LIFTING AND TRANSFER DEVICES: A BRIDGE BETWEEN SAFE PATIENT HANDLING AND PRESSURE ULCER PREVENTION

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Pressure ulcers and musculoskeletal injuries are 2 of the most common, costly, and yet largely preventable harms encountered in health care. Frequent repositioning protects the patient from pressure injury but is potentially hazardous to staff. In a series of experiments, the pressure-redistribution qualities of a novel bedsheets, designed for dual use as a lifting sling, were compared to cotton or polyester/cotton sheets, either fitted or draped. Each sheet was placed upon 1 of 3 commonly encountered therapeutic mattresses. A human analogue (mannequin) weighing 80 kg was placed on the mattress, and the pressure at the body-mattress interface recorded. The results indicate the lifting sheet has no detrimental effect on the pressure-redistributing performance of the mattress, while the inherent textile properties appear to have superior microclimate (heat and moisture control) qualities while also being soft and flexible. By replacing the hospital bedsheet with a constantly accessible lift sheet, safe practice is encouraged.

Keywords: repositioning, lifting and transfer devices, pressure redistribution, patient handling, sling, pressure ulcer

BACKGROUND

In acute and elderly care, multiple lateral transfers occur and may involve transfers into and out of bed, along with repositioning of patients while in bed. Repositioning patients while in bed is a common practice undertaken to help prevent skin breakdown and is strongly recommended in International Pressure Ulcer Clinical Practice Guidelines. Pressure ulcers are commonly encountered in all care settings; in fact, almost 20% of hospital patients present with some degree of pressure-related tissue injury. However, the frequent repositioning of patients in bed can be very strenuous both for patients and nurses, given that this intervention typically occurs every 2 to 4 hours, both day and night (Figure 1). Studies indicate that these transfers result in increased pain for patients, while rapid or extreme movements are frequently perceived to provoke adverse hemodynamic events in intensive care patients. This concern for patient safety may cause a delay or omission in turning, repositioning, and other interventions to advance patient mobility and may contribute to pressure ulcer formation.

For nurses, these transfers rank among the top 10 most strenuous activities and create a strong risk of developing occupational back, neck, and shoulder pain. Additionally, these transfers and repositioning activities require considerable nursing time; multiple nurses may be required to perform each change of position, and if lifting and transfer devices are used, the sling necessary for the transfer needs to be placed under the patient before and then removed after each transfer or repositioning activity, which alone is strenuous.

The 2014 International Pressure Ulcer Guidelines jointly developed by the US National Pressure Ulcer Advisory Panel, the European Pressure Ulcer Advisory Panel, and the Pan Pacific Pressure Injury Alliance offer a number of recommendations related to the use of transfer devices. For example, the guidelines state, “Use manual handling aids to reduce friction and shear. Lift — don’t drag — the individual while repositioning.” Such a recommendation was offered based on expert opinion and considered by more than 100 pressure ulcer experts, directly involved in developing the guidance, to be a strong positive recommendation that clinicians should...
definitely adopt. More recently, a white paper from the National Pressure Ulcer Advisory Panel provided further discussion about the use of transfer devices, highlighting the current lack of evidence that individual transfer devices can be used safely with therapeutic support surfaces. These pressure ulcer guidelines had no significant input from safe patient handling practitioners and could have been greatly strengthened by their involvement. This is particularly important, as contemporary policy is to reduce, or ideally eliminate, all forms of manual handling as far as practical. Where advice seems contradictory, nurses, who perhaps perceive the patients’ well-being as more important than their own, may be exposed to undesired occupational health risks.

One further recommendation within the International Pressure Ulcer Guidelines directly addresses transfer devices. This recommendation, again developed upon expert opinion but considered a clinical practice that should definitely be performed, was “do not leave moving and handling equipment under the individual after use, unless the equipment is specifically designed for this purpose.” This recommendation was amended from the wording used in the 2009 first edition of the International Pressure Ulcer Guidelines, which states that transfer devices should never be left under the individual.

