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Frequent manual repositioning and incidence of pressure ulcers among bedbound elderly hip fracture patients

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Abstract

Frequent manual repositioning is an established part of pressure ulcer (PU) prevention, but there is little evidence for its effectiveness. This study examined the association between repositioning and PU incidence among bedbound elderly hip fracture patients, using data from a 2004–2007 cohort study in nine Maryland and Pennsylvania hospitals. Eligible patients (n=269) were age ≥65 years, underwent hip fracture surgery, and were bedbound at index study visits (during the first five days of hospitalization). Information about repositioning on the days of index visits was collected from patient charts; study nurses assessed presence of PU stage 2+ two days later. The association between frequent manual repositioning and PU incidence was estimated, adjusting for PU risk factors using generalized estimating equations and weighted estimating equations. Patients were frequently repositioned (at least every two hours) on only 53% (187/354) of index visit days. New PU developed at 12% of visits following frequent repositioning versus 10% following less frequent repositioning; the incidence rate of PU per person-day did not differ between the two groups (incidence rate ratio 1.1, 95% confidence interval 0.5–2.4). No association was found

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Data from this study have been the subject of other analyses, the results of which have been previously published. The publications are as follows: (a) Baumgarten, M., Margolis, D.J., Orwig, D.L., Shardell, M.D., Hawkes, W.G., Langenberg, P., Palmer, M.H., Jones, P.S., McArdle, P.F., Sterling, R., Kinoshian, B.P., Rich, S.E., Sowinski, J., and Magaziner, J. 2009. "Pressure Ulcers in Elderly Patients with Hip Fracture Across the Continuum of Care." *Journal of the American Geriatrics Society*. 57(5): 863–70. (b) Baumgarten, M., Margolis, D., Orwig, D., Hawkes, W., Rich, S., Langenberg, P., Shardell, M., Palmer, M.H., McArdle, P., Sterling, R., Jones, P.S., and Magaziner, J. 2009. "Use of Pressure-Redistributing Support Surfaces Among Elderly Hip Fracture Patients Across the Continuum of Care: Adherence to Pressure Ulcer Prevention Guidelines." *Gerontologist*. Neither of these previously published articles have examined the hypotheses that are addressed in this article.

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Author contributions:

Study concept and design: Rich, Margolis, Amr, Miller, Baumgarten. Data acquisition: Rich, Shardell, Hawkes, Margolis, Baumgarten. Data management and analysis: Rich, Shardell, Hawkes. Data interpretation and preparation of manuscript: Rich, Shardell, Hawkes, Margolis, Amr, Miller, Baumgarten.

between frequent repositioning of bedbound patients and lower PU incidence, calling into question the allocation of resources for repositioning.

Keywords

repositioning; pressure ulcers; guidelines

INTRODUCTION

Pressure ulcers are a common complication of immobility among the elderly, resulting in substantial pain and suffering (1) and excess hospital costs with charges for associated hospital stays averaging more than \$15,000 (2). As of October 2008, Medicare no longer reimburses hospitals for treatment of hospital-acquired stage 3 or 4 pressure ulcers (3). This decision was based on the designation of pressure ulcers as a “reasonably preventable condition,” i.e., it is assumed that pressure ulcers will generally not develop on patients receiving care according to current evidence-based guidelines. Unfortunately, although national and international clinical guidelines for pressure ulcer prevention recommend a wide range of measures, the evidence for the effectiveness of many of these measures is fairly weak (4–6). To ensure that the measures recommended by clinical guidelines lead to a reduction in pressure ulcers, it is critical to confirm both that these measures are effective and that they are widely implemented.

One of the major methods for prevention of pressure ulcers is the frequent manual repositioning of patients with limited mobility. In particular, several clinical guidelines recommend that bedbound patients be repositioned every two hours (5,6). This recommendation is based primarily on expert opinion, with few epidemiological studies and inconclusive evidence that repositioning at this frequency is effective in preventing the development of pressure ulcers. Despite the dearth of evidence, repositioning bedbound patients every two hours has become firmly established as the standard of care.

