Objective evaluation by reflectance spectrophotometry can be of clinical value for the verification of blanching/non-blanching erythema in the sacral area

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Key words
Blanching/non-blanching erythema; Category I; Hip fracture; Pressure ulcer; Reactive hyperaemia; Reflectance spectrophotometry

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Abstract
Early detection of non-blanching erythema (pressure ulcer category I) is necessary to prevent any further skin damage. An objective method to discriminate between blanching/non-blanching erythema is presently not available. The purpose of this investigation was to explore if a non-invasive objective method could differentiate between blanching/non-blanching erythema in the sacral area of patients undergoing hip fracture surgery. Seventy-eight patients were included. The sacral area of all patients was assessed using (i) conventional finger-press test and (ii) digital reading of the erythema index assessed with reflectance spectrophotometry. The patients were examined at admission and during 5 days postsurgery. Reflectance spectrophotometry measurements proved able to discriminate between blanching/non-blanching erythema. The reliability, quantified by the intra-class correlation coefficient, was excellent between repeated measurements over the measurement period, varying between 0.82 and 0.96, and a significant change was recorded in the areas from day 1 to day 5 (P < 0.0001). The value from the reference point did not show any significant changes over the same period (P = 0.32). An objective method proven to identify early pressure damage to tissue can be a valuable tool in clinical practice.

Introduction
The development of a pressure ulcer (PU) is a serious complication that causes suffering of the patient and may lead to a reduced quality of life and results in high costs to society (1–3). In orthopaedic patients, this complication is common (1,4). In a recent Swedish study, the occurrence of hospital-acquired PUs was reported to be 11.6%. This indicates that PUs are still an issue for acute care (4,5) with a prevalence between 3% and 66% (1,6,7).

Pressure and shear are the major problems causing a disruption of the transport of oxygen and nutrients to the skin (8–10), which leads to tissue damage of varying degree, depending on the intensity and duration of the pressure applied.

Key Messages
- pressure and shear are the major problems causing a disruption of the transport of oxygen and nutrients to the skin
- the first sign that an area has been exposed to pressure is paleness due to a reduced blood flow
- the E-Index was calculated as a mean value after repeating the measuring of each point thrice
- a significant difference in the E-Index between the eight measurement points in the sacral area was demonstrated for all 5 days (p < 0.001)
Verification of blanching/non blanching erythema

Different methods have been tested both in vitro and in vivo to verify reperfusion and colour changes of the skin (21,22,27–31). A near-infrared spectroscopy has been tested to detect changes with the blanching response, without yielding a clear result (32,33). Reflectance spectrophotometry has the potential to offer an objective measurement of skin erythema and may be of helpful clinical practice (34,35). The skin colour is determined by measuring the intensity of reflected or absorbed light of a particular wavelength (28,34–36). It is assumed that with an increased flow of red blood cells to an area less light is reflected back to the instrument and the erythema index (E-index) value will be increasing (34,35). In this study, a narrow-band reflectance spectrophotometry was used. The aim of this study was to evaluate if a reflectance spectrophotometer is of clinical value in predicting skin areas at risk for PU development.

Patients and methods

The study design was a prospective observational study and was carried out at Karolinska University Hospital in Stockholm, Sweden (Figure 1). Patients aged ≥65 years with hip fracture were included. Exclusion criteria were pre-existing skin dermatosis or PUs ≥ category II in the sacral area. Patients hospitalised for major trauma were also excluded.

Patients

Ninety-seven patients fulfilled the inclusion criteria. Nineteen patients did not complete the study; the remaining 78 patients completed the study. The reasons for dropouts are presented in Figure 1.

Sample size

It was estimated that 85 subjects were required to detect a significant kappa value of 0.70 at level 0.05 with 80% power, assuming 30% non-blanching erythema and a null hypothesis kappa value of 0.40.

