Evaluation of boiled potato peel as a wound dressing

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In a series of experiments full thickness skin defects in 68 rats were covered with dressings made of boiled potato peels according to the method developed in Bombay. The wounds closed within 14 days and histologically complete repair of epidermis was found. The cork layer of the potato peel prevents dehydration of the wound and protects against exogenous agents. Experiments with homogenates revealed that a complete structure of the peel is necessary. Steroidal glycosides may have contributed to the favourable results.

Introduction

An old grandmother's recipe for burned hands of children, caused by burning stoves in potato growing regions of the Netherlands, consisted of dressing the burns with cleaned potato peels and a dry bandage.

At a meeting in the Burn Center Beverwijk in 1989 Keswani presented his Indian results on the treatment of burns with boiled potato peel dressings (BPPD). His clinical results (Keswani and Patil, 1965), his personal communication and that from Adenwalla (Trichur, Kerala, India) prompted us to undertake an experimental study with a multidisciplinary team with the aim of studying the effect of the dressing and some of its components on the healing of skin wounds.

An optimal dressing for burns and full thickness skin wounds is still a subject of current research. It is now accepted that a moist skin wound is an important factor for fast healing, including cell migration and new formation of epithelial cells resulting in normal epithelial tissue (Winters, 1962).

The ideal dressing should be semipermeable to protect the pathophysiological environment against bacteria and should have sufficient vapour permeability to avoid the macerating effect of the exudate of the wound. The healing is enhanced by the physical structure of a collagenase-resistant matrix (Park, 1978; Schor, 1980).

The skin (periderm) of a potato tuber consists of suberized cells forming a cork-like layer that prevents the loss of water. This protection is such that removal of the peel immediately leads to a 300-500-fold increase in the rate of evaporation (Burton, 1989). Exchange of gas, mainly oxygen and carbon dioxide, only takes place through the lenticells (0.3-3/cm²). The lenticells are the possible sites of entry into the tuber of plant pathogenic organisms (Rastovski, 1981).

Materials and methods

All experiments were performed under general anaesthesia and sterile conditions. Sixty-eight Wistar rats with a body weight of 200-300 g were anaesthetized with an intraperitoneal injection of pentobarbitone (min 42 mg/kg body weight) and continued with a mixture of halothane and oxygen given with a mask.

On the back of the rat six full skin thickness excised wounds covering 1 cm² were made. The dressings and their components were fixed on four defects and two defects were left untreated as controls. The dressings were fixed with corner stitches and protected from removal by Mefix and gauze bandage. The animals were individually caged and in a later series of studies a flexible neck collar was used to prevent removal of the dressings.

Healing of the wounds was judged by repeated photography. After 2 weeks the animals were killed and the healed wounds with the surrounding skin were excised en bloc for histological investigation. The material was fixed in buffered formalin solution and paraffin sections of 6 µm were stained with haematoxylin and eosin.

As a part of this study dressings made of two Dutch potato cultivars ('Prominent' and 'Elkana') were compared with the original dressing of Keswani ('Bombay').

The 'Bombay' dressing is prepared in the following manner: The potato peels are collected from various sources, the pulp side is cleaned, then boiled and dried. Thereafter a wheat starch paste is carefully applied to the outer surface, the peels are stuck to a wide mesh bandage edge to edge.
with no gaps in between. The dressing is then autoclaved. 'Prominent' and 'Elkana' boiled potato peel dressings (BPPD) were made in a similar way as the 'Bombay' dressing. Scanning electron microscopy of a BPPD sample (Figure I) indicates the cellular structure of this composite dressing.

The described fabrication method implies that potato starch, wheat starch, SGAs and the intact structure of the intact peel are important components of the BPPD.

The SGA contents of boiled 'Bombay' BPPD as well as the BPPD of two Dutch cultivars known for their high and low SGA content were analysed. The results (Table I) show that the 'Bombay' peel has a medium content of SGAs. Peels of the three sources were frozen in liquid nitrogen and homogenized to obtain a paste. Laboratory grade potato starch and wheat starch were sterilized.

Results

Pilot study
With the above-mentioned protocol a study with 18 rats was performed in order to compare the 'Bombay' BPPD with processed sheep dermal collagen (PDSC), developed in this department as a biological dressing.

All defects healed well and the histology of wounds covered with both materials was comparable, showing complete epithelialization, minimal fibrosis and inflammatory reaction. The results obtained in the pilot studies lead to continuation of the study in 50 rats.