Confirming the effectiveness of frequent repositioning is an important goal, to ensure that the standard of care is appropriate and because the labor costs associated with this intervention are considerable. Indeed, repositioning and transferring patients take up the largest proportion of the time devoted to pressure ulcer prevention (7), and in one study cost of repositioning accounted for 73% of the total cost for pressure ulcer prevention (8). Several studies have also shown that manual repositioning increases health care workers’ risk for back pain and musculoskeletal injuries (9,10). Given the shortage of both skilled and unskilled nursing labor, the allocation of nursing time to patient repositioning every two hours is only justified if this intervention is effective.

Furthermore, it is unclear to what degree the recommendation for frequent manual repositioning is being implemented in US health care facilities. A study published in 2001 by the Health Care Financing Administration (now the Centers for Medicare and Medicaid Services) found that, in 1996, only 66% of bed- and chair-bound patients were repositioned every two hours (11). A study by Bates-Jensen et al. in nursing homes in 2003 found that only 18 of 58 such patients were repositioned at least every 2 hours (12). No study since then has examined adherence to this recommendation, although a few studies have examined the use of repositioning, but not its frequency, in preventing pressure ulcers (13–15). There is some evidence that the appropriate frequency of repositioning should vary with the support surface in use (16), and guidelines differ in whether patients using mattresses and overlays designed to redistribute pressure (i.e., pressure-redistributing support surfaces, PRSS) can be repositioned less frequently than those using standard support surfaces (5,6).

Yet no studies have examined if the frequency of repositioning for patients using PRSS differs from that for patients using standard support surfaces. Thus, it is of interest to examine the degree of adherence to frequent manual repositioning recommendations in bedbound patients, particularly when considering the type of support surface in use.

Manual repositioning of bedbound patients every two hours is an established part of the clinical guidelines for pressure ulcer prevention, but there is little evidence for its effectiveness and little is known about its implementation in the hospital setting. Thus, it is unclear what effect the recommendation for frequent manual repositioning has on clinical outcomes. In this study, we aimed to determine if manual repositioning every two hours is associated with a lower incidence of pressure ulcers among bedbound elderly hip fracture patients and to examine the degree of adherence to recommendations for manual repositioning in these patients.

MATERIALS AND METHODS

Participants

Data for this study were collected as part of a prospective cohort study of patients aged 65 years or older who underwent surgery for hip fracture (ICD-9 code 820) between 2004 and 2007 in any of nine hospitals that participate in the Baltimore Hip Studies network. The methods for the parent study have been described previously (17). Data for the parent study were collected in the nine acute care hospitals and the 105 postacute facilities to which patients enrolled in this study were discharged; data for the current analysis were collected in the nine admission hospitals. All hospitals included in this analysis were voluntary non-profit acute care facilities, including four teaching hospitals. Seven of the study hospitals were in Maryland and two in Pennsylvania. The number of beds in each hospital ranged from 100 to 536 (median 253).

The parent study was approved by the Institutional Review Boards of each of the participating hospitals and the University of Maryland Baltimore; the latter also approved the current study. Permission to contact patients for screening and recruitment was obtained from attending physicians. If the patient had a Mini-Mental State Examination (MMSE) (18) score of 20 or greater, the patient's written consent was obtained; otherwise the patient's verbal assent and a proxy's written consent were obtained. Proxy consent was also obtained for patients who were unconscious or non-communicative. A total of 1,167 patients were screened for eligibility, of whom 1,055 were eligible (90% of screened), and 658 patients enrolled (62% of eligible).

Data about repositioning frequency were collected for the first five days of each patient's initial hospitalization. Thus, patients who did not have any study visits during the first five days of hospitalization (n=103) were excluded from the current study. Because national clinical guidelines only recommend repositioning for bedbound patients, patients were also excluded from the current study if they were not bedbound according to the activity item of the Braden scale (19) during at least one study visit in the first five days of hospitalization (n=286), leaving a sample of 269 patients.

Measures

Repositioning—Data about repositioning were collected from the nursing flowsheet by a specially trained chart abstractor or a registered nurse experienced in medical record review. This information included the number of times that the patient was manually repositioned on each of the first five days of the patient's initial hospital stay. If the nursing flowsheet indicated only the frequency of turning rather than the number of times the patient was

turned (e.g., “q2h” to indicate turning every two hours), the corresponding number of turns was recorded in the daily total. Repositioning was classified as frequent if there were 12 or more turns per hospital day, corresponding to an average frequency of every two hours, as recommended in several clinical guidelines for the prevention of pressure ulcers (5,6).

