Review paper

Modern methods of conservative treatment of pressure ulcers

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Abstract

This paper presents a modern concept of conservative treatment of pressure ulcers in the moist environment. Dressing types, their characteristics and a system of "colour" wound classification are presented.

Key words: "colour" model of wound treatment, modern dressings, moist wound healing, pressure ulcers.

Principles of pressure ulcer treatment

For centuries, various materials have been used for wound treatment – from hot olive oil and wax in the antiquity, animal membranes and faeces in the Middle Ages, oakum and cotton cloth in the 19th century, to flax linen, gauze, viscose and paraffin in the 1920s.

Hippocrates had already observed that a wound heals more rapidly when it is kept in a moist environment, covered by leaves [1]. Although these observations had been forgotten for centuries, they returned in 1962, when George Winter published his reports on more rapid healing of a non full-thickness wound in a young domestic pig, covered with a polyurethane membrane, compared with healing of a wound left in the open air [2]. Winter's observations and further studies led to the development of a concept of moist wound healing, and determination by Turner [3] in 1979 of the requirements that should be met by an ideal dressing (Table 1), which were repeatedly confirmed thereafter [4] (Table 2).

These findings enabled the development and production of various modern specialist dressings, both synthetic and natural. A modern dressing, owing to its properties, maintains an ideal moist environment for wound healing. Most frequently the dressings include a monolayer or multilayer plates or paste and gel. A two-layered plate usually consists of an external layer, protecting against contact with fluids, bacteria, faeces or urine, and an internal reactive layer, adhering to the wound. A monolayer plate has no protective layer. The dressings can be manufactured in the form of paste or gel in factory-made special applicators or tubes. Most dressings have a precisely defined chemical composition, e.g. dextranomers, hydrogels, polyurethane or alginate dressings.

It is known that maintaining the optimal environment for pressure ulcer healing is not always easy.

A chronic pressure ulcer can get "stuck" in a phase of the healing process, particularly in the inflammation or granulation phase. That can be caused not only by external factors, such as long-term pressure, poorly controlled diabetes, insufficient arterial blood flow, repeated trauma, vasculitis, but also internal factors directly influencing the wound – excessive exudates, disintegrated necrotic tissue, chronic infection – presence of a bacterial biofilm. Especially those wound-affecting factors exert a great influence on the healing process. Necrotic tissue in a not debrided wound increases the risk of infection and delays wound healing. The chronic inflammatory process maintains high levels of inflammatory cytokines and proteases, decreasing simultaneously the concentration of growth factors. Exudate, as is already known, accelerates healing and epidermisation, but when in excess, it can cause skin maceration, contact dermatitis, and also can increase the risk of infection. These mechanisms slowly become understandable and form the basis for future activities and treatment regimens.

Controlling pressure ulcer colonisation and infection is very important. Each pressure ulcer is colonised by bacterial flora. Wound debridement and rinsing decrease the risk of infection. Bacterial presence in a wound can be described as:

- contamination,
- colonisation,

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Table 1. Features of ideal dressing [4]

Maintains high humidity between itself and the wound
Causes no tissue damage during change
Removes excessive exudates and toxic particles
Does not adhere to the wound
Impermeable for bacteria
Allows normal gas exchange
Maintains adequate temperature
Non-toxic, non-allergenic

Table 2. Advantages of moist wound healing [3]

Less pain – lower stimulation of hydrated nerve endings
Lower risk of infection – natural defence mechanisms, less dry tissues, which constitute a medium for bacteria
Lower risk of transmission of bacteria – lower dispersion of bacteria by the aerial route
Lower possibility of damage to new tissues – moist surface of the wound and dressing
Effective autolysis mechanisms compared with dry dressings – enzymes hydrolyse proteins in the presence of moisture

- critical colonisation,
- infection.

A critical colonisation of a pressure ulcer can be characterised as a non-healing wound, variable amount of exudate, overgrowing light-coloured, fragile or bleeding granulation tissue, unpleasant smell, new areas of damage; topical treatment is then applied.

