Biologic Wound Coverings in Burn Treatment

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A review of biologic wound coverings currently in use is presented. These include homografts, xenografts, embryonic membranes, and tissue derivatives. The indications, advantages, and disadvantages of such materials are discussed. Finally, future research directions are suggested.

Basic treatment of the burned patient relies upon safe maintenance of body homeostasis, nitrogen balance, immune competency, and microorganism exclusion until the surgeon has removed nonvital tissue and safely closed the wound. The sooner total wound closure is reached, the greater the probability of successful recovery of the patient.

Advances in surgical techniques, anesthesia, diagnostic methods of burn depth, blood-banking, and antibiotics have made earlier and wider escharectomies possible. However, this has created the need for safer closure of the more extensive wound areas.

To deal with this problem a wide array of wound coverings have been developed. Based on the origin of the covering materials they can be subdivided into biologic coverings and synthetic wound coverings (Table 1). In the present survey only biologic wound coverings are discussed.

The generally accepted requirements for wound coverings are rapid and safe adherence to the wound; impermeability to water and limited permeability to water vapor; reduction of heat, electrolyte and protein loss; acceleration of wound healing and wound debridement; limitation of wound colonization; reduction of pain sensation; hemostasis; pliability, non-toxicity, non-antigenicity, and favorable aesthetic appearance; wide availability, inexpensive, easily stored, can be sterilized; and a cosmetically acceptable scar without need for secondary surgery.

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Cadaver Skin Homograft

History

The first homografting procedure probably took place soon after Reverdin performed his first autologous skin grafting in the year 1869 [6]. After this event he also included grafting with allogeneic skin. He wrote in 1872: "... in my first grafts I used skin from the patient himself, but I soon was aware that the results were the same when I used skin from another individual. This has been demonstrated with certainty ..." [7]. The first reports of homograft in burn wounds is also uncertain since the types of wounds which were grafted was not always reported.

In 1874 Menzel noted that he regarded cadaver skin as a very important treatment. He described how a burned patient had benefited from cadaver skin grafts: "After application of cadaver skin, defects healed quickly" [8]. In 1881 Girdner treated a burn on a young boy with cadaver skin and healing occurred [9].

A major problem in homografting at that time was, and still is, the transmission of infections. In 1872 a transmission of smallpox after homografting was observed when the skin of an amputated arm was used on wounds of 4 patients. A few days after the amputation the donor died from smallpox. Three of the 4 graft recipients developed smallpox and 1 died [10]. As a consequence, many surgeons advised against homografting because of the risk of infection transmission [11] and some...
recommended more selective screening of donors. In 1874 it was advised that only skin from healthy persons without smallpox, tuberculosis, or syphilis should be utilized [12].

In spite of reports of permanent success in the early years of homografting, it was soon concluded that permanent take was impossible with homografts. In 1926 it was proposed that the immunological system of the recipient was responsible for the fate of the homograft tissue [13] and that suppression of the recipient’s immune system was one of the routes available for achieving a permanent take [14].

Ironically, it was not until the goal of permanent take had been deferred that the true benefit of homograft tissue was realized. It is a non-permanent wound cover which is beneficial for the patient’s wound and as such for the patient.

Present Status

Cadaver homograft, or allograft, today is the best available wound coverage. Before the tissue harvest, a complete and careful study of the donor file and the donor is mandatory in order to reduce chances of disease transmission. The main drawback of cadaver skin application is, and has always been, the transmission of disease. Today this is emphasized due to AIDS. The time span between infection and sero-conversion is 1–3 months with the possibility of skin harvest from a false sero-negative donor. At the Burns Unit of Hvidovre Hospital cadaver skin is now reserved exclusively for life saving purposes, i.e., extensive burns. After harvest, which must be carried out under absolute sterile conditions, the skin is further processed.

Fresh Homograft

Such tissue provides the wound with an excellent barrier against efflux of water, electrolytes, and proteins and against influx of microorganisms. This barrier function is solely contained within the epidermal layer. Pain is relieved immediately after application and hemostasis achieved. The adherence is equal to autografts. The promotion of healing of underlying autoepithelial elements is well known. Furthermore, healing of partial-thickness burns underneath cadaver skin is also cosmetically superior [15].

The drawbacks of fresh homograft are, besides the possibility of disease transmission, a marked antigenicity leading to rejection within 2 weeks. Prolonged take can only be achieved by a close matching of donor and recipient HLA tissue types, by a reduction of the recipient immune system capacity [16], or by a special treatment of the donor graft material.

Short-term storage of fresh cadaver skin can be obtained in a 4°C refrigerator provided the tissue is stored in a properly buffered tissue media. A low pH is crucial to keratinocyte function under nonfreezing storage conditions. If graft storage of >1–2 weeks is desired, freezing is recommended. To maintain a high viability of the graft, tissue freezing and thawing must be performed at controlled rates of 1–5°C increments. Cryoprotection of grafts, using 5–10 volume % glycerol or DMSO and immediate thawing, is necessary.

The method of storage of frozen skin has for a long time been under debate. However, one must bear in mind that freezing as well as thawing is equally critical to the cells. An immediate thawing process is mandatory, favoring the use of sheet-packaging. A thin tissue-plate will be the subject of a negligible temperature gradient between tissue surface and center. Therefore it can be assumed that temperature alterations in the tissue center will be almost identical to the changes on the surface. Conversely, if the tissue is wrapped or rolled into a tissue block, greater temperature gradients will be observed between surface and center. Thus thawing can not, in this manner, be as rapid in the center as on the surface of the block being detrimental to the preservation of graft viability.

It has also been debated which type of viability tests future investigators should apply. In considering graft situations, the barrier function of the graft gives a superior advantage. As has previously been described, this barrier function is contained within the epidermal stratum corneum (keratin layer) and to a minor degree to the vital cell layer of the keratinocytes. A continuously well functioning keratin layer requires proper keratinocyte proliferation. Thus viability estimations should focus on the mitotic rate within the keratinocytes. Viability estimations such as recordings in different steps of cell metabolism are possible in cells which have already lost the ultimate function of the cell, i.e., mitosis.

Dermal Aspects of Cadaver Homograft

The dermis consists of collagenous tissue with few cells and ensures an immediate and safe take of the grafted skin. In the long term the dermis serves another important purpose. When, for example, a 1.5–1 meshed homograft is rejected, it is often possible to see remnants of the mesh pattern in the wound. This is also dermis (low antigenicity) which is incorporated in the wound. The same phenomenon is also observed when the autograft underlay/homograft overlay grafting technique is used [16]. After healing of the sublying autograft, the homograft mesh pattern is almost always clearly visible. Most clinical evaluators and many patients will also agree that secondary problems are few compared to autograft healed without overlaying homograft. This is probably due to allo dermis incorporation in the definitive wound. This dermis, with the typical wave pattern structure at the dermis/epidermis junction, ensures skin flexibility and serves as a template for the replacement with auto-collagen.