There were a number of reasons why the pressure ulcer community advocated not leaving transfer devices under patients, although the primary concern was whether the device would compromise the pressure redistribution provided by the bed mattress or seat cushion and, coincidentally, interfere with features of the surface designed to control temperature and moisture at the skin surface. Pressure ulcer prevention has become associated with the widespread use of specialized cushions, mattresses, and beds designed to limit exposure to the degree and duration of pressure. This exposure limit is achieved primarily in 1 of 2 ways. A support surface may increase the area of the body in contact with the said surface and thus reduce pressure at vulnerable anatomical sites such as the sacrum and heels, termed reactive support surfaces (Figure 2). Alternatively, support surfaces can reduce the amount of time during which vulnerable body sites bear pressure by sequentially inflating and deflating air cells under the patient, active support surfaces (Figure 3). Regardless of whether an active or reactive support surface is used, there were perceptions that any material between the patient and the support surface might reduce the functional capacity of the support surface to redistribute load from the body sites prone to pressure ulcers, along with detrimental effects upon skin temperature and moisture dispersion.

The 2014 clinical practice recommendation that transfer devices should not be left under patients unless specifically designed to have minimal effect on the action of the mattress

Figure 2: A reactive support surface redistributes pressure by immersion and envelopment: examples are foam mattresses (shown below and static air filled mattresses).

Figure 3: An active support surface redistributes pressure by alternately inflating and deflating a series of air-filled cells.

or cushion raises the question whether transfer devices could be shown to have no deleterious effect on the action of the primary support surface. Previous research indicated that depending on the sling fabric, prolonged sitting on a sling may not increase pressure ulcer risk. This paper takes the debate a step further by setting out laboratory evidence for the influence of 1 transfer device upon the ability of active and reactive support surfaces to redistribute pressure in bed.

METHODS

The transfer device investigated in the present study was the Maxi Transfer Sheet (MTS) produced by ArjoHuntleigh Inc., a bedsheet consisting of a 1-layer textile made of 99% woven polyester with a 1% carbon core. The sheet, designed to be used in place of the conventional bedsheet, remains beneath the patient and has the integral comfort and strength necessary for use as an in situ lifting sling for horizontal transfers and repositioning (Figure 4). The sling can be connected to a ceiling or floor-based lift and is left under the patient before and after the transfer or repositioning, comparable to regular bed linen.
Figure 4: The Maxi Transfer Sheet: a replacement bedsheet with integrated lift facility.

Some aspects of the performance of the MTS were known following independent laboratory testing conducted using recognized European and international standards including water vapor resistance, thermal resistance, and liquid wicking rate. These are illustrated in Table 1 and compared with the same tests performed on a 100% cotton hospital bedsheet used throughout the active mattress study as a control material. The test results suggest the MTS sheet would have greater breathability, reduced thermal insulation, and faster movement of fluid through the material than the cotton sheet. These characteristics are considered important to protect the skin from adverse microclimate effects, primarily increased skin temperature and humidity, recently seen to be important factors reducing tissue tolerance to pressure, shear, and friction.1

Comparison of the likely effects of the MTS and cotton sheet upon the pressure-redistribution performance of a support surface was undertaken using measures of interface (or contact) pressure in 2 separate experiments, the second of which was undertaken by the product manufacturer. Measurement of the pressure between a support surface and anatomical landmarks has been reported for many years as an approach to comparing one aspect of support surface performance.13 While measures of interface pressure do not give a direct guide to the likelihood of developing pressure ulcers given that these measures only report direct pressure at the skin surface and give no information regarding internal tissue strain,2 they do provide a relatively simple method to identify whether a material placed between the skin and support surface changes the pressure exerted at the skin surface.

