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Effect of fluid-filled support-surface utilization on prevention of pressure ulcers in the operating room: An experimental study[1]

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Abstract
Purpose: The aim of the study was to determine the effect of fluid-filled support-surface utilization on the prevention of pressure ulcers.
Methods: A fluid-filled support surface was placed onto the operating table of patients in the experimental group (n: 30) whereas patients in the control group (n: 30) were treated on standard operating tables. The study was carried out between February 2011 and May 2011 in a university hospital. A total of 60 patients who underwent surgery in orthopedic and neurosurgery clinics were included in the study. The study was an experimental study.
Results: PUs were observed in only one patient (3.3%) in the experimental group, they were observed in 15 patients (50%) in the control group ($p<0.05$). All developing pressure ulcers were stage 1 PUs. A positive relationship was found between the development of pressure ulcers and the BPURAS score, and the duration of operation.
Conclusions: We conclude that a support surface is beneficial when surgery lasts more than 4 hours and in patients whose preoperative risk score is high.

Keywords: Operating room nursing, pressure ulcer, prevention, surgical patient, support surface.

1. Introduction

Pressure ulcers (PUs) are an important health problem; their treatment is expensive, they require extensive care and they increase the risk of morbidity and mortality. They also adversely affect quality of life, causing the patient to feel pain and suffering (Tel, Özden & Çetin., 2006; Uzun & Tan, 2007; Walton-Geer, 2009). Despite developments in the fields of medicine, technology and health care, PUs continue to be a widely-encountered health problem. In the

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USA the incidence of PUs varies between 2.7 and 29% in inpatients in hospitals (Sprigle, Linden, McKenna, Davis & Riordan, 2001; Schoonhoven, Defloor & Grypdonck., 2002). In Europe the prevalence of PUs varies between 8.9 and 22% (Vanderwee, Grypdonck & Defloor, 2008). The results of local studies conducted in Turkey indicate that the prevalence and incidence of PUs are high. In Turkey the prevalence of PUs varies between 7.2 and 11.6% whereas the incidence varies between 18.3 and 41% (Tel et al., 2006; Hug et al., 2001; Akıl, Kabukçu & Karadağ, 2008; Kurtulus & Pınar, 2003).

There is a high risk of development of PUs in the operating room. The occurrence of PUs in inpatients after an operation is undesirable. The literature has emphasized the importance of utilizing a support surface in the prevention of the development of PUs in operating rooms, and the utilization of a support surface is also recommended in the guidelines issued to prevent pressure ulcers (European Pressure Ulcer Advisory Panel (EPUAP) and National Pressure Ulcer Advisory Panel (NPUAP); however, protocols regarding the utilization of support surfaces are scarce (Lyder et al., 2001; NPUAP, 2007; EPUAP- NPUAP, 2009; Yavuz, 2007; Feuchtinger, Bie, Dassen & Halfens, 2006).

Although PUs are frequently observed in patients who have undergone surgery, the lack of a sufficient number of studies on the prevention of pressure ulcers is striking. Lubbers (2001) reported that the incidence of PUs developing during an operation was 12–17% but Armstrong and Bartz (2001) reported a rate of 3.5–29.5%. In a study by Schoonhoven, Defloor, Tweel, Buskens and Grypdonck (2002) at a university hospital in Holland covering 208 patients the operation-dependent PUs incidence was 21.2%. In a study conducted by Brandeis *et al.* (2001), operation-dependent PUs prevalence was 8.5%. In Turkey Karadağ and Gümüşkaya (2005) studied 84 patients who underwent surgery, with an incidence of PUs of 54.8%.

Various risk factors play a role in the development of PUs, which are defined as a "localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear" (EPUAP- NPUAP, 2009). These factors can be intrinsic (age, nutrition, humidity, hypotension, drugs taken, chronic diseases, neural function loss, and immobility) and extrinsic (pressure, friction and laceration) (Schoonhoven et al., 2002; EPUAP- NPUAP, 2009; Yavuz, 2007). Surgery provides additional risk factors: the duration of the operation, anesthesia management, the duration of immobilization, position, excessive skin moisture, the bed that is used, the use of a warming blanket, and positioning tools (Karadağ & Gümüşkaya, 2005; Pham et al. 2011).

