GUEST EDITORIAL

Wound Healing and Tissue Repair of the Surgical Amputation of Limbs

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Wound healing and tissue repair are fundamental processes of all living things. Tissue trauma, regardless of its specific source, evokes a healing response. Some injured tissues heal with cells in kind and resume various degrees of original function. Other injured tissues may be incapable of reproducing an in kind cellular response. Healing under these circumstances is generally by one of several types of scar formation.

Some years ago, with VA research support, Prosthetics Research Study (PRS) evaluated a system of management of surgical amputations that had become popular in Europe, particularly in Poland and France. Immediately postsurgery, amputations of the limbs were immobilized in a closed, rigid dressing. Plaster of Paris was used and usually incorporated an elastic bandage, which formed a rigid support. A terminal device applied to this dressing in both upper and lower limbs facilitated early prosthetic rehabilitation. The technique was termed IPOP (Immediate Post-Operative Prosthetic). Its proponents cited a variety of advantages, including rapid and quieter surgical wound-healing, diminished postsurgical pain, earlier wound maturation, and accelerated rehabilitation by progressing rapidly to early definitive prosthetic limb fit, which enabled

earlier return to ambulation. The method also implied retention of function as a result of immediate or early temporary prosthetic use.

PRS, together with a few other centers in this country, investigated the IPOP concept. Setting aside many of the claimed advantages for the technique, we concentrated on its use in wound healing. Limb amputations are particularly suited for control of the external environment under which wounds heal. The surgery is terminal. There is no concern about compromise of distal limb tissue. Accordingly, the surgeon can modify the environment under which the amputation site heals. This control includes immobilization, applied external pressure, temperature, and dressing sterility. Other factors, such as drainage at the operative site, are used as with a soft tissue dressing system.

The more spectacular and lay newsworthy features, such as immediate walking or use of a substitute hand, we more or less ignored, although there certainly were psychological benefits to be obtained with the early functional response. A feature that was relevant, however, was the early progressive rehabilitation as compared to the then conventional methods of postoperative management. The patient went directly from the surgery to the temporary functional prosthesis with no prolonged period of residual limb wrapping and residual limb maturation. Our initial primary interest was the wound healing and secondarily, the rapid rehabilitation.

The experience of many hundreds of cases using this system encouraged us to recommend it for general use. The major objection to IPOP was the inability to inspect the wound frequently to recognize complications and treat them accordingly. The closed treatment of wounds and of bone infections dates back many decades. The Orr-Treuta techniques date from World War I. When adequately drained, the rigid dressing and closed management have proven beneficial. Over the last few decades the rigid dressing/IPOP system of management of persons with amputation has been repeated worldwide and is generally used today. It is considered by many surgeons to be the most satisfactory method of management of those with an amputation.

Regarding wound healing, it was noted (and continues to be recognized) that the rigid dressing system promotes, under appropriate circumstances, prompt, uncomplicated, and quiet wound healing. In our experience, progressive use of the temporary prosthesis "conditions" the residual limb more rapidly than the soft dressing management even when using pressure devices, such as elastic bandages and stockings. It is our experience that this particular external environment optimizes wound healing especially if, in addition to the immobilization, pressure relationships between the rigid dressing and the operated site assist in the control of edema. A number of experiments were carried out using tissue pressure studies during the course of the healing process in an attempt to establish optimum pressure relationships at the amputation site. We also gained some experience with a machine developed by the Roehampton London group, so-called Controlled Environment Treatment (CET). This system employed a plastic bag closed distally that opened proximally with a continuous flow of sterile air through the vented equipment. Pressure could be adjusted and maintained throughout the healing course and the wounds could be inspected through the dressing. The system was ingenious but had its drawbacks; it kept the patient in bed much of the time and it was quite awkward to utilize the bag as a temporary socket for prosthetic use. The pressure, humidity, and temperature of the CET were, however, appealing. This system is still being used with continuing study and improvement of the machine in Canada and England.

All of this relates to the subject of this editorial, wound healing and tissue repair. The IPOP management technique controls many of the external factors in which the amputation wound heals. The many biological factors that influence the wound healing internally have also come in for much interest and investigation in the last two or three decades. There are now wound healing societies in Asia, America, and Europe. A great deal of information has been obtained recently on the molecular biology associated with cell reproduction and wound healing. The discovery and use of a variety of biological growth factors and chemokines and cell receptors hold out the probability of their use in the clinical setting. It is interesting to recall from medical history some of the many types of applied treatment to assist wound healing in the past. A wide variety of materials has been used, including mixtures of chemicals and natural products, and even animal dung and live maggots, to promote wound healing. We are now at a stage of basic investigation of the subject that is rapidly opening up fields of knowledge that may be useful clinically.

Investigation into the basic mechanisms of wound healing is related to similar work proceeding in the field of oncology. The relationship between the cellular reproductive nature of wound healing and tumor development is obvious. Another area of

interrelated research has to do with wound healing and the aging of tissues. Clinical application of some of this basic information will certainly be forthcoming.

Basic factors of local blood supply and hemoglobin content, inhibition of wound healing by metabolic conditions (such as diabetes, uremia, and gout), and oxygen tension in the involved tissues all add to our increasing knowledge of this subject. Cultures of tissue requiring replacement (i.e., skin), when applied to appropriate bio-acceptable scaffolding, also are being studied. Such Tissue Engineering may soon replace tissue grafting. The future looks bright for applying some of the basic information obtained to the operating theater. Better control and knowledge of the response of healing wounds to both internal and external environmental factors are increasing.

It is well to recall that surgery does not heal. Surgery is primarily destructive. The moment the scalpel blade touches the skin, cells are damaged or killed. The best the surgeon can do regarding wound healing is to create an environment consistent with the circumstances, which allows the body to proceed and heal in an orderly manner. It must be remembered that the remaining residual limb is a person's contact with the earth, the environment.

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