Improved clinical outcomes in pressure ulcer prevention using the SEM scanner

Objective: An in-practice evaluation of an sub-epidermal moisture (SEM) scanner, to detect non-visible pressure damage, allowing appropriate, targeted pressure ulcer (PU) prevention interventions.

Method: The evaluation included patients on a single medical-surgical ward over a period of two months.

Results: The evaluation included 35 patients. The outcomes of the evaluation suggest that the SEM scanner provided objective evidence that both the interventions being employed and the increase in repositioning and assessment prevented further incipient skin damage.

Conclusion: We conclude that the early detection of non-visible tissue injury using the SEM scanner as an adjunct to the usual PU risk assessment strategies can reduce PU incidence, leading to improved patient outcomes and released productivity.

Declaration of interest: This in-practice study evaluated the use of SEM Scanner technology which was provided by BBI Europe Ltd (Bruin Biometrics). Assistance in the drafting and editing of content was provided to the author by Richard Shorney of Real Healthcare Solutions Ltd and Deborah Glover, Medical Editor.

early detection ● patient safety ● prevention ● pressure injury ● pressure ulcer ● SEM scanner sub-epidermal moisture

Pressure ulcers (PU; also known as pressure injury) incidence is a key quality issue for the UK National Health Service (NHS). It is widely believed that upwards of 80% of these harm events are avoidable. Preventing hospital-acquired pressure ulcers (HAPUs) through early detection will reduce both patient harm and health-care costs. Health-care organisations should take a strategic approach to PU prevention and management. National PU initiatives use care bundles such as SKIN (or SSKIN) help health professionals to focus key activities and have a strategic view in relation to reducing PU occurrence. At a local level, all individuals on admission to a hospital care setting should have an PU risk assessment using an appropriate risk assessment scale (RAS) within six hours of admission and daily thereafter. The two most frequently used RASs used in the NHS are the Braden and Waterlow. Patients deemed at risk of PU development should receive an appropriate intervention regimen to prevent pressure damage occurring.

Quality improvement collaborative

Within the my trust, improvements in PU prevention had been made, but avoidable PUs remained a key area of concern. In order to address this, a quality improvement collaborative was formed; such collaboratives bring together professionals from across health-care settings to address a particular topic using a structured, planned approach to identifying and measuring change in clinical practice. As a result of initial work, over a 12-month period the number of reported category III and IV PUs fell from 30 to 25 PU across the trust. However, with this shift in focus, the number of category II PUs increased by 57% in the same time period (from 148 to 259 PU). This increase indicated an urgent need to refocus efforts to reduce this form of avoidable harm.

A review of the PU report documentation demonstrated that there was a high prevalence of pre-existing symptoms of deep tissue injury (DTI) such as pain and oedema. Clearly these symptoms of DTI were not understood by health professionals as no PU prevention interventions were implemented.

As tissue oedema is an indicator of deep tissue pressure damage, it was agreed that the use of an objective device that could assess sub-epidermal changes in order to detect tissue damage before it became visually detectable, would facilitate early implementation of an appropriate pressure relieving regimen, minimising the risk of further deterioration. Thus, an in-practice evaluation of the SEM scanner was undertaken; if it proved to be clinically effective, it would be considered for inclusion into the PU prevention regimen.

The SEM scanner

The SEM scanner (BBI LLC; Bruin Biometrics), is a noninvasive, portable skin assessment device used as an adjunct to clinical judgement, offering an objective and reliable method for detection of early invisible tissue damage. It assesses changes in sub-epidermal moisture (SEM) (also known as localised oedema) during the initial inflammatory phase of wound healing — prolonged mechanical loading blocks blood and lymph vessels, so waste products accumulate in the cell niche and interstitial space, and increases SEM. Inflammatory changes and tissue oedema resulting from prolonged pressure occurring three to 10 days before skin breakdown. In a multisite, longitudinal
Table 1. Example delta values and Waterlow Scores

