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ORIGINAL ARTICLE

Reduced pressure for fewer pressure ulcers: can real-time feedback of interface pressure optimise repositioning in bed?

Lena Gunningberg[1] & Cheryl Carli[2,3,4]

1 Department of Public Health and Caring Sciences, Uppsala University, Uppsala, Sweden
2 Department of Haematology, Uppsala University Hospital, Uppsala, Sweden
3 Department of Dermatology, Uppsala University Hospital, Uppsala, Sweden
4 Department of Rheumatology, Uppsala University Hospital, Uppsala, Sweden

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Correspondence to
L Gunningberg
Department of Public Health and Caring Sciences
Uppsala University
Box 564 751 22
Uppsala
Sweden
E-mail: lena.gunningberg@pubcare.uu.se

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Abstract

The aim of this study was to (i) describe registered nurses' and assistant nurses' repositioning skills with regard to their existing attitudes to and theoretical knowledge of pressure ulcer (PU) prevention, and (ii) evaluate if the continuous bedside pressure mapping (CBPM) system provides staff with a pedagogic tool to optimise repositioning. A quantitative study was performed using a descriptive, comparative design. Registered nurses ($n = 19$) and assistant nurses ($n = 33$) worked in pairs, and were instructed to place two volunteers (aged over 70 years) in the best pressure-reducing position (lateral and supine), first without viewing the CBPM monitor and then again after feedback. In total, 240 positionings were conducted. The results show that for the same person with the same available pressure-reducing equipment, the peak pressure varied considerably between nursing pairs. Reducing pressure in the lateral position appeared to be the most challenging. Peak pressures were significantly reduced, based on visual feedback from the CBPM monitor. The number of preventive interventions also increased, as well as patients' comfort. For the nurses as a group, the knowledge score was 59·7% and the attitude score was 88·8%. Real-time visual feedback of pressure points appears to provide another dimension to complement decision making with respect to PU prevention.

Introduction

Pressure ulcers (PUs) are common, albeit highly preventable, occurrences in hospitals worldwide, with large European studies placing PU prevalence rates between 9·0% and 18·1% (1–4). Patients with PU often endure pain and emotional suffering as a result of suboptimal management, (5) which in turn generates a considerable burden in terms of direct and indirect costs to the public health care systems and health care consumers in Europe (6,7).

Of the many guidelines for PU prevention, most maintain that PU can be prevented by having evidence-based systems in place at the organisational level, through clinical risk assessment, and well-informed patients (8,9). Pressure relief (e.g. repositioning, pressure-reducing mattresses, chair cushions and bed cushions) is the mainstay of preventive measures (9–11); however, some studies show that nurses are not always aware of its importance (2,12). A recent Cochrane review (11) regarding the effectiveness of repositioning found only three randomised controlled trials and concluded that there is still a lack of robust evaluation regarding repositioning frequency and positions for

Key Messages

- the prevalence of PUs in Europe remains high
- pressure relief is the mainstay of prevention; however, studies regarding duration and degree of pressure are few
- a product that may help nurses to be more effective in the management of PUs was evaluated
- registered nurses and assistant nurses tested a pressure mapping system with visual real-time feedback in a controlled environment
- visual feedback of pressure points is an effective tool for optimising repositioning and reducing peak pressure

PU prevention. There is currently neither solid evidence for a reduction in PU with the 30° tilt compared with the 90° position nor good evidence for the effect of repositioning frequency (11).

In Sweden, a national patient safety initiative was launched in 2007, with one of the areas of focus being PU prevention. Public reporting of PU prevalence, which enables benchmarking between institutions, is now available, evidence-based guidelines have been disseminated and national goals have been set. Although efforts have been made nationally to encourage the prevention of PUs, the prevalence rate is still 16·1% (2). In the absence of, or as a result of underuse of, preventive interventions such as the use of pressure-reducing mattresses and prevention care plans, PU management cannot be regarded as acceptable. Gunningberg *et al.* (12) found that knowledge of PU prevention among nursing staff in Sweden was inadequate, specifically with regard to reducing the degree and duration of pressure and shear. Other studies indicate that there is room for improvement regarding knowledge of PU prevention not just among Swedish nurses (13–15).