In order to reduce or remove these risks international guidelines recommend the following five groups of intervention: risk assessment, skin assessment, nutrition for prevention of PUs, repositioning for prevention of PUs, and the utilization of support surfaces (EPUAP-NPUAP, 2009).

As it is possible to prevent pressure ulcers using conservative methods, the utilization of a support surface is important (Pham et al., 2011). One way of reducing capillary tissue pressure and the risk of pressure ulcer is via the use of support surfaces. Owing to the cost and limitations of frequent changes in the patient's position, various support surfaces have been designed to prevent pressure ulcers from developing, by reducing and alleviating the pressure on the tissues (Thomas, 2001; Karadağ, 2003; Jay, 1995). Health professionals involved in the prevention and treatment of PUs have accepted the fact that the support surfaces used in patients reduce or alleviate the external forces that contribute to the development of pressure ulcers.

The term 'support surface' is a general name given to all tools that help reduce pressure in the prevention and treatment of pressure ulcers. NPUAP defined support surfaces as "a specialized device for pressure redistribution designed for management of tissue loads, micro-climate, and/or other therapeutic functions (i.e. any mattresses, integrated bed system, mattress replacement, overlay or seat cushion" (Lyder et al., 2001). Support surfaces ensure that the pressure between the patient and the support surface is distributed over a wide area and help maintain the capillary circulation in tissues and reduce the risk of breakdown of skin integrity (Lyder et al., 2001; NPUAP, 2007; Yavuz, 2007; Uzun, 2007). Support surfaces, when used alone, neither prevent pressure ulcers nor heal them. Support surfaces must be used as part of a specific prevention and treatment programme. A proper support surface that is specific to the needs of the patient must be provided in terms of the redistribution of pressure, decrease in laceration force, heat and humidity control (EPUAP- NPUAP, 2009; Karadağ, 2003; Brienza & Geyer, 2011). Defloor and Schuijimer (1998) examined the efficiency of different mattresses (standard operating table, foam, gel, polyester and polyurethane) in reducing pressure, and found that a foam or gel mattress had little benefit in comparison with the standard operating table whereas polyester and polyurethane mattresses reduced pressure to a large extent in comparison with the other types of mattress. Challian and Kagan (2001) compared a fluid-filled support surface with the standard operating table and found that PUs did not develop in patients who used the fluid-filled support surface, whereas PUs developed in 21% of patients who did not use this support surface. Nixon, McElvenny, Mason, Brown & Bond (1998) compared a dry visco-

elastic polymer mattress and the standard operating table mattress and observed PUs in 11% of patients who had operations over a dry visco-elastic polymer mattress and in 20% of patients who had operations over the standard operating table mattress.

The foregoing information indicates that the utilization of a support surface in the operating room is necessary and useful but guidelines regarding the prevention and treatment of PUs contain little evidence regarding this issue. No scientific studies regarding the utilization of a support surface to reduce the risk of development of PUs in patients in our country have been published. The current study aimed to fill this gap, and the results will thus contribute to current scientific knowledge, provide evidence and will be used in forming protocols intended for the care of patients during operations.

2. Purpose

This research was performed to determine the effect of the utilization of a fluid-filled support surface in the prevention of PUs in operations lasting more than 2 hours in the operating room.

3. Material and method

3.1.Population and sample selection

The study was carried out between February 2011 and May 2011 in a university hospital with a 1100-bed capacity.

The NCSS-PASS 2007 (Number Cruncher Statistical System) statistics package was used to determine the sample number (Machin, Campbell, Fayers, Pinol, 1997; Blackwelder, 1998). Power was taken as 80% and alpha was taken as 0.05. Use of this package requires knowledge of the average prevalence of the condition. Sample number was determined depending on the study conducted the by Chalian and Kagan (2001) in which the use of a fluid-filled support surface and standard operating table were compared. The prevalence of PUs in patients for whom the fluid-filled support surface was used was calculated as 0% whereas for patients who had operations on standard operating tables it was calculated as 21%.

