REVIEW

The local treatment and available dressings designed for chronic wounds

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The great diversity of wounds and the broad range of available dressings complicate the selection of proper chronic wound treatment. Choosing the right treatment is the essential step in the healing process. In this review, we focus on chronic nonhealing ulcers, which are a critical problem in clinical practice, and current knowledge about persistent wound care. Here, we present the objectives of local treatment with description of several types of dressings and their ingredients, features, indications, and contraindications. These include hydrocolloid, alginate, hydrogel, and dextranomer dressings; polyurethane foam and membrane dressings; semipermeable polyurethane membrane dressings; and TenderWet (Hartmann, Rock Hill, SC) and flax dressings. There is also a brief section on the use of other alternative wound-healing accelerators, such as platelet-rich plasma and light-emitting diode therapy. (J Am Acad Dermatol 10.1016/j.jaad.2011.06.028.)

Key words: chronic wounds; wound dressings; wound therapy.

Chronic wounds are wounds that take more than 8 weeks to heal despite optimal local and general treatment.[1,2] They include venous ulcers, ischemic wounds (mostly of atherosclerotic origin), diabetic foot syndrome, and decubitus ulcers (trophic). Chronic wounds that rarely occur in clinical practice include burning (chemical, thermal, electric) and frost-bite wounds, wounds remaining after surgical intervention, wounds caused by cancer, immunologic and hematologic wounds, pyoderma gangrenosum, wounds accompanied by congenital vascular malformations, and iatrogenic wounds such as complications arising from treatment. Chronic nonhealing ulcers are a critical problem in clinical practice. Slow healing, difficulty in providing proper healing support or treatment methods, and patient suffering are great challenges for modern medicine.[3]

TREATMENT

The treatment of chronic wounds involves ensuring the balance of factors that determine wound healing. Such treatment should be complex, organized, and based on cooperation between the physician and the patient.

The complex treatment of ulcers consists of the following methods:

- Wound diagnostics.
- Causal treatment directed at the principal disease (eg, metabolic control of diabetes, prevention of chronic venous insufficiency, slowing the progression of *atherosclerosis*), with a discontinuation of medications that inhibit wound healing, if possible. This could include:
  - conservative treatment, eg, compression therapy, laser therapy, correction of risk factors, education;
  - pharmacotherapy, eg, anti-inflammatory therapy, analgesic treatment, anticoagulant therapy, antibiotic therapy; or
  - invasive treatment, eg, thromboendarterectomy, recanalization of thrombus, elimination of venous reflux.
- Exclusion of other factors that inhibit healing processes.
- Local treatment. This could be:
  - the mechanical removal of necrotic tissues through surgical procedures, ulceration hygiene, and enzymatic debridement;

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  - in some cases of invasive infection, bacteriologic control and treatment consistent with bacteriologic culture and antibiogram;
  - the application of biologically active dressings, and skin and skin-muscle grafts.

- General treatment, systemic treatment (anticoagulant treatment, systemic antibiotic therapy, anti-inflammatory therapy, therapy inhibiting immunologic reactions, vasodilator treatment, rheology-improving drugs, and protein, vitamin, and microelement supplements).
- Systemic evaluations of healing progress.
- Patient education.

CAPSULE SUMMARY

- Chronic nonhealing ulcers are a critical problem because of slow healing, difficulty in providing proper healing support/treatment methods, and patient suffering.
- We present the main objectives of local treatment in terms of healing pathophysiology.
- We focus on persistent wound care using local treatment with description of several types of dressings, their content, mechanism of action, advantages, and disadvantages.

Local treatment—objects

- Cleaning stage

This stage involves the mechanical debridement of necrotic tissues, contaminations, foreign bodies, infectious ulcer tissues, and often wound edges to achieve improved perfusion. When abscesses appear, they must be opened and drained. After the wound cleaning, it is crucial to provide the optimal conditions for the biochemical processes and activity of the cells that take part in regeneration. These include moderate humidity of the wound bed environment, oxygen supplementation, normal gas exchange, and the optimal temperature and pH. Furthermore, it is essential to perform active diagnoses and aggressively treat infections.