Figure 1 Flowchart shows the study profile for data collection. Nineteen patients did not complete the study. The reason for this was that 11 patients had to wait for more than 24 hours for surgery and 5 of them had pressure ulcers category II–III, 4 patients were referred to another ward, 1 patient died and 3 patients denied to participate in the follow-up, leaving 78 patients fulfilled the study.
A strong correlation of decreasing values of the E-index of the instrument on a red area after pressure relief were could find no influence. Second, to determine if the readings thesia on the perfusion of the sacral area was investigated. We performed on 37 volunteers. First, the impact of spinal anaes-
thesia on the perfusion of the sacral area was relieved of pressure for 5 minutes before the assessment was carried out to determine if there was any effect of pressure. Reflectance spectrophotometry was used after marking the skin with eight standardised measuring points and one reference point located on the opposite side of the hip fracture (Figure 3). Each point was measured three times daily at breakfast time. Calibration of the instrument and cleaning of the probe were carried out daily. The area measured was documented photographically.

### Statistical analysis

Reliability of the E-index in the sacral area and at the reference point was tested with repeated triple measurements for calculation of a mean value. The reliability coefficient was quantified using the intra-class correlation coefficient (ICC) and the absolute index of reliability was quantified by the standard error of measurement (SEM) and presented as a percentage of the mean value (SEM%). The results of ICC were interpreted according to Landis and Koch (39). A mixed linear model was used to analyse the difference of the mean values of the E-index between the eight points in the sacral area (40).

Changes in the E-index over time were analysed using a mixed linear model. If significant differences were present, pairwise comparisons between the mean values were performed. The P-values were then adjusted according to the Bonferroni procedure. To analyse the association between finger-press test and E-index, a mixed model was used (within-group factor, between-group factor and group–point interaction). The group factor was defined according to the agreement between assessors performing the finger-press test.

The difference between the mean value of the E-index from the eight measuring points and the reference point was analysed using a mixed linear model with two within-group factors (reference and sacral area, days 1–5, area–day interaction). Estimates from the mixed model were presented as a mean and 95% confidence intervals (CIs). Receiver-operating characteristic (ROC) curves were used to graphically represent the relationship between sensitivity and specificity. The software used was Statistica 10.0 (StatSoft Inc, Tulsa, OK), SAS System 9.1 (SAS Institute Inc, Cary, NC) and IBM SPSS Statistics 19 (IBM Inc., Armonk, NY).

### Procedures

After admission, daily registrations were performed using a standardised protocol. Recordings were taken from admission to maximum 5 days after surgery, depending on when the patients were discharged. Prior to the skin assessment, the patient was placed in a lateral position and the skin was cleansed using tap water (37°C) and mild shower gel. The sacral area was relieved of pressure for 5 minutes before the assessment was carried out. The skin was first inspected and the finger-press test was carried out to determine if there was any effect of pressure. Reflectance spectrophotometry was used after marking the skin with eight standardised measuring points and one reference point located on the opposite side of the hip fracture (Figure 3). Each point was measured three times daily at breakfast time. Calibration of the instrument and cleaning of the probe were carried out daily. The area measured was documented photographically.

**Figure 2** The skin consists of three layers, epidermis, dermis and subcutis. This illustration is modified from the original presented in Dawson et al. (34) for how the amount of light is transported differently in different human tissue. The non-invasive instrument can quantify minor changes in the colour of the skin due to how transparent the skin is and how thin it is.

**Reflectance spectrophotometry**

The instrument measures the amount of light reflected by the skin (green light 568 nm and red light 655 nm) from different structures in the tissue (Figure 2). The amount of erythrocytes correlates to the amount of absorbed green light. The absorption is measured as an increased E-index. The theory behind this technique had been described (34–38). The penetration through the skin is limited to a depth of maximum 3 mm depending on the skin surface. The E-index is calculated as follows:

\[
\text{E-Index} = 100 \times \log \left( \frac{\text{Intensity of reflected red light}}{\text{Intensity of reflected green light}} \right)
\]

After visual inspection, the sacral area was then scrutinised using a narrow-band spectrophotometer (Derma Spectrometer, Cortex Technology, Hadsund, Denmark). Two pretests were performed on 37 volunteers. First, the impact of spinal anaesthesia on the perfusion of the sacral area was investigated. We could find no influence. Second, to determine if the readings of the instrument on a red area after pressure relief were correct. A strong correlation of decreasing values of the E-index over time could be identified (data not shown).

