Effect of visco-elastic foam mattresses on the development of pressure ulcers in patients with hip fractures

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This study had three aims: to investigate if visco-elastic foam mattresses are more effective than standard hospital mattresses in reducing the incidence of pressure ulcers in patients with hip fractures; to compare pressure ulcer grade and location and documented nursing prevention and treatment interventions in patients using the two types of mattresses; to identify possible predictors of pressure ulcer development.

Using a prospective randomised controlled trial design 101 patients (mean age: 84 years) were randomly allocated either a visco-elastic foam mattress or a standard mattress. There was no significant difference in the incidence of pressure ulcers between the two groups, but patients on standard mattresses tended to develop more severe pressure ulcers. Furthermore, according to the documentation, patients with grade I pressure ulcers who were allocated a standard mattress received more preventive interventions, which may have reduced the differences in outcomes between the two groups. The researchers concluded that the results support the use of the test mattress. Significant predictors of pressure ulcer development were long waiting times for surgery and low haemoglobin levels at hospital admission.

Pressure ulcer prevention and prediction; Visco-elastic foam mattress; Randomised controlled trial

Pressure ulcer prevention is usually managed with interventions such as manual repositioning of patients and the use of special beds, mattresses, mattress overlays and chair cushions.[1-3] Pressure-relieving beds and mattresses act by either moulding around the shape of the patient to distribute his or her weight over a larger area (constant low-pressure devices) or by mechanically varying the pressure beneath the patient, reducing the duration for which the pressure is applied (alternating-pressure devices). Other devices, such as turning beds, frames and nets, and turning/tilting beds, move patients who are unable to turn themselves.[2]

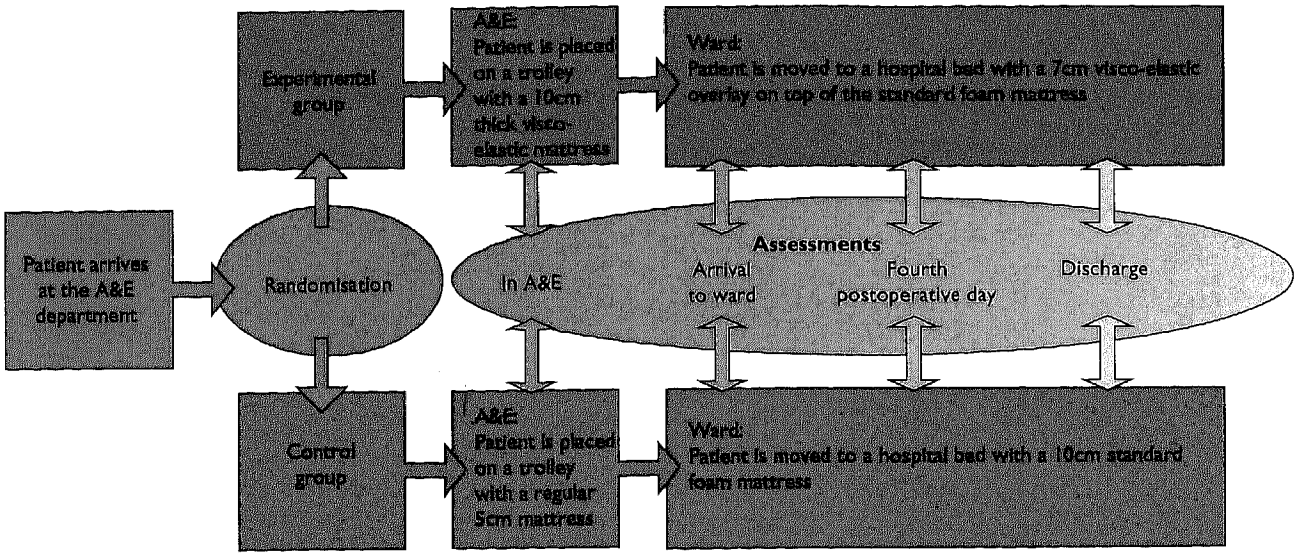
This article describes a study that aimed to:

- Investigate if the use of a visco-elastic foam mattress is more effective than a standard hospital mattress in reducing the incidence of pressure ulcers in patients with hip fractures
- Compare the differences in pressure ulcer grade and location and the number of documented nursing interventions relating to the prevention and treatment of pressure ulcers in patients using the two types of mattress
- Identify possible predictors of pressure ulcer development.