Till recently, the actual pressure relieving effectiveness of nurses' PU prevention interventions in real time had not been possible. Rather, the development of a PU has been the proof, after the fact, of failure in pressure reduction. A recently launched product, the continuous bedside pressure mapping (CBPM) system, claims to provide real-time feedback about which parts of the body are exposed to potentially damaging pressure in bedridden patients. So far, two studies have evaluated this system in critical care settings in the United States (16,17). Thus, the evaluation of the usefulness of CBPM in other clinical contexts is warranted.

The aim of this study was twofold – first, to describe registered nurses' and assistant nurses' repositioning skills with regard to their existing attitudes to and theoretical knowledge of PU prevention, and second, to evaluate if the CBPM system provides nursing staff with a pedagogic tool to optimise repositioning.

Methods

Design

A prospective, quantitative study was carried out using a descriptive, comparative design. Observational sessions of repositioning were combined with a questionnaire on knowledge and attitudes related to PUs.

Sample

A convenience sample of 17 registered nurses (RNs) and 35 assistant nurses (ANs) was recruited from the 1000-bed Uppsala University Hospital in Sweden. The nurses were all females, except for three male ANs. Demographic data for 71·2% (n = 37) of the sample that completed the PU knowledge and PU attitude questionnaires are shown in Table 1.

Continuous bedside pressure mapping

CBPM (MAP™ System, Wellsense USA, Inc, Nashville, TN) consists of a pressure-sensing mat and a control unit. The mat contains thousands of sensors designed to measure levels of pressure between 0 and 100 mm Hg (17). The control unit is a small computer with a screen, which retrieves pressure data continuously. These data are displayed on the screen as real-time, colour imagery and depict how pressure is distributed at the body–mat interface. The colours exhibited on the monitor are relative to an upper pressure threshold, which is programmed into the control unit by the nurse. Red signifies areas of high pressure, defined in this study to be ≥60 mm Hg. The colours from blue to dark orange signify an increasing pressure from 10 to <60 mm Hg.

Table 1 Demographic data for registered nurses (RNs) and assistant nurses (ANs)

	Total (n = 37)	RN (n = 12)	AN (n = 25)
Age (years) (mean (SD) range)	47·4 (11·7)	46·2 (12·6)	47·9 (11·3)
	20–62	24–62	20–62
Work experience (years) (mean (SD) range)	20·1 (15·7)	21·2 (10·1)	19·6 (12·9)
	1–45	2–44	1–45
Pressure ulcer ward nurse (n)	14	3	11
Bachelor of nursing (n)	7	7	0
In-service education*, 1 hour to half day (n)	8	3	5
In-service education*, 1 day or more (n)	22	5	17
Post-graduate university course* (n)	2	2	0

*Education pertaining specifically to pressure ulcer management.

Data collection

Primary outcome:

Peak interface pressure measured in mm Hg.

Secondary outcomes:

(a) The number of pressure-reducing changes made relative to the bed's horizontal starting position.
(b) Patient comfort assessed with a Visual Analogy Scale with the endpoints of 1 = very low level of comfort and 10 = very high level of comfort.
(c) PU knowledge score.
(d) PU attitude score.

Observational session of repositioning: peak pressure, number of interventions and comfort

Data collection was conducted at the university hospital's Clinical Training Centre. For the purpose of this study, two volunteers, (one male and one female) over the age of 70 and with normal body mass indices were recruited as 'patients' (Table 2). These patients were assigned separate rooms. Their beds were equipped with an optimal five-zone mattress, a commonly used pressure-reducing foam mattress in the hospital, and a CBPM mat was placed over each mattress and under a bed sheet and a draw sheet. The bed frames could be tipped relative to the floor and the head-end of the beds could be raised and the foot-end lowered independently. Each bed was equipped with one large pillow at the head of the mattress, which was completely horizontal at the start of each observational session. Patients were instructed to be physically passive and to refrain from giving verbal prompts or advice about how to improve comfort.

