The Effect of High Frequency Ultrasound on the Prevention of Pressure Ulcers in Long-term Care Patients

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INTRODUCTION

In 2005, America spent close to 2 trillion dollars on health care. The cost of providing health care in the older American is three to five times greater than the cost for someone younger than 65. The number of persons in the U.S. who are 65 and over is expected to double within the next 25 years. By 2030, almost one out of five Americans, some 71 million people, will be 65 years or older. “The population age 65 and over is increasing at a faster rate than the total population.” By 2040, the population age 75 years of age and over will exceed the population 65-74 years of age.” The cost of health care is therefore a major concern for America’s elderly.

Wilkes-Barre, Pennsylvania has a large geriatric population. According to the 2000 census, approximately twenty percent of the population in Wilkes-Barre was 65 years old and older, compared with eighteen percent in Wilkes-Barre’s county of Luzerne, fifteen percent in the state of Pennsylvania, and twelve percent in the United States. Wilkes-Barre, therefore, has an eight percent higher population aged 65 years old and older than the nation. Many of these residents are now residing in nursing homes in the area.

“In 2000, 4.5 percent of people aged 75-84 and 18.2 percent of those 85 and older lived in nursing homes.” Nursing home care accounted for 7% of personal health care expenditures in 2005. The development of pressure ulcers in nursing homes can add to these expenditures. The prevalence rate for pressure ulcers in long term care facilities is approximately 9%. More than 20% of residents who have been in long-term care facilities for 2 or more years will develop at least one pressure ulcer.

Pressure ulcers are a major health problem in the United States, and are especially prevalent in the elderly, due primarily to increased co-morbidities and chronic medical conditions in this population. The incidence and economic burden of this disease has been increasing yearly—“estimates are that between 1.5 and 3 million people in the United States have pressure ulcers and that these chronic wounds cost approximately $5 billion annually to treat.”
Health care professionals are seeing a rise in the numbers of pressure ulcers in hospitals, assisted living facilities, patients’ residences and long-term care facilities. It is essential for health care providers to recognize the symptoms early and to treat them appropriately and aggressively in order to prevent progression of the disease and associated adverse events that occur from prolonged breakdown of tissue. In addition, providers should recognize the major risk factors of pressure ulcers in their patients and treat them assertively, taking preventive medical measures to help reverse the progression of this disease process.

The development of pressure ulcers in long-term placement facilities increases patients’ mortality and infection rate of soft tissue, bone, and blood. Pressure ulcers are too often associated with patient suffering, morbidity, and mortality. Overall, patients with pressure ulcers have a two-time greater chance of mortality than those without. The continuing occurrence of pressure ulcers can be a quality indicator of the facilities’ lack of preventive care. Nursing homes must therefore place a greater emphasis on the evaluation, treatment, and prevention of pressure ulcers.

Prevention of pressure ulcers for patients of long-term care facilities should be incorporated into the protocols of the facility for all residents. The U.S. Department of Health and Human Services (AHCPR) has provided clinical practice guidelines for both the prevention and treatment of pressure ulcers. The multidisciplinary approach outlined in this publication has been shown to be an effective means to reduce the incidence of pressure ulcers, improve quality of patient care, and reduce the cost of treatment. On November 12, 2004, the Centers for Medicare and Medicaid Services released new interpretive guidelines to Federal Tag 314 for pressure ulcer prevention and management. These regulations are to be utilized at both the federal and state levels to allow surveyors of Medicare and Medicaid Services who certify nursing homes to assess the quality of pressure ulcer care provided to residents in long-term care facilities. These guidelines must be followed in order to decrease the risk of financial penalties and/or closure by the government as a result of federal and state monetary withholdings to the facility.

The overall adherence to these guidelines, however, has been poor, with a wide range of compliance among individual nursing homes. Risk assessment tools are often underutilized and the recent shortage of nurses has certainly affected the ability to assess patients. Nursing home facilities must place a greater emphasis on the importance of pressure ulcer clinical practice guidelines. The implementation of these guidelines needs to become a universal standard care practice in all nursing homes. Multidisciplinary team care is essential for the treatment of the elderly with pressure ulcers. Active strategies that involve education have been shown to increase the effectiveness of the utilization of preventive pressure ulcer guidelines.

The purpose of this study was to explore the use of ultrasound technology and educated student teams as a diagnostic tool for assessing pressure ulcer formation in nursing home patients. Ultrasound scans can detect early skin breakdown and edema before clinical signs of pressure ulcers are evident. The early detection of patients at high-risk for pressure ulcers allows health care workers to implement preventive care measures and if necessary begin treatment sooner than waiting for clinical signs. Overall, the study aimed to show a reduction of pressure ulcers of the heel and sacrum, the most common sites of pressure ulcer formation, in long-term care facilities through the early use of ultrasound technology and/or educated student teams in the evaluation and preventive management of pressure ulcers.

