EDEMA, HEMATOMA, AND INFECTION

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PURPOSE

The purpose of this paper is to discuss several factors which will contribute to optimal healing and a reduction in complications following forefoot surgery.

DEFINITIONS

Edema

Edema may be described as an abnormal accumulation of fluid in the interstitial space of the body. Classically, four types of edema have been described: dependent, malignant, non-pitting, and pitting edema. Dependent edema refers to swelling affecting the lower, or dependent parts of the body. Malignant edema is characterized by a rapid extension, quick destruction of tissue, and the formation of gas. This form of swelling is secondary to serious infections.

Non-pitting edema is usually caused by the coagulation of fluid within the tissues. The clinical hallmark is that this fluid can not be expelled or mobilized to other areas by external pressure. Also known as brawny edema, these findings are common characteristics of the patient with chronic venous stasis.

Pitting edema is noted when external pressure is applied to a limb and a persistent, slowly resolving depression is formed. This phenomena is a result of intercellular fluid being compressed and mobilized into adjacent tissue spaces. Upon release of the pressure the fluid slowly flows back into the previous location.

Hematoma

Hematoma is a mass of coagulated or extravasated blood in a cavity or closed tissue space. Postoperative hematoma may be caused by inadequate hemostasis, poor tissue handling during surgery, or whenever extensive dissection is required. At times it will be difficult to determine the exact cause, but one must still deal with the consequences. The body will respond to surgery with a variable amount of inflammation. Generally, the local postoperative response reflects the degree of tissue disruption. This leads to increased capillary pressures, enhanced capillary permeability, and the possibility of internal bleeding. Excessive edema may encourage some of these same effects. Failure of the patient to comply with postoperative instructions is another common reason for hematoma to develop.

Dehiscence

Dehiscence is a separation of wound margins which were previously approximated. This surgical complication may be caused by events specifically associated with the wound itself such as local tissue hypoxia due to excessive manipulation of the incisional area. More generalized problems such as a compromised vascular supply, metabolic or nutritional factors, and the anatomic location of the incision may create deficiencies favoring dehiscence. Excessive edema or hematoma may place undue stress on the incisional area or secondarily compromise vascular supply and local oxygenation. Tight dressings may also be implicated in some instances.

Infection

Excessive postoperative edema, hematoma, and wound dehiscence may create a scenario which favors the development of an infection. Hematoma may encourage the formation of a wound infection by obstructing the migration of inflammatory cells to the area of bacterial contamination. Local tissue oxygenation is also compromised. Blood is an excellent culture medium for bacteria, especially where tissues are not in optimal condition. If infection is suspected in the presence of a wound dehiscence or hematoma, it is essential that the surgeon obtain appropriate gram stains and culture and sensitivity studies. Appropriate antibiotics should be instituted as soon as possible, pending the results of the gram stain and culture and sensitivity tests. Proper tissue handling and anatomical dissection will help prevent excessive trauma to the tissues, and therefore, minimize inflammation and the chances for wound complications.

SURGICAL INJURY - INFLAMMATORY REACTION

Postoperative inflammation is a necessary factor for normal wound healing. Understanding the normal phases of wound repair will enhance the healing potential and minimize the risks of complications. Wound healing may be divided into three phases: the substrate or inflammatory phase, the proliferative phase, and the remodeling phase. The reader is referred to the additional references in the bibliography for a detailed understanding of each phase of wound physiology.

The first phase of wound healing (substrate or inflammatory phase) begins immediately after the skin incision is made and may last 3 to 5 days. At the time of surgical injury there is significant disruption of blood cells, subsequent mast cell degranulation, and general cell damage. Histamine, serotonin, lysomal enzymes and other compliment factors are released which cause increased vasodilation and enhanced capillary permeability. Serum, plasma proteins, and leukocytes will enter the intercellular spaces heightening this initial inflammatory response. The general effects of this inflammatory phase include leukocytosis, fever, and an increased erythrocyte sedimentation rate. (Fig. 1)

The proliferative phase of wound repair begins 3 to 5 days following surgery and ends at approximately 21 days. This period is characterized by epithelialization, wound contracture, the production of collagen, and the formation of fibroblasts. The latter events serve to increase the tensile strength of the wound. Suture removal is usually performed between the 14th and 21st days following surgery since the tensile strength of the wound is approximately 35% of normal by this time.

