Continuing Medical Education

Surgical Complications and Their Treatments

A comprehensive approach can minimize the consequences of these events.

Goals and Objectives

After completing this CME, the reader should:

1) Be able to have a better understanding of the potential types of complications noted with reconstructive foot and ankle surgery.

2) Better understand the physiological changes that occur when complications appear following elective surgery of the foot.

3) Have a better appreciation for the methods necessary to prevent many of the possible complications from occurring.

4) Be able to describe the factors involved with postoperative infections and their prevention.

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Following this article, an answer sheet and full set of instructions are provided (p. 198).—***Editor***

By Mary Elizabeth Crawford, DPM

This CME is adapted from: Dockery GL and Crawford ME (eds): Lower Extremity Soft Tissue & Cutaneous Plastic Surgery, Elsevier Sciences (Saunders), Philadelphia, 2006.

Introduction

The final surgical outcome of any operative procedure is unknown until healing is complete and scar remodeling has taken place. It is the goal of any surgeon to have an optimal outcome but in some cases, complications can occur that may compromise the end result. It is with this thought in mind that a comprehensive treatment program for the most common complications be discussed.

Complications can be as trivial as slight increased bleeding intra-operatively that is easily controlled with electrocautery or ligation of a vessel, to major complications such as cardiac arrhythmia or arrest. As the surgeon embarks on a surgical procedure, many issues must be addressed. The overall health status of the patient must be assessed. Some patient factors significantly impact the final outcome, such as malnutrition, particularly a lack of adequate protein. Albumin less than 3.5 g/dL has been found to adversely affect healing, as has dehydration, anemia and vitamin deficiency.

Certain underlying systemic medical conditions and medications also need to be taken into considera-

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tion by the surgeon as they may affect the healing potential of the patient. It is imperative that the surgeon be aware of any underlying medical conditions or current medications that the patient may be taking so as to manage the surgical wounds appropriately.

Uncontrolled diabetes mellitus may increase the patient risk of post-operative infection due to hyperglycemia impeding leukocytic phagocytosis and white blood cell migration. Immunosuppression disorders and immunosuppressive drugs such as adrenal corticosteroids predispose the patient to delayed healing by retarding the required inflammatory reaction that wounds must go through, and thereby increase the risk of infection. Chemotherapeutic agents have a similar effect on wound healing, and result in immunosuppression that can interfere with the development of wound tensile strength. A patient on current anticoagulation therapy, or a patient with an underlying coagulation disorder such as hemophilia, can predispose the patient to hematoma formation that leads to many related post-operative complications.

Smoking is a major risk factor in cutaneous surgery, especially procedures that involve the creation of a skin flap. Skin flaps rely on small fragile vessels to provide blood supply to the flap; the chemical agents found in cigarette smoke significantly affect these vessels. Vasoconstriction from these products occludes the blood supply to the flap and results in flap necrosis and flap failure. Abstaining from smoking is a mandatory requirement for all patients undergoing plastic or cutaneous surgery to avoid these unnecessary complications. As the surgeon evaluates a patient for possible surgical intervention, these factors should all be taken into consideration to better manage the patient peri-operatively.

Smoking is a major risk factor in cutaneous surgery, especially procedures that involve the creation of a skin flap.

Although many of the above factors are not within the control of the surgeon, there are some complications that can be avoided, providing the surgeon follows certain precautions. Meticulous handling of tissues, proper placement of surgical incision preferably within relaxed skin tension lines, minimal tourniquet time, avoidance of deep dead space, closing of wounds without tension, and everting wound edges can all lead to fewer post-operative complications.

Many surgical complications are often interrelated, with bleeding being the most expected and most common surgical complication. Bleeding can lead to hematoma formation post-operatively, which can result in increased swelling and increased tension on the wound. Increased tension on the wound may lead to wound dehiscence and necrosis that may then increase the risk of post-operative infection. This cascade of complications can be interrupted anywhere along its path to alter the final outcome.

Bleeding Complications

As stated above, bleeding complications are the most common peri-operative difficulties and should be expected during every surgery. Some bleeding occurs during every surgery and usually is not a complication unless the surgeon is unaware of an underlying bleeding disorder, and precautions were not taken or meticulous dissection is not performed to appropriately cauterize or ligate bleeding vessels intra-operatively.