**BACKGROUND**

Pressure ulcers are common among patients admitted to nursing homes. The prevalence rate for pressure ulcers in long-term care facilities is approximately 9%. According to the Centers for Medicare and Medicaid Services, 40 percent of the 25 nursing homes in Luzerne County experienced increased rates of pressure ulcers in their high-risk residents in comparison to the state average.

The development of a pressure ulcer is a complex process that requires the application of external forces, such as pressure, to the skin. The interaction of the pressure with host-specific factors culminates in tissue damage. The major risk factors for development of pressure ulcers include immobilization for increased periods of time, co-morbid conditions, utilization of steroids, increased age, decrease or loss of sensory-neural function, vascular and cardiovascular insufficiency, weight loss, edema, dehydration, undernourishment, and incontinent bladder and bowel.

External forces that contribute to the development of pressure ulcers include pressure, shearing forces, friction, and moisture. Pressure applied to the skin in excess of the arteriolar pressure (32 mmHg) prevents the delivery of oxygen and nutrients to tissues, resulting in tissue hypoxia,
the accumulation of metabolic waste products, and free radical generation. Pressure in excess of 70 mmHg for two hours results in irreversible tissue damage in animal models. Muscle tissue is the most susceptible to pressure induced injury, followed by subcutaneous fat and dermis.

Pressure ulcers are categorized by stages. The most commonly used system is published by the National Pressure Ulcer Advisory Panel. The panel redefined the staging of pressure ulcers in February 2007, including the 4 original stages and adding 2 stages on deep tissue injury and unstageable pressure ulcers.

- Suspected deep tissue injury: Purple or maroon localized area of discolored intact skin or blood-filled blister due to damage of underlying soft tissue from pressure and/or shear. The area may be preceded by tissue that is painful, firm, mushy, boggy, warmer or cooler as compared to adjacent tissue.

- Stage I: Intact skin with non-blanchable redness of a localized area usually over a bony prominence. Darkly pigmented skin may not have visible blanching; its color may differ from the surrounding areas.

- Stage II: Partial thickness loss of dermis presenting as a shallow open ulcer with a red pink wound bed, without slough. May also present as an intact or open/ruptured serum filled blister.

- Stage III: Full thickness tissue loss. Subcutaneous fat may be visible but bone, tendon, or muscle are not exposed. Slough may be present but not obscure the depth of tissue loss. May include undermining and tunneling.

- Stage IV: Full thickness tissue loss with exposed bone, tendon, or muscle. Slough or eschar may be present on some parts of the wound bed. Often include undermining and tunneling.

- Unstageable: Full thickness tissue loss in which the base of the ulcer is covered by slough (yellow, tan, gray, green or brown) and/or eschar (tan, brown, and black) in the wound bed.

Ultrasound utilizes sound wave echoes to create images of soft tissue anatomy. A probe transmits sound waves into the body. When these sound waves hit different types of tissues, energy of differing proportions is reflected back. The calculation of the intensity and distance of these reflections allows for the identification of various tissue types. The ultrasound machine converts these calculations and displays a 2-dimensional image of these reflections.

New advances in ultrasound technology have lead to the increase in ultrasound frequency, high frequency ultrasound (HFUS). This type of ultrasound allows for greater resolution, but the depth of penetration of the sound waves is less. This is ideal for imaging near-surface pathology. High-resolution ultrasound can be used to demonstrate the fluid content of tissue. Greater fluid content in tissue results in a decrease in echogenicity readily detectable by HRUS.

**Figure 1**

The use of HRUS has been shown to be effective in measuring skin thickness. HRUS can also be used to determine dermal edema and the architectural structure of skin. The layers of the epidermis, the dermis, and the subcutaneous tissue can be distinguished. The interface between bone and soft tissue can be identified by a strong reflection.

If an area has eschar, the ulcer cannot be accurately staged until it is removed and the underlying tissues are visualized. When an ulcer has eschar, high frequency ultrasound is used to detect epidermal layer destruction. This will allow for earlier staging of the ulcer. The ultrasound findings can demonstrate edema in the subdermal tissue and skin before clinical signs are apparent. High-frequency ultrasound can therefore detect early signs of pressure ulcer development independent of clinical signs. This can allow preventative measures to be applied prior to further ulcer development. This may become a new method of determining a stage one pressure ulcer.

HRUS units are now more portable and affordable. The HRUS unit can be brought to the patient’s bedside, making it a safe, non-invasive, convenient modality to assess the skin and superficial tissue of patients that may be at risk for pressure ulcers in a variety of settings.
If HRUS units are utilized to screen patients, especially high risk patients, pressure ulcers could be recognized prior to signs and symptoms being present. This could help healthcare providers to apply more aggressive preventative measures to help ensure than skin break down does not occur.