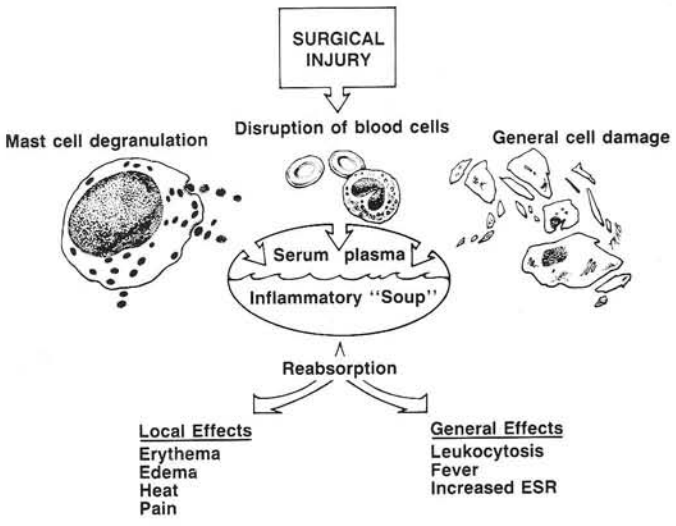

Fig. 1. Local effects and general effects of inflammatory response to surgical injury.

The last phase of wound healing is known as the maturation or remolding phase and may last for up to one year postoperatively. This is characterized by maturation of the scar with the enhancement of tensile strength as a more normal tissue state is approached. Existing collagen, after undergoing degradation and resynthesis, is reinforced by further cross-linkage significantly increasing the tensile strength of the wound.

CRITICAL ELEMENTS IN GAINING CONTROL OF THE HEALING PROCESS

RICE is an acronym for rest, ice, compression, and elevation. An understanding of the physiological effects of these basic elements will assist the surgeon in obtaining the most optimal surgical result.

Rest

Rest refers to physiological immobilization which restricts movement. Resting an injured area or surgical site postoperatively for the first several days not only helps to stop excessive bleeding, but promotes healing of damaged tissues. Immobilization can be instituted with simple bandaging techniques, splints, or casting. The functional importance of proper dressing techniques for operative wounds is discussed elsewhere in this paper. If saline soaked sponges are used directly over the wound, the bandage not only provides compression, but also an initial moist environment for the tissues. Fluids are pulled into deeper layers of gauze by an osmotic effect, leaving the wound itself free of drainage accumulation.

Ice

Cryotherapy following surgery reduces pain by decreasing the conduction velocity of the nerve fibers. Muscle spasms are also controlled postoperatively with the use of ice as it reduces the responsiveness of the muscle to stretching by blocking nerve conduction. Ice further produces a reflex vasoconstriction of the sympathetic fibers, thus decreasing painful swelling and bleeding following trauma or surgery. The normal postoperative inflammatory reaction is also diminished. However, excessive use of cryotherapy may actually retard the healing process by sustaining vasoconstriction.

Compression

Compression dressings when applied appropriately can help control excessive postoperative edema. The compressive bandage should be applied in concentric layers utilizing increased compression distally at the level of the digits, and

decreased compression proximally. It is important to have adequate layers of gauze coverage and to minimize any direct contact of inelastic materials such as Kling directly on the skin. Compressive dressings when applied evenly and without wrinkles or excessive tension will allow the normal postoperative inflammatory response without compromising circulation to the surgical site. An improperly applied compressive bandage can cause skin irritation and ulceration over potential danger zones such as the tibialis anterior tendon, first metatarsal-cuneiform joint, and the base or head of the 5th metatarsal. The Jones compression dressing is an excellent adjunct in postoperative care. Concentric layers of 4 inch cast padding and 6 inch ace wraps are utilized to immobilize the foot and lower leg in a supportive, yet very comfortable surgical dressing.

