BIOTECH MACHINE EXERCISE

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AIM:

To develop a device that can effect a faster and effective healing of wounds in specific problem cases of impaired wound regression states like diabetics, debilitated, malnourished and immunodeficeint individuals.

BACKGROUND:
Wound management has moved on from the old "cover and conceal" methods since wound healing can be actively stimulated by a favourable environment at the wound site. It has been shown that a moist environment is far superior to the dry environment created by the old dry bandage approach. Removal of toxic exudates, a moist but bacteria-free environment, access to oxygen and prevention of trauma are important factors.[1]

BIOLOGICAL PROCESS OF WOUND HEALING:

Wound healing is divided into overlapping stages - inflammation, new tissue formation, and matrix remodeling. Infected or contaminated wounds should be surgically debrided and lavaged with copious amounts of lavage solution. Wounds that are managed as open wounds heal by contraction and epithelialization. Initially, there is an infiltration of neutrophils which attempt to clear the area of foreign particles and bacteria. Monocytes are attracted next, activated, and evolve into macrophages. Macrophages help with the phagocytosis, debridement, and initiation of changes that promote granulation tissue formation. As the inflammation progresses, the infiltrate changes from primarily a neutrophil based to that of macrophage based. Macrophages also produce cytokines and growth factors which stimulate wound healing. .

Initially, wide meshed gauze dressing pads are applied. The larger interstices of such dressings facilitate the incorporation of debris, foreign bodies, and necrotic material into the pad; these are then removed with the bandage change. As the wound starts to heal, this reparative stage is characterised by a bed of granulation tissue as well as development of epithelial tissue from the wound edges. Granulation tissue involves the proliferation of fibroblasts and the infiltration of capillaries. There may also be a serosanguinous discharge. The matrix remodeling stage is a period of consolidation, remodeling, and strengthening of the wound. Collagen is synthesised by the fibroblasts. Maturation and remodeling takes place by cross linkages and changes in the physical weave of collagen fibers. At this stage, fine mesh dressings combined with wound stimulants provide an optimal environment during the healing process. Wound epithelialization and finally, wound contraction, complete the process.

This normal process of healing of wounds may sometimes pose serious problems, especially in elderly, diabetics, malnourished and immunocompromised individuals.

The normal efforts of managing medical personnel like, good nutrition and supplementation of required chemicals also becomes troublesome sometimes. For instance.[2]

1. Arginine fuels the cellular immune response and fights against bacterial challenges. But it can not be used freely in normal doses in cases of patients with cancer, liver failure, kidney failure and congenital argininemia.
2. Glutamine stimulates the proliferation of fibroblasts, thereby helping in wound closure. It is the major amino acid lost during any tissue injury, implying that it has a significant role in the preservation of lean body mass. Yet it can not be used in liver and kidney failure. Oral administration of it in large doses can lead to nausea and diarrhea.
3. Glucosamine provides the raw material needed to repair the connective tissue found in skin, tendons, ligaments, and joints. However its use in diabetics is dangerous. It is known to increase insulin resistance. If given orally in large doses can lead to diarrhea and vomiting.
4. Zinc deficiency has been associated with delayed wound healing. Zinc may stimulate leg ulcer healing by enhancing re-epithelialization, decreasing inflammation and bacterial growth. But large doses of zinc .can cause a metallic taste, headache, drowsiness, and gastrointestinal symptoms and may lead to copper deficiency and hypochromic, microcytic anemia. High doses of zinc may suppress the immune system.

In view of this type of problems, managing wounds in these patients needs some innovative techniques to get effective healing. Supplementation of chemicals and nutrients using some innovative technique that can deliver the required substances right at the site of need and also reducing the need for using large doses that are necessary if given orally or parenterally.

It is also known that Control of H+ flows represents a very important new modality that, together with traditional biochemical approaches, may eventually allow augmentation of regeneration for therapeutic applications.

I would like to utilize this knowledge in designing a device that can deliver the required substances like L-Arginine, Zinc gluconate, etc. at the site of wounds and use the ion pump principle it facilitate the entry of these ions in to the wound site by applying required electrical stimulus.

BASIS FOR DEVICE DESIGN**:**

The Vacuum-Assisted Closure (V.A.C.) device developed at Wake Forest is now being used worldwide to promote healing in large abdominal wounds, fight infection following open heart surgery and enhance healing of burns. More than a million Americans now are using the device as part of their home therapy. There the application of negative pressure technique is used to draw out the edematous fluid from the wound site and promote better perfusion with blood which in turn helps in faster wound healing. [3]

Unlike the VAC system, my device is an active interventional contraption that can literally inject chemicals in to damaged area, in controlled conditions – to promote better and fasted wound healing without any adverse effects.[4]

DESIGN BASIS:

Materials:

1. A membrane containing any suitable combination of lipids, long-chain (C_{12} - C_{24}) organic compounds, plastic materials or like polymers for physical reinforcement. Each membrane-forming lipid includes a long chain through which the lipid is anchored to a binding site on the support, and another long chain unattached to the support.[5]
2. An additional object to provide a compact, economical, easily portable, self-contained sensor which can be adapted for a variety of chemical or biological agents.
3. The gated membrane and measuring device may be produced separately as an indicator module, to which the biochemical switch is applied prior to use.
4. The gate membrane contains a thin membrane molecular monolayer or bilayer, in either fluid form or solid form, and in a preferred embodiment,
5. The gate material is a gramicidin antibiotic producing gramicidin channels embedded therein.[6]
6. The membrane contains a mixture of an acrylic polymer such as polylaurylmethacrylate with phosphatidylethanolamine and phosphatidylserine or a mixture of a carboxylated polyacrylamide with minor amounts of surfactant and antibiotic activity. [11]
7. Electrochemical biosensor for chemical or biological target agent detection - comprised of
    a. a bioresponse simulator, which is a biochemical switch module containing in film form
    b. a recognition biomolecule to which is conjugated
    c. an ion channel blocker moiety which controls ion permeation in a gate membrane [7]
8. An injection pump device to introduce into the contraption the required chemical in desired concentration

The process includes the step of applying across the lipid membrane of the device an electrical potential difference to produce an analytical signal based upon an increase in membrane ion permeability.[8]

APPLICATION:

1. The contraption is applied firmly over the cleaned and thoroughly debrided wound –
2. Polyurethane sponge based support helps in applying the device firmly over the wound area.
3. Electrical connections are checked for integrity and earthing..
4. The trap door closed and checked for any air leaks.
5. Required chemicals like Zinc gluconate[9], Glutamine, glycosamine or L-Arginine, etc. therapeutic formulations are added to injection pump.
6. The system activated by switching on the power
7. The chemical in the injection device gradually seeps in to the membrane area and the absorption into the wound area is controlled by the electrical gradient applied.[10]

8. The duration and frequency of application in decided by the clinician based on the severity of the lesion and required rapidity of expected healing response.

INSTRUCTIONS:

An operating manual is provide along with the contraption for the convenience of the users with all the specifications for electrical current settings and the specific ionic dosage, etc.

CONCLUSION:

Using the principles of ion transport an attempt was made to design an innovative contraption that can come handy to the medical practitioners in treating indolent ulcers and wounds which pose a serious problem in their day to day practice. Popular wound healing promoting substances were made available at the site of requirement with controlled release to enable optimum availability and with little adverse effects.

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