<table>
<thead>
<tr>
<th>Age bracket/gender</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Waterlow</td>
<td>S</td>
<td>LH</td>
<td>RH</td>
<td>S</td>
</tr>
<tr>
<td>80–84 / M</td>
<td>18</td>
<td>0.7</td>
<td>1.2</td>
<td>0.4</td>
<td>0.7</td>
</tr>
<tr>
<td>95–99 / M</td>
<td>20</td>
<td>1.6</td>
<td>2.1</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>90–94 / F</td>
<td>23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85–89 / F</td>
<td>N/A</td>
<td>1.9</td>
<td>0.9</td>
<td>1</td>
<td>0.7</td>
</tr>
<tr>
<td>80–84 / M</td>
<td>27</td>
<td>0.8</td>
<td>0.3</td>
<td>0.3</td>
<td>0.9</td>
</tr>
<tr>
<td>75–79 / M</td>
<td>N/A</td>
<td>0.3</td>
<td>0.2</td>
<td>1</td>
<td>0.5</td>
</tr>
<tr>
<td>75–79 / M</td>
<td>12</td>
<td>1.2</td>
<td>0.9</td>
<td>0.7</td>
<td>1</td>
</tr>
</tbody>
</table>

S—sacrum; LH—left heel; RH—right heel; N/A—not available; M—male; F—female; CII—category II; measurements stopped at discharge

study, the SEM scanner was found to identify increases in sub-epidermal moisture five days (median) before visual skin assessment (VSA).

Furthermore, data from use in clinical practice scanning 905 patients across 11 sites, demonstrated that 64% of hospitals using the SEM scanner, in combination with visual skin assessment, observed no HAPUs during the period that the SEM scanner was implemented. The weighted average reduction in HAPUs at all 11 sites was >62.5% while the straight average reduction at all 11 sites was 86.2%.

Sub-epidermal moisture relates to the quantity of skin and tissue water and is measured by capacitance (impedance of the skin to electrical forces). The SEM scanner measurements (SEM value units) range from 0.3 to 3.9; measurements are taken at high pressure risk sites such as the sacrum, heels and elbows and at contiguous locations. The difference between the highest and lowest measurements, the delta (Δ), is used to assess pressure ulceration; a value ≤0.5 is indicative of low site-specific SEM variance, which can be equated to healthy tissue, whereas values >0.5 reflect increased site-specific SEM variance, indicative of developing pressure damage.

Evaluation

The evaluation was conducted in a singel medical-surgical mixed ward for a two month period to ensure enough data was collected. This time-frame was calculated based on the local medical electronics process for the evaluation for the potential introduction of medical devices. The numbers were not specific but had to provide enough ‘real world’ evidence to support a business case for the purchase or hire of the equipment. Upon admission, the PU risk of all patients was assessed using the Waterlow scale. Those who scored ≥10 and/or could not be repositioned, were invited to participate, information about the in-practice evaluation was given and verbal consent to participate obtained. Participants had a unique identifying number and were tracked through from hospital admission to discharge. Each SEM scanner assessment had a separate number.

On the ward, both heels and sacrum were scanned upon admission and daily thereafter by the healthcare assistants. The registered nurses were responsible for interpreting the results and adjusting the clinical preventative interventions accordingly. Participants were scanned at the same time every day. The evaluation was supported by staff from BBI (Europe) Ltd representatives with biweekly visits. Integration of scanning into the ward routine, which included intentional rounding, became normal practice within about two weeks.

Results

Of the 35 participants included in the evaluation, 9% were aged 65–75 (n=3), 74% were aged >75 (n=26), 51% (n=18) were female, and 49% (n=17) male. A SEM delta value of >0.5 indicated developing pressure damage. In accordance with the results, adjustments to any clinical preventative interventions were made by a registered nurse.

Clinical outcomes

On admission, 91% (n=32) of patients had delta values >0.5 indicating inflammatory changes that without clinical intervention could develop into PUs. However, none of the 35 patients developed a new PU during their inpatient stay (Fig 1). This suggests that while the delta values indicate damage, further damage was arrested by good interventions. In one patient, SEM value was 3.2 upon admission to the emergency department and a PU appeared within hours of transfer onto the ward despite implementing preventative measures. However, the development of a PU or deterioration in the delta indicates that the pre-existing damage was ‘irredeemable’ and therefore any intervention would not be successful. The delta is indicative of non-visible damage, but the seriousness the damage and when it occurred cannot be determined.