The Agency for Health Care Policy and Research (AHCPR) recommendations to prevent pressure ulcers include risk assessment, measures to relieve pressure, proper skin care and nutrition, and steps to minimize moisture from urinary and fecal incontinence. Common acceptable preventive measures for pressure ulcers include frequent changes in position in a chair or bed, the use of air mattresses, the use of cushions underneath pressure areas of the body, and the use of protective barrier cream over common pressure ulcer sites. Areas particularly prone to pressure ulcers, such as the sacral prominence and heels, should be examined more frequently. In addition, health care providers need to monitor patients’ nutritional status and fluid/hydration levels, as well as manage incontinence and personal hygiene. The more preventive medical measures used, the better the overall outcome for the patient.

Risk assessment should be performed on all patient groups that are known to be at an increased risk of developing pressure ulcers, including nursing home patients and patients who are bound to a bed or wheelchair.

The Braden Scale is internationally recognized for its high reliability in predicting patients at risk for pressure ulcers. The Braden Scale has six components: sensory perceptions, moisture, mobility, activity, nutrition, and friction/shear. Each component is defined and rated on a scale of 1 to 4, with the exception of friction/shear, which is rated on a 3 point scale. The total is added together for a maximum total score of 23. Lower scores equal higher risk for pressure ulcers. A score of 15 to 18 indicates at risk, 13 to 14 indicates moderate risk, 10 to 12 indicates high risk, and 9 or below indicates very high risk.

Figure 2

Table 1: Braden Scale for Predicting Pressure Ulcer Risk

<table>
<thead>
<tr>
<th>Patient’s Name</th>
<th>Evaluator’s Name</th>
<th>Date of Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensory perception</td>
<td>Mobility</td>
<td>Friction/shear</td>
</tr>
</tbody>
</table>


Initial assessment should be done within 48 hours of admission and subsequent assessments should be made weekly for a month, then once every 3 months or more frequently with a change in mental or health status. After risk assessment with the Braden Scale and assessment with ultrasound, preventative measures can be taken to prevent pressure ulcer formation or pressure ulcer worsening.

Most healthcare facilities, including nursing homes, have protocols and guidelines for pressure ulcer prevention and treatment. The protocols at the specific facility in which this study was performed included specific actions upon admission or re-admission and also continued assessment of
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The residents comprehensive assessment/care plan, which included the Resident Assessment Instrument (RAI), would evaluate the resident’s intrinsic risks, the resident’s skin condition, other factors (including causal factors) which placed the resident at risk of developing pressure ulcers and/or experiencing delayed healing, and the nature of the pressure to which the resident may be subjected. The assessment would identify which risk factors could be removed or modified.

The comprehensive assessment would address the factors that have been identified as having an impact on the development, treatment and/or healing of pressure ulcers, including at a minimum risk factors, pressure points, under-nutrition, and hydration deficits, and moisture and the impact of moisture on the skin.

Preventative measures and interventions were outlined in the Skin Care Protocol. The following preventative measures would be put in place if indicated based on the location of the affected area as follows per physician order:

- Pressure relief mattress will be placed on bed (e.g. Air mattress, Low Air Loss mattress, Tri-cell mattress, etc)
- A pressure relief cushion (convoluted foam pads, gels) will be placed on wheelchair/gerichair
- Heel protectors to both feet will be ordered
- Lambs wool to bottom of bed
- OT evaluation for pressure relief and positioning when out of bed if indicated
- Repositioning every 2 hours or sooner if necessary off the affected area for total pressure relief; residents unable to reposition themselves will be repositioned every 2 hours or sooner if indicated when in bed and when out of bed
- Pillow under both feet for pressure relief
- Elbow protectors
- Pillow between legs to prevent pressure at the knees and/or knee protectors
- Minimize exposure to moisture on the resident’s skin from urine and feces with checks every 2 hours by direct care staff

Upon admission to the facility at which this study was performed the charge nurse or nurse supervisor was to complete a head to toe body audit. Once the complete body audit was done, the nurse then documented the findings on a specific form within the patient’s chart. Information in this document includes staging, location, description of the affected area, and current treatment and preventative measures in place. The Braden Scale was also completed on all admissions and re-admissions, weekly four times following admission or re-admission and then quarterly by a charge nurse. The facility’s Skin Care Protocol also states that any resident admitted with a Stage I or II pressure area would initially be placed on an air mattress and any resident admitted with a Stage III or IV pressure area would be placed on a low air loss mattress.

An admission or re-admission evaluation would be completed by the Wound Care Nurse in collaboration with the Registered Nurse Assessment Coordinator (RNAC) to help identify the resident at risk of developing a pressure ulcer, and/or the resident with existing pressure ulcer(s) or areas of skin that were at risk for breakdown. Braden Scale scores would also be evaluated by the Wound Care Nurse and the RNAC.