The surgeon must fully understand the various processes that the bleeding vessels undergo to achieve hemostasis and where certain disorders or medications may affect that process. There are two methods of hemostasis that work together to resolve bleeding. The primary method is platelet-driven and, after vessel injury, results in formation of a platelet plug. The secondary method is fibrin-driven that stabilizes and matures the platelet plug. Vascular injury exposes the subendothelial connective tissue to which platelets adhere. Collagen then binds to the platelet cell receptor and activates the platelets to release a chemical that causes the platelets to begin to aggregate and adhere to each other.

Activation of the platelets modifies the surface so that fibrinogen can link platelets and lead to clot maturation. As the platelet plug matures, the secondary phase begins. Prothrombin converts to thrombin and the thrombin converts the fibrinogen to fibrin. Fibrin polymerizes with the platelet plug to form an insoluble gel. Cross-linking of the insoluble gel produces a final

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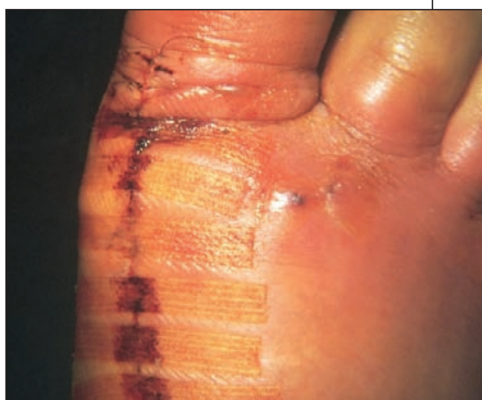

Figure 1: Late sequelae of bleeding with hematoma formation. It is important to evacuate the hematoma at this time before it totally coagulates.

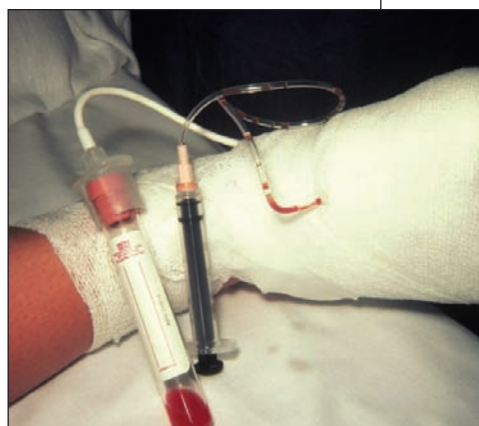

Figure 2: Prevention of hematoma from deep wound site by using small vacuum drains post-operatively.

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mature clot. Any factor that interferes with this cascade of events may result in undesirable bleeding peri-operatively. These factors include mechanical failure, thrombocytopenia, platelet dysfunction, pharmacological interference and acquired or congenital defects.

When a blood vessel is cut, it immediately constricts to reduce the diameter of the vessel and to slow the blood flow so that platelet aggregation can occur. A vessel that is only partially transected may not be able to constrict or retract, thereby preventing the reduction of blood flow and platelet aggregation required to create the platelet plug. Vasoconstriction may be aided with the addition of epinephrine to the local anesthetic infiltrated in the area; however, the surgeon should exercise caution in relying on the epinephrine to decrease bleeding. The induced vasoconstriction may mask the bleeding site until after closure when the effects of the epinephrine dissipate and bleeding begins again. This will lead to complications of excessive swelling and hematoma formation. All bleeding areas should be explored and identified when possible to avoid these complications.

The platelet plug formation is crucial to achieving hemostasis during any operative procedure. A reduction in number of available platelets or dysfunction of the platelets present can lead to disastrous bleeding complications. Thrombocytopenia is a reduction in the number of available platelets. It may be seen with either impaired production of platelets or increased destruction of platelets. As platelets are produced primarily in bone marrow, a bone marrow malfunction can lead to reduced numbers of platelet. An increased destruction of platelets can be seen with idiopathic thrombocytopenia purpura, drug reactions, disseminated intravascular coagulation (DIC) or vasculitis.