- Proliferation stage

The crucial element of the local treatment of an ulcer is providing the newly formed tissue with the optimal humidity. Drying an ulcer causes cell death and inhibits healing. However, it is crucial to remove the excess exudates to prevent wound edge maceration. It is necessary to protect the sensitive granulation and epithelium against injury. During this stage of healing, it is also important to have the optimal level of oxygen access to the wound. Some authors emphasize the role of antioxidants (vitamin C) in wound healing.

- Wound closure and scar formation stage

Similarly to granulation tissue, the newly formed epithelium needs the optimal humidity, temperature, pH, and oxygen, which are all crucial for cell migration. The wound needs to be protected against harmful external factors.

The European Wound Management Association described a strategy called TIME, which refers to the methods of reinforcing the natural healing processes, and eliminating aggressive and proliferation-inhibiting activities.

- T (tissue management)—wound cleaning
- I (infection or inflammation)—decolonization and inhibition of infection
- M (moisture imbalance)—humidification
- E (edge of the wound, epithelium)—epithelialization support

These objectives can be reached by using the appropriate wound dressings and other alternative wound-healing accelerators that take an active part in the healing process. For example, an autologous platelet concentrate suspended in plasma, known as platelet-rich plasma, is a rich source of platelet-derived growth factors, which accelerate healing via the activation of fibroblast, smooth muscle cell, and osteoblast proliferation. There are some commercially available devices used for the preparation of platelet-rich plasma, eg, AutoloGel (Cytomedix, Gaithersburg, MD) and SafeBlood (SafeBlood Technologies Little Rock, AR). These two methods can be prepared at the bedside for immediate application.[4] Also of interest is the use of a light-emitting diode, which is a safer alternative to laser therapy and improves fibroblast proliferation by providing energy to the cells. The mitochondria of the damaged cells are provided with photon energy, which increases the respiratory metabolism of the cells thus enhancing the chance of survival and repair.[5]

For effective local treatment, it is crucial to choose an appropriate dressing with reference to the localization, character, depth and area of the injury, the level of exudates, any infection, the healing stage (Table I), and the skin type.[6-8]

Local treatment—an optimal dressing[6]

- guarantees the physical continuity of the wound;
- actively cleans the wound;
- absorbs excess exudates;
- protects against infection and external factors;
- provides the optimal pH, thermoregulation, gas exchange, and humidity;

Table I. Dressings for different phases of healing

Recommended dressing	Healing phase		
	Cleaning	Granulation	Epithelialization
	Alginate dressing	Alginate dressing	Hydrofiber dressing (ConvaTec Ltd, Skillman, NJ)
	Dextranomer dressing	Hydrocolloid dressing	Hydrocolloid dressing
	Hydrofiber dressing (ConvaTec Ltd)	Hydrogel dressing	Hydrogel dressing
	Hydrogel dressing	Flax dressing	Flax dressing
	Flax dressing	Polyurethane foam dressing	Semipermeable dressing
	Polyurethane foam dressing	TenderWet dressing	
	TenderWet dressing (Hartmann, Rock Hill, SC)		
	Silver-supplemented dressing		
	Enzyme-supplemented dressing		

- cooperates with wound-healing processes;
- prevents rejection reactions (granulation suppression, fibrin formation);
- is not allergenic;
- is comfortable to use; and
- does not damage the edges of the ulcer.

Local treatment—the available dressings

- Common dressings

Aseptic and septic dressings made from 100% cotton (Sterilux ES, Hartmann, Łódź, Poland) or from fleece (Medicomp, Hartman) are soft and characterized by high absorption properties and air permeability. They are intended for general wounds. Because of their lack of bioactivity, these are used as secondary dressing supporting bioactive dressings.

- Bioactive dressings

In 1962, Winter[9] proved that the humid environment of active dressings accelerates healing 2-fold compared with traditional dressings that dry the wound surface, cause scab formation, and disrupt collagen fiber formation. A humid environment promotes cell migration and early epithelialization.[6,9] After that publication, the mass production of different active dressings began.

There are several main types of dressings currently produced worldwide (Table II). The actual choice of the dressing is always influenced by the clinical features of the wound, the physician's knowledge and experience, and patient's preference. The main dressing types are:

- hydrocolloid dressings;
- alginate dressings;
- hydrogel dressings;
- dextranomer dressings (granules);
- polyurethane foam and membrane dressings;
- semipermeable polyurethane membrane dressings; and
- flax dressings based on genetic engineering methods.