A total of 30 patients (15 in the experimental group and 15 in the control group) from the orthopedics clinic and 30 patients (15 in the experimental group and 15 in the control group) from the neurosurgery clinic were included in the study.

Inclusion criteria:

- Undergoing an operation in the Departments of Orthopedics and Neorosurgery: When we looked at the literature, as they are among the parts where the pressure ulcer is seen the most, and both the operations last long and the state of living bedridden takes a long time, the patients that have undergone operations in these clinics were included within the scope of the study (Schoonhoven et al., 2002a; EPUAP- NPUAP, 2009; Karadağ & Gümüşkaya 2005).

- Patients who underwent operations lasting more than 2 hours. Schouchoff (2002) and Beğer (2004) reported that immobility in the same position for more than 1–2 hours results in the development of PUs.

- Aged 18 and over,

- Having an operation in elective conditions,

- Being in a moderate or high-risk group according to the assessment performed using the preoperative BPURAS,

- Having no preoperative PUs,

- Volunteering to join in the study.

- The study was an experimental study.

3.2.Type of study

The study was an experimental study.

3.3. Data collection

Data were collected by the researchers. The following forms were used for data collection:

Patient Characteristics Form: This form was prepared by the researcher related with the literature (Walton-Geer, 2009; Lubbers, 2001; Karadağ & Gümüşkaya, 2005; Chalian & Kagan; 2001; Katran, 2008). The form consists of two parts. The first part comprises 16 items on the socio-demographic characteristics of the patient (age, gender, body mass index, etc.) and their health (medical diagnosis, coexisting diseases, drugs taken, preoperative fasting periods, etc.).

The second part concerns information regarding the patients' preoperative and post-operative development of PUs (pressure areas, stage, etc.).

Braden Pressure Ulcer Risk Assessment Scale: BPURAS assesses six risk factors including sensory perception, mobility, humidity, nutrition, activity, and friction-irritation in order to determine the potential risk of the patient developing pressure ulcers. In BPURAS the friction-irritation risk factor is scored from 1 to 3; the other five risk factors score from 1 to 4 and thus the total score ranges from 6 to 23. In this assessment a score of 12 or below is considered to indicate high risk, 13–14 indicates moderate risk, and 15–16 indicates low risk. In people aged 75 and over 15–18 is considered to indicate low risk. BPURAS is a widely used scale and was adapted for the Turkish population in two studies conducted by Oğuz and Olgun (1998) (Cronbach Alpha: 0,95) and Pınar and Oğuz (1998) (Cronbach Alpha: 0.85).

Pressure Ulcer Staging Form: This form includes PUs stages. The International Pressure Ulcer Classification System developed by NPUAP-EPUAP and translated into Turkish by the Turkish Wound Ostomy Continence Nurses Association (2009) was used in this study.

Support surfaces:

Standard operating table: The operating tables used in this study comprised five sections: Head section, back section, an extension for the back section, seat section, and leg section. The position of the operating table could be altered using an electro-hydraulic system. The operating table mattresses were 2.5–5 cm thick and had an antistatic, soft cover. **Fluid-filled operating table pad:** This pad is used in long operations for the prevention and treatment of pressure ulcers. Its surface contains micro flow sacs. The viscous fluid it contains adjusts to the curved lines of the body and the patient's movements and so reduces any pressure and helps prevent friction and laceration. It has an anti-static and waterproof surface, which is resistant to staining. The support surface operates without electricity. In our study liquid-filled support surface was used in our study as it is one of the support surfaces we may use as portable in limited number.