**Procedures**

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Changes in the E-index over time were analysed using a mixed linear model. If significant differences were present, pairwise comparisons between the mean values were performed. The P-values were then adjusted according to the Bonferroni procedure. To analyse the association between finger-press test and E-index, a mixed model was used (within-group factor, between-group factor and group–point interaction). The group factor was defined according to the agreement between assessors performing the finger-press test.

The difference between the mean value of the E-index from the eight measuring points and the reference point was analysed using a mixed linear model with two within-group factors (reference and sacral area, days 1–5, area–day interaction). Estimates from the mixed model were presented as a mean and 95% confidence intervals (CIs). Receiver-operating characteristic (ROC) curves were used to graphically represent the relationship between sensitivity and specificity. The software used was Statistica 10.0 (StatSoft Inc, Tulsa, OK), SAS System 9.1 (SAS Institute Inc, Cary, NC) and IBM SPSS Statistics 19 (IBM Inc., Armonk, NY).

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Ethical considerations

The study was approved by the Ethics Committee (Dnr 00-423) at Karolinska University Hospital and Karolinska Institutet in Stockholm, Sweden and was conducted in accordance with the ethical principles of the Helsinki Declaration 1989. This study also complied with the ICN Code of Ethics for Nurses (ICN 2006). The patients were included after giving informed consent.

Results

When the two assessors assessed the area with the finger-press test to be a category 1 PU, the instrument showed a higher digital value. This indicates that the area was erythematic.

Seventy-eight patients completed the study and all were Caucasian. There were 14 men (mean age 74, range 65–91 years) and 64 women (mean age 82, range 65–100 years). The fracture type was pertrochanteric or subtrochanteric in 41 patients, and 37 patients had a femoral neck fracture. The demographic data of the patients are presented in Table 1.

Table 1 Descriptive demographic data*  

<table>
<thead>
<tr>
<th>Fracture of femoral neck</th>
<th>Total</th>
<th>Female &lt; 70</th>
<th>Female ≥ 70</th>
<th>Male &lt; 70</th>
<th>Male ≥ 70</th>
<th>Pressure ulcers at admission</th>
<th>Pressure ulcers at discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture of femoral neck</td>
<td>37</td>
<td>1</td>
<td>25</td>
<td>2</td>
<td>9</td>
<td>11/35</td>
<td>20/37</td>
</tr>
<tr>
<td>Pertrochanteric fracture</td>
<td>34</td>
<td>0</td>
<td>32</td>
<td>0</td>
<td>2</td>
<td>10/34</td>
<td>21/34</td>
</tr>
<tr>
<td>Subtrochanteric fracture</td>
<td>7</td>
<td>1</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0/6</td>
<td>3/7</td>
</tr>
<tr>
<td>Modified Norton scale &lt; 20</td>
<td>38</td>
<td>2</td>
<td>31</td>
<td>0</td>
<td>5</td>
<td>10/35</td>
<td>22/38</td>
</tr>
<tr>
<td>Modified Norton scale ≥ 20</td>
<td>40</td>
<td>0</td>
<td>31</td>
<td>2</td>
<td>7</td>
<td>11/40</td>
<td>22/40</td>
</tr>
<tr>
<td>Body mass index &lt; 22</td>
<td>28</td>
<td>1</td>
<td>21</td>
<td>0</td>
<td>6</td>
<td>11/27</td>
<td>17/28</td>
</tr>
<tr>
<td>Body mass index &gt; 22–29</td>
<td>38</td>
<td>0</td>
<td>30</td>
<td>2</td>
<td>6</td>
<td>8/37</td>
<td>21/38</td>
</tr>
<tr>
<td>Body mass index &gt; 30</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0/3</td>
<td>3/4</td>
</tr>
<tr>
<td>Missing value</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Patients with pressure ulcers at admission and discharge, grouped by sex, age and comorbid conditions.

