performed by Gan & colleagues, suboptimal serum ascorbic acid levels were reported in
60% of hospitalized patients, with deficient levels being reported in 19% of patients (Doley, 2010). Such deficiencies resulted in “increased incidence of wound dehiscence, defective collagen formation, and decreased wound tensile stress” (Doley, 2010). Deficits in vitamin C are expensive to diagnose through assay, but the supplement is well tolerated by most patients, and is often implemented in wound care regimen (Doley, 2010). The NIH recommends a daily amount of 90mg for males over eighteen, and 75mg for women over eighteen (National Institute of Health, 2013). Vitamin C should be used cautiously in those with a history of kidney stones or iron overload (Sernekos, 2013).

Taylor & colleagues performed a double blinded, randomized control trial to discover the effects of Vitamin C on the healing on 20 post-surgical patients (mean age 74.5) with decubitus ulcers (Sernekos, 2013). Half of the patients were administered 500mg ascorbic acid twice a day for 4 weeks, while the control group received a placebo. After 4 weeks, the treatment group showed an 84% reduction in the surface area of their ulcers, while the control group showed a 42.7% reduction (Sernekos, 2013)

Glutamine, the most abundant amino acid in plasma, plays a crucial role in metabolic energy, as it is a fuel source for cells such as fibroblasts, epithelial cells, macrophages and lymphocytes (Guo & DiPietro, 2010). Additionally, the end product of glutamine metabolism is collagen, known for its wound healing ability (Da Costa, Campos, Coelho, Barros & Mastumoto, 2003). Together, glutamine and the amino acid alanine, are responsible for the transport of more than half of free circulating nitrogen, and compose more than 50% of the amino acids released from skeletal muscle after injury. Glutamine concentrations are depleted drastically after injury or catabolic illness, with intracellular concentrations decreasing as much as 50% (plasma levels fall only 20-
30%). Glutamine is a particularly important amino acid, as “the decline in glutamine concentrations exceeds that of any other amino acid” and “persists during recovery after all amino acid concentrations have returned to normal” (Da Costa et al, 2003).

Research suggests that oral glutamine supplementation results in increased levels of collagen and further wound strengthening (Guo & DiPietro, 2010). Although a majority of the studies on glutamine involve burn patients, glutamine has been proven to conserve mucosal integrity and reduce infection rates in wound healing (Doley, 2010). Results found that glutamine supplementation enhanced the anastomotic healing process by significantly improving the percentage of anastomosis site embedded with mature collagen and by increasing the wound’s total rupture strength on postoperative days 3 and 8 (Da Costa et al., 2003). This study suggests that rats who received parenteral nutrition enhanced with 2-3% glutamine “presented higher colonic weights, mucosal proteins, DNA concentrations, and mucosal thicknesses” when compared with rats receiving standard parenteral nutrition (Da Costa et al, 2003).

In addition to the nutrients above, Zinc has also been found to have positive effects in healing. Because zinc is a co-factor for both RNA and DNA polymerase, a zinc deficit “causes a significant impairment in wound healing”. Zinc is responsible for the synthesis of granulation and epithelial tissue, and promotes anti-inflammatory and anti-microbial effects (Doley, 2010). There is a direct correlation between zinc deficiencies and wound healing, as zinc is transported by albumin, and serum albumin levels are often insufficient in times of inflammation (Doley, 2010). Furthermore, the inflammatory process within itself results in the hepatic uptake of zinc (Doley, 2010). Nurses should take note that zinc deficiencies are more common amongst smokers and alcoholics when
compared to the general population. The National Institute of Health has set the RDA for zinc at 8mg/day for women over the age of eighteen, and for 11mg/day for men over the age of eighteen (National Institutes of Health, 2013). While zinc assays are unreliable, plasma levels less than 60ug/dL indicate a zinc deficiency. In clinical practice, zinc is most commonly supplemented for 10-14 days (Doley, 2010). It should be noted that excessive supplementation may interfere with copper metabolism, and may interfere with healing.