In the first series of studies (five rats) four full skin thickness defects were covered with the 'Elkana' dressing with a high SGA content. The wounds healed well and histological examination revealed an intact epidermis with a thickened and flat aspect; the dermis showed a few giant cells, granulation tissue and a slight inflammatory reaction with round cells (Figures 2–4).

In the second series of studies (five rats) the four defects were covered with 'Prominent' dressing (low SGA content). Histologically the epidermis showed the same appearance as in the first studies, however, the dermis contained more active granulation tissue with an inflammatory reaction which still showed leucocytes.

In the third series of studies (15 rats) the four defects were closed with peel pastes made of 'Elkana', 'Prominent' and 'Bombay' respectively, each in five animals.

Histology
The 'Elkana' type-covered wound gave epidermal healing with crustae and subepidermal oedema; in the dermis there was diffuse infiltration with round cells, leucocytes and cell debris. The wounds treated with the 'Prominent' paste showed a more severe inflammatory reaction. The histology of wounds covered with 'Bombay' paste was comparable to the histology of the 'Prominent'-paste-covered wounds (Figures 5, 6).

In a fourth series of five rats two defects were covered with a 10 per cent wheat starch paste, two other defects

Table I. SGA content of boiled potato peels, dried in air

<table>
<thead>
<tr>
<th>Potato cultivar</th>
<th>Dry Total SGA (mg/100 g)</th>
<th>% of 'Bombay'</th>
<th>% of dry residue</th>
<th>Fresh Total SGA (mg/100 g)</th>
<th>% of 'Bombay'</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Bombay'</td>
<td>223</td>
<td>100</td>
<td>91.7</td>
<td>205</td>
<td>100</td>
</tr>
<tr>
<td>'Prominent'</td>
<td>190</td>
<td>85</td>
<td>88.9</td>
<td>169</td>
<td>82</td>
</tr>
<tr>
<td>'Elkana'</td>
<td>330</td>
<td>145</td>
<td>90.0</td>
<td>297</td>
<td>145</td>
</tr>
</tbody>
</table>
were covered with potato starch paste. The remaining two defects served as controls. The histology of the healed wounds of these two starch-paste-treated defects was more or less comparable. The epidermis was intact with a thickened and flat appearance. The dermis showed granulation and fibrosis with only a slight inflammatory reaction.

In the fifth series of studies (10 rats) the experiments with the starch paste of series four were repeated because of good healing of the wounds. It was not clear, though, if the animals were interfering with the dressing in spite of the fact that the animals were individually caged. The animals of the fifth series were supplied with a flexible neck collar to prevent removal of the starch. The histological results were the same as those of the fourth series, therefore excluding premature removal of the starch.

In the sixth series (10 animals) the sterilized pieces of 'Elkana' and 'Prominent' peels were fixed with corner sutures alternatively with the pulp side or with the outer surface of the peel fixed to the surface of the wound. The histology showed that the defects covered with the outer surface of the peels to the woundbed of both varieties of the peels,
revealed a distinct inflammatory reaction with granulating tissue in contrast to the defects covered with the pulp side in contact with the wound surface.

Table II summarizes the overall results of the different series of studies and shows that peels with a higher SGA content cause less inflammatory reaction than those with a lower SGA. Homogenized samples of the three varieties gave a more disturbed mode of healing than was seen in the wound covered with the intact peel.

Starch paste made of wheat gave a good healing of the wound with only slight signs of inflammation. Potato starch, however, gave a more extended infiltrate in which granulae and giant cells could be found. Possibly the dimension of the potato starch granula or a difference in antigenicity influenced the observed inflammatory reaction.

Treatment of the defect with small pieces of peel of the two Dutch varieties with the outside of the peel in contact with the woundbed showed the same results as in the first series, but it was clearly shown that undisturbed healing was only seen if the tuber side of the peel was covering the wound.
Discussion

This study shows that the potato peel dressing gives undisturbed healing of full thickness skin defects in rats and confirms the effect of this dressing as described by Patil and Keswani (1985) and Keswani et al. (1990) in patients with burns. The finding in the more recent report, that BPPD gives a diminished extent of inflammatory changes compared to the gauze-dressed wound, was also found in our experimental wounds.

BPPD is a composite dressing. From analysis of the various components of this dressing with the rat model, we conclude that an intact cork-like structure of the peel applied with the pulp side to the wound is essential for the healing of full skin thickness wounds with minimal inflammatory reaction.