Table 2 Body constitution and age of volunteers

	Height (cm)	Weight (kg)	BMI	Age (years)
Male 1	197	93	23·9	71
Female 1	162	62	23·9	75
Male 2	176	91	29·4	68
Female 2	162	52	19	80

BMI, body mass index.

RNs and ANs worked in pairs and were instructed to place the patient in the best pressure-reducing position using their choice of pressure-reducing interventions. Apart from the pillow at the head of the bed, nurses had at their disposal two large pillows, four small pillows, a heel cushion, two wedges and one quilt. For the purpose of this study, each pillow, cushion, and so on, and adjustment to the position of the bed frame was counted as a pressure-reducing intervention. Thus, nursing pairs could use a maximum of 13 pressure-reducing interventions compared with the bed's initial horizontal position with one pillow.

A study-specific protocol was used to register peak pressure, comfort and the number of pressure-reducing interventions at the point when the nurses were finally satisfied that their patient was placed in the best pressure-reducing position. Patients were first placed in the lateral position and measurements were recorded according to the protocol. Thereafter, the patient's lateral position was adjusted with the help of feedback from the CIIPM monitor and a second set of measurements was recorded. This procedure was repeated with the patient in the supine position, thus giving four recorded positions per patient and nursing pair. Each nursing pair then repeated the same procedure on the second patient. All the pairs completed the whole session, which also included instruction and information about a planned follow-up session within an hour.

After 3 months, the same RNs and ANs were invited to participate in a follow-up session. The repositioning sessions were repeated with four new volunteers with different body types (two overweight males and two underweight females) (Table 2). At the end of the sessions, the nurses were asked to assess two statements about the usefulness of the CIIPM system; 'I think the CIIPM system is a valuable complement to existing pressure-reducing interventions to prevent PUs' and 'I think it was easy to interpret the data on the CIIPM monitor'. There were four response alternatives with the endpoints of 'Agree completely' and 'Do not agree at all'.

Questionnaire – pressure ulcer knowledge and attitudes

A questionnaire consisting of the PU knowledge assessment tool (PUKAT) (18) and attitudes towards PU (APuP) (19) was used to assess the nurses' knowledge about and attitudes to PU prevention. The questionnaire comprised 26 items from which six different themes are derived: (i) aetiology and development, (ii) classification and observation, (iii) nutrition, (iv) risk assessment, (v) reduction of the magnitude and (vi) reduction of the duration of pressure and shearing. The questions on attitudes towards PU prevention include 13 items/statements on a 4-point Likert scale (1 = strongly agree to 4 = strongly disagree). A mean knowledge score > 60% and a mean attitudes score > 75% are considered satisfactory (20). The questionnaire had previously been translated into Swedish (12). Another set of questions regarding nurses' sex, type and level of education and nursing category was included at the end of the questionnaire.

Procedure

A letter of invitation to the study was sent by email to all nurse managers ($n = 40$) caring for somatically ill, adult patients. Interested RNs and ANs signed up for a session through the hospital's intranet and received the questionnaire electronically before participating in the observational session in the Clinical Training Centre. Data were collected by two data collectors over 8 days in November 2013 and, for the follow-up session, over 3 days in February 2014. The data collectors trained in using both the control monitor and the procedure with the study-specific protocol several times prior to the start of the study. Attrition of nurses because of heavy workload on the ward or illness resulted in the occasional AN ($n = 3$) or RN ($n = 3$) coming alone to a session. In such a case, an extra nurse was available as a passive partner, that is she followed the instruction of the single nurse when positioning the patient.