The admission evaluation would identify pre-existing signs such as a purple or very dark area that was surrounded by profound redness, edema or induration, suggesting that deep tissue damage had already occurred and additional deep tissue loss may occur. In a darker skinned resident, it may be necessary to focus more on other evidence of pressure ulcer development such as bogginess, induration, coolness, or increased warmth as well as signs of skin discoloration.

the skin. These protocols are very detailed and include an in-depth admission evaluation along with guidelines for re-evaluation, prevention and treatment. The nursing home that this study was conducted at had a detailed plan of action for pressure ulcer prevention and treatment which seemed to follow the Agency for Health Care Policy and Research (AHCPR) recommendations. It also had one of the highest number of Medicare certified beds in Luzerne County in Pennsylvania. This allowed for a larger number of residents to be included into the study. This nursing home also had a lower number of pressure ulcers reported in high risk patients compared with the state and national averages, 10 percent verses 14 percent in December of 2005. This suggests that this nursing home’s pressure ulcer protocols have already been shown to be effective in the prevention of pressure ulcer development.
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Individual Physician Assistant students were randomly assigned a patient case load and followed these patients for a year. The nursing home residents participating in the study were initially evaluated through a complete history and physical by a King’s College PA student within the first 24 hours of starting the trial. All of the patients selected, except for the control group, were seen on a regular basis and depending on their assigned experimental group received high frequency ultrasound scans and/or physical evaluation. Based on the initial evaluations, residents in the experimental groups with ulcers that were stage 1 or worse were re-evaluated weekly throughout the entire study. Monthly re-evaluation was conducted if no ulcers were detected. If a change in ulcer status was noted, if the patient’s risk factors worsened or if the patient was readmitted to the nursing home after a hospitalization, the patient was again seen weekly.

Based on the findings, assessments and treatment plans were implemented weekly. A faculty member from King’s College worked with the students and helped provide evidence-based recommendations to the nursing home for each individual resident identified. Recommendations were passed to the patients’ personal physicians by the nursing staff and the physicians decided if an adjustment in the patient’s treatment plan would occur.

All information, such as ultrasound results and patients’ progress notes, was stored and recorded utilizing a computer software program called SharePoint. The SharePoint program is a secure website that could only be accessed by the students and faculty carrying out the study. The site maintained confidentiality of all residents and allowed the student and faculty research team to be aware of all residents’ current conditions. SharePoint also allowed the research team to hold meetings while at various locales.

All facility residents with Braden scales of less than or equal to 16 with written participation consents were randomly selected and divided into four groups. The four primary study groups were labeled as follows: (1) the control group—no students, no ultrasound; (2) students only; (3) ultrasound only; and (4) students and ultrasound intervention group.

The control group underwent a chart review at the beginning and end of the study. Braden scales and pressure ulcers were documented. Throughout the course of the study they did not have any ongoing pressure ulcer assessment by the King’s College PA students. The nursing home’s protocol for

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• Obtain an order for Barrier Cream every shift and as needed from the physician for all residents with incontinence

• Observe for drug reactions that my worsen risk factors for development of pressure ulcers or for non-healing pressure ulcers (ex. Causing anorexia, lethargy, or creating increased confusion)

Appropriate recognition of the prevalence of pressure ulcers in patients, especially nursing home patients, can help the health care team provide risk assessment, screening, including use of HRUS, and preventative measures in appropriate patients. Rapid assessments and preventive care of pressure ulcers can help prevent unnecessary patient discomfort and may help to decrease healthcare costs.

METHODS

A randomized study was conducted to explore the reduction of pressure ulcers located on the heel and sacrum of 27 residents in a long-term nursing facility in Luzerne County, Pennsylvania, from May 2007 to March 2008. The participants’ ages ranged from 39 to 99 years of age, with a mean age of 43.7 years. The Braden scale for risk assessment was used on all residents within the nursing home to evaluate each patient’s risk. All patients selected had Braden scales less than or equal to 16 with multiple comorbidities, making them a high risk for developing pressure ulcers. These risk factors included increased age, prolonged immobilization, poor nutrition, vascular/venous deficiencies, urinary/bowel incontinence, and chronic medical conditions. Exclusion criteria included any resident or new admission at the start of the study with a Braden scale greater than or equal to 16 or patients who refused to participate in the study. If the patient was mentally incapable of understanding and signing a consent form to participate in the study, the patient’s medical power of attorney signed the consent for permission to participate. No new admissions were allowed into the study once the study had begun and two participants died during the first month of the one-year trial.

Physician assistant graduate students from King’s College classes of 2006-2008 volunteered to assist in the research study. Physician assistant students and select King’s College faculty were trained in the usage of high frequency ultrasound techniques and in the interpretation of results, as well as the clinical evaluation of pressure ulcers through physical exam and history taking.