Either way, the loss of platelet plug formation prevents the usual cascade of events from occurring and increases bleeding complications. Dysfunction of the platelets present is more commonly seen and is usually a result of aspirin intake. Aspirin irreversibly binds to platelets and inhibits platelet aggregation. Once the platelet plug forms several days post-operatively, aspirin will not affect the stability of the clot. Non-steroidal anti-inflammatory drugs (NSAID's) bind reversibly to the same point on the platelet as aspirin. They also inhibit platelet function but not permanently. The effect of the NSAID is usually voided after approximately four half-lives of the medication and the surgeon can proceed with the operative procedure with diminished risk of bleeding.

Bleeding complications are the most common peri-operative difficulties and should be expected during every surgery.

Inherited clotting disorders are more difficult for the surgeon to regulate. Some disorders are almost impossible to detect until bleeding complications occur peri-operatively and further investigation and advanced testing is performed after the fact to determine the cause.

Any alteration of the intrinsic or extrinsic clotting mechanism will lead to abnormal bleeding. One of the most common genetic disorders is von Willebrand's factor deficiency. Unless a patient was aware of having this disorder and reported it in the initial history, most surgeons would be unaware of this condition until post-operative testing was done to reveal the deficiency. The von Willebrand's factor deficiency is an autosomal dominant inherited disorder. It serves as a plasma carrier for Factor VIII, which is vital for the clotting cascade. The factor also facilitates platelet adhesion. A decrease in von Willebrand's factor may lead to a decrease in Factor VIII. Laboratory evaluation of the patient will reveal prolonged bleeding time and a decrease quantitative value for von Willebrand's factor.

A patient may also have a true decrease in Factor VIII resulting in Hemophilia A disorder. Factor VIII regulates activation of Factor X, and can lead to gross deficiency in clotting mechanism with a multitude of post-operative bleeding complications. Hemophilia B, also known as Christmas disease, is a deficiency of Factor IX and is inherited only in males. It cannot be clinically distinguished from Hemophilia A. Other deficient elements, such as fibrinogen or other clotting factors, can all lead to bleeding complications but are rarely tested for until post-operative difficulties develop.

Surgical bleeding complications can be seen acutely during the surgery, immediate post-operatively, or several days later. Acute bleeding is usually seen

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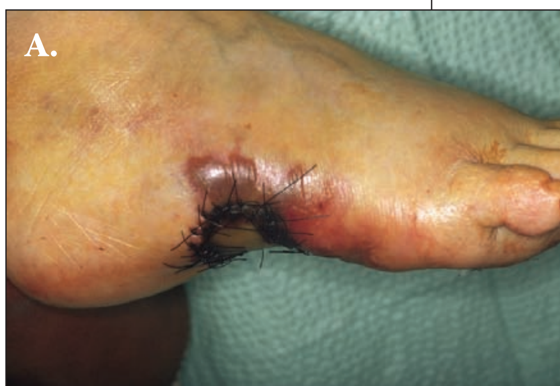

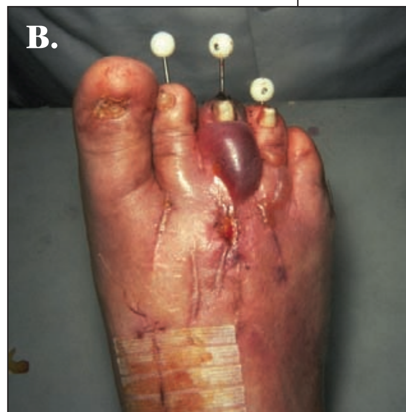

Figure 3: Seroma formation. A) Adjacent to a rotation flap. B) Involving the third toe which had previously undergone several surgeries. The serosanguinous fluid was evacuated in each case with no further complications of healing noted.

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with the transection of a vessel intra-operatively. The vessel is usually clamped and cauterized or ligated to prevent further bleeding. In patients with some form of bleeding disorder, whether drug induced or inherited, bleeding from small, almost invisible vessels may result in a persistent oozing that makes it difficult to isolate a vessel to achieve hemostasis. A surgeon may choose to utilize a Shaw scalpel or carbon dioxide laser to perform the incision and dissection as these instruments cauterize and seal the bleeding vessels as the incision is being made.