Active (alternating) mattress performance

In the first experiment, all pressure measurements were performed upon an active support surface designed to replace the hospital mattress and consisting of an array of 20 transverse air cells, which alternately inflate and deflate over a 10-minute cycle (Figure 3). In each test a flat wooden surface representing the human body was positioned centrally upon the mattress surface with 80 kg weight applied in a set order to the areas corresponding to the "head," "trunk," "pelvis," and "feet" of the mannequin. When fully loaded, the mannequin bore 80 kg (Figure 5). A pair of raised solid objects was attached to the foot region of the mannequin prior to application of weight to mimic the heel region (Figure 6).

Interface pressures were measured using a calibrated pressure transducer, which provided a continuous recording (1 Hz) of interface pressure (in mmHg) over time. The pressure transducer was connected to a single 28 mm diameter pressure sensor.

The first two 10-minute cycles, where the support surface inflated and deflated the transverse air cells running along the entire mattress, were edited from the pressure sensor output files as the mattress was adjusting to the weight of the loaded mannequin during this initial phase. In each test, 3 full cycles (30 minutes) of stable interface pressure measurements have been used to characterise the effects of the cotton sheet and MTS upon interface pressure. Each test was repeated 3 times. The proportion of time during the 3 cycles when interface pressure was under an arbitrary threshold of 30 mmHg was

<table>
<thead>
<tr>
<th>TABLE 1</th>
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<tr>
<td><strong>Material Properties of the Maxi Transfer Sheet and a 100% Cotton Hospital Bedsheet</strong></td>
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<tr>
<th></th>
<th>Water Vapor Resistance m²Pa/W</th>
<th>Thermal Resistance m²K/W</th>
<th>Liquid Wicking Rate Capillary rise in 60 seconds (warp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton Sheet</td>
<td>3.45</td>
<td>0.0200</td>
<td>36mm</td>
</tr>
<tr>
<td>Maxi Transfer Sheet</td>
<td>2.38</td>
<td>0.0096</td>
<td>53mm</td>
</tr>
<tr>
<td>(Polyester 99% / carbon core 1%)</td>
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calculated, and time over the threshold was assumed to reflect more hostile loading conditions at the skin surface.

Reactive mattress performance

The next series of measurements was undertaken in controlled laboratory conditions. Two surfaces were investigated: a pressure-distributing foam mattress and a powered low-air-loss (air-filled) mattress. Each mattress was tested with the MTS and a polyester/cotton (40%;60%) bedsheets in 2 test conditions: (1) loosely draped and (2) fitted close to the mattress. A full bed-length pressure mapping system (XSensor) was placed between the covered mattress and a full body analogue mannequin weighted to 127 kg. Pressures in mmHg were reported as P values representing the mean and standard deviation of all sensors recording a minimum of 10 mmHg while the loaded mannequin was placed on the bed surface.

RESULTS

Single pressure sensor study – Active Surface

Table 2 details the proportion of each set of interface pressure measurements when the measured interface pressure was below 30 mmHg. Where no sheet was placed between the mannequin and mattress between 53.7% and 91.1% of all sacral interface pressure measurements were under 30 mmHg. This nominal threshold has been used for several decades, initially when considered to represent a safety margin below capillary closing pressure and, today, to simply provide a reference point characterising performance.

Introduction of a cotton sheet between the mannequin and mattress did not markedly change interface pressure, while the use of the MTS sheet appeared to reduce interface pressure, resulting in 91.4% of all measurements over the 3 tests falling below 30 mmHg.

At the “heel” area of the mannequin, measured interface pressures were higher than at the sacrum (Table 3).

Pressure mapping study – Reactive Surfaces

Table 4 illustrates the mean and standard deviation of P value measurements obtained by the manufacturer from 10 measurement sessions performed with each sheet material. In each case the P value mean was lower when the MTS was placed between the mannequin and bed surface than where loose or fitted sheets were used (P < 0.01).

DISCUSSION

The sacral and heel interface pressure measurements measured during the single sensor study were similar to sacral and heel measurements performed using human volunteers and patients. This suggests that the use of the loaded mannequin, with 10 mm high heel contact points, gave interface pressure measurements consistent with human data and was a valid test method to compare different products and bedsheets.