Individual Physician Assistant students were randomly assigned a patient case load and followed these patients for a year. The nursing home residents participating in the study were initially evaluated through a complete history and physical by a King’s College PA student within the first 24 hours of starting the trial. All of the patients selected, except for the control group, were seen on a regular basis and depending on their assigned experimental group received high frequency ultrasound scans and/or physical evaluation. Based on the initial evaluations, residents in the experimental groups with ulcers that were stage 1 or worse were re-evaluated weekly throughout the entire study. Monthly re-evaluation was conducted if no ulcers were detected. If a change in ulcer status was noted, if the patient’s risk factors worsened or if the patient was readmitted to the nursing home after a hospitalization, the patient was again seen weekly.

Based on the findings, assessments and treatment plans were implemented weekly. A faculty member from King’s College worked with the students and helped provide evidence-based recommendations to the nursing home for each individual resident identified. Recommendations were passed to the patients’ personal physicians by the nursing staff and the physicians decided if an adjustment in the patient’s treatment plan would occur.

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The control group underwent a chart review at the beginning and end of the study. Braden scales and pressure ulcers were documented. Throughout the course of the study they did not have any ongoing pressure ulcer assessment by the King’s College PA students. The nursing home’s protocol for
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pressure ulcer prevention, recognition, and treatment were used for these patients. The King’s College PA students’ evidence-based recommendations for preventive measures and intervention were not applied to this group of patients.

The second group, student intervention only, received history and physical examinations and chart review by the students weekly. Based on the clinical exam, recommendations were made for implementation of pressure ulcer protocols, utilizing the most accurate and up-to-date evidence-based guidelines for the prevention, detection, and treatment of pressure ulcers and associated co-morbidities.

The third group, ultrasound only, was scanned with high frequency ultrasound for pressure ulcer detection. Patients in this group had their lateral, posterior, and medial heels and sacrum scanned on a weekly basis. These areas were scanned in the study because the heel and sacrum are the most common sites for pressure ulcer development, accounting for 30% of all pressure ulcers.\textsuperscript{2} The results of the ultrasounds were interpreted and the data found was applied to the patients’ care plans. Again the physician assistant students utilized the most accurate and up-to-date evidence-based guidelines for the prevention and treatment of pressure ulcers when recommending a pressure ulcer protocol for these patients. These patients did not undergo physical examination and their co-morbidities were not addressed by the PA students.

The fourth group, student and ultrasound intervention, were scanned with the high frequency ultrasound on their lateral, posterior, and medial heels and sacrum and also underwent clinical evaluation by the PA students on a weekly basis. The students applied both the patients’ clinical exam findings and ultrasound scan results to formulate an assessment and plan for the patients. The care plans for these patients addressed the patients’ pressure ulcer status and co-morbidities.

The following evidence-based student protocol for prevention, and treatment of stage 1 pressure ulcers was utilized on patients in groups 2, 3 and 4:

1. Re-position the patient in bed every 2 hours.
2. Keep the head of the bed at 30 degrees.
3. Re-position the patient out of bed in their chair every 30 minutes.
4. Keep patients as mobile as possible.
5. Heel protectors should be worn in bed at all times.
6. Elbow protectors should be worn in bed at all times.
7. If patients can tolerate shoes, they should be worn out of bed and in their chairs. If patients can’t tolerate shoes, they should wear heel protectors out of bed.
8. Pillows or foam wedges should be applied between the knees, ankles, and heels when the patient is lying on their side.
9. Pillows or foam should also be applied under the knees and under the heels when the patient is supine.
10. Pressure-affected areas (scapula, elbows, coccyx, heels) should be cleansed using a mild cleansing agent.
   a. Normal Saline Solution 35 ml
   b. 4 x 4 sterile gauze
   c. Do not use Iodine or Peroxide
11. Barrier ointment should be applied to the patient’s sacrum/coccyx after every toileting. Barrier ointment should be kept at the bedside.
12. Skin protectant ointment should be applied to the patient’s heels bilaterally BID.
13. Skin protectant should be kept at the bedside.
14. Skin protectant should be kept at the bedside.
15. Patients with dependant edema should have their feet elevated while out of bed. They should also wear medium compression, below the knee compression stockings.
16. Patients with dependant edema should have their feet elevated above the level of their heart while in bed.
17. Pressure relief mattresses (air mattresses) should be placed on the bed of any patient with a Stage I ulcer.
18. Obtain dietary consult:
   a. Patient should receive 50 mg of Zinc TID.
b. Patient should receive 1 gram of Vitamin C daily.

c. Protein intake should be approx. 1.25-1.5 grams/kg/day.

