PRESSURE MAPPING

Review article – The effects of clinical support surfaces on pressure as a risk factor in the development of pressure ulcers, from a radiographical perspective: a narrative literature review

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KEYWORDS

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ABSTRACT

Purpose: Pressure ulcers are a high cost, high volume issue for health and medical care providers, having a detrimental effect on patients and relatives. Pressure ulcer prevention is widely covered in the literature, but little has been published regarding the risk to patients in the radiographical setting. This review of the current literature is to identify findings relevant to radiographical context.

Methods: Literature searching was performed using Science Direct and Medline databases. The search was limited to articles published in the last ten years to remain current and excluded studies containing participants less than 17 years of age. In total 14 studies were acquired; three were excluded as they were not relevant. The remaining 11 studies were compared and reviewed.

Discussion: Eight of the studies used 'healthy' participants and three used symptomatic participants. Nine studies explored interface pressure with a range of pressure mat technologies, two studies measured shear (MRI finite element modelling, and a non-invasive instrument), and one looked at blood flow and haemoglobin oxygenation. A range of surfaces were considered from trauma, nursing and surgical backgrounds for their ability to reduce pressure including standard mattresses, high specification mattresses, rigid and soft layer spine boards, various overlays (gel, air filled, foam).

Conclusion: The current literature is not appropriate for the radiographic patient and cannot be extrapolated to a radiologic context. Sufficient evidence is presented in this review to support the need for further work specific to radiography in order to minimise the development of PU in at risk patients.

INTRODUCTION

Pressure Ulcers (PUs) are an injury to the skin and deep tissue, mostly occurring over bony prominences, resulting from pressure, or the combination of pressure and shear[1]. PUs are a high cost problem for health care providers across Europe. The number of patients afflicted reaching over 18%[2] with one UK study as high as 20%[3] costing the National Health Service £1.4–£2.1 billion annually (4% of total NHS expenditure)[4]. PUs also have a detrimental effect to the patients physical and psychological wellbeing. It is widely accepted that the action being taken to treat and prevent

PUs is outweighed by the size of the problem[5]. Therefore it is imperative that all measures must be taken to identify avoidable instances, where the risk can be reduced or eliminated.

Unrelieved pressure leads to the formation of PUs, and immobility is a significant risk factor in this process[6-8]. The current literature is focused towards finding the minimum safe time and pressure parameters, before mobilisation is necessary to avoid formation of PU. Pressure ulcer prevention policies and guidelines have been published in Europe and the UK[9-10]. The main focus of these guidelines is repositioning to reduce the time of immobility and the amount of pressure on vulnerable areas. The evidence suggest that high pressures for a short time are just as damaging as low pressures over a long time. In a number of radiological procedures within Nuclear Medicine, Computed Tomography, Magnetic Resonance and Interventional Radiology, the patient is purposefully immobilised for periods of 20 minutes, sometimes in excess of 2 hours. On occasion patients are restrained to inhibit movement for the acquisition of useful images and minimise exposure to ionising radiation.

Table 1: Search terms for databases

Healthy Volunteers	OR	Healthy participant*	OR	Healthy adults		OR	Patient*	
AND								
Pressure Ulcer*	AND	Interface	OR	Average				
AND								
Supine								
AND								
(Cushioned	OR	Mattress)	AND	(Hard	OR	Flat	OR	Rigid)

Within the radiographic field, movement during an examination would cause the resultant images to be diagnostically unacceptable, leading to repeat examinations and increasing the dose to the patient. This review of the literature will identify current pressure ulcer research useful to the field of radiography and possibilities for further work.

METHODS

Literature searching was performed using Science Direct and MEDLINE databases using the search terms as seen in Table 1, from January 2004 to August 2014. Paediatric studies were excluded. Fourteen studies in total were acquired of which three were excluded as one was only available in Japanese, one was a duplicate across the databases and another looked at wheelchair users. This paper will review the remaining 11 studies.

Limit to	≦ 10 years old
	Journal articles only
Exclude	studies of participants < 18 years age
	Seated - Wheelchair

Discussion

All studies were published in peer reviewed journals with a mean impact factor of 1.4059.

Participant demographics

Eight of the eleven studies were performed with 'healthy/able bodied participants'. The remaining three were samples of convenience including acute care, hernia repair and patients at risk of developing PUs. Although using healthy participants is a convenient and acceptable practice for this kind of study, it brings with it a number of limitations. The health of the 'patients' is a determining risk factor for the formation of PUs[11], studying 'healthy' participants will affect the external validity of the findings as they cannot be extrapolated to the population at risk.