Ornithine alpha-ketoglutarate (OKG, Cétonan®) acts as the precursor for of glutamine and arginine, and plays a multifactorial role in wound healing by stimulating the immune system, assisting in cell multiplication, and stimulating the secretion of insulin and growth hormone. OKG has been developed and marketed by pharmaceutical companies in France, and is used as a supportive treatment for undernourished elderly patients or those in hyper-catabolic states (Meaume, Kerihuel, Constans, Teot, Lerebours, Kern & Marchasson, 2009). OKG is beneficial to these patients because it promotes optimal nutrient uptake and “accelerates improvement in nutritional status” (Meaume et al., 2009). When administered to patients with burn wounds, the anabolic properties of OKG treatment (10-20g/day) accelerate wound healing by increasing the rate of protein synthesis and counteracting protein hyper-catabolism (Meaume et al., 2009). OKG has also proven effective in improving nitrogen balance and wound healing rates in septic and poly-trauma patients (Meaume et al., 2009). Meaume & colleagues reference their previous study, in which “67.1% of pressure ulcers allocated to OKG decreased by at least 40%.” (Meaume et al., 2009).
Meaume and colleagues conducted a subsequent, multi-center, randomized, double-blinded study lasting 6 weeks and including 70 patients in the treatment group (mean age 80 years). The trial, which was conducted in geriatrics, internal medicine, physical medicine/rehabilitation, trauma, plastic surgery, cardiology, neurology, and dermatology settings, aimed to document the influence of OKG on reduction of pressure ulcers on the heel (Meaume et al., 2009). The treatment group received 10g of OKG mixed in 200ml of water or food once daily. The control group, which also consisted of 70 patients, received a placebo. To specifically test the effects of OKG, patient medications such as corticosteroids and supplements such as amino acids, vitamin C, zinc, or omega-3 fatty acid supplements were discontinued. All wounds were cleansed with saline and Betadine, and heel elevation was performed for all patients (Meaume et al., 2009). Each week, pressure ulcers were assessed based on clinical description, length and width, and number of necessary dressing changes. After 6 weeks, patients with baseline pressure ulcer area $\leq 8\text{cm}^2$ showed a closure rate and decrease in wound area that was significantly higher in the OKG group than in the control group ($-0.07 \pm 0.11\text{cm}^2/\text{day}$ vs. $0.04\pm 0.08\text{cm}^2/\text{day}$; $p=0.007$) (Meaume et al., 2009). The outcome was influenced by OKG’s direct influence and “booster effect” on the closure rate of the ulcers during the first two weeks of healing (Meaume et al., 2009). Interestingly, OKG did not produce a significant difference in closure rates in patients with baseline pressure ulcers $\geq 8\text{cm}^2$, perhaps because such ulcers required more time for healing progression than the allotted 6 week trial period (Meaume et al., 2009). Overall, OKG showed few adverse side effects, with the majority of reported symptoms being higher incidence of gastrointestinal distress in patients receiving OKG compared to the control group.
However, it cannot be proven that OKG was a cause of this distress (Meaume et al., 2009).

International research on nutrition and pressure ulcer further emphasizes the pervasiveness of such a global pandemic and is helpful in determining the effects of adjunctive nutrition on healing times by utilizing a multitude of assessment tools. The following study is particularly valuable because it implements use of the Braden Scale in addition to the DEISGN tool, which was developed by the Scientific Education Committee of Japanese Society of Pressure Ulcers (Omote, Sugmata, Sanada, Konya, Okuwa, Kitagawa, 2005). Conducted in Kanazawa City, Japan, such an experiment examined the healing process of pressure ulcers after a change in the nutrition regimen of seven bedridden elders (ages 70-92) in a long-term care facility. The healing process was described for 4 weeks prior, and 4 weeks following supplemental nutrition therapies. The study was based on such a premise: “if elderly people with pressure ulcers are in a stage of latent protein-energy malnutrition, healing of pressure ulcers will be delayed, and aggressive nutritional management is necessary” (Omote et al., 2005). To evaluate the findings, two wound ostomy and continence nurses and four expert wound nurses evaluated pressure ulcers weekly based off DESIGN scores, wound surface area, and Braden scores. In addition, pressure ulcers were photographed and sketched weekly (Omote et al., 2005). The DESIGN tool is a “reliable tool that provides good interrater reliability with a standard of r=0.9 and a high intraclass correlation coefficient with a standard of r=0.98” (Omote et al., 2005). As part of the DESIGN assessment, depth of pressure ulcer is scored 0-5; exudate 0-3; size 0-6; inflammation/infection 0-3;
granulation tissue 0-5; necrotic tissue 0-2, and pocket size 0-4. Wounds are addressed according to the score for each item as well as the total (Omote et al., 2005).

Of the seven patients, 6 had pressure ulcers in the granulation phase of healing, with one patient in the epithelialization phase. The majority of ulcers were located in trunk region and were stage III. Design scores ranged from 7-22, with the median wound surface area being 1.16-2.02.97 cm (Omote et al., 2005). Total Braden scale scores ranged from 9-14, with no changes being observed in sensory perception, activity, mobility, moisture, or friction/shear. All patients received additional nutrition, with 6 patients receiving supplemental protein (Omote et al., 2005). Such additive nutrition resulted in patients’ calorie consumption increasing from 900-1400kcal/day to 980-1433kcal/day, with protein intake increasing from 0.9-1.5g/kg/day to 0.9-2.0g/kg/day (Omote et al., 2005). Patients’ serum total protein, albumin, and hemoglobin were obtained from monthly clinical records.