There are also "mixed" dressings, which include a mixture of active components: hydrocolloid, hydrogel, alginate, dextranomer, and polyurethane material and different substances and preparations for the stimulation of wound healing and intended for treating particular kinds of wound (eg, infected, resistant to common local treatments, with odor). These substances include enzymatic agents, activated carbon, silver ions,[10] iodine, mild antiseptics/antibiotics, collagen, growth factors, and manuka honey.

Finally, there are "composite" dressings, which usually consist of a combination of several sequential layers of basal dressings, such as a hydrocolloid and polyurethane foam conjunction, or a dressing composed of 3 layers, consisting of hydrocolloid, Hydrofiber (ConvaTec Ltd, Skillman, NJ), and an external polyurethane membrane.

Hydrocolloid dressing

Content. Produced in two forms: a plate and a self-adhesive hydrocolloid gel, both made of carboxymethylcellulose, gelatin, and pectins. Plate-formed dressings have a semiocclusive effect. The external layer is semipermeable and protects the wound against debris and pathogenic microbial penetration. The active internal layer contains hydrophilic molecules of carboxymethylcellulose, suspended in a hydrophobic mass of gelatin and pectins. The gel form has the same purifying features, and is mostly used to fill decubitus caves.

Mechanism of action. In the presence of wound exudates, hydrocolloids absorb liquid and form a soft gel, the properties of which are determined by the nature of the formulation. Some

Table II. Active dressings*

Dressing containing	Content	Indications	Advantages	Disadvantages	Examples
Alginates	Sodium and calcium salts of alginic acid, an anionic polysaccharide derived from brown algae.	Wounds with heavy exudates, eg, skin ulcers, pressure ulcers, fistulas, wet ulcers with abundance of fibrin, inflamed wounds with bacterial contamination, deep chronic wounds, and surface granulating wounds with heavy and medium exudates.	Forms gel on wound and provides moist environment. Reduces pain. Can pack cavities. Absorbent in exudative wounds. Promotes hemostasis. Low allergenic. Can be used with infected wounds.	Does not provide thermoregulation, and application to deep wounds needs to be monitored carefully because overstimulation of fibroblasts can slow wound healing. May require secondary dressing. Not recommended in anaerobic infections. Gel can be confused with slough or pus in wound.	Kaltostat Tegaderm AlgiSite AlgiSite M Algosteril Curasorb Kaltostat Melgisorb SeaSorb Sorbalgon Sorbsan Tegagen
Dextranomers	Hydrophilic polysaccharide granules (dextran copolymer).	Ulcers with heavy and medium exudates, infected wounds in need of cleaning, with bad smell.		It is necessary to use additional protective covering.	Debrisan, Acudex, Iodosorb. Debrisan, Debrisan Beads
Hydrocolloids	Self-adhesive gel made from carboxymethylcellulose, gellatine, and pectins.	Chronic wounds with minor or medium amounts of exudate (skin ulcers, pressure ulcers, diabetic foot, burns, abrasions).	Retains moisture, painless removal. Dressings in forms of paste and powders could be used for treatment of deep wounds and fistulas.	Cannot be used for infected or necrotic wounds or wound with very high exudate levels.	Comfeel Tegasorb Cutinova hydro Askina Biofilm Transparent Varihesive E Granuflex Hydrocoll
Hydrofiber	Carboxymethylcellulose as band or plate.	Bacteria-infected wounds, neglected wounds or wounds in danger of becoming infected, with heavy and medium exudates.	Can be used for treatment of deep wounds (inside a wound).	It has to be covered with secondary top dressing.	Aquacel Hydrofiber