In the case of pressure ulcer infection, the following is observed: local pain, increased warmth, oedema, reddening, purulent exudate and elevated body temperature – topical and systemic treatment. In that case, it may be necessary to take a swab for bacteriological investigation and administration of empirical antibiotic therapy.

Treatment:

- early debridement and rinsing of the pressure ulcer;
- topical antiseptics – avoid cytotoxic compounds, such as chlorhexidine, hydrogen peroxide solution and sodium hypochlorite; the least cytotoxic octenidine dihydrochloride (Octenisept) can be used for some time, e.g. 3 to 4 weeks until a reduction of the inflammatory reaction;
- silver has a broad spectrum of antibacterial activity; currently, a number of dressings exist, containing and continuously releasing silver ions into the wound;
- systemic antibiotics, administered according to antibiogram for a longer time – up to 14 days.

Dressing types

In order to correctly treat pressure ulcers with various dressings, knowledge of their structure and properties is necessary, to use the best suitable one for a given clinical situation. The dressings currently manufactured worldwide can be generally divided into seven main groups. They include: polyurethane membranes, hydrocolloids, hydrogels, polyurethane foams, dextranomers – alginate dressings, and other or combined.

Polyurethane membranes

They are thin, elastic and transparent polyurethane membranes. One side of the membrane is highly adhesive, which results in good adhesion to the wound and surrounding skin, reducing the risk of the dressing slipping off.

The membrane structure enables easy evaporation from the wound surface, being impermeable for water and bacteria from the outside. It protects thus against contamination with e.g. urine or faeces and, in consequence, infection. The evaporation, however, is always lower than the fluid loss from the damaged tissues, resulting in high humidity under the dressing, which allows the granulation and epidermisation processes to go smoothly. The healing pressure ulcer can be observed through the transparent surface.

Polyurethane membranes have no absorbing properties, so the exudate can accumulate under them to form a "blister". That may cause the membrane to slip off from pressure ulcer surface and may require a more frequent dressing change. Under appropriate conditions, a membrane can stay on a pressure ulcer for up to 14 days.

These dressings are recommended for treatment of grade I and II pressure ulcers, epidermising with minimal amounts of exudate. They are also very effective, serving as dressings applied prophylactically onto sites at the highest risk of pressure and friction. They can be also used to cover other dressings in order to keep them on a wound.

Very highly secreting or infected pressure ulcer caverns are a contraindication to polyurethane membrane application. Polyurethane membranes are manufactured in various sizes to make their adjustment to the size of pressure ulcers possible.

Preparations: Opsite Flexigride (Smith&Nephew), Tegaderm (3M), Bioclusive (Systagenix), Hydrofilm (Hartmann).

Hydrocolloids

They are available in the form of plates or paste. The plate is two-layered: the external protective layer protects the wound against contamination with fluids, feces or urine from the outside, and the internal adhesive active layer contains hydrophilic molecules of three hydrocolloids of honeycomb structure made of sodium car-

boxymethyl cellulose suspended in hydrophobic polymer mass of pectin and gelatin. In contact with the wound exudate, the internal layer forms a gel covering the wound and simultaneously absorbs excessive exudate, creating an ideal moist environment [5].

Hydrocolloids ensure thermal isolation of the wound, keeping it at body temperature. Slightly acidic pH created under the dressing causes an inflow of viable polynuclear granulocytes able to phagocytosis, which inhibit the growth of many pathogenic bacteria, and thus eliminate the risk of infection. The acidic pH facilitates also the action of its own lytic enzymes dissolving damaged tissues. The acidic pH and reduced oxygen pressure under the dressing increase angiogenesis and, thus, granulation. Moist exudate under the dressing enables migration of cells and during dressing change does not cause their tearing off or damage. The dressings alleviate the pain of the wound itself and their change is also painless. That happens because, with reduced oxygen pressure, the production of prostaglandin E_2 is reduced, which sensitizes nerve endings to pain stimuli, and because, in a moist environment, nerve endings are less stimulated than when they are dehydrated. Besides, the pain is alleviated because the dressing itself acts as a protective mechanism against friction and other forces affecting the wound. Hydrocolloids can be used at all stages of the healing process: debridement, granulation and epidermisation in pressure ulcers with low and moderately intense exudate [6, 7].