The literature review

The Cochrane Wounds Group[4] reviewed 29 randomised controlled trials relating to pressure prevention and relief, including four comparing foam alternatives with the standard hospital foam mattress.[5-8] They concluded that there is good evidence of the effectiveness of high-specification foam over standard hospital foam, although the standard mattress was poorly described in many of the studies and varied between hospitals and countries and over time. This illustrates the difficulties in determining the most effective surface for prevention or treatment.

Fig 1. The prospective randomised controlled trial design



In a recent randomised trial Defloor et al.[9] evaluated the effect of different turning intervals and the use of a pressure-reducing mattress (visco-elastic foam) on the development of pressure ulcers in geriatric high-risk patients. They concluded that turning every four hours on a visco-elastic mattress was more effective and less labour-intensive than the traditional two- or three-hour turning regimen. Turning had a preventive effect on the development of grade II–IV pressure ulcers but not on grade I ulcers.

A prospective controlled study[10] conducted by the authors of the present study found that approximately 20% of patients admitted to University Hospital, Uppsala, Sweden, with hip fractures had pressure ulcers on arrival, increasing to 40% at discharge. The incidence of pressure ulcers (including grade I ulcers) was 55%. Eighty-four per cent of the patients developed pressure ulcers between admission and the fourth postoperative day. The nurses' documentation and knowledge of prevention and treatment interventions were unsatisfactory.[11] Following these two studies an educational programme was developed. A modified Norton scale[3] (MNS) and a system for classifying pressure ulcers[1,12,13-15] were also introduced.

Cullum and Clark[16] found that there is a relationship between serum protein concentration, systolic blood pressure and predisposition to pressure ulcer development. In a review of a surgical population Stotts[17] identified the following risk factors: age, risk status, length of surgery, nutritional status, haematocrit and haemoglobin levels, and extracorporeal circulation. She concluded that there is limited information about pressure ulcer risk in the pre-operative, intra-operative and postoperative periods.

Method

Study design

The study used a prospective randomised controlled trial design (Fig 1). On arrival in A&E patients with a suspected hip fracture were randomised to an experimental or a control group with concealed allocation.

In order to decide how many patients should be recruited a priori sample size calculation was performed. To detect a clinically relevant reduction in the incidence of pressure ulcers with the statistical safeguards of α=0.05, power=0.80 and effect size=medium-large, 50 patients were needed in each group.[18] (α=5% risk to find a difference that is not there; power=20% risk of not finding a difference that is there; effect size=clinical significance.)

Setting

The study was carried out at the University Hospital, Uppsala, Sweden. The A&E has a fast-track programme for patients with hip fractures. Registered nurses administer intravenous fluid and morphine, and refer patients to X-ray in accordance with a protocol. A special antidecubitus heel protection device (Lassekudden) is used instead of traction.

On the orthopaedic wards written guidelines for pressure ulcer care encourage the use of heel cushions, 30° tilt position and a skin inspection once every shift (three times a

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Table 1. Characteristics of patients in the experimental and control groups

	Experimental group (n=48)	Control group (n=53)
Gender: women/men	38/10	43/10
Mean age (years) (range)	84 (66–102)	85 (67–96)
Mean MNS score at ward admission (range)	18.6 (10–25)	18.8 (11–24)
Mean time interval between arrival in A&E and:		
ward (hours) (range)	4 (1–11)	4 (1–11)
surgery (hours) (range)	21 (4–73)	22 (3–97)
discharge (days) (range)	12 (3–32)	13 (4–39)
Mean time in operating theatre (minutes) (range)	153 (60–390)	136 (75–465)
Number of smokers	9	5
Number of patients with diabetes	4	1
Body constitution: overweight/underweight	6/11	3/12
Skin moisture: dry/moist	7/3	12/2
Mean haemoglobin (mg/100ml) (range)	128 (95–161)	129 (98–167)
Mean blood pressure systolic (mmHg) (range)	154 (110–210)	159 (120–260)
Mean blood pressure diastolic (mmHg) (range)	79 (60–130)	86 (60–170)

day).[12,14,19,20] Beds have a 10cm foam mattress (two years old) and nurses access to hollow core fibre overlays. Patients are generally mobilised the day following surgery.

Intervention

Patients in the experimental group were placed on a 10cm thick visco-elastic foam mattress (7cm visco-elastic foam plus 3cm 35kg/m^3 foam: Tempur-Pedic, Fagerdala, Sweden) immediately on arrival in A&E. A 7cm visco-elastic foam overlay was placed on the standard mattresses used in the wards.