Data analyses

Statistical analyses were performed using SPSS 21.0 (SPSS Inc., Chicago, IL). Categorical data were presented as numbers and percentages, whereas continuous data were presented as means, standard deviations, minimums and maximums. A paired sample t-test was used to compare peak pressures, levels of comfort and number of preventive interventions before and after feedback from the monitor. An independent student's t-test was used for comparison between RN pairs and AN pairs (four mixed pairs were analysed as RN pairs as the RN has a leadership role in nursing care).

The answer to each PUKAT question was dichotomised (correct–incorrect). The mean knowledge score was calculated by dividing the number of correct answers by the number of questions and multiplying the result by 100. Negatively worded attitude questions were reversed to obtain a total score so that a higher score indicated more positive attitudes (19). The mean attitude score for each person was calculated, divided by the maximum total score and multiplied by 100. A student's t-test was used for comparison between RNs and ANs. A P-value of 0·05 was considered significant.

Ethical considerations

The study was approved by the Ethics Review Board in Uppsala (No 2013/279). The principles set out in the Declaration of Helsinki as well as national and local guidelines for research were followed (21). The purpose and procedure of the study, the voluntary nature of participation and assured confidentiality were fully explained to the participants.

Results

Peak pressure, number of interventions and comfort

Nine RN pairs, 17 AN pairs and 4 RN–AN pairs carried out 120 positionings without CIIPM and an additional 120 with

Table 2 Peak pressure, number of interventions and comfort in lateral and supine positions without and with feedback from the CIPM system

	Male 80 kg – normal BMI			Female 67 kg – normal BMI		
	Without feedback	With feedback	*P* value	Without feedback	With feedback	*P* value
Lateral left						
Mean peak pressure, mm Hg (SD)	67·3 (13·3)	54·9 (8·3)	0·000	47·6 (7·1)	43·7 (4·0)	0·001
Min–max	44–95	41–70		37–67	37–57	
Number of interventions	4·7	4·9	<0·001	4·1	4·6	0·007
Mean comfort	9·0	9·4	<0·001	9·1	9·4	0·094
Supine						
Mean peak pressure, mm Hg (SD)	50·2 (4·3)	45·3 (6·8)	<0·001	39·7 (4·5)	37·7 (3·0)	0·071
Min–max	37–58	35–57		29–49	29–42	
Number of interventions	3·8	4·9	<0·001	4·1	4·6	0·001
Mean comfort	9·4	9·8	<0·001	9·7	9·5	<0·001

BMI, body mass index.

the help of CIPM. Three months later, 8 RNs and 8 ANs returned to participate in the follow-up study. As explained earlier, on the occasion where an uneven number of nurses came to the session, an extra nurse was available to make up a pair. This provided 10 pairs to perform 40 repositionings without feedback from the CIPM and 40 with the help of CIPM.

Peak pressures were higher for male 1 compared with female 1 and higher in lateral positions compared with supine positions (Table 3). Peak pressures for the same patient ranged from 44 to 95 mm Hg, depending on the nursing pair. Positioning patients with feedback from the control unit significantly reduced peak pressures in all positions. The number of interventions increased significantly and the level of comfort in all positions was greater with visual feedback, except for one.

When AN pairs placed both male 1 and female 1 in the supine position after feedback from CIPM, peak pressures were lower ($P = 0·014$, $P = 0·031$), levels of comfort were higher ($P = 0·035$, $P = 0·006$) and more preventive interventions were used ($P = 0·002$, $P = 0·031$) compared with RN pairs. AN pairs used a significantly increased number of preventive interventions in all positions except for the lateral position without feedback.

In the 3-month follow-up, peak pressures were significantly reduced after feedback from CIPM in both positions for female 2. For male 2, peak pressures were significantly reduced after feedback in the lateral position only and he also received a significantly greater number of preventive interventions (Table 4).

The nurses agreed completely ($n = 12$) or to a large extent ($n = 4$) that the CIPM system was a valuable complement to existing pressure-reducing interventions. All nurses ($n = 16$) agreed completely that it was easy to interpret the data on the CIPM monitor.