Elevation

The venous hydrostatic pressure in a standing adult male is approximately 90 mm of mercury at the level of the foot. In the postoperative foot this pressure may contribute significantly to the development of postoperative edema and pain. This is why elevation is the single most important factor in controlling excessive edema and preventing other complications. Elevation reduces internal bleeding and helps with the venous blood return to the heart. Postoperative throbbing can be readily alleviated by elevation of the foot above the level of the heart. Lymphatic drainage is also facilitated by elevation of the extremity. The urethane foam cast elevator (Spanaid) is commonly used at our institution for positioning and elevating the extremity following surgery.

WOUND MANAGEMENT - SURGICAL DRESSINGS

The surgical dressing not only maintains a sterile environment following surgery, but also serves as a source of compression, absorbency, and immobilization. Many different dressing materials have been employed at our institution. The saline soaked sponge has been the most widely used postoperative dressing for the past several years. In contrast to Adaptic and Owens dressing, the saline soaked sponge has the advantage of being a non-macerating dressing which discourages fluid collection at the surgical site. An osmotic effect tends to pull any drainage or debris away from the wound in the moistened dressing. Adaptic is an occlusive dressing which tends to increase fluid collection around the surgical site encouraging maceration. Owens dressing was originally fabricated from silk, but is now made of nylon, and also tends to increase fluid collection around the wound.

The use of postoperative drains following foot surgery has reduced the incidence of excessive edema and hematoma formation. At our institution an active drain is utilized known as the TLS closed suction drainage system. The closed suction (TLS) system has the advantage of working in a dependent and elevated position, while maintaining a sterile environment which can readily be cultured from the collection vacutainer. The system is also at less risk for contamination in contrast to the traditional penrose drain which is prone to maceration and strike-through. The use of drains is indicated whenever there is extensive dissection or exposure of large segments of medullary bone, and when there is the potential for the formation of a dead space. The use of closed suction drainage following surgery of the foot and leg has markedly decreased the incidence of excessive postoperative edema, hematoma, and wound dehiscence, as well as reducing postoperative pain and discomfort. Once the drain is non-functional, it is carefully removed followed by compressive bandaging.

Surgical Suturing Techniques to Prevent Delayed Healing and Wound Dehiscence

Delayed healing may be avoided by proper wound closure techniques. The optimal skin closure should be end to end skin closure with direct approximation of the skin margins of the wound or slight eversion of the skin margins. The surgeon should avoid inversion of skin edges to help prevent delayed healing or wound dehiscence (Fig. 2).

Sutures which are too tight and too few in number are also a potential cause of delayed healing which may lead to wound dehiscence (Fig. 3).

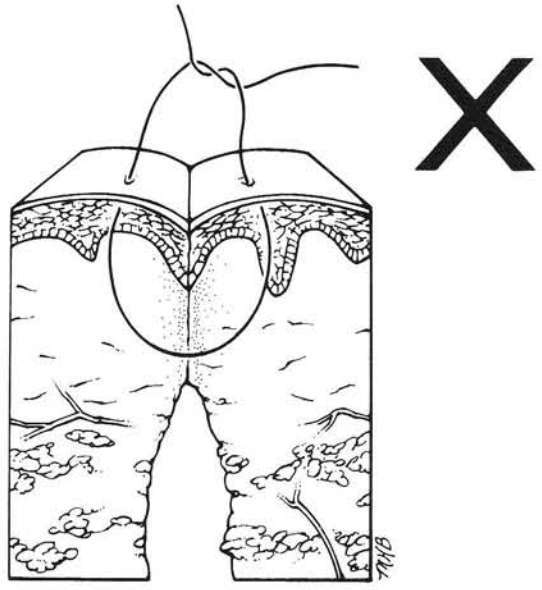

Fig. 2. Avoid inversion of skin edges.