Continued

Table II. Cont'd

Dressing containing	Content	Indications	Advantages	Disadvantages	Examples
Hydrogel dressings	Insoluble methylacrylate polymers with hydrophilic water-binding moieties, synthetic or semisynthetic. In addition can contain methylcellulose, propylene glycol, pectins, alginates.	Dry wounds covered with fibrin and necrotic tissue, even those with medium-level and heavy exudates, deep wounds, fistulas with heavy exudates, surface wounds with granulation and minor exudates.	Gel dressings can be applied directly onto wound.	Have to also be protected with secondary dressings.	Aguagel, Granugel, Hydrosorb, IntraSite Gel, Nu-Gel, Purilon. Tegagel
Polyurethane foam	Hydrophilic polyurethane foam with porous structure or polymethylsiloxan.	Wounds with mild to moderate exudate. Ulcers in terminal stage of clearing process, wound in their granulation stage, with heavy and medium-level exudates, without infections, and surface epithelial wounds with sensitive skin.	Could be used together with compression therapy in case of venous ulcers, could be used for second-degree burns. Moist, highly absorbent, and protective.	Could stimulate overgranulation in wounds with low levels of exudates. Cannot be used together with disinfectants. Set size of foam may be limited by wound size. Cannot be used for dry wounds. Wounds that need frequent review.	Allevyn, Biatain, Lyofoam, PermaFoam, Tielle. Tegaderm foam nonadherent Dressing PolyMem
Semipermeable wound dressings	Dressing includes semipermeable, transparent polyurethane film and plurality of concentric polyethylene foam rings or disks. Application of foam rings to semipermeable thin film permits modification of moisture/vapor transmission characteristics of wound dressing, which can be adjusted to suit wound environment.	Surgical wounds, cannulas and catheter fixation and protection, almost-healed wounds in epithelialization stage with very little exudate. Also used as secondary dressing with alginates and hydrogels.	Prevents secondary infection and additional mechanical trauma of dry wounds and skin transplants. Waterproof, allowing for regular body care. Some moisture evaporation, reduces pain. Barrier to external contamination. Allows inspection.	Cannot be used with infected or necrotic wounds, or for wounds with heavy exudates or bleeding or with large uneven surfaces. Exudate may pool, may be traumatic to remove.	Bioclusiv, Cutifilm, Hydrofilm, OpSite, Tegaderm.

Continued

Table II. Cont'd

Dressing containing	Content	Indications	Advantages	Disadvantages	Examples
TenderWet	Superabsorbent polymer (polyacrylate) with Ringer (sodium, potassium, calcium) solution released to wound site.	Chronic ulcers with medium and heavy exudates, infected necrotic wounds in need of cleaning, wounds in beginning of granulation stage.	Produces continuous rinsing effect at wound bed for up to 24 h. Eases use of interactive moist wound therapy, supports wound cleansing and formation of granulation tissue.		TenderWet

*Manufacturers of brand-name products follow. Alginianes: Kaltostat, ConvaTec Ltd, Skillman, NJ; Tegaderm, 3M, St. Paul, MN; Algisite, Smith & Nephew, St. Laurent, Quebec, Canada; Algisite M, Smith & Nephew, St. Laurent, Quebec, Canada; Algosteril, Smith & Nephew, St. Laurent, Quebec, Canada; Curasorb, Kendall/Covidien, Mansfield, MA; Kaltostat, ConvaTec Ltd, Skillman, NJ; Melgisorb, Mölnlycke Health Care, Norcross, GA; SeaSorb, Smith & Nephew, Auckland, New Zealand; Sorbalgon, Hartmann, Łódź, Poland; Sorbsan, Pharma-Plast Ltd, Redditch, Worcestershire, UK; Tegagen, 3M, St. Paul, MN. Dextranomers: Acudex, Polfa Kutno, Kutno, Poland; Iodosorb, Smith & Nephew, St. Laurent, Quebec, Canada; Debrisan, Debrisan Beads, Pharmacia and Upjohn Ltd, Milton Keynes, UK. Hydrocolloids: Comfeel, Coloplast, Rosny Sous Bois, France; Tegasorb, 3M, St. Paul, MN; Cutinova hydro, Beiersdorf AG, Hamburg, Germany; Askina Biofilm Transparent, Braun, Melsungen, Germany; Varihesive E, ConvaTec Ltd, München, Germany; Granuflex, ConvaTec Ltd, Ickenham, Uxbridge, Middlesex, UK; Hydrocoll, Hartmann, Heidenheim, Germany; Hydrofiber: Aquacel Hydrofibre, ConvaTec Ltd, München, Germany. Hydrogel dressings: AquaGel, Kikgel, Ujazd, Poland; GranuGEL, ConvaTec Ltd, Ickenham, Uxbridge, Middlesex, UK; Hydrosorb, Hartmann, Łódź, Poland; IntraSite Gel, Smith & Nephew, London, UK; Nu-Gel, Johnson & Johnson, New Brunswick, NJ; Purilon, Coloplast, Peterborough, UK; Tegagel, 3M, St. Paul, MN. Polyurethane foam: Allevyn, Smith & Nephew, London, UK; Biatain, Coloplast, Peterborough, UK; Lyofoam, Mölnlycke Health Care, Bedfordshire, UK; PermaFoam, Hartmann, Łódź, Poland; Tielle, Johnson & Johnson, New Brunswick, NJ; Tegaderm foam nonadherent, 3M, St. Paul, MN; PolyMem, Ferris Manufacturing Corp, Burr Ridge, IL. Semipermeable wound dressings: Bioclusive, Systagenix, Gatwick, UK; Cutifilm, Smith & Nephew, London, UK; Hydrofilm, Hartmann, Łódź, Poland; OpSite, Smith & Nephew, London, UK; Tegaderm, 3M, St. Paul, MN. TenderWet: TenderWet, Hartmann, Rock Hill, SC.