Patients in the control group were placed on the routine standard trolley (5cm mattress) and then on the standard hospital mattress (10cm foam 50kg/m^3: Prodenso, Ranson AB, Sweden) when transferred to the ward.

Both the visco-elastic and the standard hospital mattresses had polyurethane covers. The theatre operating tables used a standard mattress on both groups. All patients received the standard pressure prevention described above.

Subjects

The study, conducted between March and December 1999, included 119 patients aged over 65 years with a hip fracture (pertrochanteric femur or medial collum). Eighteen were excluded because they:

- Died (two)
- Did not have a skin assessment documented on arrival (three)
- Were admitted with pressure ulcers (13).

Of the remaining 101 patients, 48 and 53 were allocated to the experimental and control groups, respectively. No significant differences were found between the groups in terms of gender, age, MNS scores, waiting time for surgery, time in operating theatre and other inclusion characteristics (Table 1).

Fifty-one eligible patients admitted with hip fractures were not identified and therefore excluded from the study. Reasons for this included the absence of typical symptoms of hip fractures (seven patients) and the presence of multiple fractures (one). The heavy workload and lack of communication caused by the large number of staff members may explain why the remaining patients were not included.

Data collection

Risk assessment

Each subscale (mental condition, activity, mobility, food intake, fluid intake, incontinence and general physical condition) in the MNS is scored between one and four, with one indicating complete lack of function and four normal function.[21] Patients with a total score of ≤21 are considered at risk of developing pressure ulcers.[3]

Pressure ulcer classification

Pressure ulcer stages were classified as:[1,12-14]

- Grade I: non-blanching erythema of intact skin
- Grade II: partial-thickness skin loss involving epidermis, dermis or both

Table 2. Number of patients assessed for pressure ulcer classification

	Experimental group (n=48)	Control group (n=53)
A&E department	33	42
Arrival at the ward	40	44
Fourth postoperative day	45	52
Discharge/14 days post-surgery	42	46

- Grade III: full-thickness skin loss involving damage to or necrosis of subcutaneous tissue that may extend down to, but not through, underlying fascia
- Grade IV: full-thickness skin loss with extensive destruction, tissue necrosis or damage to muscle, bone or supporting structures.

A form with sections for recording the MNS score, stage and location of pressure ulcers, haemoglobin count, blood pressure measurement, diagnosis of diabetes, smoking status, body constitution, skin moisture level, ward arrival time and time in surgery was developed. Data on the first two variables were collected on admission to A&E, on arrival at the orthopaedic ward, on the fourth postoperative day and at discharge from the ward or two weeks postoperatively. The registered nurse on duty performed the risk assessment and skin observation on the patient's arrival at A&E and the ward. The pressure ulcer nurse on the ward usually performed the assessments on the fourth postoperative day and at discharge. The pressure ulcers were photographed.

Photo inter-rater agreement

Twenty-five pressure ulcers (one in A&E and 24 on the ward) in 13 patients were photographed during the study. The ulcers in these photos were graded by an expert nurse (the second author), who was blinded to treatment, and compared with the classifications performed by the nurses in A&E and on the wards. Cohen's kappa,[22] which takes chance agreement into account, was calculated to be 0.86. According to Fleiss,[23] this is an excellent agreement.

Patient perception of comfort

At discharge the pressure ulcer nurse assessed the patients' perceptions of mattress comfort using a standardised question: 'How did you experience the comfort of the hospital mattress?' The rating scale used was: 'very good' (5), 'good' (4), 'adequate' (3), 'bad' (2) and 'very bad' (1). Forty-one patients (21 in the experimental and 20 in the control group) with a mean age of 84 years (SD: 7.6, 67–102) answered this question.

Audit of patient records

To identify the nursing interventions performed to prevent and treat pressure ulcers, a retrospective audit of patient records was undertaken on the 17 patients who only developed a grade I pressure ulcer. The researchers noted whether or not the following pressure-relief strategies had been used: turning schedule, repositioning, cushions, overlays, the 30° tilt, reduction of shear and friction, nutritional support, skin care, patient education and dressings.[12,14,19,20] The timing of interventions and characteristics of the nursing notes (nursing history, nursing status, nursing diagnosis, goals, nursing intervention, nursing outcome, nursing discharge note) were also noted.

Data analysis

The assessments performed are given in Table 2. The most severe grade was used for patients with multiple or 'changing' pressure ulcers.