Application of data collection forms and interventions

The researcher visited the orthopedics and neurosurgery clinics one day before surgery to collect the following day's operation list from the clinic assistants. Those patients whose operations were expected to last more than 2 hours were identified after receiving information from the physician. Patients were informed about the study and got verbal consent to participate. BPURAS was applied to patients who agreed to participate and the moderate- and high-risk

patients were identified. The 'Patient's Characteristics Form' was completed, and the patients' skin was assessed according to the pressure ulcer assessment criteria and Pressure Ulcer Staging Form. At the end of the assessment those patients with no pressure ulcers in the moderate- and high-risk groups were included in the study. Patients were randomly assigned to the experimental and control group. For randomization the patients were numbered from 1 onwards according to their order on the operation list. Patients with odd numbers were included in the experimental group; those with even numbers were included in the control group. Informed consent forms were prepared separately for each group. On the day of surgery the support surface was placed onto the operating tables of patients in the experimental group whereas patients in the control group were treated on standard operating tables. The patients' skin was reassessed systematically 30 min postoperatively and on the first, second and third day after surgery. Whether PUs developed or not was recorded according to the PUs assessment form and PUs Staging Form. The patients' routine care continued in their clinics and no additional preventive intervention for the development of PUs was performed by the researchers.

3.4. Research ethics

Written permission was received from the Director of the hospital and the Head of the Departments of Orthopaedics (permission number: 10/371) and Neurosurgery (permission number: 86/11) prior to the study. The study was performed in accordance with the principles of the Declaration of Helsinki. Informed consent was obtained from all the patients.

3.5. Evaluation of data

SPSS 17.0 (IBM Software Group Business Analytics Portfolio) was used for the statistical analysis. The results are presented as average± standard deviation (Min– Max), n (%). In all statistical analyses performed, $p<0.05$ was accepted as the limit of significance. The Kolmogorov-Smirnov test was applied to the measurable parameters and the normality of distribution was determined. Student's t-test was used to test differences between independent groups with a normal distribution. Numerical data were assessed using the Chi-square test or Fisher's exact Chi-square tests. The relation between the PU and some parameters was assessed with the Pearson correlation analysis.

4. Results

As shown in Table 1, the characteristics of patients in the experimental and control groups were similar. However, whereas PUs were observed in only one patient (3.3%) in the

experimental group, they were observed in 15 patients (50%) in the control group ($p<0.05$). All developing pressure ulcers were stage 1 PUs.

Table 1: Patient characteristics in the experimental and control groups

Characteristics	Experimental group (n:30)	Control group (n:30)	*P**
Age			
Mean	=60.40 11.60	= 59.57 15.03	0.811
Gender			
Female	21	19	0.584
Male	9	11	
BMI			
BMI	= 27.93 4.62	=26.53 3.34	0.185
Comorbidity			
Yes	19	16	0.432
No	11	14	
Laboratory tests			
Haemoglobin	13.26 1.55	13.26 1.80	0.999
Albumin	4.06 0.30	4.07 0.23	0.885
BPURAS score			
Moderate risk	25	26	0.718
High risk	5	4	
BPURAS score	= 13.50 0.78	= 13.50 0.9	
PU status			
Developed	1	15	
Non-developed	29	15	0.05

Mean ± SD, $*P < 0.05$

Table 2: Patients' characteristics according to operation

Properties of surgery	Experimental group (n:30)	Control group (n:30)	*P**
Position			
Supine	24	29	
Lateral	2	-	
Sitting	1	-	
Prone	3	1	
Anaesthesia type			0.333
General	26	22	
Regional	4	8	
Duration of operation (hours)			
Less than 3 hours	19	17	0.486
3–4 hours	10	10	
More than 4 hours	1	3	
Mean	= 2.92 0.77	= 3.11 1.27	

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Length of time until mobilization (hours)			
Less than 24 hours	13	13	0.423
25–48 hours	16	16	
More than 48 hours	1	1	
Mean	=24.77 □ 5.16	=26.37±9.55	

Mean ± SD, * $P < 0.05$

There was no significant difference between the experimental and control group in terms of properties of surgery.

As shown in Table 3, a first-stage pressure ulcer was observed in six patients in whom surgery lasted between 3 and 4 hours, in nine patients who were overweight, and in four patients whose BPURAS score placed them in the high-risk category.