dressings form a cohesive gel, which is largely contained within the adhesive matrix, whereas others form more mobile, less viscous gels that are not retained within the dressing structure.

In the intact state, most hydrocolloids are impermeable to water vapors, but as the gelling process takes place, the dressing becomes progressively more permeable. The loss of water through the dressing in this way enhances the ability of the product to cope with exudate production and lowers the pH, thus preventing bacterial growth. This also keeps the wound at an optimal stable temperature and moisture level. These conditions activate the successive phases of wound healing: clearing, proliferation, angiogenesis, and epidermization.

This decreases the pain associated with wound existence not only through moisture that suppresses nerve fiber stimulation,[11] but thanks to the acidic pH, it also lowers prostaglandin prostaglandin E2 production.[12] Prostaglandin E2 sensitizes nerve endings.[13]

Hydrocolloid dressings facilitate proteolysis through the activity of host enzymes, because of the low pH environment of the wound.[14] The dressing causes an inflow of granulocytes that suppress pathogen growth.[15]

Together with compression therapy, these dressings also show fibrinolytic properties via plasminogen activation.[16]

Used for. Chronic wounds, also deep, with minor or medium amounts of exudates (skin ulcers, pressure ulcers, diabetic foot, burns, abrasions, also fistulas) in every stage of healing of the wound.[17] Should not be used for infected or necrotic wounds.

Additional information. Dressing changes are painless and injury free. The upper layer forms a barrier to water, so it is possible to take a shower when wearing such a dressing.

Alginate dressing

Content. Sodium and calcium salts of alginic acid, an anionic polysaccharide derived from brown algae; available in the form of a plate (for shallow wounds) and a band (for deep wounds).

Mechanism of action. Water-insoluble calcium alginate is transformed into a hydrophilic gel by exchanging the calcium for sodium ions. The wound exudates are the source of the sodium ions. The hydrophilic gel clears the ulcer and keeps the wound in a moist state, and facilitates granulation and epithelialization. It also helps wound homeostasis through the release of calcium, which causes platelet activation and hemostasis, and binds microorganisms and necrotic tissue debris, enclosing them in the gel structure, thus separating them from the wound bed. It has good absorbing features: the dressing can absorb an 18-fold greater mass than its own weight. This kind of dressing activates fibroblast growth and cell-mediated responses in the wound bed, and accelerates clotting processes. The residues of alginate dressing gels in the wound are biodegraded to glucose particles without causing allergic reactions.[18]

Used for. Wounds with a heavy or medium amount of exudates (thanks to the high absorbance) such as skin ulcers, pressure ulcers, fistulas, diabetic foot, wet ulcers with an abundance of fibrin, inflamed wounds with bacterial contamination and pus, deep chronic wounds, and surface granulating wounds with heavy and medium exudates.[19] Thanks to the hemostatic features, they can be used for bleeding wounds.

Thanks to its soft and loose framework, this type adjusts to different types of wound, and can be cut and fitted to the wound.

Additional information. Does not provide thermoregulation, and application to deep wounds needs to be monitored carefully as the overstimulation of fibroblasts can slow wound healing. Contraindicated in dry wounds, and in wounds covered by dead, black tissues, as the exudates are necessary for gel formation.

Dressing changes are painless and injury free. Dressings have analgesic features. Reasonable usage of secondary dressing.