Neither the cotton sheet nor the MTS appeared to degrade the performance of the active support surface. In the case of
Table 2

<table>
<thead>
<tr>
<th>Proportion (%) of time interface pressure was below selected pressure thresholds</th>
<th>No sheet</th>
<th>Cotton sheet</th>
<th>MTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Run</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>&lt;= 30 mmHg</td>
<td>54.2</td>
<td>91.1*</td>
<td>53.7</td>
</tr>
<tr>
<td>20-30 mmHg</td>
<td>7.3</td>
<td>42.0</td>
<td>20.8</td>
</tr>
<tr>
<td>10-19 mmHg</td>
<td>13.9</td>
<td>15.7</td>
<td>14.2</td>
</tr>
<tr>
<td>&lt; 10 mmHg</td>
<td>33.0</td>
<td>33.4</td>
<td>18.7</td>
</tr>
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</table>

* Pressure sensor may have been slightly displaced from the apex of the inflatable cell under the “sacrum” of the loaded wooden surface.

Table 3

<table>
<thead>
<tr>
<th>Proportion (%) of time interface pressure was below selected pressure thresholds</th>
<th>Cotton sheet</th>
<th>MTS</th>
</tr>
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<tbody>
<tr>
<td>Test Run</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>&lt;= 150 mmHg</td>
<td>88</td>
<td>84</td>
</tr>
<tr>
<td>Maximum interface pressure (mmHg)</td>
<td>153</td>
<td>154</td>
</tr>
<tr>
<td>Minimum interface pressure (mmHg)</td>
<td>18</td>
<td>18</td>
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Table 4

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<tr>
<th>Mean and Standard Deviation P value measurements performed with different sheet materials positioned between the mannequin and a powered and nonpowered reactive bed surface.</th>
<th>Foam mattress</th>
<th>Low-Air-Loss Bed</th>
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<tr>
<td></td>
<td>Fitted sheet</td>
<td>Loose sheet</td>
</tr>
<tr>
<td>Mean</td>
<td>32.25</td>
<td>31.08</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.78</td>
<td>0.99</td>
</tr>
</tbody>
</table>

the support surface with no covering sheet and where the cotton sheet was placed between the wooden surface and the support surface, around 50% of all measured “sacral” interface pressures were below 30 mmHg. When the MTS was placed between the support surface and wooden surface, 91.4% of pressure measurements were below 30 mmHg. This is challenging to interpret as it could be considered that the inclusion of the MTS improved the performance of the support surface. Other studies have also shown unexpected improvements in performance of chairs and cushions where transfer devices were left in situ. Similar results were seen in the pressure mapping study, where the lowest pressures were seen using MTS, rather than loose or cotton sheets, between the mannequin and bed.

Measuring interface pressure where transfer devices are left in place between the patient and their support surface does not appear to automatically degrade the performance of the support surface, at least in terms of interface pressures applied to the skin surface. It should not be considered, however, that all textiles placed between the patient and support surface will not pose hazards to the development of pressure ulcers. This is particularly true where slings may be constructed with raised seams or inflexible, nonbreathable fabrics. This raises the likelihood of creating areas subjected to high surface pressure gradients, shear, and adverse microclimate conditions such as heat and moisture retention, considered causal factors for pressure ulcer development. The effect of any device placed between the skin and supporting surfaces should...
be quantified to help establish the safety of new textiles used to assist repositioning.