A less common bleeding complication occurs post-operatively generally within the first few hours after the procedure with sudden spontaneous bleeding within the wound. As the wound is already closed, direct pressure for 10 to 15 minutes may control the bleeding and allow early clot formation; however, if not successful, the wound may need to be reopened and the bleeding vessel identified. This may be a complication of the vasoconstrictive property of epinephrine that provides the surgeon with a false sense of security that the bleeding is well-controlled upon closure. When the epinephrine effect dissipates, there is a risk of return of bleeding from smaller vessels that were not cauterized at the time of the surgery. Fortunately, the vasoconstriction of epinephrine is usually short-lived and most vessels are properly identified prior to completion of surgery.

Hematomas

The late sequela of post-operative bleeding is the formation of a hematoma within the closed tissue space (Figure 1). A patient will experience increasing post-operative pain with greater swelling, scarring, and wound complications that could increase the risk of infection. It is often difficult to differentiate the formation of a hematoma from an early post-operative infection. There is usually intense local inflammation and pain due to increasing expansion of the hematoma within the tissues.

The platelet plug formation is crucial to achieving hemostasis during any operative procedure.

Pain and swelling occur customarily earlier in hematoma formation than in infection, usually within the first 24 hours, while infection is ordinarily within the first 72 hours or longer.

As the hematoma develops, the pressure on the surgical wound could result in necrosis of the tissue or wound dehiscence that may require the surgeon to open the wound and evacuate the hematoma, allowing the wound to heal by secondary intention. There is increased risk of infection as the accumulated blood provides an excellent culture medium for bacterial growth. The hematoma obstructs the phagocytic cells from entering into the area to remove the bacteria and the presence of the excess ferric ions makes the bacteria more virulent.

With the decreased phagocytosis, along with a more virulent bacterial strain, the hematoma enhances the formation of a post-operative infection. In some cases, the hematoma will not be discovered in time and may consolidate and become fibrotic. This will lead to increased induration with dense scarring due to the increased fibroplasia and can be difficult to resolve.

Prevention and Treatment

The best treatment for hematoma formation is prevention with meticulous dissection and attention to hemostasis along with compressive dressings and closed suction drains in deep dead spaces (Figure 2). In the early stages of hematoma development, evacuation of the hematoma may be of benefit to decrease the tension on the wound edges. A few of the overlying sutures can be removed and then gentle pressure on the sides of the wound may express the hematoma. The incision is then left open and allowed to heal secondarily.

The longer the hematoma has been developing, the less effective this method as the hematoma is too organized. Aspiration is also possible to remove some of the clotted blood but only early on when the hematoma is still somewhat fluctuant. In some cases, the hematoma applies too great a pressure on the wound and interferes with normal post-operative healing. The hematoma should be evacuated under sterile operating room conditions with liberal irrigation and vessel ligation to avoid further bleeding complications. Once a hematoma consolidates within the wound, gentle massage and warming of the tissues may accelerate enzymatic degradation of the hematoma. Ultrasound, hydrotherapy and range of motion exercises may also be helpful to break up the fibrin network of the hematoma and reduce future scarring.

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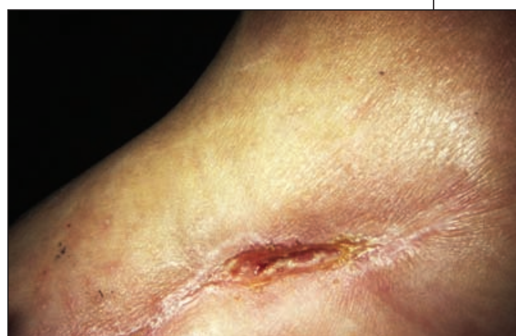

Figure 4: Wound dehiscence. Frequently there will be thick fibrous tissue formation at the edges of the incision following dehiscence.