Statistical methods used were the student's t test for continuous variables, Chi-square test for dichotomous variables, Mann-Whitney U test for non-parametric analyses of continuous variables and logistic regression (statistical) to determine predictors. In the logistic regression the outcome was defined as the presence or absence of a pressure ulcer (including grade I ulcers) during the hospital stay. Variables tested for prediction were those which differed significantly between patients with and without pressure ulcers ($p<0.05$).

The study was approved by the research ethics committee of the faculty of medicine at Uppsala University. Verbal consent was sought wherever possible, but patients who were unable to give it due to confusion or for medical reasons were still included as it was thought they could benefit from pressure ulcer prevention. There was no reason to suspect any of the mattresses would harm the patients.

Results

Pressure ulcer development

The overall incidence of pressure ulcers, including those at grade I, was 29%. MNS scores undertaken on arrival suggest that 33 (69%) and 34 (64%) patients in the experimental and control groups, respectively, were at risk of developing a pressure ulcer. Twelve patients in the experimental group and 17 in the control group developed pressure ulcers (experimental group: eight grade I and four grade II ulcers; control group: nine grade I ulcers, seven grade II ulcers and one grade IV ulcer). The incidence of grade II–IV pressure ulcers was 8% in the experimental group and 15% in the controls (Table 3). These differences did not reach statistical significance.

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Table 3. Number of patients with pressure ulcers in the experimental and control groups

	Experimental group (n=48) n (%)	Control group (n=53) n (%)	Total n (%)
No pressure ulcer	36 (75)	36 (68)	72 (71)
Grade I	8 (17)	9 (17)	17 (17)
Grade II	4 (8)	7 (14)	11 (11)
Grade III	0 (0)	0 (0)	0 (0)
Grade IV*	0 (0)	1 (2)	1 (1)
Total	**12 (25)**	**17 (32)**	**29 (29)**

* Represents the highest reported grade of pressure ulcer recorded during the hospital stay

Table 4. Number of documented nursing interventions in patients with pressure ulcers grade I

	Experimental group (n=8)	Control group (n=9)
Turning schedule	1	1
Repositioning/turning	3	5
Overlay	–	3
Cushions for heels	2	4
Cushions for 30° tilt	1	4
Cushions for chair	1	0
Lotion	3	0
Observation	3	5
Dressing	0	1
Total	**14**	**23**
Mean intervention/patient	1.75	2.89

The most common body locations for the pressure ulcers in both groups were the sacrum, buttocks, back and heels. In 12 patients in the experimental group there were seven grade I and three grade II ulcers on the sacrum, buttocks and back; one grade I ulcer on the left heel and two grade II ulcers on the right heel (left-hip fracture); and one grade I ulcer on the foot. In 17 patients in the control group there were nine grade I, six grade II ulcers and one grade IV ulcer on the sacrum, buttocks and back; one grade I ulcer on the left heel and one grade I ulcer on the right heel ulcer (left-hip fracture); one grade II ulcer on the left heel and two grade II ulcers on the right heel (right-hip fractures).

The audit of patient records demonstrated that patients who developed grade I ulcers received a mean of 1.8 and 2.9 types of interventions per patient in the experimental and control groups, respectively (Table 4). In the control group three patients with grade I ulcers and two patients with grade II or above ulcers were given overlays.

The mean rating of mattress comfort was 4.2 and 4.0 in the experimental and control groups, respectively. Thirty-eight patients out of 41 (both groups) reported that the comfort was good or very good. One patient in the experimental group reported it was very bad.

Predictors of pressure ulcer development

Three variables (the timespan between arrival in A&E and surgery, haemoglobin concentration at admission and skin moisture level) differed significantly between patients with and without pressure ulcers. Patients who developed pressure ulcers waited longer for surgery (mean=27 hours, median=24, SD=17, range=8–97) than those without ulcers (mean=19 hours, median=19, SD=13, r=3–73) ($t=2.37$, df=99, $p<0.05$). Patients who developed pressure ulcers had lower haemoglobin concentrations on admission (mean=124, median=125, SD=12, range=98–149) than patients without pressure ulcers (mean=130, median=132, SD=14, range=95–167) ($t=2.07$, df=99, $p<0.05$). Finally, more patients who developed pressure ulcers had dry or moist skin compared with those without pressure ulcers ($\chi^2=15.63$, df=2, $p<0.001$). The result of the logistic regression ($\chi^2=5.87$, df=1, p=0.024) showed that significant predictors for the development of pressure ulcers were the timespan between arrival at A&E and surgery (odds ratio=1.04, p=0.03) and the haemoglobin concentration (odds ratio=0.97, p=0.04).