Pressure Ulcer Status—Specially trained research nurses assessed pressure ulcer status at study visits that occurred at baseline (as soon as possible after hospital admission) and on alternating days for 21 days. The presence and stage of pressure ulcers were determined at each study visit by a whole-body skin examination conducted according to standard wound assessment practice(20). Standard definitions of pressure ulcer stages (21) were used: stage 1 (alteration of intact skin with persistent redness), stage 2 (partial thickness dermal loss or serum-filled blister), and stages 3 and 4 (full thickness tissue loss without/with exposed bone, tendon, or muscle). The study outcome was development of one or more new pressure ulcers stage 2 or higher at the visit following the day for which repositioning frequency was recorded. Results were similar when the study outcome was restricted to stage 2 pressure ulcers. Because only 16 of the pressure ulcers observed in the study ever reached stages 3 or 4, it was not possible to perform an analysis restricting the study outcome to stage 3 and 4 pressure ulcers. Patients with pressure ulcers continued to be considered at risk for additional pressure ulcers. Results were virtually identical when patients with pressure ulcers present at hospital admission were excluded from the analysis.

Covariates

At each assessment, the research nurse recorded the patient’s Braden scale score(19,22), based on observation and discussion with clinical staff. The Braden scale comprises six items: mobility, activity, sensory perception, exposure to friction and shear forces, skin moisture, and nutritional status. The “friction and shear” item is rated on a three-point scale; each of the other five items is rated on a four-point scale. The values for each item are summed to provide a score ranging from six to 23, with lower scores indicating a higher risk for pressure ulcer development. A cut-off point of 16 is commonly used to indicate “at-risk” patients(23).

Acute mental status was also assessed at each visit by counting the number of orientations to person, place, and time. Incontinence status was based primarily on the research nurses’ observation of skin moisture and/or soiling with stool during the skin assessment and secondarily on the four-point incontinence item of the Norton scale of pressure ulcer risk(24). Information about use of PRSS was recorded by the research nurses on a structured form at each study visit. PRSS were considered to be in use if any overlays were observed to be on the patient’s bed or if the mattress on the patient’s bed was made of any materials other than standard foam and spring. For pressure ulcer preventive devices other than PRSS, cushions were considered in use if they were on the patient’s chair or wheelchair, even if the patient was not seated at the time of the assessment, whereas heel protectors, elbow protectors, and positioning pillows/wedges were only recorded as being in use if they were observed to be on, or supporting, the patient at the time of assessment.

Data about all other covariates were obtained by clinical observation at the baseline study visit, by patient or proxy interview, or by chart review. At the baseline visit, research nurses used the Subjective Global Assessment of Nutritional Status (25) to classify individuals as being at low, moderate, or high risk of nutrition-associated complications. Arterial insufficiency, defined as absence of pedal pulses or ankle brachial index <1, was also determined at the baseline visit. Weight and height were obtained from the medical chart or, when missing, from patient or proxy interview; this information was used to calculate the patient’s body mass index (weight [kg]/height[m]²)(26). Standard definitions (26) were used

to define weight status: underweight (body mass index < 18.5), normal weight (body mass index = 18.5–24.9), and overweight/obese (body mass index ≥ 25.0). Severity of illness was measured on the Rand Sickness at Admission Scale (hip fracture version) (27) and comorbidity by the Charlson Comorbidity Index (28), both of which use information from the medical chart. The number of days since hospital admission was determined according to the information in the medical chart.

Analysis

To describe the study population, the distributions of the patients' characteristics noted at the baseline visit were compared for those repositioned frequently (at least every two hours) on the day of the baseline visit and those repositioned less frequently. We used simple counts and proportions for categorical variables, and means with standard deviations for continuous variables. P-values were obtained by chi-square test for categorical variables or by two-sample t-test for continuous variables.

Study visits at which patients in the study sample were bedbound during the first five days of hospitalization (354 person-visits) were designated as index visits. Because some patients had multiple index visits, generalized estimating equations (GEE) analysis (29) with an exchangeable working correlation matrix was used to account for within-patient correlation. GEE models with a log link, Poisson working model, and offset of log number of days between visits (to account for differing amounts of patient follow-up) were fit to determine the association between repositioning frequency on the day of an index visit and incidence of pressure ulcers stage 2 or higher at the following visit. Estimates of incidence rate ratios (IRR) and 95% confidence intervals (CI) were reported, both unadjusted and adjusted for covariates. The number of days since hospital admission was included in the adjusted model as a continuous variable using a linear spline with a knot at hospital day two, and some admission hospitals with few outcomes were combined in the adjusted model. To determine whether the association between repositioning frequency and pressure ulcer incidence was modified by pressure ulcer risk status, another adjusted model was fit with additional covariates for the patient's Braden scale score (dichotomized at the sample's median) at the index visit and a term for the interaction between Braden scale score and repositioning frequency.