Hydrogel dressing

Content. Mechanically resistant, insoluble methylacrylate polymers forming a 3-dimensional network with synthetic or semisynthetic hydrophilic water-binding moieties. The applicable form is a sterile, transparent, elastic 4-mm thick slice of hydrogel. Can also contain methylcellulose, propylene glycol, pectins, and alginates.

Mechanism of action. Clears the ulcer of necrotic tissue and micro-organisms by binding them into the gel structure.[20] By initiating the autolysis process, provides a moist environment inside the wound, thus stimulating the growth of new tissue and the migration of epithelial cells. Decreases feelings of pain by cooling the application site. In contact with water, swells and stores the water (>90%), and thanks to its hydrophilic features can intensively moisten a dry wound bed, dissolve crust/black necrosis, and simultaneously activate lyses in the wound.[21]

The upper layer forms a barrier to external pathogens, but is permeable to oxygen and medicines that can be overlaid.

Used for. Dry wounds covered with fibrin and necrotic tissue. Surgical debridement is not necessary before using this type of dressing. Deep wounds such as burns, decubitus, diabetic foot sores, areas post-skin graft sampling, fistulas. Elastic, thus can be used for hard-to-fit locations on the body, such as the joints, hands, and face. The absorption features of this kind of dressing are too weak to be used for treating wounds producing medium or high levels of exudates.

Additional information. Gel dressings applied directly onto the wound, also protected with secondary dressings. Good cosmetic effects mostly with burns. Dressing changes are painless and injury free even with new epithelium. The dressing is wiped from the wound with the exudates and necrotic tissue.

When the wound is very dry, it is necessary to moisten the dressing by putting a compress filled with 0.9% sodium chloride on the surface of the dressing for 15 to 20 minutes, even 2 to 4 times per 24 hours if necessary.

Hydrocolloid gel is a dressing that contains hydrocolloid and hydrogel. Thanks to the high hydration rate of the hydrogel (includes >90% water) hydrates the wound and makes separation of necrotic tissues easier. Thanks to the absorptive features of hydrocolloid, it can stay in the wound longer. Necessary to use a secondary dressing.

Hydrofiber dressing

Content. "Composite" dressing, sodium carboxymethylcellulose (the main component of hydrocolloid dressing) prepared as fibers that form a band or plate. The hydrofibers look like alginate fibers, and as a result of the same mechanism make a gel coating of the wound bed in contact with the exudates. The exudates are absorbed into the fibers and closed inside, whereas with an alginate dressing exudates are absorbed into the space between the fibers. Of interest is the high degree of retention of exudates: the dressing can increase its weight even 25-fold.

Mechanism of action. After the absorption of wound exudates, this dressing forms a gel filling the wound bed, binds exudates and keeps them inside the gel, keeps micro-organisms inside the gel isolating them from the wound, inhibits bacterial growth by lowering the wound pH, prevents skin maceration and irritation of the wound surroundings, keeps the wound at the optimal moisture level, and activates angiogenesis and fibrinolysis.

Used for. Bacteria-infected wounds, neglected wounds or wounds in danger of becoming infected, with heavy and medium exudates. Should not be used for dry wounds with a low amount of exudates.[22,23]

Additional information. Can be used for the treatment of deep wounds (inside a wound). The dressing has to be covered with a secondary top dressing. Dressing changes are painless and injury free.

Dextranomer dressing

Content. Hydrophilic polysaccharide granules (dextran copolymer) available in powder or paste form.

Mechanism of action. Absorbs overabundance of exudates, including pathogens, pus, dead cellular elements, toxins, and inflammation mediators; prevents maceration of the wound edges; keeps the wound at the optimal moisture level; helps in the wound-clearing process. In contact with exudates it forms a moist gel, hydrates necrosis, and activates autolysis enzymes.

Used for. Ulcers with heavy and medium exudates, infected, contaminated, deep wounds in need of cleaning, and wounds with odor.[24]

Additional information. It is necessary to use additional protective covering in the form of a second dressing.

Polyurethane foam dressing

Content. Hydrophilic foam with a porous structure polyurethane or polymethylsiloxan.