Discussion

Although there was a tendency towards a lower incidence of pressure ulcers in the experimental group, this was not significant (Table 3). Patients in both groups developed the same number of grade I ulcers. This supports the findings of Defloor et al.,[9] who studied the same visco-elastic mattress. In Hofman et al.'s[6] study 12 out of 42 patients with hip fractures allocated to either foam or standard hospital mattresses developed grade III or IV pressure ulcers after one week (two patients on the foam mattress and 10 on the standard hospital mattress). In the present study 64–69% of the patients were assessed as at risk. However, if those not at risk are subtracted, the incidence of severe pressure ulcers is still lower than in the Hofman et al.[6] study.

One interpretation is that there was no significant difference in pressure relief between the visco-elastic and standard hospital mattresses. This would contradict the conclusions of the Cochrane review,[4] which stated that

high-specification foam mattresses are more effective than standard hospital mattresses. However, in the present study the nursing documentation of the prevention and treatment of grade I pressure ulcers demonstrated a tendency to offer more interventions per patient in the control group. Furthermore, five patients in this group were placed on an overlay (hollow core fibre), so the performed comparison is of the visco-elastic mattress versus standard nursing care that includes the use of both overlays and the standard hospital mattress. This illustrates the difficulty in achieving a 'pure' comparison of mattresses only. An alternative interpretation of the results is that good nursing care may have compensated for the absence of the visco-elastic mattress in the control group. Finally, patients in this study were mobilised the day after surgery; the visco-elastic mattress may have a more pronounced preventive effect on patients who are bedridden for longer periods.

The study demonstrated that overall pressure ulcer incidence at the hospital has fallen since it was assessed in 1997 (29% versus 55%).[11] The effect of the visco-elastic mattress may have been more pronounced in 1997. In a prevalence study Clark and Cullum reported an increase from 6.8% (n=586) to 14.2% (n=541) over three years, during which the number of pressure-redistributing mattresses used increased from 69 to 186.[24] They suggested that the mattresses may have replaced other forms of preventive nursing care. In contrast, nursing care at the study hospital may have improved since 1997.

Overall comfort of both mattresses was rated as high, supporting a study by Bale et al.[25]

Significant predictors of pressure ulcer development were found to be the haemoglobin level on admission and the timespan between admission to A&E and surgery, highlighting the importance of not delaying surgery. As haemoglobin levels are counted on admission, low levels should signal the need for pressure ulcer prevention. Cullum and Clark[16] found that patients who developed pressure ulcers during their hospital stay had lower mean haemoglobin levels than those who did not, although the differences were not significant. In this study, none of the other MNS subscales were significantly related to pressure ulcer development. One explanation may be that the effect of fluid and nutrition intake and continence are well known and therefore addressed.

Methodological discussion

Seventy percent of the eligible patients admitted with hip fractures were identified and included in the study. There were no significant age or gender differences between the patients included and excluded. There is no reason to suspect that systematic error (including or allocating patients with special characteristics) influenced the findings.

The power analysis yielded an estimate of 50 patients per group, but due to the low incidence of pressure ulcers this may have been too low to reveal significant differences.

It was not possible to use visco-elastic foam mattresses in the ambulance or the operating theatre. The maximum transportation time in the ambulance was 60 minutes. In theatres it is routine to give a spinal anaesthetic when the patient is still on the hospital bed to minimise the time spent on the operating table. With the randomisation procedure, however, there is no reason to suspect that these gaps in the use of support surfaces influenced the comparison between mattresses.

In Sweden a model for nursing documentation is widely used, supporting systematic thinking and the use of common terms in nursing care.[26] Although the nurses knew which study group the patient belonged to, there is no reason to suspect that there were any differences in the documentation procedure between them.

Only 41 patients (34%) completed the mattress comfort question. Many patients were old and confused and could not perform these ratings. Due to heavy workload, the nurses also sometimes forgot to ask the patients this question.

Conclusion

There was no significant difference in the incidence of pressure ulcers between patients who used the visco-elastic foam mattress and the standard hospital mattress. However, patients on standard mattresses had a tendency to develop more severe pressure ulcers. Patients with grade I pressure ulcers in the control group appeared to receive more documented preventive interventions, suggesting that good nursing care may have compensated for the absence of the visco-elastic mattress. Nevertheless, the authors concluded that the results support the use of the test mattress. Significant predictors for pressure ulcer development were a long waiting time for surgery and low haemoglobin level at admission to the hospital. ■

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