Because repositioning data and covariate data were missing for 10% (37/354) and 9% (33/354) of index visits, respectively, weighted estimating equations analysis (30) was used to account for possible selection bias due to missing data. To compute the weights for this analysis, the probability of having observed (non-missing) repositioning data was estimated using a GEE model with a logit link, binomial working model, and predictor variables (admission hospital, severity of illness, use of pressure ulcer preventive devices other than PRSS, pressure ulcer incidence before or at the index visit, linear spline of days since hospital admission, and completeness of other covariate data). The probability of having complete covariate data was estimated in a similar way with admission hospital as the predictor variable. Weights were then estimated as the product of the inverse probability of having complete covariate data and the inverse probability of having observed repositioning data.

GEE models were fit with a binomial distribution and identity link to determine estimates and 95% CI for the proportion of index visit days on which patients were frequently repositioned, for the whole study sample, for subgroups of patients using each type of support surface, and for subgroups of patients in each admission hospital. GEE models with a logit link and binomial working model were fit to determine whether PRSS use on a given day was associated with frequent repositioning on the same day. Estimates of prevalence odds ratios (OR) and 95% CI are reported, both unadjusted and adjusted for covariates. To

avoid overfitting, age, sex, acute mental status, comorbidity, arterial insufficiency, use of preventive devices other than PRSS, and presence of a pressure ulcer at the index visit were eliminated from the model, after it was determined that these variables did not change the estimate of the coefficient of interest by more than 10%. Because the use of frequent repositioning and PRSS were expected to vary based on hospital policy and resources, it was expected that there may be important clustering effects by admission hospital. To examine these effects, additional models were fit that adjusted for admission hospital using indicator variables. All analyses were performed using SAS 9.1 (SAS Institute Inc., Cary, NC).

RESULTS

Study Sample

Patients' baseline characteristics, by repositioning frequency on the day of the baseline visit, are shown in Table 1. Patients repositioned frequently (at least 12 times/day or every two hours on average) were more likely than those repositioned less frequently to have a pressure ulcer at the baseline visit ($p=0.006$). Those repositioned frequently were also more likely to have a high risk of nutrition-related complications ($p=0.06$) and to have a lower mean Braden scale score ($p=0.07$) than patients repositioned less frequently.

Effect of Frequent Repositioning on Incidence of Pressure Ulcers—Patients in the study sample had an incident pressure ulcer stage 2 or higher at 11% (38/354) of visits following an index visit; the proportion was 12% (22/187) for visits following days on which patients were frequently repositioned and 10% (16/167) following days on which patients were repositioned less frequently (Table 2). The rate of incident pressure ulcers stage 2 or higher at the visit following an index visit per person-day of follow-up was similar whether or not the patient was repositioned frequently on the day of the index visit (unadjusted IRR 1.22, 95% CI 0.65–2.30; covariate-adjusted IRR 1.12, 95% CI 0.52–2.42).

The effect of frequent repositioning on pressure ulcer incidence varied somewhat (p for the interaction=0.07 in adjusted model) according to whether or not the patient was at high risk of pressure ulcers, as indicated by a Braden scale score less than the study sample median value of 14. Among the higher risk patients, the incidence rate of pressure ulcers per person-day of follow-up was lower for those frequently repositioned on the day of the index visit compared to those repositioned less frequently (adjusted IRR 0.39, 95% CI 0.08–1.84), whereas in lower risk patients, the incidence rate of pressure ulcers for those repositioned frequently was higher than for those repositioned less frequently (adjusted IRR 2.19, 95% CI 0.73–6.60).