Table 3: Pressure ulcer development according to patients' characteristics

Characteristics	**Experimental group (n:1)**	**Control group (n:15)**
Duration of operation		
Less than 3 hours	1	6
Between 3 and 4 hours	-	6
More than 4 hours	-	3
Timing of pressure ulcer development		
First 30 minutes postop	-	7
First day postop	1	14
Second day postop	1	5
Third day postop	-	4
BMI		
Underweight	-	-
Normal	-	3
Overweight	-	9
Obese	1	3
BPURAS score		
Moderate risk	1	11
High risk	-	4
Timing of postoperative mobilization		
Within 24 hours	-	7
Within 25–48 hours	1	7
After 48 hours	-	1

Table 4: Distribution of pressure ulcer sites in the experimental and control groups

PU sites	Experimental group (n: 1)	Control group (n: 15)
First 30 minutes postop		
Sacrum	-	4
Gluteal	-	1
Sacrum/gluteal/heel	-	2
First day postop		
Heel	-	-
Sacrum	-	3
Gluteal	-	5
Sacrum/gluteal/heel	-	1
Sacrum/elbow	-	1
Sacrum/heel	-	1
Sacrum/gluteal/heel/ear	-	1
Ear	-	1
Dorsal side	-	1
Second day postop		
Heel	1	-
Sacrum	-	3
Gluteal	-	1
Sacrum/elbow	-	1
Third day postop		
Sacrum	-	3
Ear	-	1

A pressure ulcer developed in one patient in the control group on the third postoperative day due to the use of a nasal cannula supplying oxygen.

A positive relationship was found between the development of pressure ulcers and the BPURAS score (r: 0.392), and the duration of operation (r: 0.437) ($p<0.05$).

Table 5: Relationships between patients' characteristics and the development of pressure ulcers

	Experimental group n:30	Control group n: 30
Age	r= 0.188 p= 0.320	r=0.359 p=0.052
Gender (M/F)	r= 0.122 p= 0.522	r=0.069 p=0.716
BMI	r= 0.160 p= 0.399	r=0.043 p=0.822

BPURAS score	r= 0.083 p= 0.663	r=0.392 p=0.032
Duration of operation (hours)	r=0.020 p=0.916	r=0.437 p=0.016
Length of time until mobilization (hours)	r=0.118 p=0.533	r=0.195 p=0.301
Haemoglobin	r=-0.178 p=0.347	r=-0.224 p=0.234
Albumin	r=0.277 p=0.139	r=-0.104 p=0.586
Drug usage	r=0.152 p=0.424	r=0.136 p=0.473
Position	r=0.084 p=0.658	r=0.186 p=0.326
Anaesthesia type	r=0.073 p=0,702	r=0.151 p=0,426

5. Discussion

This study was an experimental study with 30 patients in the experimental group and 30 patients in the control group, all of whom underwent operations in the orthopedics and neurosurgery clinics. The aim was to determine the effect of the use of a fluid-filled support surface for the prevention of pressure ulcers. The most important limitation of the study is that it only considered patients who underwent orthopedic and neurosurgery at a single center, in whom operations lasted more than 2 hours. Thus, the results cannot be generalized to other patient groups.

Although the groups were similar in terms of patients' characteristics, PUs developed in 15 (50%) of the patients in the control group and in only one (3.3%) patient in the experimental group. It has previously been reported that the features of the operating table influence the development of PUs and that the use of a support surface will reduce the rate of development of PUs (Vanderwee et al., 2008; Nixon et al., 1998; Chalian & Kagan, 2001; Feuchtinger et al., 2006). The viscous fluid contained within the fluid-filled support surface used in our study adjusts to the curved lines of the body and the patient's movements and so reduces any pressure and helps prevent friction and laceration, and thus the development of PUs.