PU knowledge and attitudes

The mean knowledge score for the total sample was 59·7%. The highest score was in the theme of 'nutrition' (86·5%) and the lowest score was in the theme of 'reduction in the amount of pressure and shear' (32·1%). There were no significant differences between RNs and ANs with regard to the results of the questionnaire ($P = 0·760$, $t = -0·308$, df 35). Five (26·3%) RNs and 14 (42·4%) ANs did not reach the knowledge score of 60%.

The mean attitude score for the total sample was 88·8%, with no significant difference ($P = 0·599$, $t = -0·530$, df 35) between RNs (87·9%) and ANs (89·2%). There were two ANs who did not reach the 75% threshold (Table 5).

Discussion

In the majority of cases, the mean peak pressures were significantly reduced with visual feedback from the CIPM monitor. There was an increase in the number of preventive interventions used, as well as in the comfort level. For the nurses as a group, the knowledge score was 59·7% and the attitude score was 88·8%.

Our data show a high degree of variation in the positioning of patients. For the same person with the same available pressure-reducing equipment, peak pressure varied considerably. This suggests that the quality of nursing care is different depending on the person performing the repositioning, even when the support surfaces and available equipment are the same. Reducing pressure on patients in the lateral position appeared to be the most challenging for nurses. The highest recorded pressure before feedback from the CIPM monitor was 95 mm Hg for male 1 with a normal body mass index (BMI) and 76 mm Hg for female 2 with a low BMI. It seems important to be aware of different body constitutions and how they affect pressure points (22).

Repositioning improved after feedback from the CIPM monitor. We observed that after feedback, the nurses became more resourceful, diverged from their normal routines and tried other methods of positioning. They also used a significantly larger number of cushions, as well as the function of raising or lowering the ends of the bed. Patients reported their levels of comfort as good in all positions, but as even better after feedback.

It is important to bear in mind that the colours on the CIPM monitor are relative and not absolute indicators of the risk for the development of PUs. A 'safe' interface pressure for one individual may be a primary factor leading to tissue breakdown in another. Furthermore, exactly how repositioning is accomplished may not matter as much as how the at-risk tissue is relieved regularly from pressure. PU prevention is one of the fundamentals of care and it is often taken for granted that

Table 4 Three-month follow-up. Peak pressure, interventions and comfort in lateral and supine positions without and with feedback from the CBPM system

	Male 91 kg – high BMI			Female 57 kg – low BMI		
	Without feedback	With feedback	*P*-value	Without feedback	With feedback	*P*-value
Lateral left						
Mean peak pressure, mm Hg (SD)	49·4 (3·7)	42·1 (4·7)	0·011	46·7 (12·4)	40·4 (10·6)	0·008
Min–max	44–56	37–49		27–76	24–61	
Number of interventions	5·6	6·0	0·037	4·8	4·7	0·581
Mean comfort	7·6	8·1	0·057	8·4	8·8	0·772
Supine						
Mean peak pressure, mm Hg (SD)	40·5 (3·9)	39·6 (4·7)	0·778	35·2 (5·3)	37·2 (6·3)	0·019
Min–max	35–47	35–57		27–42	27–41	
Number of interventions	3·7	4·5	0·159	3·9	4·1	0·689
Mean comfort	8·2	8·4	0·342	9·1	9·6	0·057

BMI, body mass index.

Table 5 PU knowledge of registered nurses (RNs) and assistant nurses (ANs)

	Total (n = 37)		RN (n = 12)		AN (n = 25)		
	m	SD	*m*	SD	*m*	SD	*P*-value
Themes							
Aetiology and causes	64·0	25·6	70·8	27·6	60·7	24·5	
Classification and observation	49·7	20·2	50·0	23·4	49·8	19·7	
Risk assessment	67·6	25·8	70·7	23·4	67·0	26·7	
Nutrition	86·5	24·7	75·0	45·7	87·0	27·7	
Reduction in the amount of pressure and shear	52·1	23·1	51·7	21·5	52·6	24·2	
Reduction in the duration of pressure and shear	65·5	18·2	61·7	21·7	68·8	16·4	
Total score	58·6	13·7	60·6	16·2	58·1	12·6	0·620

nurses know how to reposition patients. Visual feedback from a mapping system, such as the CBPM system, can help nurses in providing a higher quality of care.