Hydrocolloids are also ideal dressings for covering of e.g. hydrogels, hydrocolloid gels or combined dressings. For the treatment of flat pressure ulcers with small amounts of exudate, super thin hydrocolloids in the form of plates are used.

Preparations: Granuflex (ConvaTec), Tegasorb (3M), Comfeel (Coloplast), UltecPro (Kendal).

Hydrogels

They are dressings produced in a polymerisation process and they are built of a three-dimensional net of hydrophobic polymers containing hydrophilic groups in their structure. Depending on the polymer type used, they are highly hydrated – they contain about 92-95% of water. For that reason they have very good cleaning properties and are used in the initial period of wound treatment in order to hydrate the wounds, to start autolysis and debridement [8].

In Poland, hydrogels are available in the form of plates or gel in special applicators and tubes. In order to increase their absorbing properties and to prolong the duration of their stay on a wound, they are combined with e.g. hydrocolloids – Granugel hydrocolloid gel (ConvaTec) or alginates – Nu-Gel (Systagenix) and Purilon Gel (Coloplast).

Preparations: Aquagel (Kik Gel), IntraSite Gel (Smith&Nephew), Purilon (Coloplast), Granugel (ConvaTec), Nu-Gel (Systagenix), Hydrosorb (Hartmann).

Polyurethane foams

They are 5-8 mm thick plates, or oval or round sponges. In the dressing manufacturing process, polyurethane in high temperature creates a foam with the air cell structure, which absorbs exudate. The dressings have very good absorbing properties: plates are used on debrided superficial pressure ulcers and sponges – deep pressure ulcers. They exert a thermoregulatory effect and are particularly recommended for treatment of not only pressure ulcers but also venous leg ulcers. They cannot be used on dry wounds covered with crust, and they should not be soaked or combined with antiseptics on a wound [9, 10].

Preparations: Tielle (Systagenix), Biatain (Coloplast), Allevyn (Smith&Nephew), Allevyn Cavity (Smith&Nephew), Permafoam (Hartmann).

Dextranomers

They are dressings made of polysaccharide grains, which produce gel after contact with wound exudate. They are used for debridement of wounds covered with sloughly necrosis, frequently deep wounds. They require covering with another dressing.

Iodosorb is a dextranomer containing 0.9% iodopovidone, which is released during exudate absorption, exerting an antiseptic effect. Acudex is available in Poland in the form of granules, which can hinder its application in the case of deep pressure ulcers. Some clinicians mix it with glycerine in order to obtain a semiliquid mass.

Preparations: Debrisan (Pharmacia), Acudex (Polfa Kutno), Iodosorb (Perstorp Pharma Ltd).

Alginate dressings

They are dressings naturally obtained from seaweed, mainly brown algae (*Phaeophyceae*), which are composed of sodium and calcium salts of the alginate acids – D-mannuronic acid and L-glucuronic acid. After contact with wound exudate, the dressing forms an elastic gel-fibrous coat, maintaining an ideal environment for the healing wound, and the exudate is absorbed around alginate fibres. Dressing change is painless. During exudate absorption, calcium ions from the dressing are exchanged for sodium ions from the exudate, which influences blood coagulation processes and inhibits any possible bleeding. This is an extremely useful advantage in the treatment of neoplastic ulcers.

Alginates have very good absorbing properties: they can absorb about 18 times more than their weight. They are available in the form of the dense net of pressed fibres, as a plate for flat wounds or a rope for deep ones. They require covering with another dressing [11].

Preparations: Kaltostat (ConvaTec), Sorbalgon (Convatec).

Combined/other dressings

They are state-of-the-art dressings, which, owing to their structure and composition, combine the characteristics of several groups of dressings and thus can exert

a multidirectional effect on the surface of the healing wound.

Preparations: Aquacel® (ConvaTec), Combiderm (ConvaTec), Promogran* (Systagenix), Polymem (Ferris), Versiva XC™ (ConvaTec).