SEM delta values

There was a wide distribution of SEM values (Fig 2). Almost 30% of the assessments indicated that the tissue
did not show signs of damage, hence no intervention was needed. The majority of SEM delta values were between 0.5–1.5, although several were significantly higher and lower. Of the readings taken 28 were ≤0.5, indicating that the areas scanned were healthy at that time, 10 readings taken during the evaluation period were >1.5 indicating significant inflammatory changes were present. Table 1 provides an example of delta values from seven participants.

**SEM and risk assessment**

The relationship between Waterlow scores and SEM readings was measured. In most cases, the Waterlow risk assessment was only undertaken upon admission. All patients showed SEM scanner delta values >0.5 at some point during their stay, which indicated compromised skin integrity. This was expected given that all patients were at-risk for PU development, with 76% of scanned patients considered at ‘high risk’ or ‘very high risk based on their Waterlow score (Table 2). Daily scanning proved to be a more effective method of assessing damage objectively, as opposed to using visual assessment alone. Using the Waterlow score, patients were assessed to be ‘at-risk’, but their SEM readings indicated no damage was present. In practice, SEM scanning was shown to be a simpler, faster and more practical way of conducting daily assessments when compared with risk assessment tools (Fig 2). This was not a formally evaluated comparison, rather an adjunct comparison as a point of interest.

**Discussion**

The evaluation suggests that the inclusion of the SEM scanner as part of the examination of the patient informed clinicians about early damage so they could intervene before visual signs of further deterioration occurred, reflecting the results of other studies.\(^{22,23}\) Furthermore, analysis of this data allowed the staff to create targeted care plans for patients and to deploy preventative care resources more appropriately that is, at the anatomical point of scanning rather than using ‘whole body’ interventions. The objective data provided by the SEM scanner was informative to the clinicians and helped front-line staff in their efforts to mitigate PU risk in the area in which the technology was evaluated.

The evaluation also suggests that the SEM scanner provided good objective evidence that the interventions being employed were improving the non-visible incipient skin damage. This allowed clinicians to monitor the interventions to assure clinical effectiveness. This further supported the need for tools that assess microscopic changes occurring below the skin in order to best care for patients—to prevent avoidable damage from occurring and to alert clinicians when damage occurs. Indeed, the audit which led to this evaluation suggested that up to two-thirds of the PUs occurred within five to ten days of admission. Theoretically this is within the window in which pressure damage may already be present, as was demonstrated in the evaluation in one patient scanned.

Anecdotal evidence given by the participants was positive and the healthcare assistants felt that the scanner gave them immediate feedback as to whether the pressure areas were improving, rather than having to wait for the visual signs of skin damage and that their methods of prevention were working on a daily basis, as the comparative deviation reduced. Furthermore, staff indicated that in future, the risk assessment could be replaced by the SEM scanner assessment.
Limitations

The patients included in this clinical evaluation were assessed to be at high or very high risk according to the Waterlow risk assessment scale and PU prevention interventions would be put in place as a matter of course in accordance with national and local guidelines. However, risk assessment scales by nature only indicate an overall risk. The SEM scanner indicates pre-existing non-visible tissue damage at the areas assessed (for example, sacrum and heels), and thus facilitates targeted interventions, rather than ‘whole body’ interventions.

The biweekly visit by Bruin staff could be perceived as a limitation, for example staff may have been more motivated by their presence. Their role, after initial training on use of the scanner was advisory, answering questions regarding the use of the scanner.

Finally, once mastered, although scanning is fairly rapid it does take longer than visual skin assessment. However, the benefits such as identifying developing damage before it is visible allows targeted interventions, and the immediate feedback to staff regarding the effectiveness of such interventions, outweigh this difference.

Conclusion

PUs are a barometer of safe high-quality care and PU development can suggest the care provided is not of a high standard. The results of this evaluation and other studies, suggests that the injuring or precipitating event that caused the skin damage may predate the visual detection of damage by several days. Being able to detect such damage before it is visible would allow the most appropriate resource use to prevent further damage.

As a result of the evaluation and business case, the SEM scanners are being used on medical and surgical wards and with the tissue viability team, with a view to embed them as the objective measurement of risk, rather than risk stratification tools such as Braden or Waterlow. It is envisaged that over time a more objective approach to PU prevention can be taken with these devices. In addition, the tissue viability team intends to scan patients on admission to the hospital to determine how many patients are being admitted with developing damage that is not visually detectable.

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