After a change in patients’ nutritional regimen, the most significant changes were seen with the increased formation of granulation tissue. As reflected by the DESIGN scores, depth of the wound, color and appearance of granulation tissue, and wound surface area all showed improvement. Although the wound area decreased in 6 of the 7 cases before the change in nutritional regimen, “it improved in all cases after the change” (Omote et al., 2005). During the 4-week period prior to additive nutrition, the color of the pressure ulcers was “generally poor” (Omote et al., 2005). However, in the 4-week period after nutrition was supplemented, there was “proliferation of granulation tissue from the wound edge, which was tightly attached to the wound bed” (Omote et al., 2005). Proliferation of granulation tissue began in the second week, with wound bed color
improving in the 3rd week. Decreases in the depth of the wound occurred in the 4th week. Omote and colleagues attest in their research that protein and zinc deficiencies during the granulation phase of wound healing cause a decrease in fibroblast function and collagen synthesis, and thus believe that prior to additive nutrition, the patients’ nutritional status was inadequate for wound repair, “thus the healing of pressure ulcers was delayed” (Omote et al., 2005). Afterwards, however, nutritional supplementation promoted fibroblast and cell proliferation, and synthesis of collagen, which yielded speedy formation of granulation tissue (Omote et al., 2005).

In summary, the formation of granulation tissue and documented improvements in DESIGN scores following nutritional intervention have led Omote and colleagues to believe that assessment of the effects of nutritional intervention can be carried out “quickly and appropriately by the nurses who observe the wounds daily” (Omote et al., 2005). Such beliefs are promising to fellow nurses, who are ultimately responsible for such assessments.

Although Omote’s research was successful, he admits that a definitive consensus regarding supplemental nutrition cannot be reached, attributing the “delay in clinical application” to the co-factors surrounding pressure ulcer healing. Results of previous studies, although promising, cannot attribute their results solely to nutrition, as factors such as wound care, mattress type, positional changes, and generalized patient health statuses also contribute to research findings.

Although many nutritional co-factors have proven beneficial in the healing of pressure ulcers, there remains a “lack of clinical guidance” regarding nutritional interventions and treatment of pressure ulcers (Choo, Hayter & Watson, 2013).
Unfortunately, current EPUAP, NPUAP, and NIH guidelines have “yet to fully reflect the growing importance of nutritional supplementation in the treatment of pressure ulcers” (Choo, Hayter & Watson, 2013). While there is much evidence supporting the role of supplemental nutrition, more specific randomized control trials are necessary. The need to revise current guidelines and to promote the supporting role of nutritional supplementation in treating pressure ulcers is “more pertinent now than ever” (Choo, Hayter & Watson, 2013).

**Management Strategies**

To promote the idea of supplemental nutrition in the healing of decubitus ulcers, nurses must first create awareness of the issue if management strategies are to ensue. Nurses must educate themselves, as well as their patients, regarding the vast correlations between proper nutrition and timely healing/prevention of pressure ulcers. Possible interventions for this dilemma include educational assessments for nursing staff, pilot studies to further the current research on nutrition and pressure ulcers, and visual aides to promote nutritional education, patient decision-making, and compliance in patients at risk for developing bedsores. Currently, there are multiple management strategies encompassing education regarding pressure ulcers, and most of them incorporate nutritional interventions to at least some degree.

In 2013, the National Pressure Ulcer Advisory Panel identified “Research Priorities for Pressure Ulcer Prevention, Treatment, and Policy” (National Pressure Ulcer Advisory Panel, 2013). Among their highest research priorities were the cost of pressure ulcer care in the United States, which they aimed to reduce via “effects of nutritional
interventions on outcomes of pressure ulcers”, as well as various other interventions such as selection of appropriate support surfaces, etc. The fact that the NPUAP has identified nutrition as a key intervention conveys the importance of establishing nutritional guidelines through further research and promoting nutrition to patient populations (National Pressure Ulcer Advisory Panel, 2013).