Aquacel® is a dressing based on the hydrofibre® technology, completely made of sodium carboxymethyl cellulose (NaCMC) in the fibrous form, derived from natural cellulose. Aquacel fibres gelate after contact with wound exudate, forming clean, soft, hydrated gel, which precisely fills the wound floor, not allowing for development of the so-called dead spaces where bacteria could accumulate. Exudate and bacteria are "closed-sequestrated" in the dressing structure, which prevents their leaking and maceration of healthy skin [12]. The dressing can be used in the form of plates or cord for treatment of pressure ulcers with moderately intense and profuse exudate. The dressing maintains the moist pressure ulcer environment and supports autolytic debridement, absorbs about 25 times more than its weight, causes no damage to fragile granulation tissue and causes no pain during change [13].

Combiderm is a dressing that is a combination of hydrocolloid with absorbing hydropolymer foam. The exudate is absorbed into the foam structure, and the hydrocolloid keeps the dressing on the wound. Combiderm can be used as a covering dressing. It is available in self-adhesive or non-adhesive forms.

*Promogran** is a dressing made of collagen (55%) and oxygenated regenerated cellulose (45%). It is bioabsorbable in the wound environment so it does not require removal from the wound surface. Promogran* actively modulates the wound environment as it inactivates excessive metalloproteases and protects growth factors, scavenging also heavy metal ions and oxygen free radicals. It also has haemostatic properties [14, 15].

Polymem is a multifunctional dressing, effectively filling the wound. The dressing's membrane does not adhere to the wound but gently adjusts to it. The dressing is made of a superabsorbent, i.e. a starch copolymer that absorbs exudate and glycerine that maintains an adequate level of hydration, and F68 surfactant – a non-ionic surface-active agent, which supports necrotic tissue autolysis through reduction of the surface tension between healthy and necrotic tissues [16].

Versiva XC™ is a dressing made of three layers: external polyurethane covering foam, wound-contact layer covered with gentle betahesive® hydrocolloid adhesive, and absorbent and wound-contact layer made of non-woven fibres in hydrofibre® technology. After contact with exudate, the wound-contact layer "gelates", stops exudation and closely adheres to the wound, thus enabling smooth and undisturbed healing processes, and makes autolytic debridement possible without damaging the newly developing tissues. The external layer provides protection and enables evaporation of moisture excess from the wound. Versiva™ can be used as a primary or secondary dressing [17].

Dressings with silver

Silver has been used for centuries as an antibacterial agent for disinfection and sterilisation of water (Egyptians, Romans, Arabs) [18]. A comeback of silver occurred in the 1960s, when a surgeon, Moyer, applied silver nitrate with thick cotton dressings with a good effect against *Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Streptococcus* spp. [19].

The main advantages of silver include:

- particularly broad antibacterial spectrum *in vitro* and absence of resistance development,
- interference with the transfer of bacterial electrons,
- impairment of cell replication through binding to bacterial DNA,
- binding to cell membrane causing its damage and damage to receptors at the cell level; binding to sulfhydryl (SH) groups, inhibition of bacterial respiration,
- low toxicity profile – the only reported reactions included skin irritation and argyria – irreversible blue-grey