Table 2 Relative reliability (ICC) and absolute reliability measured as percentage of the mean value*  

<table>
<thead>
<tr>
<th>Day 1 after surgery</th>
<th>Day 2 after surgery</th>
<th>Day 3 after surgery</th>
<th>Day 4 after surgery</th>
<th>Day 5 after surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>ICC</td>
<td>SEM%</td>
<td>N</td>
<td>ICC</td>
</tr>
<tr>
<td>P1</td>
<td>77</td>
<td>0.930</td>
<td>13.29</td>
<td>78</td>
</tr>
<tr>
<td>P2</td>
<td>77</td>
<td>0.935</td>
<td>13.11</td>
<td>78</td>
</tr>
<tr>
<td>P3a</td>
<td>66</td>
<td>0.902</td>
<td>9.96</td>
<td>67</td>
</tr>
<tr>
<td>P3b</td>
<td>66</td>
<td>0.938</td>
<td>8.78</td>
<td>67</td>
</tr>
<tr>
<td>P4</td>
<td>77</td>
<td>0.930</td>
<td>11.03</td>
<td>78</td>
</tr>
<tr>
<td>P5</td>
<td>77</td>
<td>0.912</td>
<td>13.34</td>
<td>78</td>
</tr>
<tr>
<td>P6</td>
<td>77</td>
<td>0.882</td>
<td>14.68</td>
<td>77</td>
</tr>
<tr>
<td>Ref at hip</td>
<td>76</td>
<td>0.917</td>
<td>16.39</td>
<td>76</td>
</tr>
</tbody>
</table>

*Present good to excellent reliability according to Landis and Koch (SEM%).

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that in disagreement with the finger-press test. On all of the days except day 4, the results showed a significant difference between the groups (\(P = 0.021\), \(P = 0.015\), \(P = 0.001\), \(P = 0.058\) and \(P = 0.006\), respectively) (Table 3). The mean difference in E-index between the ‘non-blanching erythema’ group and the ‘blanching’ group across the eight measuring points on day 1 to day 5 was 4.04 (95% CI: 1.20–6.88), 3.44 (95% CI: 1.11–5.76), 4.74 (95% CI: 2.19–7.29), 1.88 (95% CI: −0.86–4.63) and 4.42 (95% CI: 1.27–7.57). A significant Group × Point interaction could be demonstrated on day 1 (\(P = 0.020\)) and day 5 (\(P = 0.021\)). The difference between the groups only was significant for the points P1, P3b, P5 and P6 on day 1, and for the points P1, P3, P4, P5 and P6 on day 5. Figure 4 shows the point profile in the three groups on day 3. A significant difference in the E-index between the eight measurement points in the sacral area was demonstrated on all 5 days (\(P < 0.001\)). Pairwise comparisons between the points displayed a significantly higher E-index in P3 compared with all other points except P6 on days 1, 4 and 5. For the other days, the group difference could be generalised over the eight measuring points because of non-significant interaction.

For the assessments performed with reflectance spectrophotometry, the results showed a significant change over time for the mean value of the E-index across the eight points in the sacral area (\(P < 0.001\)). Post hoc contrasts showed significantly higher E-index values from day 2 to day 5 compared with day 1 (\(P = 0.015\), \(P = 0.002\), \(P < 0.001\) and \(P < 0.001\), respectively) (Figure 5). The reference point on the hip (that was not exposed to pressure) showed no significant changes during the measurement period (\(P = 0.32\)) (Figure 5). The mean value of the E-index in the sacral area was significantly higher than the value of the reference point on the hip for all 5 days (\(P < 0.001\)) (Figure 5). The estimated mean difference over the 5 days was 11.0 (95% CI: 10.2–11.8); however, the Area × Day interaction was significant (\(P < 0.001\)), indicating a significantly lower difference between the sacral area and the hip on day 1 compared with the other days. A higher E-index value demonstrated that there was more erythema in the sacral area than on the hip (Figure 5).