Mechanism of action. One side of the dressing is thermally processed to form moisture-absorbing capillaries that keep the wound at the optimal moisture level. The dressing stimulates angiogenesis and autolysis, and provides thermoregulation. The second layer of the dressing is an elastic membrane that makes a semiocclusion of the wound and is impermeable to pathogens and water, although it allows evaporation from the wound surface. The rate of evaporation is lower than that of secretion, which means a wet environment of the wound.

Used for. Ulcers in the terminal stage of the clearing process, wounds in their granulation stage, with heavy and medium-level exudates, without infections, and surface epithelial wounds with sensitive skin. Used for surgical wounds, areas from which skin grafts were taken and other superficial wounds, or as a secondary dressing. Contraindicated in dry wounds covered by black necrosis or scabs.[25,26]

Additional information. Could stimulate overgranulation in wounds with low levels of exudates, could be used together with compression therapy in the case of venous ulcers, could be used for second-degree burns. Cannot be used together with disinfectants.

Semipermeable polyurethane membrane dressing

Content. Dressing includes a semipermeable, transparent polyurethane film and a plurality of concentric polyethylene foam rings or disks. Application of the foam rings to a semipermeable thin film permits modification of the moisture/vapor transmission characteristics of the wound dressing, which can be adjusted to suit the wound environment.

Mechanism of action. Prevents secondary infection and additional mechanical trauma, permeable to oxygen and water but not to other liquids, allows the skin to breathe, and keeps the wound at the optimal moisture level.

Used for. Surgical wounds, cannulas and catheter fixation and protection, almost-healed wounds in the epithelialization stage with very few exudates. Prevents secondary infection and additional mechanical trauma of dry wounds and skin transplants. Also used as a secondary dressing with alginates and hydrogels. Contraindicated in dry wounds covered by black necrosis or scabs.

Additional information. Not for use with infected or necrotic wounds, or for wounds with heavy exudates or bleeding or with large uneven surfaces. Waterproof, allowing for regular body care.

TenderWet dressing

Content. Superabsorbent polymer (polyacrylate) with Ringer (sodium, potassium, calcium) solution released to the wound site.

Mechanism of action. Does not contain active ingredients; activation with Ringer solution necessary before application to the wound site, allowing for self-regulation of the exudate level. Microorganisms, necrotic tissue, and toxins are continuously washed away from the wound site. Activation of autolysis, optimization of moisture levels. Provides the electrolytes sodium, calcium, and potassium, stimulating cell growth at the granulation stage.[27]

Used for. Chronic ulcers with medium and heavy exudates, infected necrotic wounds in need of cleaning, wounds at the start of the granulation stage.[28]

Additional information. This is a composite dressing

Flax dressings based on genetic engineering methods

Content. Three-component wound dressing based on a genetically engineered flax product. Cellulose, vanillin, acetovanillone, lutein, cannabidiol, and ferulic acid are the main constituents of the first wound dressing component, Flax Aid (Linum Foundation, Wrocław, Poland). The second component, Oilfix (Linum Foundation), consists of polyunsaturated fatty acids, β-carotene, tocopherol, and plastochromanol; whereas the third component, Linfix (Linum Foundation), mainly consists of secoisolariciresinol diglucoside (lignan), ferulic acid, p-coumaric acid, and their glycoside derivatives.

Mechanism of action. Provides optimal humidity for the ulcer and absorbs the excess of exudates, thanks to the hygroscopic properties of the flax fibers. Reduces the inflammation in the wound, thanks to the phenolic acid and flavonoid contents in the flax fibers. These compounds are washed away from the dressing in the humid environment of the wound. The unsaturated fatty acids present in the dressing diffuse to the ulcer milieu, thereby reinforcing the integrity of the plasma membranes of the fibroblasts. The lignans present in the dressing stimulate fibroblast proliferation and attract them to the wound environment (stimulation of granulation and epithelialization). Protects the wound from mechanical irritation. Necrotic elements and contamination that move beyond the dressing surface are isolated from the wound. Prevents maceration along the wound edges.[29]

Used for. The flax dressing is designed for chronic ulcers, with small, medium, and abundant exudates and for medium intensity clinical symptoms of ulcer inflammation (venous ulcers, decubitus ulcers, diabetic foot syndrome).

Additional information. The flax dressing treatment consists of 3 stages. The first is the use of a dry flax dressing; the second is the application of Oilfix, and the third is the application of Linfix.

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