Another management strategy was identified by the AHRQ, and was named “Preventing Pressure Ulcers in Hospitals: A Toolkit for Improving Quality of Care” (Berlowitz et al., 2011). Using a systemic approach, the toolkit aimed to create a standardized understanding of pressure ulcer interventions, as attitudes regarding this subject differ throughout various facilities (Berlowitz et al., 2013). The toolkit aimed to update knowledge and promote changing attitudes of health care personnel, as ”past surveys of both medical and nursing staff have shown that both groups have a poor understanding of the costs and importance of pressure ulcers” (Berlowitz et al., 2013).

Another, more current intervention was developed through the “Developer Challenge Project”, sponsored by the organization Health 2.0, through the U.S Department of Health & Human Services. The 2013 “Mobilizing Data for Pressure Ulcer Prevention Challenge” aimed to provide a mobile application that would facilitate the “prevention, early detection and appropriate management of pressure ulcers in clinical setting”. (“Mobilizing Data for Pressure Ulcer Prevention Challenge, 2012). The challenge yielded creation of numerous mobile applications such as the WoundMap©, WoundMender®, and PressureMap© allow nurses to electronically perform pressure ulcer risk assessments and photographic documentation at the bedside (“Mobilizing Data for Pressure Ulcer Prevention Challenge, 2012).
Recommendations & Implications for Future Practice

The strategies described above illustrate profound progress in caring for decubitus ulcers and convey an acknowledgement of nutritional interventions. However, most are still aimed at the prevention of pressure ulcers, rather than on interventions to promote healing. Furthermore, these strategies place greater emphasis on education of organizations and healthcare staff, and do not focus directly on the patient. Complications of delayed pressure ulcer healing continues to be a significant problem, thus current interventions appear to be insufficient.

A visual aid titled “Pressure Ulcer Healing Tray“ was created to facilitate intake of foods that contribute to healing (Appendix A). The visual tool displays a tray, with components of Arginine/glutamine, Zinc, Vitamin A, Vitamin C, and Fluids, with pictures of foods containing each nutrient listed adjacent to the tray. Below the tray are the same listed nutrients, except with food types written instead of displayed in pictorial form. The visual aide would be presented to the patient upon admission, and explained by the nurse. While the patient would still have access to the normal hospital menu, the visual aide will serve as a tool to guide patients into choosing foods that are beneficial for healing. Patients who receive enteral or parenteral feedings would receive the same supplements and nutrition through liquid feedings.

By implementing a visual aide that encompasses adjunctive nutrition that is supported by research, patients will be able to take an active role in their nutritional intake and healing of pressure ulcers. This is particularly beneficial to patients, as Mary Litchford, PhD, wrote in the Association of Nutrition and Foodservice Professionals that,
“patients who chose not to participate in their own pressure ulcer prevention could develop unavoidable pressure ulcers” (Litchford, 2010). In addition, the visual aide will serve as a reminder to nurses to assess progression of healing, encourage that patients order a variety of foods, and chart nutritional intake. Litchford recommends offering pressure ulcer patients a minimum of 30-35 kcal per kg body weight per day, with 1.25-1.5 g/kg/day protein and 1 ml of fluid intake per kcal per day.

Visual aids are a recommended approach in improving the overall health and education of older adults (Choi, 2011). The Office of Disease Prevention and Health Promotion at the US Department of Health and Human Services, as well as the National Quality Forum, advise simplifying health instructions with pictures. Appropriate visuals and simplified text can “direct patients’ attention to important details and reduce reliance on complex textual information, thus improving their understanding” (Choi, 2011).

Photographs provide realistic images; thus, “they are good at gaining users’ attention and generating emotional responses” which are pivotal to patient participation in their own care (Choi, 2011). Literature shows that visual aides are particularly beneficial for elderly and low-literacy learners, as text heavy teaching can often cause such population’s eyes to skim over large sums of information and miss key concepts (Choi, 2011). Furthermore, pictographs, a simple drawing conveying health-related information, is an especially effective form of visual aide to promote learning (Choi, 2011).

For patients who are following a new diet in order to establish health-promotion visual aides can be particularly effective (Evans et al., 2009). A study by Evans et al. showed that “better knowledge about an appropriate diet leads to improved metabolic
control” (Evans et al., 2009). In his study, children with metabolic disorders who required low protein diets benefited from the use of educational visual aids. The visual aides, in the form of recipe books and DVD’s, helped the children to better interpret health-related information and to take an active role in their self care (Evans et al., 2009). Through their studies and previous reviews of literature, Evans & colleagues noted that patients who received a visual aid in addition to verbal dietary counseling showed increased dietary compliance than the control group who did not receive several methodologies of teaching (Evans et al., 2009).