To analyse the ability of the E-index to discriminate between the sub-groups ‘blanching’ and ‘non-blanching erythema’, ROC curves were used daily. A cutoff value was

### Table 3 Estimated means and 95% confidence intervals of E-index in the sacral area (mean value of the eight points)*

<table>
<thead>
<tr>
<th>Day</th>
<th>Blanching skin, 95% CI</th>
<th>Non-blanching erythema, 95% CI</th>
<th>Disagreement, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Lower–upper</td>
<td>Mean</td>
</tr>
<tr>
<td>1</td>
<td>13.5</td>
<td>12.2–14.7</td>
<td>17.5</td>
</tr>
<tr>
<td>2</td>
<td>14.3</td>
<td>13.0–15.7</td>
<td>17.8</td>
</tr>
<tr>
<td>3</td>
<td>13.8</td>
<td>12.4–15.1</td>
<td>18.5</td>
</tr>
<tr>
<td>4</td>
<td>14.4</td>
<td>12.9–15.8</td>
<td>16.2</td>
</tr>
<tr>
<td>5</td>
<td>13.8</td>
<td>11.9–15.7</td>
<td>18.3</td>
</tr>
</tbody>
</table>

E-index, erythema index.

*Patients were divided into three groups depending on the agreement of the assessors on the finger-press test. Comparison between groups at day 1 (\(P = 0.021\)), day 2 (\(P = 0.015\)), day 3 (\(P = 0.001\)), day 4 (\(P = 0.058\)) and day 5 (\(P = 0.006\)).
Figure 6 Receiver-operating characteristic (ROC) curve finger-press test versus reflectance spectrophotometry, mean P1–P6 at day 3, for presenting the relationship between sensitivity and specificity of the erythema index versus the “true skin classification” (i.e. when both assessors are in agreement) from the finger-press test. A good cutoff level for a diagnostic test is when the ROC curve rises quickly, that is, when both the sensitivity and specificity are high. $P < 0.05$ was considered statistically significant.

Table 4 Results from ROC curves day 1 to day 5*

<table>
<thead>
<tr>
<th>Day</th>
<th>Cutoff point</th>
<th>Sensitivity</th>
<th>1-Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15:933</td>
<td>0.636</td>
<td>0.292</td>
</tr>
<tr>
<td>2</td>
<td>16:137</td>
<td>0.700</td>
<td>0.216</td>
</tr>
<tr>
<td>3</td>
<td>16:370</td>
<td>0.714</td>
<td>0.235</td>
</tr>
<tr>
<td>4</td>
<td>14:452</td>
<td>0.750</td>
<td>0.414</td>
</tr>
<tr>
<td>5</td>
<td>18:167</td>
<td>0.636</td>
<td>0.211</td>
</tr>
</tbody>
</table>

ROC, receiver-operating characteristic.

*E-index (mean value) versus ‘true skin classification’ by finger-press test blanching/non-blanching (yes/no).