RNs have the formal responsibility for the evaluation of risk for PUs and creating appropriate care plans (23,24). ANs, however, were significantly more skilled at reducing pressure. This can be explained by the fact that most PU prevention interventions are delegated to assistant nurses in Sweden and they have more bedside experience.

Our results reveal that the knowledge score did not reach the threshold of 60% suggested by Beeckman (20). Although the level of knowledge concerning reduction of the amount of pressure and shear was low (52·1%), it was somewhat higher than that seen in a multi-centre study (47·5%) including 415 Swedish RNs and ANs (12). In both studies, the theme of 'nutrition' generated a high knowledge score (86·5% versus 83·1%). National prevalence studies in Sweden show that pressure-relieving interventions are still lacking in hospital settings, even for patients with PUs (2).

Both RNs and ANs in our study reported the CBPM system to be a useful tool that was also easy to understand. Our results confirm those of Siddiqui *et al.* who found that 90% of the nurses in the intensive care unit (ICU) reported that the CBPM system contributed to improved pressure detection and relief, 88% indicated that the CBPM assisted them with repositioning protocols and 84% reported that the pressure map facilitated more efficient and effective repositioning of patients (16). Earlier, pressure mapping was often used for clients with complex seating needs as part of the evaluation procedure for customised seating (25). However, the field of clinical pressure mapping has developed greatly during the last decade as a result of improved technology and graphical user interfaces (26), and our results show that the CBPM system could provide clinical utility. A recent controlled study including 422 patients in an ICU (17) reported that significantly fewer hospital-acquired PUs occurred in the CBPM group compared with the control group, indicating the effectiveness of real-time visual feedback in repositioning patients to prevent the formation of new PUs.

Methodological considerations

This was a feasibility study, its strength lying in the standardised study environment, that is person to reposition, bed, pressure-reducing mattress, and available equipment for pressure reduction. The data collectors were only two, one in each room, and they were trained in using the procedure and the CBPM system. A limitation was that the relation between different peak pressures (warm colours) and the development of PUs in different patients was unknown. These interface pressures do not directly measure internal tissue and capillary pressures, but this is currently the best non-invasive method to measure pressures applied to the skin. It is possible that the interface pressure between the pillows or wedges that were supporting the laterally turned position remained high, but this was unable to be measured by the CBPM system.

Furthermore, our volunteer patients may have scored levels of comfort higher after the repositioning with feedback from the monitor, as they wished to please the nurses who had successfully reduced pressure. The RNs and ANs were of different ages and had differing work experience. They had all applied to participate in the study because they were interested in PU prevention. Therefore, the result may be somewhat better than if staff had been randomly assigned to the study. Unfortunately, only 37 out of 52 (71·2%) participants answered the knowledge and attitude questionnaire. The hospital was extremely busy at the time of the study and there was a critical shortage of nurses. Lack of time to answer the questionnaire could, in part, account for the attrition. Another reason may have been that the nurses found the questions difficult to answer. It was not possible to save an uncompleted questionnaire; thus, if the nurses were interrupted, they had to start from the beginning.

Conclusions and relevance to clinical practice

In this study, nurses acknowledged the importance of preventing PUs. Their knowledge of how pressure and shear are reduced was inadequate, yet preventing these problems is the mainstay of PU management. Real-time visual feedback of pressure points appears to provide another dimension to complement decision making about PU prevention. The authors and data collectors observed that many nurses spoke spontaneously during repositioning after visual feedback about the positive effects of small adjustments in repositioning and about the 30% lateral position for pressure reduction. Although the nurses' comments were not measured or recorded systematically, taken together with the nurses' general acceptance of the CIIPM system as an easy and useful tool, they suggest that the system may have pedagogical value in PU management and in continuing education related to PUs.

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