STIMULATION OF TISSUE REGENERATION IN WOUNDS THROUGH SYSTEMS OF UNIDIRECTIONAL PASSIVE PUMPS INCLUDED IN SURGICAL DRESSINGS

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Abstract: *Solutions of continuity of the skin and tissue expressed through traumatic wounds or of other nature represent a cause of increased morbidity and mortality, involving significant resources and unconventional approaches. Permanent inventory of new protective devices for free tissues aims at wound healing in a short time, at a reasonable cost and with predictable results.*

Cuvinte cheie: *plăgi, regenerare, vindecare*

Rezumat: *Soluţiile de continuitate ale tegumentelor şi ţesuturilor, exprimate prin plăgi traumatice sau de altă natură, constituie o cauză de morbiditate şi mortalitate crescută, care implică resurse importante şi abordări neconvenţionale. Inventarea permanentă a unor noi dispozitive de protecţie pentru ţesuturile indemne are ca scop vindecarea plăgilor într-un timp scurt, la un cost rezonabil şi cu rezultate predictibile.*

The wounds affect 1.5% of world population, having a major impact on quality of life. In Great Britain, the costs for wounds care represent 4% of total health expenses and takes 66% of the time dedicated to home care.(1)

With regard to wounds, the injured tissues lack multiple abilities of an integral tissue, therefore there appear hypersensitivity reactions that become harmful in default of some adequate treatments. In order to supply the functions of the injured tissues there are used various devices of covering and protection that developed during the history, to achieve healing as soon as possible.

Medical devices used for dressing the wounds or for absorption of intraoperative fluids are of different types and shapes and the producing societies are using woven, non-woven or knitted materials which have been the subject of multiple patents, known as surgical compresses.

Surgical compresses made of knitted material, gauze type, were the main protection devices of wounds but as a disadvantage, they impregnate with the exudate secreted by the underlying tissue, passing into the tissue network and forming, by drying, a solid and adherent crust at the first layer (figure no. 1). Changing the dressing generates local micro-injuries and pain (2), detachment of the regeneration tissue and fast and uncontrolled proliferation reactions of the injured tissue which delays wound healing. Using gauze dressings may cause formation of unaesthetic, hypertrophic or keloid scars with negative effects on patient's quality of life.(3)

In specialized literature there are several patents that deal with the domain of surgical compresses: patent no. GB 1478454 which refers to a knitted surgical compress having the extremities closed with a folded strip (4), patent no. US 4540398 which describes a knitted surgical compress made on warp frame with the extremities joined through inter-knitting (5) and patent no. RO 115935 B which refers to a knitted surgical compress (6) with the extremities overcastted.

With structure in plain network, these compresses have the same imperfections as the gauze, being necessary another type of approach for wounds protection devices. Asepsis and antisepsis capacity of these compresses is low due to equal gradient of osmotic pressure between the face located on the wound and the external face that allows germs to penetrate, by diffusion, from outside to inside, at impregnation with wound fluids.

New devices for wounds protection

Figure no. 1. Flat grid structure

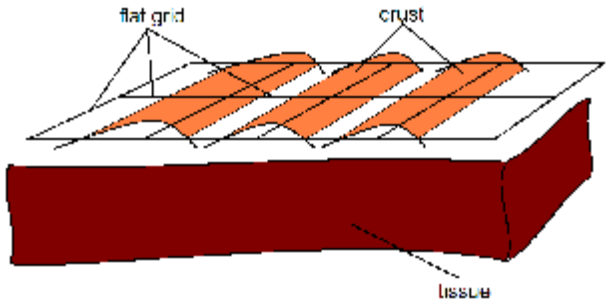

Figure 1. flat grid structure

After the publication of patent RO 115935B in 2000, a new approach of research in domain of devices intended to wounds dressing was imposed, which led to the invention of a new technical solution registered as regular national deposit at OSIM (State Office for Inventions and Trademarks) Bucharest under no. A000248 in March 25, 2013.

The invention describes a surgical compress whose structure contains several pedicles provided with systems of passive pumps (figure no. 2) for modulated unidirectional transfer of wound fluids.(7) This new device eliminates the imperfections found in previous patterns by maintaining an

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optimum moist environment, reducing the adhesion no. of points to the wound and achievement of local asepsis and antisepsis.

Recent studies have demonstrated that wound moist environment provided by the exudate continually secreted by the injured tissues is favorable to tissue regeneration if it is kept in optimum limits and the tissue is “not too wet not too dry”.(8,9)

The structural unit of the new device consists of a pedicle which has at its base, attached, a modulation ring of wound fluids transport in order to ensure it the features required by new inventions in wounds treatment domain.

Pediculate structure gives surgical compress aseptic and antiseptic properties through the difference of osmotic pressure between the pediculate face applied on the wound and the external face. The difference of osmotic pressure between the 2 sides of the surgical compression is carried out by means of a system of unidirectional passive pumps included in the pediculate structure which generates superficial tension powers, called surface phenomena, around the pedicle fibers and capillarity phenomena inside the fibers, eliminating the fluids to the outside. The fluids get in the capillary lumen through membrane pores, within some phenomena related to baromembranes called direct osmosis processes caused by enormous superficial tension powers which exert on the pedicle. Through osmotic pumps, previously described, the wound fluids are forced to get into the capillary lumen where the pressure is lower than the forces around the pedicle fibers. In capillary lumen, the fluids are subjected to some capillary phenomena and ascend to the external layer level of the compress.(7)

Fluids’ ascending way is led through a modulating ring (figure no. 2) that impregnates with the fluids taken from the pedicle, by diffusion and increases its volume due to the hydrophilic microscopic structure. By increasing the volume, the modulating ring compresses the fibers which form the pedicle and blocks the transport of fluids towards the surface of compress. At the same time, the fluids in the modulating ring undergo an evaporation process, by phase transformations produced by heat pumps which determine the diminution of its volume, the circulation from pedicle to outside is released and the cycle repeats.