The visual aid should remain with the patient, either at the bedside, or posted on the wall in clear sight, at all times. The is especially beneficial for adults 65+, as the Journal of Gerontological Nursing states that older adults require multiple periods of repetition to retain new health information (Thomas, 2007). By keeping the visual aid in the patient’s room, it will allow the patient to feel as if their diet is not simply an “acute” issue, but rather an ongoing strategy for management of healing. Furthermore, the visual aide correlates nicely Erikson’s stage of “integrity vs. despair”, which many older adults enter into after age 65. In this stage, older adults define their sense of satisfaction by reflecting on their life, and “integrating new information into their own personal philosophy” (Thomas, 2007). By placing the visual aide within the hospital room, the older adult learns to make connections between their current medical ailment (pressure ulcer) and solutions for change (proper nutrition). The use of a visual aide is further supported by Knowles’ Theory, which emphasizes that adults are more likely to learn information that is of immediate and beneficial value to them. Thus, presenting solutions rather than general information about the problem will be more likely to result in
compliance (proper nutrition), especially if they know if could potentially result in a faster discharge out of the hospital (Thomas, 2007).

Due to limited research, the NPUAP/EUAP has not yet identified set standards on daily recommendations of micronutrients for pressure ulcer healing. Recommendations were instead based on the NIH & U.S Department of Health and Human Services guidelines. The Office of Dietary Supplements, within the U.S Department of Health & Human services, sets the recommended daily intake of zinc for 11mg/day for men and 8mg/day for women. For all adults, the upper safe limit is 40mg/zinc per day. Oysters, are the best source of zinc, while red meats, poultry, seafood such as crab and lobsters, and fortified breakfast cereals also provide sufficient zinc sources (NIH, 2013). The Office of Dietary Supplements recommends Vitamin C intake in amounts of 90mg/day for men, and 75mg/day for women, with an upper safe limit of 2,000mg/day for all adults (NIH, 2013). Foods high in vitamin C include citrus fruits, such as oranges and grapefruit, as well as kiwifruit, and red or green peppers. Broccoli, cantaloupe, strawberries, baked potatoes and tomatoes also are good sources of vitamin C (NIH, 2013). Foods rich in vitamin A include organ meats (limit with high cholesterol), fish (especially salmon), green, leafy vegetables such as kale and broccoli, orange and yellow vegetables such as carrots and squash, and dairy products --one of the main sources of vitamin A for Americans (NIH, 2013).

Arginine, an amino acid found in many proteins, can be obtained naturally, or in commercially purchased supplement form. Foods that contain natural sources of arginine include nuts (walnuts, hazelnuts, pecans, peanuts, almonds, cashews, and Brazil nuts), oats, corn, cereals, seeds (sesame and sunflower), buckwheat, brown rice, dairy products,
beef such as veal, chicken, and chocolate (WebMD, 2012). Arginine can also be found in lima beans, kidney beans, crustaceans, cod, grain sources such as quinoa and brown rice, and in soy based products (Murray & Pizzorno, 2005). Sources of Glutamine include high protein foods such as eggs, whey protein, ricotta cheese, milk, yogurt, pork and poultry, parsley and cabbage (Erhlich, 2013; Murray & Pizzorno, 2005). Glutamine is also available as a commercially purchased supplement.

Future considerations involve including a Pressure Ulcer Diet Menu, which will be ordered by physicians, and made known to cafeteria staff. Similar to patients on low sodium or low fat diets, the “Pressure Ulcer Diet” will be recommended for patients who are at risk or who have present/developing ulcers. Pressure ulcer healing and the effects of nutrition is an underserved area of research, and should be further developed through future randomized control trials to establish more detailed protocols for nutritional recommendations and healing of decubitus ulcers.

Summary

Although current practices have not eradicated the incidence of pressure ulcers, implementing nutritional-based strategies to speed the healing of such ulcers is a promising alternative, and one which encompasses the entire multidisciplinary health-care team. Nutrition is a key factor influencing the rate of healing wounds, and should be given more attention in patient plans of care, nursing interventions, and risk assessment tools regarding patients with pressure ulcers. While there is a variety of research to support the healing effects of Vitamin A, Vitamin C, Zinc, Arginine and Glutamine on the effects of healing, further research is needed in order to establish NPUAP and EPUAP guidelines and to
develop new pressure ulcer protocols which place more critical emphasis on nutrition. In the interim, the “Pressure Ulcer Healing Tray” can serve as a simple and naturally-based guide of suggested food groups that will facilitate healing. Health-care staff, especially nurses, can use this tool to provide education to their patients and to promote self-efficacy in patients ordering foods which are conducive to healing.
Appendix A
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