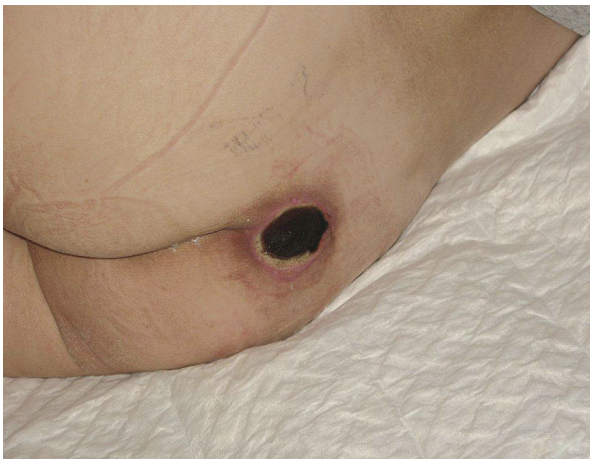

Figure 1. "Black-brown" wound

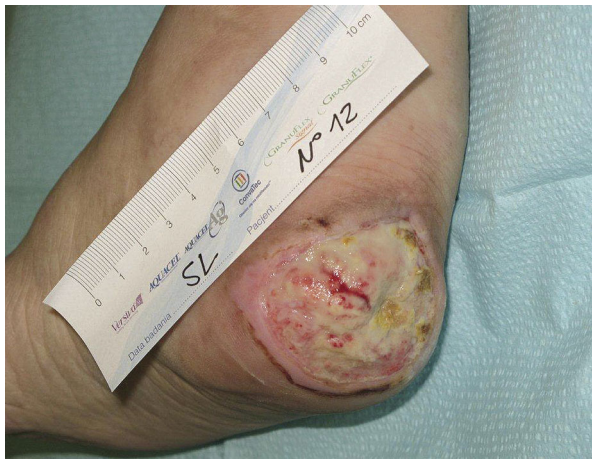

Figure 2. "Yellow" wound

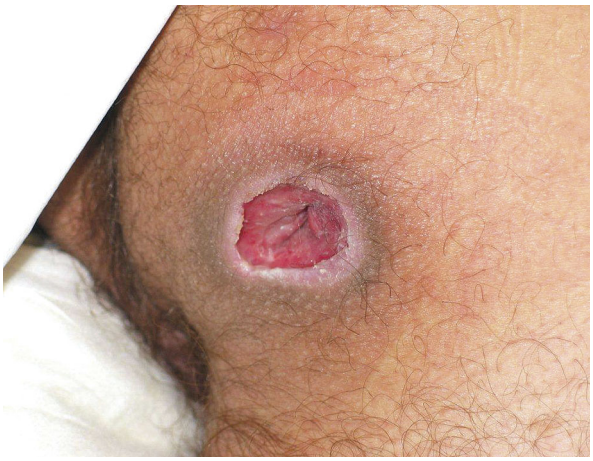

Figure 3. "Red" wound

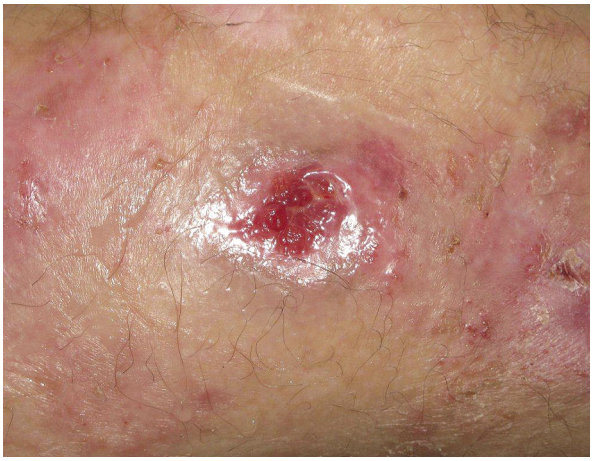

Figure 4. "Pink" wound

colouration of the skin or mucosae after longer silver nitrate application.

Silver itself is inactive, its ionic salts are active, releasing cationic silver. This antibacterial effect of silver seems particularly important in cases of chronic presence of bacteria, which cause the aforementioned situation of a chronic wound getting stuck in a phase of the healing process. Silver also exerts effects on healing processes: increases haemostasis, reduces inflammation, increases angiogenesis, increases re-epithelisation and directly inhibits metalloproteases [20, 21].