Relationship Between Use of PRSS and Frequent Repositioning—Patients were repositioned frequently on 53% of the days on which an index visit occurred (95% CI 47%–58%); the proportion was 54% (78/145) among patients using PRSS and 52% (106/204) among patients using standard mattresses. The proportion of days with frequent repositioning according to type of support surface ranged from 42% to 66% (Figure 1). The use of frequent repositioning also differed substantially by admission hospital; the hospital-specific proportion of days on which frequent repositioning was in use ranged from 23% to 77%. Examining the role of admission hospital in detail, we found that hospitals with more PRSS use tended to have less use of frequent repositioning and vice versa, indicating that admission hospital was a negative confounder of the association between PRSS use and frequent repositioning. Thus, although there was no association between using PRSS and frequent repositioning in models not accounting for admission hospital (unadjusted OR 1.14, 95% CI 0.74–1.75; covariate-adjusted OR 1.06, 95% CI 0.67–1.70), the odds of frequent repositioning in patients using PRSS were more than twice as high as the odds in patients

using standard mattresses in models accounting for admission hospital (hospital-adjusted OR 2.08, 95% CI 1.10–3.92; fully-adjusted OR 2.28, 95% CI 1.15–4.54).

DISCUSSION

In this study of bedbound elderly hip fracture patients, we did not find that repositioning patients at least every two hours is associated with a decreased incidence of pressure ulcers, suggesting that manual repositioning at this frequency may not effectively prevent pressure ulcers. Previous studies of frequent repositioning for pressure ulcer prevention have yielded inconsistent results. Although a randomized trial (16) found a lower incidence of pressure ulcers for patients repositioned every two hours than for those repositioned every three hours among patients using a standard mattress, the same group (31) found no significant difference in pressure ulcer incidence when they compared groups under two repositioning-interval regimens (two hours in a lateral position and four hours in a supine position versus four hours in each position). Observational studies in humans have only shown that the duration of pressure likely to result in pressure ulcers falls within a range of one to six hours (32,33). Finally, studies in humans using surrogate endpoints (skin temperature and redness, and contact pressure) and animal studies and in vitro tissue studies suggest that even a two-hour interval of repositioning might be insufficient to prevent tissue damage (34–36). Thus, the evidence for an optimal repositioning interval is inconclusive, with biological plausibility for an interval less than two hours but little difference in clinical outcomes between this interval and longer intervals. Taken together, the published literature and the present study findings suggest that the clinical recommendations for manual repositioning with a specified interval are not well-founded.

Recent guidelines have recognized the limitations of the evidence for manual repositioning, and these guidelines have recommended that frequency of manual repositioning should be tailored to each patient based on characteristics such as mobility and general medical condition(37). Given the substantial costs and burden of repositioning every two hours, it is important to target this intervention to patients who are most likely to benefit. In this study, there was some suggestion that the effect of repositioning was modified by the patient's pressure ulcer risk status. Among patients at high risk of pressure ulcers (as indicated by low Braden scale scores), those repositioned at least every two hours had a lower rate of incident pressure ulcers than those repositioned less frequently; among patients at low risk of pressure ulcers, those repositioned at least every two hours had a higher rate of incident pressure ulcers than those repositioned less frequently, although neither difference was statistically significant. If confirmed in future studies, these findings suggest that, even among bedbound patients, repositioning may only be effective as a prevention measure for those at particularly high risk of pressure ulcers and patients at high risk according to Braden scale score may be a population of particular interest. Additional studies should examine if frequent repositioning is only effective in this patient population.

We found limited adherence to the recommendation for frequent manual repositioning despite the fact that the study population, bedbound elderly hip fracture patients, is recognized as being at high risk of pressure ulcers (7,38). It is reassuring that patients who were repositioned frequently were more likely than those who were repositioned less frequently to have a lower Braden scale score. Overall, though, patients were repositioned at least every two hours on only 53% of days. This finding is consistent with several previous studies showing a low prevalence of repositioning, although the prevalence may vary substantially by hospital unit (11,13). In one study, staff members did not reposition patients as regularly as prescribed despite knowledge that repositioning should be done (39), and several studies have found that the main reasons cited for not regularly repositioning patients include lack of time and lack of staff, rather than a lack of knowledge of turning

protocols(40). Thus, despite indications that repositioning is widely accepted as standard care for pressure ulcer prevention, repositioning does not appear to be fully implemented.