Low and high BMI has previously been discussed as a factor increasing operation-dependent Pus (Schoonhoven et al., 2002b; Scott., Mayhev & Harris, 1992). In our study, PUs

were not encountered in patients with a low BMI, either in the experimental or control group. In addition, there was no relationship between the development of PUs and BMI. Similarly, Karadağ and Gümüşkaya (2005) found no evidence that BMI was an important factor in the development of PUs. Contrary to our findings, Scott *et al.* (1992) reported that individuals having less than 90% and more than 20% of the ideal body weight were at risk in terms of development of PUs, with the average BMI of those who developed PUs being 24.2. They also found that low BMI increased risk. Our results may however have been affected by the low sample number.

One of the critical interventions in the prevention of PUs is the risk assessment. The risk assessment instruments used for this purpose determine the risk level of the individual and contribute to the planning of the intervention. According to BPURAS, the most widely utilized risk assessment instrument, the risk of developing PUs increases with the degree of risk of the individual. In this study, while a pressure ulcer developed in one patient in the experimental group with a moderate risk score, PUs developed in all 11 patients in the control group with moderate risk scores and four patients with high risk scores. Our findings are consistent with the literature. In their study, Karadağ and Gümüşkaya (2005) found that when patients with low preoperative BPURAS scores were assessed postoperatively in the first 3 days following the operation, they became inadequate at a significant rate in all areas of risk.

In this study, there was a relationship between the duration of the operation and PUs. While the duration of operation of the patient with a pressure ulcer in the experimental group was under 3 hours, 60% of patients in the control group developing PUs had operations lasting more than 3 hours. Pressure ulcers were observed in all three patients in the control group who underwent operations lasting 4 hours or longer. Many previous studies indicate that the duration of operation is an important risk factor in the development of operation-dependent PUs. In the study conducted by Schoonhoven *et al.* (2002b) on 208 surgical patients, PUs were encountered at a rate of 21% in those whose operations lasted more than 4 hours, and that with the increase in the duration of the operation the incidence of pressure ulcers increased in operations lasting longer than 4 hours, at a rate of 33% every 30 minutes. Bours, found that in patients with an operation lasting 3.1–4.4 hours, the incidence of PUs varied from 21.7% to 39.1% and that the risk of PUs increased with the increase in operation duration (Schoonhoven *et al.*, 2002b). Likewise, Lee *et al.* (1998) reported that the risk of PUs increased in operations lasting more than 3 hours.

Among the control group, PUs were observed in seven patients with mobilization periods under 24 hours and eight with mobilization periods of 25 hours and over. Scott *et al.* (1992) reported that lack of mobilization constituted a risk in the development of operation-dependent PUs and that surgical patients lacked mobilization not only during the operation but also after the operation. Karadağ and Gümüşkaya (2005) found that when the period until mobilization after an operation increased, pressure ulcers were encountered at a higher rate; however, in our study there was no relationship between the mobilization period and the development of PUs. Medical devices and equipment that may create external pressure over the tissue also cause pressure ulcers. The development of an ear pressure ulcer in a patient receiving oxygen with a nasal cannula is striking. When positioning the patient, the positioning of tubes and catheters is thus important.

6. Conclusion

In this experimental study conducted on 60 patients who underwent orthopedic and neurosurgery at a university hospital, pressure ulcers developed in one patient in the experimental group, and in 15 patients in the control group. A positive correlation was found between operation duration and the BPURAS score and the development of PUs. It can be concluded that the utilization of a fluid-filled support surface during operation in patients in the high-risk group according to the BPURAS score prevented the development of PUs. Based on the results it is suggested that care should be taken to utilize support surfaces on operating tables for patients in the moderate and higher risk groups, and particularly in all high risk patients, or when operations are expected to last 4 hours or more. Nurses should assess patients in terms of the risk of the development of pressure ulcers particularly in the first 3 days post-operation. Furthermore, it is recommended that studies should be conducted to determine the effectiveness of various available support surfaces in the prevention of operation-dependent PUs.

6.1. Usability of study results

- This paper provides data setting forth the prevention of pressure ulcers in particularly high-risk operations and operations spanning more than 4 hours by placing fluid-filled support surfaces on standard operating tables.
- Data were obtained on the utilization of support surfaces in operating rooms in Turkey and this issue is discussed.

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