The intact periderm of the potato peel prevents dehydration of the wound. The lenticells of the periderm permit exchange of gas and allow excess exudate from the wound to escape to the outer layer of the dressing. The periderm seems to protect the wound against environmental bacteria, however in the study of Keswani et al. (1990) no distinct differences between BPP- and gauze-dressed wounds could be observed.

The cork-like inner surface of the periderm, being in good contact with the wound bed, acts as a scaffold to enhance the migration of epithelial cells from the wound edge. This is similar to the findings with a collagen-based dressing (Chvapil et al., 1987).

In the BPPDs the coating of wheat starch paste on the outside and the potato starch on the inner surface, both seem to enhance the same action. The results obtained in the studies in which homogenized peel was tested show that the effect is only seen if the peel remains intact and at the same time it was shown that healing is retarded if the outer side of the peel is on the surface of the wound.

Table II. Summary of histology

<table>
<thead>
<tr>
<th>Type of dressing</th>
<th>Epidermis</th>
<th>Dermis</th>
<th>Inflammation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Homogenized paste of potato peels (3 varieties)</td>
<td>Scab formation, subepidermal oedema</td>
<td>Extensive granulation tissue, oedema and capillary formation</td>
<td>Giant cell reaction around debris of paste mixed inflammatory infiltrate</td>
</tr>
<tr>
<td>2. Potato peels, fixed with outer surface to woundbed (3 varieties)</td>
<td>Scab formation, oedema, ulceration</td>
<td>As 1</td>
<td>Granulation reaction with inflammatory cells in the muscle layer</td>
</tr>
<tr>
<td>3. 'Bombay' potato peel dressing</td>
<td>Intact thickening, flattening</td>
<td>Granulating with fibrosis, few giant cells</td>
<td>Moderate inflammatory reaction</td>
</tr>
<tr>
<td>4. 'Prominent' potato peel dressing</td>
<td>As 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. 'Elkana' potato peel dressing</td>
<td>Intact, thickened</td>
<td>Granulating reaction fibrosis</td>
<td>Inflammatory reaction with lymphocytes and plasma cells</td>
</tr>
<tr>
<td>6. Potato starch paste</td>
<td>Intact, thickened</td>
<td>As 5 and starch granules</td>
<td>Inflammatory reaction less than in 4</td>
</tr>
<tr>
<td>7. Wheat starch paste</td>
<td>As 6</td>
<td>As 5 without starch granules</td>
<td>Inflammatory reaction less than in 5</td>
</tr>
</tbody>
</table>

Figure 6. Granulomatous reaction with giant cells is seen around debris of paste (× 85).
Our experiments indicate that pure starch dressings do not retard wound healing. This confirms the wound healing effects seen after application of modified corn starch dressing (Jeter et al., 1986). One of the beneficial factors is probably the high hygroscopic properties of the starch in comparison to other products like Karayagum (Spence and Bates, 1981; Geronemus and Robins, 1982). In our experiments the results obtained with wheat starch were better than those obtained with potato starch dressing.

The SGA contents of the three types of BPPD applied in our study were not toxic to the rats. The 'Elkana' potato peel dressing with the highest SGA content seems to give the best histology of the healed wounds with minimal inflammatory reaction. The toxic effects in rats mentioned in the literature were seen after an intraperitoneal dose of 20–85 mg/kg, the LTD dose appears to be 580 mg/kg of bodyweight. Interpolating this data 10 g of dry potato peel in rats of 200 g would be required.

To prevent intoxication after covering large wounds more information about the absorption of SGAs from skin wound surfaces is necessary. Whether SGAs have a local analgesic effect needs to be investigated.

A study of the permeability characteristics of boiled potato peels coated with starch is planned.

Pig skin is comparable to human skin. In most studies on skin wounds and burns a pig model is employed to evaluate the efficacy of a dressing for wound healing. We are extending our study with a pig model to evaluate BPPD in treating split skin and burn wounds.

The advantage of the BPPD is the low cost compared to the synthetic and biological dressings currently used in treating burns and chronic wounds. However, the fabrication of a composite potato peel dressing is labour intensive and requires meticulous control of peels and dressing. Therefore the low manufacturing costs are only applicable for low labour cost countries.

A method of steam peeling of potatoes has been developed recently in connection with the potato chips (French fry) industries. Such a peel is clean and intact. An innovative technology with steam peeling should reduce the labour costs of making a BPPD in an industrialized country.

References


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