The prevalence of frequent repositioning was higher among patients using PRSS when compared to patients on standard support surfaces, allaying concerns that use of a PRSS reduces frequent repositioning. These results suggest that providers are using these preventive measures together for high risk patients, as is appropriate under current guidelines, rather than using PRSS alone. The presence of a PRSS may also be a cue to remind providers to frequently reposition patients. However, we found substantial variation in the prevalence of frequent repositioning and PRSS use by hospital, indicating that differences in resource availability or facility policies, such as the presence of quality improvement initiatives, may play major roles in the implementation of pressure ulcer prevention guidelines.

An important limitation of this study is its observational design; randomized studies are required to provide strong evidence regarding the effectiveness of this intervention. However, given that repositioning every two hours is the current standard of care, it would be difficult and possibly unethical to perform experimental studies where patients are randomized to less frequent intervals of repositioning. To strengthen the inferences drawn from this study, we adjusted for many known confounders of the association of interest, but bias due to unmeasured confounders cannot be excluded. Also, there may be errors in the information about frequency of repositioning obtained from medical records. This limitation is particularly salient as the prior study by Bates-Jensen et al. found a wide discrepancy between actual repositioning practices and medical record documentation, with documentation rates much higher than repositioning rates measured by thigh monitors(12). As such errors are probably equally likely among patients who do and do not develop pressure ulcers, the errors tend to bias results towards the null. Another limitation of this study was the relatively small sample size which limited the power to test the associations of interest. Finally, our study population was limited to hip fracture patients age 65 years or older, and results may not be generalizable to other patients at risk for pressure ulcers. However, because hip fracture patients are frequently bedbound for long periods of time in the peri-operative period, pressure ulcers are a common complication of immobility among these patients (17). Thus, elderly hip fracture patients represent an excellent population in which to examine repositioning as an intervention to prevent pressure ulcers, and there is no known reason that the effect of frequent repositioning in this population would differ from that in other populations at risk for pressure ulcers. The high incidence of pressure ulcers seen in this study may be due to the choice of elderly hip fracture patients (a particularly high-risk group) as the study sample, but it may also be linked to infrequent repositioning practices in study facilities. Unfortunately, data were not available to examine facility policies, practices, or resources related to repositioning; the contribution of these factors to pressure ulcer incidence may be an important future area of study.

Pressure ulcers have been recognized as an important indicator of quality of care, particularly since the identification of stage 3 or 4 pressure ulcers as one of the hospital-acquired conditions for which the Centers for Medicare and Medicaid Services will not provide reimbursement. Clinical practice guidelines for pressure ulcer prevention recommend the use of frequent manual repositioning in bedbound patients, but this study found that the implementation of this intervention was suboptimal. The implementation also varied substantially by hospital, indicating that factors other than patient need influence the choice of pressure ulcer prevention methods and that the quality of care for pressure ulcer prevention may differ by facility. However, the results of this study and others indicate that we do not yet have evidence for the efficacy of frequent repositioning for pressure ulcer prevention. Additional study is needed to determine if there is a standard interval at which

manual repositioning is effective at preventing pressure ulcers, or if manual repositioning is only effective in a subpopulation of bedbound patients. In the absence of this information, it is unclear if the variations in care demonstrated in this study translate into a difference in patient outcomes, or if decreasing the frequency of repositioning might reduce the cost and burden of this intervention without increasing the incidence of pressure ulcers.

The current findings call to question the efficacy of turning as a pressure ulcer prevention strategy, but it is premature to suggest that frequent manual repositioning is unnecessary. Repositioning may be more important for patients at higher risk (i.e., lower scores) by the Braden Scale, but further research is required.

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Glossary

CI	confidence interval
GEE	generalized estimating equations
IRR	incidence rate ratio
MMSE	Mini-Mental State Examination
OR	odds ratio
PRSS	pressure-redistributing support surfaces

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Figure 1.
Proportion of Days (and 95% Confidence Intervals) on Which Patients Were Repositioned At Least Every Two Hours (≥ 12 times/day), by Type of Support Surface

Table 1

Baseline Characteristics of Study Participants, by Repositioning Frequency on Day of Baseline Visit