d. An albumin level should be drawn monthly to evaluate nutritional status. Patients with a level <3.5 mg/dl, or patients who are less than 80% of the ideal weight will require immediate changes in dietary status.23242526272829

At the termination of the study, all information was gathered, reviewed, and analyzed. The statistical analysis was performed through a univariate analysis of variants. The groups at the beginning of the experiment were placed into a hypothesis test to determine whether the treatments affected patients’ Braden scores differently than the response variable. The response variable in this experiment is the “Braden Difference” which can be defined as the ending Braden score minus the beginning Braden score. The estimated marginal means of the various groups were determined and the mean Braden Difference for each group was compared. The second part of the experiment considered 3 distinct groups – student intervention only, both ultrasound groups together, and the control group. Again a hypothesis test was conducted to determine whether the separate treatment variables produced different results on the response variable.

RESULTS

At the end of the study, the experimental group consisted of nineteen patients and six control patients. Of the original twenty-seven patients, two were removed from the trial due to deaths. Twelve of nineteen patients, making up the experimental group, were used for ultrasound scanning.

The ultrasound data was then plotted graphically to demonstrate the overall trends week by week. Out of twelve patients chosen for ultrasound only, one patient was excluded due to patient refusal to exam. All patients were found to have a stage I ulcer of the heel on ultrasound. One patient did develop a stage II heel ulcer of the right posterior heel near the beginning of the trial according to ultrasound and exam. Stage II ulcer protocol was then implemented and the ulcer improved to a stage I. The same patient later developed a new onset stage I ulcer of the left lateral heel found on ultrasound but not on visual exam near the same time and remained there throughout the entire trial. Another patient developed a stage I ulcer of the sacrum during the trial and remained there through the end of the study. In another patient a stage II sacral ulcer was diagnosed prior to the study which improved to a stage I.

Throughout the entire study, most patients with stage I ulcer at the beginning or those who developed a stage I ulcer, remained with a stage I ulcer with no significant changes. Of all the patients who were placed in the ultrasound group, only two of the eleven patients (18%) developed a new onset stage I ulcer. Of these patients, only one (9%) progressed to a stage II, but then improved back to a stage I. Of the eleven ultrasound patients, only 27% showed worsening to a stage I ulcer and 18% showed sacral breakdown to stage I.

The student only group originally included nine patients. Two of these patients died early in the study prior to initiating a change in protocol for pressure ulcer prevention and treatment. Of the remaining seven patients, one patient entered the trial with a previously diagnosed stage I heel ulcer found on exam. This same patient later developed a new onset stage II heel ulcer that eventually resolved to stage I after protocol treatment was implemented. Another patient developed a new onset stage I heel ulcer found on visual exam. This ulcer remained stable up to the end of the trial with no change. Of the remaining six participants of the student only group, 16% presented with an established stage I ulcer with 33% developing new onset ulcers.

Statistical analysis of the four groups revealed a mean Braden score of 14.28 at the beginning of the experiment. The p-value revealed no significant difference concerning the Braden scales between the groups. Calculations were then made for “Braden Score Difference” (Table 1-4). Decreases in the Braden Score Difference would be desired resulting from a higher ending Braden Score. Virtually all groups except for the ultrasound only group showed improvements in end Braden scores. In fact the control group showed the greatest improvement with a mean decrease of -1.1667. In the end, with low p-values, the analysis showed there was no statistical significance for the interaction of student and ultrasound, the main effect of student involvement, or with the effect of performing ultrasounds (Table 1-5). In conclusion, there was no statistically significant difference between the four groups in the treatment modalities of the patients.

A second analysis was done consisting of three groups: 1)
student involvement/no ultrasound; 2) student involvement/ultrasound (consisting of data of all ultrasound patients whether or not student involvement was included); and 3) no student involvement/no ultrasound (control group). Mean Braden scale remained at 14.28. The p-value for the three groups was 3.30 which demonstrated no significant difference between the group mean Braden scores at the beginning of the experiment. Final analysis for these three groups also showed there was no significant differences between the three treatment groups with comparison of end Braden scores.

In conclusion, the results show that there was no statistical significance between the treatment groups revealing that management of one group was not superior to another, however due to such a small sample size, the data neither proves nor disproves that the set treatments affect the diagnosis and treatment of pressure ulcers.

Braden scores at beginning of experiment.

**Figure 3**

![Descriptive Statistics Table](image)

Beginning average Braden scores between four test groups.

**Figure 4**

![Descriptive Statistics Table](image)

Beginning Braden score analysis. P-value – 0.942 = no significant difference between four groups.

**Figure 5**

![Tests of Between-Subjects Effects](image)

Braden Score Difference for four test groups.

**Figure 6**

![Descriptive Statistics](image)

Statistical analysis of four groups.