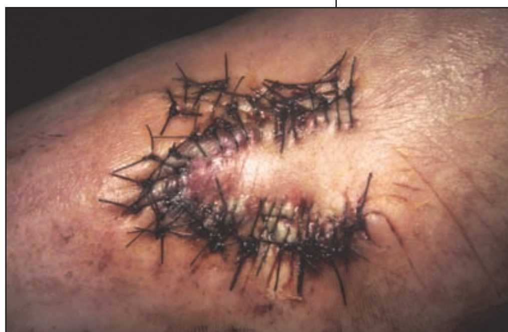

Figure 5: Flap tip necrosis due to inadequate blood flow to tip of the flap. Very large flaps or ones that are poorly designed also are at risk for failure.

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Occasionally, intralesional injection of corticosteroids can be utilized, if the wound is sufficiently healed.

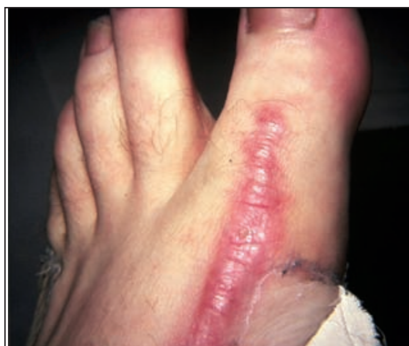

Figure 6: Hypertrophic scar with thickened raised hyperpigmentation.

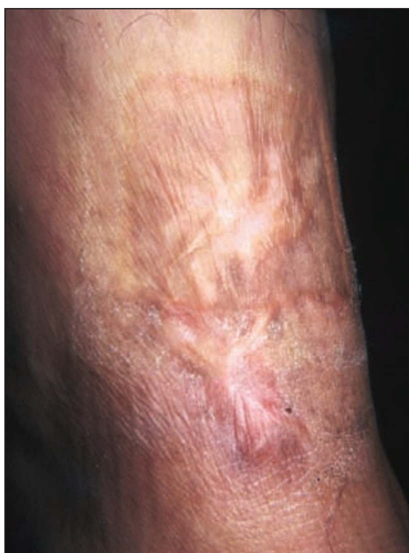

Figure 7: Keloid formation well beyond the original wound margins.

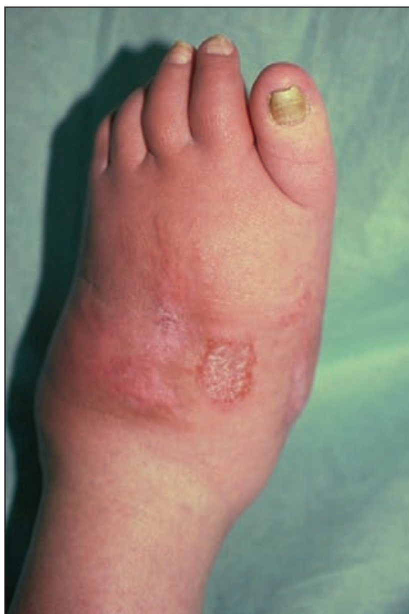

Figure 8: Severe postoperative edema.

Seroma formation has similar effects on the wound as the hematoma, with the extravasation of serum or serosanguinous fluid into a closed space. Usually seen early in the inflammatory process of wound healing, seroma is a common complication of skin grafts and is frequently noted in areas of previous surgery (Figure 3). Serum does not clot; therefore it is amenable to extraction with a large bore needle and syringe, or if under a skin graft, a small nick can be made in the graft to remove the fluid and allow the graft to lie down on the recipient bed.

Wound Dehiscence and Necrosis

Wound dehiscence is almost always related to some other complicating event, such as hematoma formation, edema, superficial or deep infection, or premature suture removal (Figure 4). In some situations, the sutures may be prematurely removed due to infection or the need to express an underlying hematoma. Some patients heal more slowly than others due to underlying systemic diseases, vascular compromise or smoking. Wound dehiscence is usually treated with wound care and healing by secondary intention, although some surgeons may choose to close a wound if within the first 24 hours and there is no underlying contraindication such as infection. If the dehiscence is left to heal slowly, there may be excessive fibrous tissue formation along the edges of the incision.

The late sequela of post-operative bleeding is the formation of a hematoma within the closed tissue space.