The samples disclosed are representative of the general population, with ages ranging from 17 to 95. Five of the studies include BMI details of the participants, of these only one analyses the data for comparison as a variable. Of the 308 participants for the 11 studies 52% were female and 47% male, showing no overall gender bias. One study omitted gender information (5 participants).

Pressure measurement tools

Measuring Interface Pressure (IP), as force per unit, is not the recommended gold standard indication for ischemia in tissue. The process of PU development involves a complex interplay of several factors such as shear, blood flow, deep tissue pressure etc. However it is a convenient and widely accepted method. Pressure mats consist of capacitative sensors, placing pressure on these sensors results in potential difference. Nine of the studies used pressure mapping technology from various manufacturers. Rothenberger et al[12] explored skin perfusion dynamics due to external pressure, for this they used Doppler flowmetry and tissue spectrophotometry. This study is the first to assess micro perfusion and although the justification for this is sound, it results in research that cannot be compared to the existing body of work on PU.

Shear is when two parallel forces act against one another to cause distortion in the body stretching and narrowing blood vessels. Fontaine et al propose a measurement combining pressure and shear, for this they have developed a shear sensor consisting of two parallel plates with an electronic device measuring relative movement between plates. Shear is also explored by Oomens et al[13] with the use of finite element modelling. This method is complex and lengthy meaning the study only included 3 participants.

Comfort / Pain measurement tools

Of the 11 studies only two mention patient comfort, King et al[14] noted that comfort is not usually taken into account and gave a brief narrative of participant comments but offers no further analysis. Keller et al[15] used a 10-point visual analogue scale to collect participants' assessment of comfort. Visual analogue scales are considered to have good reliability and construct validity but do have some potential for error in interpretation[16]. This can be due to participant variation across a group. A published review of alternating pressure air mattresses for preventing PU by Vanderwee et al[2] found that only 4 of 35 studies reported comfort as a primary outcome. The review goes further, discussing the validity of the methods for collecting comfort data, concluding that more studies are needed to evaluate comfort and better measures need to be devised. A Cochrane review[17] of support surfaces for pressure ulcer prevention excluded two studies in 112 for only measuring 'subjective' outcomes, and included 5 with comfort as a secondary outcome showing a large gap in the current research.

Visual erythema grading tools

Two studies performed visual inspections for erythema, as an indication of tissue damage[18-19]. Thorne et al offer no information about the tool used so no further comment can be made. A published grading tool used by Hemmes et al[18] showed a significant number of patients with hyperaemia. No interpretation of the data is offered, so further work is needed to see how this relates to necrosis and ischemia.

RESULTS

The gold standard clinical outcome for PU studies is the measure of pressure ulcer incidence, due to cost, availability of resources, and time, intermediate outcomes are often measured in the literature.

Nine studies used IP as the primary outcome. Three of them recorded mean average pressure[20-22]. Miller et al[20] noted the capillary occluding measurement of 32mmHg. They compared the average number of red sensors with a reading over 90mmHg across the two surfaces. It was noted that the lab surface with 2-20 red sensors would be less effective at reducing pressure than the surgical table pad with 1-6 red sensors. No further justification is offered for considering the higher mmHg. Moysidis et al compare mean IP with contact surface area and pressure distribution as rate of low pressures (5-33mmHg) for three surfaces. The findings are not statistically significant, but do suggest that the higher specification surfaces produce less IP, and as the specification of the surface increases so does the contact area. Patel et al[22] compared 5 existing high specification mattresses against a standard mattress using measures of mean IP, contact area and contact area of pressures above 32mmHg. From the findings the mattresses were 'ranked' according to the ability to reduce interface pressure.

Three studies assessed mean peak pressure of 'jeopardy' sites, the areas more likely to be at risk of developing PUs, including head, scapula, sacrum, and heels[15,19,23]. Fontaine et al[23] also explored shear as a secondary outcome measure as the right-heel measuring force. Findings were compared for three surfaces in both supine and head of bed (HOB) elevation positions. Whilst the comparisons for supine position are relevant to the radiography setting the HOB elevation results cannot be considered. For the supine position no significant results were obtained for any of the 'jeopardy' areas measured. Three surfaces including two mattresses and a spinal board studied by Keller et al[15] directly compared the mean IP for the 'jeopardy' areas and found the spinal board to have the highest pressure. This finding was also reflected in the mean comfort scores. Thorne et al[19] explored the use of a gel overlay in an ancillary setting and found no significant reduction in mean peak pressure. None of these studies divulged the regions of interest for the mean peak IP.