**Figure 7**

![Tests of Between-Subjects Effects](image)

Student/ultrasound interaction. P-value - 0.412
Student main effect. P-value -0.757
Ultrasound main effect. P-value -0.499

Conclusion: no statistically significant difference between the four groups.
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2-1. Beginning average Braden scores for three test groups.

2-2. Beginning Braden score analysis. The p-value is $0.330 = \text{no significant difference between three groups}.$

2-3. Mean Braden Score Difference for three test groups.

2-4. Ending Braden score analysis between three test groups. P-value $0.551 = \text{no significant difference between groups}.$

STUDENT ONLY GROUP RESULTS

Of the seven total patients in this group sixteen percent presented initially with a Stage 1 ulcer. During the study one patient developed a new ulcer, and one patient progressed to a Stage 2 ulcer before reverting to a Stage 1 ulcer. According to protocol this group did not utilize ultrasound to diagnose and follow pressure ulcers. Students utilized the Braden Scale to determine the presence or absence of pressure ulcers. Stage 1 ulcers are notoriously difficult to diagnose due to the intact skin. Color change can help with the diagnosis, along with patient discomfort; however, in this study lighting was suboptimal and the majority of study subjects were unable to communicate. Thirty-three percent developed a new ulcer but this may be an exaggerated value due to the small study population. In addition, two subjects died further corrupting the data. All patients had significant comorbidities which increased their risk of developing ulcers. The average Braden scale initially was 15, which improved at the conclusion. We can speculate that our efforts helped to keep the other 67% of patients from developing new ulcers. The study protocol did decrease the Stage 2 ulcer to Stage 1. Patient quality of life increased due to weekly student/patient interaction; the resulting buoyed mood may have caused increased patient mobility and facility activity participation which in turn decreased the risk of future pressure ulcer development. Weekly checks of the patients may have increased the staff’s awareness of patient health and prevented ulcer formation as well.

The nursing home protocols were similar to those utilized by the study, including decreasing the number of risks factors by providing adequate nutrition/hydration, and limiting the amount of pressure and moisture in ulcer prone areas. The facility completed a compressive skin evaluation weekly while showering the patients. Student evaluation was more specific to pressure areas and the presence of subtle Stage 1 ulcer signs. The stated preventative protocols were similar, but in the diagnosis of a Stage 1 ulcer, student groups were able to treat more expeditiously than facility staff. However, it is uncertain whether staff followed student recommendations. For example, protocol stated that upon patient readmission from hospital stays, Braden scales were to be reevaluated weekly for one month, then quarterly...
The Effect of High Frequency Ultrasound on the Prevention of Pressure Ulcers in Long-term Care Patients

The study examined the impact of high frequency ultrasound on the prevention of pressure ulcers in long-term care patients. At the conclusion of the study, inspection of Braden scores demonstrated no ulcers with initially 13.67. This group showed the most improvement in the Braden score mean in this group of six total patients was 13.2. Initially this group did show some improvement; however the study found no significant difference in the two groups utilizing ultrasound—whether students were or were not involved—therefore the groups were merged during comparison of results. These patients too were all diagnosed with a Stage 1 ulcer of the heel. One patient’s ulcer declined to a Stage 2 ulcer but healed to at the conclusion. One new sacral ulcer was diagnosed during the study, which remained a Stage 1 throughout. Eighteen percent of patients in the ultrasound group developed new ulcers, as compared with thirty-three percent in the student-only group. Both groups demonstrated diagnosed Stage 2 ulcers successfully treated by the conclusion of the study. In two instances Stage 1 ulcers worsened to Stage 2. The findings revealed that student intervention with ultrasound diagnosis did not produce significant differences in pressure ulcer development.

CONTROL GROUP
The Braden score mean in this group of six total patients was initially 13.67. This group showed the most improvement in Braden scores. Initial scores demonstrated no ulcers with examination. At the conclusion of the study, inspection again showed no ulcers in these patients. Data collected in this group proved the efficacy of the nursing home protocol.

Nursing home patients have increased risks for developing pressure ulcers. In the state of Pennsylvania the average number of patients with pressure ulcers per capita is equivalent to the national average per capita; twelve percent of high-risk long-stay residents have pressure sores. The facility in which this study was conducted averaged only six percent, despite the four percent increase of patients bed- or chair-bound as compared to national and state average. In statistical conclusion, the patients in this study had a higher risk of forming an ulcer, but instead had a lower rate of ulcer development than predicted. It is possible that the facility incorporated greater emphasis on pressure-ulcer prevention during the study and staff paid greater attention to those patients involved. If this is true, the study did make a difference to the patients. As stated before, study protocol and facility protocol were very similar; initial research did not find additional measures to be incorporated.

The data collected could not exclude variables such as ultrasound operator differences and skill sets, epidermal depth, equipment idiosyncrasies, etc. Researchers consisted of Masters level students which did increase the accuracy of the data leading to better comprehension of results and nuances of scientific research.