Regular repositioning, the cornerstone of pressure ulcer prevention, is most likely to occur when clinicians have immediate access to lifting equipment. This access is particularly relevant for the very sick patient at high risk of pressure injury because of his or her underlying extreme morbidity. For these patients, the ability to move slowly, gentle movements, without having to place the sling, gives them access to a protective intervention that might otherwise be considered too hazardous. Biomechanically, the use of a transfer sheet is likely to reduce shear and tissue deformation during patient movement, helping to protect the skin from pressure ulcers and deep tissue injury. A pragmatic, and refreshingly simple solution, to address the lack of access to lift equipment would be sheets designed to work in synergy with therapeutic support surfaces, to provide an environment conducive to tissue viability when retained in situ and to serve as a useful tool for repositioning the patient. Replacing the standard bedsheet with a lifting device may positively affect concordance with repositioning protocols and so improve patient outcomes. There are also additional and important benefits targeting caregiver safety and efficiency. A controlled prospective trial within an ICU indicates that the occupational risks and the nursing time required for the transfers are significantly reduced, resulting in fewer occupational hazards, increased efficiency, and increased productivity of nursing time.

Preventing pressure ulcers and caregiver musculoskeletal disorders represents a significant challenge to healthcare providers; both conditions are common, costly, and difficult to control. It is important to recognize that the very act that protects the patient also places the caregiver at greatest risk, and so the solution must bring together expertise and collaboration from the fields of both tissue viability and safe patient handling. This challenge emphasizes the need for cross-discipline involvement of nurses, ergonomists, and occupational health specialists when clinical guidelines for patient care are developed and updated. Equally, nurses and other specialists should be involved when developing and updating occupational health guidelines such as ones featured in the International Consensus on Manual Handling of People in the Healthcare Sector (EN-ISO TR 12296). Fortunately, the development of contemporary textiles has eradicated many of the drawbacks associated with traditional repositioning equipment, and so, today, lifting sheets may be similar in feel, appearance, and quality to the standard cotton or polyester-cotton hospital bedsheet. Synthetic textiles may drape in the same way as cotton, can be seam free, may dry quickly, and may have equitable or superior moisture-vapor transfer rates as well as being pleasant to lie upon. These characteristics support the recent recommendation in the International Pressure Ulcer Guidelines that lift equipment, provided it has been shown to have suitable characteristics, may be left in situ. This development also has obvious advantages for an SPHM program, as it has been shown to significantly reduce both the magnitude of the forces exerted during patient handling and repositioning and also the frequency of these activities. In a recent study, a significant reduction in physical load for the nurses was seen when the transfer sheet was used in comparison to normal slings used in combination with a lifter, sliding sheets, and manual transfers. This result was partly due to reduced biomechanical forces and partly due to activities that were eliminated entirely as the sheet can stay under the patient.

As with any study, there were limitations associated with the current work. The study only examined the effect of a single transfer device and should be expanded to consider alternative designs and materials. There were challenges in the correct positioning of the interface pressure sensor. Small displacement from the apex of an inflatable cell of the active support surface could give rise to large reductions in reported interface pressure. Perhaps some of these application issues could be resolved if the mannequin was replaced with a solid but transparent surface. Finally, the influence of textiles with different material properties upon the performance of interface pressure sensors would be interesting to explore further and may ultimately lead to improvements in support surface cover materials, better transfer devices, and perhaps load management using nightwear and clothing.

REFERENCES


Michael Clark, PhD has worked in tissue viability and wound healing since 1980. He is Professor in Tissue Viability, Birmingham City University, UK supporting its Wound Healing Practice Development Unit one day a week. Professor Clark was Chief Executive of the Lindsay Leg Club Foundation and has been President of the European Pressure Ulcer Advisory Panel. He was Editor in Chief of the Journal of Tissue Viability from 2000 to 2010 and now serves as Emeritus Editor of that publication. Prof Clark has served on the Guideline Development Group of the International Pressure Ulcer Guidelines since 2005.

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Hanneke Jj Knibbe, Msc, BSc holds a masters in Human Movement Science (Cum Laude) and an additional bachelors in Physical Therapy. She received the 2010 Bernice Owen Award for Research in Patient Handling from the University of South Florida. Hanneke works at Locomotion Health and Research and has been involved as an independent researcher in all phases of the national implementation of the Dutch Guidelines for Practice over the past 20 years.

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