Two studies also looked at 'jeopardy' areas but recorded the pressure of the single highest sensor (peak)[14,24]. Chung et al explored the changes in pressure for a standard mattress at various HOB angles, and no comment is made about the peak pressure in the supine position. King and Bridges compared three surgical patient surfaces designed to reduce pressure, all surfaces reported a peak pressure measurement in the 'jeopardy' areas lower than 90mmHg. The use of the 90mmHg benchmark is attributed to previous work by Kosiak[7]. Only one study includes the head in this assessment as most studies use a pillow to support the head[14]. The use of support aids in the radiological setting may not always be appropriate.

One study measured both peak pressure for scapula and heels, and mean peak pressure for the sacrum[18]. The single highest sensor readings were taken for the sites with prominent bone near the surface. For the sacrum which is a larger area of high pressure the sensor with the highest value and the 8 adjacent to it were averaged for the peak pressure index. Two spinal boards were compared with these measures and significantly lower readings were reported on the soft layered spinal board compared to the rigid spinal board.

Oomens et al[13] measured shear, as maximum shear strains for the primary outcome of a comparison of rigid and soft layer spinal boards. A region of interest was selected around the sacrum and the maximum shear strains recorded. The findings on the rigid spinal board exceed the critical range for inducing deformation of tissue, those on the soft layered did not exceed the threshold for damage.

Rothenberger et al[12] measured blood flow and haemoglobin oxygenation as arbitrary units. They used the Oxygen to See (O2C) device to calculate the blood flow. Findings show that there was significant difference in the sacral area between the three mattress surfaces and the hard control surface. This is the only study to compare a hard surface to the support surfaces. Haemoglobin readings showed no significant change.

Overall, three studies found that IP decreases on soft layer spinal boards. Two studies found the results to be body morphology dependant suggesting the need for further work exploring BMI, waist to hip ratio, and body morphology. Both Thorne et al and King and Bridges[14,19] found no significant differences between surfaces. All studies compare different surface options for the clinical setting giving recommendations on which is best to reduce pressure.

Surfaces

Support surfaces from trauma, surgical and nursing settings are explored in the literature. Spinal boards, both rigid and soft layer were compared by Hemmes et al, and Oomens et al. Keller et al[13,15,18] also looked at a rigid spinal board in comparison to vacuum mattress, and semisoft overlay mattress. Standard hospital mattresses with a number of pressure reducing overlays; air, gel, fluid, foam, and viso-elastic were explored in four studies (Fontaine et al, King and Bridges, Miller et al, and Thorne et al)[14,19-20,23]. A range of 'standard', higher specification, vacuum, and viso-elastic hospital mattresses were compared by Myodis et al, Patel et al, and Rothberger et al. Chung et al[12,21-22,24] compared HOB elevations on a standard hospital bed and mattress. None of the studies explored the use of ancillary support surfaces.

Time for acquisition

Four of the studies gave no indication of how long the participants were monitored during measurement acquisition. 'Settling in' time to allow for stable pressure measurements is documented in the wider literature as being between 4 and 6 minutes. Three studies allowed settling in time before acquisition, Miller et al[20] allowed 4 minutes, Moysidis et al and Rothenberger et al[12,21] both allowed 6 minutes. Hemmes et al, and Keller et al[15,18] only disclose the total time on the surface of 15 and 5 minutes respectively giving no information about when during this time the pressure data acquisition occurs. 5 frames in total were collected by Thorne et al at 5 minute intervals over 20 minutes starting at zero. Three frames at 50s, 100s, and 150s were collected by King and Bridges[14] after a 150s settling in period.

Data analysis

Analysis of the data was performed using a range of programmes including SPSS, SAS, Microsoft Excel and Access.

Radiography

No studies include imaging surfaces for comparison. The literature as of 2010 showed only one study of PU development in the radiography field, showing the incidence of PU in patients undergoing radiology procedures was 53.8%[25]. Sufficient evidence has been found to suggest that ancillary support surfaces can incur high interface pressures. Results from the studies included in this review cannot be accurately interpreted for radiological surfaces. Radiological surfaces are designed by manufacturers to be radiolucent and anything added to the table such as mattresses or overlays would increase dose to the patient. Also patients undergoing radiological examination are required to be immobile. None of these considerations have been taken into account in the current literature.

Validity

Whilst all the studies are valid for their intended clinical audience for example Trauma, Nursing, and Surgery, they cannot be interpreted for the radiographic context. The exclusion of all unnecessary materials, positioning aids, mattresses and the use of immobilisation devices all contribute to a controlled environment. These specific constraints are not yet represented in the literature.

CONCLUSION

This review offers an overview of the current literature that could also be relevant to imaging surfaces in a radiological context. The literature is offered from two main backgrounds, nursing and surgery. Whilst the recommendations from the studies reviewed are applicable to the fields they are designed from they cannot be extrapolated for radiographic context. The need for further work, specific to radiography, is essential to minimise the development of PU in at risk patients.

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