The wound may be compromised as well by the sutures implanted at the time of closing. The sutures can be tied too tightly, causing ischemia or necrosis, especially with the post-operative edema that naturally occurs. Conversely, sutures can become untied and the wound will open. A suture can also lead to a sterile stitch abscess after removal. The sterile abscess is a result of an inflammatory reaction in the suture tract. This differs from a suture reaction in which there is "spitting" of the stitches. This can occur if a deep suture knot is tied too closely to the surface and a small erosion occurs, exposing the tuft of suture.

Wound necrosis may result from similar conditions as wound dehiscence and can actually be one of the causes of wound dehiscence. Necrosis can be seen with formation of a large hematoma or seroma, infection, or inadequate blood supply to the wound, usually as a result of pressure. Flap survival is dependent on circulation from the base to the tip of the flap. This may be compromised for a variety of reasons, the most common being poor flap design (Figure 5).

In most cases of failure due to inadequate circulation, the base of the flap is too narrow for the length of the flap or the flap was created at the wrong intersection of the angiosomes. It used to be dogma that the length to base ratio could not be greater than 3:1. Any longer of a flap, the pedicle could not supply adequate circulation to the apex of the flap and necrosis would occur. The knowledge of the angiosomes and the opening of choke vessels have now made this belief almost obsolete, although many surgeons still adhere to this rule. Another reason for flap necrosis is the inadvertent cutting or cauterization of the pedicle arterial vessel that feeds the flap.

Necrosis of a graft that relies on the vascularity of the recipient bed below usually occurs when a seroma or hematoma lifts the graft from the underlying bed. A graft that is cut too small to cover the defect and then stretched to accomplish this also is at risk for necrosis. As with a flap and other surgical procedures, smoking results in increased hypoxemia and eventual necrosis. In contrast to wound dehiscence, debridement for wound necrosis is per-

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formed early only if infection is present. Otherwise, the wound is allowed to demarcate so only nonviable tissue is removed.

As wound dehiscence and necrosis can result from excess tension on the wound at the time of wound closure, surgical techniques may be necessary to alleviate tension on the wound. The first is to perform a relaxing incision approximately 2 to 3 cm. away from and parallel to the wound edge. The initial wound is closed first and then the relaxing incision is undermined and closed.

Another option, if available, is to utilize a commercially available tissue expander or other device to stretch the tissues. A final option may be to only partially close the wound up to the point of excessive tension, and then allow the remaining portion of the wound to close by secondary intention. These techniques may help avoid some of the wound complications that occur with excess tension such as wound dehiscence, necrosis, scar widening, and hypertrophic scar formation.

Wound dehiscence is almost always related to some other complicating event, such as hematoma formation, edema, superficial or deep infection, or premature suture removal.

Scar Formation

Scar formation post-operatively can be a frustration for the surgeon and the patient. Hypertrophic scars are usually symptomatic, thickened, raised, usually pigmented scars that do not extend beyond the margins of the wound (Figure 6). One of the treatments available is high potency steroid injected into scar or applied topically. The steroid will usually decrease the erythema, itching, and pain associated with the scar, but will not return it to normal. Another popular treatment for scars is the use of silicone gel sheeting topically. This decreases the thickness and hyperpigmented nature of scars and softens them significantly.

A keloid scar formation is even more of a dilemma. The scar is extensive, hyperpigmented and forms well beyond the original wound. The scar can be massive and often painful (Figure 7). Unfortunately, the keloid scar is very resistant to many treatments. Excising the keloid will usually just lead to more keloid formation, possibly even larger than it was prior to excision. Injected steroids may help some. The carbon dioxide laser may show some improvement when employed to excise a keloid. In any event, the scar is the only aspect of the surgery that the patient can see and efforts should be taken to minimize scarring as much as possible with atraumatic surgical technique, buried sutures to reduce tension on the scar, and appropriate post-operative wound care.

Post-operative Edema

Some post-operative edema can be expected as part of the increased vascular permeability of the normal inflammatory process. Inflammation is a universal response of tissue to injury whether trauma or surgically induced. The early inflammatory response serves three purposes: initiate a massive humoral and phagocytic assault on tissue invaded by bacteria, localize and isolate the reactive area and prevent the spread of bacteria, and provide the initial clean-up by removing bacterial debris and dead tissue.