Figure no. 2. Pedicle, passive pump system

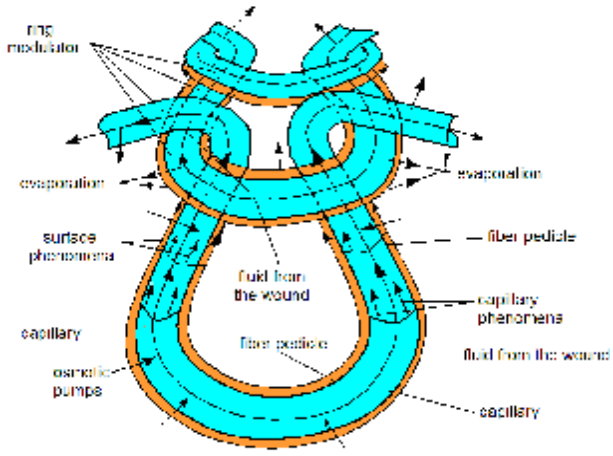

Figure 2. The pedicle, pump system passive

Heat pumps provide evaporation processes involved in unidirectional transport of fluids, from the wound to the outside, by exerting a negative pressure on pediculate capillaries. The necessary energy of heat pumps involved in the evaporation processes is produced by human body and air convection from the outside controls the evaporation rate at the dressing level.

Through this complex mechanism it modulates the fluids transfer from the wound to the outside, it is provided an optimum moist environment for tissue regeneration and it is avoided crusts formation. Through the same mechanism it is blocked, biomechanically, the access of germs to the wound and the existing germs are already eliminated towards the surface of compress.

In the first stage the pedicles rapidly absorb the exudates from the wound until the maximum capacity is reached, rapidly releasing the excess of fluids of the area, which are toxic in large quantities, by proteinases involved in the autolysis of health tissues at wound’s extremity.(3) In the second stage, the fluids activate the transport modulating system by impregnation of modulating circle and blocking the transport of fluids to the surface, maintaining an optimum moist environment necessary for tissue regeneration processes.

Figure no. 3. Schematic view of pedicles

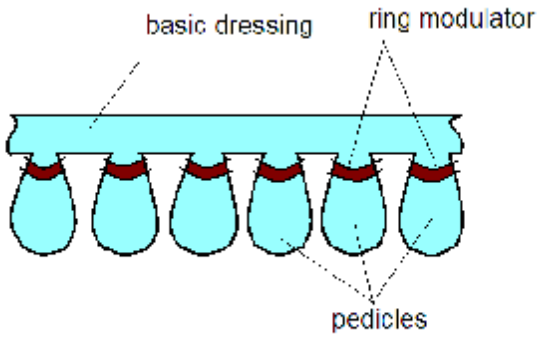

Figure 3. Schematic view of pedicles

Recent investigations specify that injured tissues react by continually secreting exudate in wound which stimulates tissue regeneration if it is kept in optimum limits. Exudates’ excess in wound is toxic and its diminution delay healing increasing the risk of formation of some hypertrophic or keloid scars.

Evaluation of wounds’ exudate level has become a common practice, recommended by WUWHS (World Union of Wound Healing Societies) since 2007, in order to ensure a quick healing of any type of wound. Moist environment kept within optimum limits stimulates tissue regeneration because it provides autolytic debridement of wound necrotic extremities.(10,11) and epithelial cells migration in the wound.(2) If the wound is rapidly dried, it takes place the blocking of epithelial cells migration necessary for tissue regeneration and the healing process is delayed. When the wound is invaded by excess exudate, it takes place maceration of tissues, by autolysis enzymatic processes and the regeneration is also delayed. Modulation of wound exudate absorption by choosing some adequate surgical compresses ensures a rapid healing of wounds.(8,9)

By using surgical compresses, teguments’ functions are taken over by these, providing a favorable environment to their regeneration. As for surgical compresses with structure in plane network, this transfer of powers is carried out only partially and their effectiveness is reduced by blocking the regeneration processes due to rapid drying of exudate.

The pediculate surgical compress forms, at wound’s level, an active interface, biologically speaking, by maintaining an optimum moist environment and transferring protective powers to the external layer, located at distance.(7)

The pediculate surgical compress behaves as a biomembrane which replaces, for a while, the functions of undamaged tissue and allows regeneration mechanisms to act quickly and effectively to heal the wound.

Modulating the fluids' transport from the wound, together with the thermal barrier made of insulating layers of the surgical compress, generates an increase of local temperature over 37 Celsius degrees necessary for stimulating the enzymatic reactions and increasing the keratocites.

Each surgical compress is made of a very large number of pedicles (figure no. 3) which contribute to unidirectional and modulated absorption of wound fluids through the passive pumps' system described above.

The article is made on the strength of an invention registered as regular deposit at State Office for Inventions and Trademarks in Bucharest and will be analyzed in specialized committees according to the procedures.

Patenting of the technical solution must be followed by randomized studies that will verify the conclusions of this study.

Conclusions:

Using pediculate surgical compresses represent the ideal solution in order to increase the tissue regeneration capacity by systems of unidirectional passive transport and modulated absorption of fluids in wounds.

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