Characteristics	Patients repositioned at least every two hours (N=139)	Patients repositioned less frequently than every two hours (N=130)*	All patients (N=269) [†]	P value [‡]
	n (%)			
Age ≥ 85 years	68 (48.9)	71 (54.6)	139 (51.7)	0.35
Male sex	36 (25.9)	32 (24.6)	68 (25.3)	0.81
White race	137 (98.6)	128 (98.5)	265 (98.5)	0.95
Community resident before admission	83 (59.7)	86 (66.2)	169 (62.8)	0.27
Medicaid payor	12 (8.6)	6 (4.6)	18 (6.7)	0.19
Trochanteric fracture	53 (38.1)	57 (43.9)	110 (40.9)	0.34
Partial or total arthroplasty	58 (41.7)	56 (43.1)	114 (42.4)	0.82
Albumin < 3.0 g/dL	48 (34.5)	45 (34.6)	93 (34.6)	0.99
Not fully oriented to person, place, and time	61 (45.9)	46 (36.2)	107 (41.2)	0.11
High risk of nutrition-related complications	22 (16.3)	11 (8.5)	33 (12.5)	0.06
Incontinence				0.97
None	95 (68.8)	91 (70.0)	186 (69.4)	
Urinary only	28 (20.3)	26 (20.0)	54 (20.2)	
Fecal with or without urinary	15 (10.9)	13 (10.0)	28 (10.5)	
Arterial insufficiency	56 (40.3)	62 (47.7)	118 (43.9)	0.22
Braden scale score ≤ 16	129 (94.9)	119 (93.7)	248 (94.3)	0.69
Pressure ulcers present at baseline visit	25 (20.2)	9 (7.8)	34 (14.2)	0.006
	Mean (standard deviation)			
Mean age (years)	83.9 (6.4)	84.0 (6.5)	84.0 (6.5)	0.90
Mean Rand Sickness at Admission score	13.6 (7.5)	12.9 (6.3)	13.3 (6.9)	0.40
Mean Charlson Comorbidity Index	1.5 (1.5)	1.5 (1.5)	1.5 (1.5)	0.67
Mean MMSE score	15.8 (11.1)	17.5 (10.8)	16.6 (11.0)	0.21
Mean BMI (weight [kg]/height [m] ²)	23.4 (5.3)	24.2 (4.7)	23.8 (5.0)	0.24
Mean Braden scale score	13.8 (1.7)	14.2 (1.6)	14.0 (1.7)	0.07
Mean length of hospital stay (days)	6.0 (2.7)	5.7 (3.1)	5.9 (2.9)	0.35
Mean interval between admission and baseline visit (days)	1.8 (1.1)	1.6 (1.1)	1.7 (1.1)	0.15

MMSE, Mini-Mental State Examination. BMI, body mass index.

* Includes patients with missing repositioning data and two study participants who did not have a baseline visit in the first five days of hospitalization at which the patient was bedbound.

[†] Due to missing data, N for individual items ranges from 240 to 269.[‡] p-value determined by two-sample t-test for continuous variables or chi-square for categorical variables

Table 2

Unadjusted and Adjusted Incidence Rate Ratios for Developing a Pressure Ulcer Stage 2 or Higher at the Following Visit, by Frequency of Repositioning on the Day of an Index Visit

Repositioning Frequency	Number of visits	% who developed ≥ 1 IPU at following visit	Unadjusted IRR (95% CI)	Fully adjusted* IRR (95% CI)
Among all patients				
Less than every two hours	167	10%	Reference	–
At least every two hours	187	12%	1.22 (0.65, 2.30)	1.12 (0.52, 2.42)
Among patients at higher risk of pressure ulcers (Braden scale score <14)				
Less than every two hours	60	13%	Reference	–
At least every two hours	80	6%	0.51 (0.20, 1.26)	0.39 (0.08, 1.84)
Among patients at lower risk of pressure ulcers (Braden scale score ≥ 14)				
Less than every two hours	107	7%	Reference	–
At least every two hours	107	16%	2.11 (0.92, 4.87)	2.19 (0.73, 6.60)

IPU, incident pressure ulcer stage 2 or higher. IRR, incidence rate ratio. CI, confidence interval.

All models account for within-patient correlation by generalized estimating equations using an exchangeable structure for the working correlation matrix.

* Accounts for missing repositioning and missing covariate data using weighted estimating equations, and adjusts for age, sex, acute mental status, risk of nutrition-related complications, weight status, incontinence status, arterial insufficiency, severity of illness, comorbidity, use of pressure-redistributing support surfaces, use of any other pressure ulcer preventive device, admission hospital, prior pressure ulcer of any stage, and number of days since hospital admission