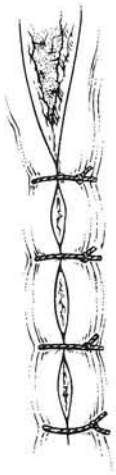

Fig. 3. Avoid Sutures too tight and few in number.

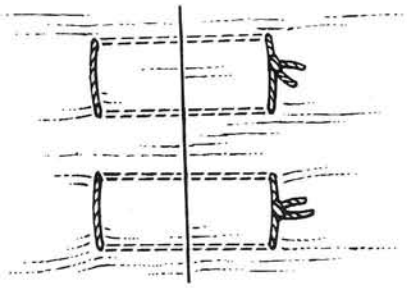

Fig. 4. Avoid incisions at right angles to the skin lines. Note that a horizontal mattress suture in this case helps prevent separation of the skin incision.

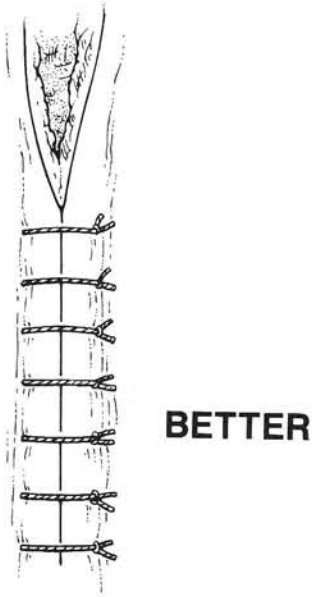

Fig. 5. Plan incisions parallel to the skin lines to help prevent delayed healing.

The placement of the skin incision is important in preventing post-operative complications including delayed healing. Incisions placed at right angles to the relaxed skin tension lines are more difficult to coapt without tension and more likely to produce greater scar formation. In these instances, the choice of a horizontal or vertical mattress type suture is recommended to increase the tensile strength of the skin closure (Fig. 4).

The surgeon should plan incisions parallel to the relaxed skin tension lines if possible (Fig. 5).

Anatomical dissection and proper tissue handling is essential in preventing wound complications. The experienced surgeon will dissect layer by layer identifying the anatomical structures while preserving the neurovascular supply to the tissues. The use of proper surgical technique, hemostasis, intraoperative irrigation, and proper compressive dressings help prevent the formation of dead space in the surgical

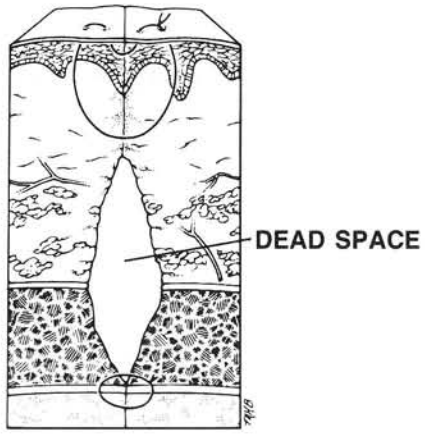

Fig. 6. Eliminate dead space to help prevent the formation of fibrosis and hematoma formation.