The facility did demonstrate considerable staff turnover of approximately 35% and great variability in staff training, qualifications, and skills. The designated wound care nurse was replaced once, as well as the facility coordinator. With full capacity the nursing home at which the study was performed employs one Registered Nurse as the facility head during all hours. One to two Licensed Practical Nurses work on each floor and are in charge of 18-30 patients each, with four Certified Nurses Aids per floor caring for 8-10 patients per shift.

DATA
While gathering information for the graphs, several problems were encountered. The most significant issue was missing data, which occurred for several reasons. Some ultrasound scans were unable to be read due to uncooperative patients, manpower issues and student error with capturing patient images at appropriate depth. A few lapses in visits due to equipment failure, student illness, etc caused loss of additional data. Due to the learning curve required, early results were poorly recorded, causing unreliable data for several of the ultrasound patients. Despite
these difficulties trends could still be seen most of the time in all patients.

Due to manpower issues, only a small portion of the hoped-for study population was able to be enrolled in the study. The small sample size made it difficult to produce statistically significant results.

**BARRIERS IN CARE**

Nursing homes must constantly struggle with continually-increasing numbers of new patients along with longer life spans coupled with a lack of qualified and trained personnel. Inadequate staffing due to education requirements and poor pay directly impact patient care. In the study facility a higher-than-average number of patients were completely non-ambulatory, thus requiring direct hands-on care for transfer, toileting, bathing, and for many, feeding. The time required to provide basic care is enormous, asking an already overburdened staff to be responsible for turning each patient every hour, change moist bedding several times a day and transfer the patient several times a day may be met with exasperation and resignations from the workplace. Vast increases in qualified staffing would be required to tend to these tasks, which would require increases in base pay and investment in training and retention of employees.

**PRACTICAL APPLICATION AND USE OF ULTRASOUND**

Utilizing ultrasound in the manner of the study would, at present, not be economical for the diagnosis and following of pressure ulcers. Monies required would include not only the apparatus itself, but also training of personnel to operate the ultrasound and to read and interpret the images. The impressions would then need to be transmitted to patient charts with protocol changes of that patient’s care. As the study was unable to determine a difference between number and severity of pressure ulcers of control patients as compared with those patients receiving student intervention, it would be unwise to implement such measures at this time.

Ultrasound may be more useful in identifying new patients as being at-risk for pressure ulcer development with the immediate implementation of prevention protocol. As mentioned before, Stage 1 ulcers can be difficult to diagnose due to intact skin and ultrasound is extremely useful here. Nursing facilities may be able to effectively use HFUS to evaluate patients for pressure ulcers after initial admission and after re-admissions after hospitalization. Nursing homes may capture more pressure ulcer diagnosis in this manner and be able to initiate quicker preventive and treatment protocols. This would also cut down on the time required to perform and interpret the ultrasounds.

Beginning in October of 2008, Medicare will no longer pay for hospital acquired pressure ulcers. Hospitals can perhaps begin screening for pressure ulcers in those at risk for ulcer development with the HFUS on admission. This will allow hospitals to document that ulcers were not hospital acquired by early identification and they can prevent worsening of documented ulcers by the application of early preventive protocols. Reimbursement for the care of the ulcers that were not hospital acquired should then be covered.

**CONCLUSION**

Due to the prevalence of pressure ulcers in long-term care facilities, it is important to know how to implement the best preventive care guidelines for pressure ulcers. This study evaluated the efficacy of using ultrasound technology to prevent the formation and progression of pressure ulcers in susceptible patients. Prevention is important due to the affect pressure ulcers can have on the health and quality of life of the patients, as well as the increased financial burdens on the healthcare systems. The data demonstrated that the use of ultrasound to identify ulcers and change management was not statically different from the established prevention tactics of regular turning, dry/moist skin care, and good nutrition. The experimental treatment did not improve or deteriorate the patients’ ulcer status. Due to the statistically insignificant results, it cannot be argued that using ultrasound technology and up-to-date pressure ulcer protocol is an effective means to reduce pressure ulcer development in long-term care facilities.

Future studies are needed to determine the actual effectiveness of ultrasound technology as a diagnostic tool used for the prevention, detection, and treatment of pressure ulcers in nursing facilities. Additional studies with a larger sample population and better variable control may show different results with statistical significance. Once there is more significant data demonstrating the affect ultrasound technology has on nursing home pressure ulcer care, it can be determined whether or not ultrasounds are a cost-effective and efficient tool for long-term care facilities to invest their time and labor.

**ACKNOWLEDGEMENTS**

The authors would like to acknowledge Longport, Inc. for providing the high frequency ultrasound machine, Philip Mertz, PhD, CWS, FCCWS for his training of the students
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