Discussion

The findings of this study indicate that a reflectance spectrophotometer can be a useful tool in evaluating an area of skin at risk for developing a PU. Special risk areas are located over bony prominences, for example, the sacrum, heels and hips (15,21). During the first postoperative days, most hip-fracture patients are resting in the supine position, which means that they cannot relieve pressure on the sacral area. Furthermore, this patient group often has problems with the function of the microcirculation and/or neurological problems, which may lead to reduced reactive hyperaemia and eventually poor reperfusion (8). Development of PUs is only partly explained by tissue ischaemia/hypoxia. Normally, the reaction after pressure is an increased perfusion. However, in elderly patients this response may be delayed (41,42) making it difficult to detect early signs of tissue damage. Repeated episodes of prolonged persistent erythema over several days can either progress to skin deterioration or return to normal tissue perfusion (8,14,22). The ability to distinguish between reactive hyperaemia and blanching/non-blanching erythema is difficult but important (1,8,14,30,32,43,44). In an earlier study involving hip-fracture patients, a low correlation was found between independent assessors using the finger-press test to determine whether an area of erythema in the sacral region was blanching or non-blanching (26). An objective method to discriminate between hyperaemia with blanching/non-blanching erythema would prove valuable. We have therefore chosen to study the use of a reflectance spectrophotometer in the sacral area in patients operated for a hip fracture.

Methodological considerations

In this study, reflectance spectrophotometry (Derma Spectrophotometer, Cortex Technology) providing an E-index was used. The instrument has been used in both animal and human studies, and the values of the E-index are dependent on skin colour (28,34–36). Skin colour varies spontaneously during the day and it is suggested that repeated measurements should be carried out at the same time of the day, at the same room temperature and after the skin has been uncovered for at least 5 minutes (45). We followed these guidelines as far as was possible in the clinical setting.

The instrument was easy to use and proved to be precise in distinguishing between blanching/non-blanching erythema. This was demonstrated by the fact that the value from the reference point did not show any significant changes over time, the ICC was high during the measurement period and a significant change was observed between the different areas from day 1 to day 5. One possible weakness of the study may be that the sample size was limited. The significant difference in the E-index between the eight points in the sacral area was demonstrated on all 5 days. Furthermore, there was a significant difference between blanching/non-blanching erythema. The value of the E-index from the measurement of the eight points ranged between 14·5 and 18·2. For these cutoff points, the sensitivity and specificity were satisfactory as demonstrated by the ROC curve. These cutoff values are lower than the E-index presented by Differy on untanned Caucasian skin (35). An E-index for non-erythema was noted at 0·114 and for moderate erythema at 0·292. Differy’s E-index was not multiplied by 100 as in this study. An increased E-index may also indicate that the skin has been affected by pressure or that the deeper tissues may already have been damaged and further deterioration resulting in PUs may have occurred. It is also possible that after repeated periods of prolonged pressure, tissue damage can be caused by reperfusion injury as a result of increased blood flow to the area after occlusion (8,15,46).
One interesting observation from this study was that in group 3 (disagreement between assessors), the E-index value fell between the values of groups 1 and 2. This may indicate that the reflectance spectrophotometry verified erythematous areas.

The instrument was only tested in the sacral area. As it worked well in this area it appears probable that the method will also work in other locations as well. The time taken for the measuring process was approximately 20 minutes, which appears to be acceptable. Several assessors were involved in the measurement process, and this reflects clinical practice showing that the instrument can be used as a tool in the clinical setting. It was important that all assessors were carefully instructed in the use of the Derma spectrophotometer before the measurements was carried out. One technical problem was that the instrument had a small optical measuring head, and if there was a red area near the measuring point, it was not clear whether this may have influenced the results or not. Another problem with the present device occurs when the area to be investigated is large, as the optical head is small and several measuring points will be necessary. This may jeopardise the reliability of the results as the small optical head can be held in different positions. A larger optical head would be more suitable.

Conclusion

This is one of the few clinical studies that has followed patients throughout the entire admission to the orthopaedic ward with regular objective assessments of erythema of the skin in the sacral area. Reflectance spectrophotometry appears to be a useful tool in detecting areas at risk for the development of PUs. The technique is simple to use and can register minor changes in skin colour. High precision in classification of blanching/non-blanching erythema was reached in this study. Further development of the equipment would be beneficial.

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References

44. Beeckman D, Defloor T, Schoonhoven L, Vanderwee K. Knowledge and attitudes of nurses on pressure ulcer prevention: a cross-sectional multicenter study in Belgian hospitals. Worldviews Evid Based Nurs 2011;8:166–76.