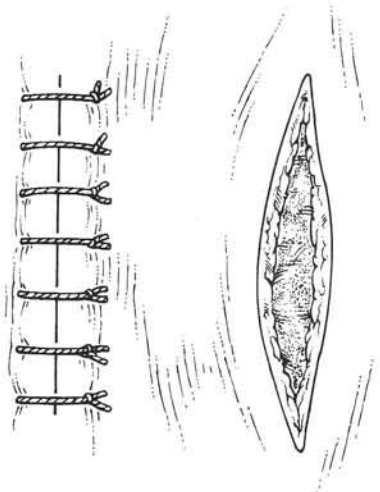

Fig. 7. Parallel release skin incisions help to release tension on the surgical wound.

wound. This dead space may become filled with blood. In addition to the immediate concerns regarding hematoma previously discussed, coagulated blood will eventually be converted to a fibrous mass before full resorption. This tends to encourage excessive fibrosis at the surgical site (Fig. 6).

There are occasions when the surgeon may utilize relaxation incisions to prevent tension on the wound before final closure. The relaxation incisions are placed parallel to the primary surgical incision allow primary closure of the surgical wound without necrosis or damage to the skin margins, hopefully preventing delayed healing and wound dehiscence (Fig. 7).

CONCLUSION - SUMMARY

This paper presents and discusses the factors which contribute to optimal healing following forefoot surgery. The inflammatory reaction following surgery is a normal phase which is necessary for wound healing. The importance of proper tissue handling and anatomical dissection cannot be over emphasized as they are essential in preventing excessive trauma to the tissues. Otherwise, the inflammatory response following surgery will be exaggerated and possibly lead to excessive edema, hematoma, wound dehiscence, and conditions which favor infection. Early recognition of these complications and aggressive treatment of the excessive inflammatory response is essential in preventing later sequelae.

It is hoped that this presentation will help stimulate more interest in applying basic physiology and fundamentals in the postoperative management of the surgical wound.

Bibliography

1. Berger DL: "Use of Drains in Foot Surgery," *J Foot Surg* 27:245-247, 1988.
2. Black JR, Ward RJ: "Infection and Immunosuppression," *J Am Podiatr Med Assoc* 77:165-169, 1987.
3. Cocke WM, Lynch DJ, White RR, Verheyden CN: *Wound Care.* Churchill Livingstone Inc, pp. 10-13, 1986.
4. Davis RH, Kabbani JM, Maro NP: "Aloe vera and Wound Healing," *J Am Podiatr Med Assoc* 77:165-169, 1987.
5. Davis RH, Leitner MG, Russo JM: "Aloe Vera; A Natural Approach for Treating Wounds, Edema, and Pain in Diabetes," *J Am Podiatr Med Assoc* 78:60-68, 1988.
6. Dennis KJ, Harkless LB: "Plantar Skin Graft Complications in a Diabetic Male," *J Am Podiatr Med Assoc* 76:341-343, 1986.
7. Elsahy NI, Kalish S, Vito GR: "Cross-Leg Full-Thickness Skin Graft," *J Am Podiatr Med Assoc* 78:632-635, 1988.
8. Guyton AC: *Textbook of Medical Physiology,* III ed. W.B. Saunders Co: 130, 446-456, 1966.
9. Hoffman SJ, Thul JR, Zainer GR: "Use of Tissue Expansion in Podiatric Surgery," J Am Podiatr Med Assoc 78:34-40, 1988.
10. Latham W, Lefkowitz H, Steiner I: "Hydrocolloid for Deep Wound Dehiscence," *J Am Podiatr Med Assoc* 79:74-76, 1989.
11. Miller SJ: "Edema, Hematoma, and Infection," in McGlamry, ED (ed) *Comprehensive Textbook of Foot Surgery,* Williams & Wilkins, Baltimore, Maryland, 1015, 1031, 1034, 1987.
12. Miller SJ: "Postoperative Management," in McGlamry ED (ed) *Fundamentals of Foot Surgery,* Williams & Wilkins, Baltimore, Maryland, pp. 294-314,1987.
13. Nealon TF: *Fundamental Skills in Surgery.* W.B. Saunders Co: pp. 46-54, 1962.
14. Peacock EE, Winkle WV: *Surgery and Biology of Wound Repair.* W.B. Saunders Co: pp. 28-29, 532-535, 1970.