Preparations: Aquacel Ag®, Aquacel Ag® Surgical, Aquacel Ag® Burn (ConvaTec) – a hydrofibre dressing made of carboxymethyl cellulose with incorporated ionic silver [22], Acticoat, Acticoat 7 (Smith&Nephew) – polyethylene-nylon layers with incorporated nanocrystalline silver, Actisorb Silver 220 (Systagenix) – contains silver impregnated in activated carbon, closed in a nylon sleeve,

Table 3. "Colour" model of pressure ulcer treatment

Healing phase	Task	Exudate	Aim	Recommended management
Dry/moist necrosis – "black/brown"	• Dissolution of necrotic tissue, wound debridement	• Small amount or absent • Moderately intense	• Keeping the wound in a moist environment • Absorption of exudate	• Surgical debridement • Biosurgery • Debridement with an antiseptic e.g. Octenisept® • Hydrogel • Hydrocolloid paste + plate • Hydrocolloid gel
Colliquative necrosis – "yellow"	• Wound debridement	• Profuse • Moderately intense • Small amount	• Absorption of exudate • Maintenance of the moist environment	• Alginates rope or plate • Hydrofibre • Octenisept® • Hydrocolloids • Hydrocolloid gel • Dextranomers
Granulation – "red"	• Stimulation and main taining of granulation	• Profuse • Moderately intense	• Absorption of exudate • Maintenance of the moist environment	• Alginates rope or plate • Hydrofibre covered hydrocolloid/polyurethane foams • Versiva XC • Hydrocolloid gel • Hydrocolloids • Polyurethane foams
Epidermisation – "pink"	• Stimulation and protection of epidermisation	• Small amount	• Stimulation of epidermal growth	• Super thin hydrocolloid • Hydrocolloid gel • Semipermeable membrane

Biatain Ag (Coloplast) – a polyurethane sponge with incorporated ionic silver, Allevyn Ag (Smith&Nephew) – a polyurethane sponge with incorporated silver.

Pressure ulcer treatment regimen

Each pressure wound requires precise debridement and preparation to the healing process. This can be done based on the TIME scheme, in which T means tissue necrosis (debridement), I – infection and inflammation control, M – moisture balance, and E – epithelial edges. That scheme has been developed in detail and used in practice for several years [23-25].

The modern dressings described earlier can be used in pressure ulcers of various degree of progression and at various stages of the healing process. In the Chair and Department of Palliative Medicine we have proposed and have used also a very useful, so-called "colour" model of wound treatment. Each pressure ulcer, depending on its stage of healing, is assigned an adequate colour: black/brown for pressure ulcers with tissue necrosis, yellow for pressure ulcers with colliquative necrosis, red for granulating wounds and pink for epidermising wounds (Figures 1-4).

Correct management of a pressure ulcer at every stage includes application of various methods, means and dressings from the above groups. It should be mentioned here that we talk about conservative management in the treatment of that type of pressure ulcers. In the case of extensive, advanced pressure ulcers, surgical treatment should be always considered, which is then most effective, rapid and makes it possible to avoid a long period of conservative treatment. It also reduces the cost, makes it possible to avoid dangerous infectious complications and improves the patient's quality of life [26].

Correct wound debridement is of key importance in the case of black/brown and yellow pressure ulcers. This can be done surgically but only when the staff has adequate equipment and experience. The patient can also perceive that action as very unpleasant.

Recently, biosurgery – wound debridement with *Lucila seratica* larvae, has become a very popular method in Western countries. The larvae are applied in the form of "tea bags" onto wounds for 4 days, they debride the wounds and secrete enzymes, which selectively liquefy necrotic tissue.

Application of gauze pads moistened with octenidine dihydrochloride (Octenisept®), changed twice daily, is a very popular and effective method of debridement. The method is effective, causes no damage to healthy tissues and simultaneously it enables eradication of bacteria, including alarm pathogens and multiresistant strains, which makes it possible to control the microbiological contamination of the wound and to prevent possible infections [27].

The "colour" model of pressure ulcer treatment is shown in Table 3.

Conclusions

We hope that the paper presented and the described "colour" model of treatment will contribute to the correct and optimal use of a wide range of dressings available on our market. That system enables, for pressure ulcer treatment purposes, application of a dressing depending on the phase of the wound healing process. It can be used both in hospital and at the patient's home.

We are glad to see that also owing to the activity of the Polish Wound Treatment Society, since the beginning of this year another group of modern dressings has been present on the new list of reimbursed medications, which are now available with 50% payment for patients. This can facilitate their use and is a step in the right direction – for the good of the patient suffering from pressure ulcers.

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