The inflammatory process results in four cardinal signs that can easily be confused with signs of hematoma formation or incipient infection. Swelling (tumor), redness (rubor), heat (calor) and pain (dolor) are seen with all three of the above conditions, which make for a difficult differentiation. The amount of post-operative edema can be excessive as a result of a patient's response to the injury, a more significant tissue injury or extensive procedure, or patient non-compliance (Figure 8).

The increased vascular permeability allows for the extravasation of fluid into the extracellular tissue spaces, primarily the subcutaneous tissue. Increased permeability may be the result of histamine and histamine-like permeability factors that are released early on as a result of the surgical insult, or increased vascular permeability may be due to direct vascular or cellular injury. Endothelial cell destruction occurs by extensive surgical dissection and may take one or two days to repair the area.

The more damage the cells sus-

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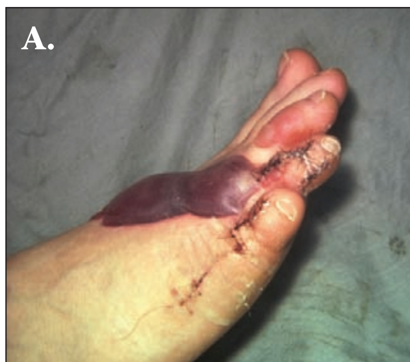

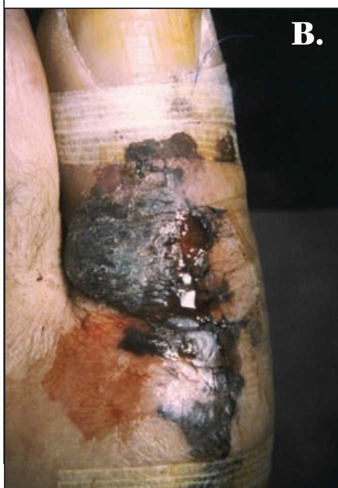

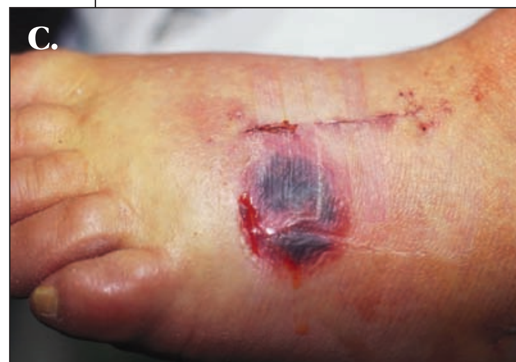

Figure 9: Fracture blisters. A) following severe edema. B) and C) due to edema and reaction to Steri-strips.

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tain, the more protracted the edema. Lymphatic vessels play a key role in removing the protein-rich fluid from the extracellular spaces and rapidly dilate to several times their normal caliber early in the inflammatory phase.

Prevention and Treatment

The prevention and treatment of excessive edema are important to avoid unnecessary complications. Utilizing proper surgical atraumatic techniques and anatomic dissection can prevent some edema. Injection of short-acting corticosteroids, mixed with local anesthetic agents, at the time of the surgery can help limit the intensity of early inflammation and control edema formation but a certain amount of inflammation must take place for normal post-operative healing to occur. Compressive dressings can be part of the collaborative effort along with elevation to assist lymphatic drainage and ice to provide some vascular constriction to control post-operative edema. NSAIDS can also be utilized to reduce the amount of inflammation and swelling. Other treatments to reduce the degree of edema include range of motion exercises to indirectly pump lymphatic fluid and encourage circulation, compression therapy, massage, therapeutic ultrasound, and galvanic stimulation.

Fracture blisters can occur with the insult of surgery and usually present when large amounts of swelling occur (Figure 9 A-c). There are two different types of fracture blisters, clear fluid-filled and blood-filled. Clear-filled blisters retain some epidermal cells still attached to the dermis, whereas blood-filled ones retain none of the epidermis. The preferred method of treatment is to aspirate or drain under sterile conditions, but to retain the roof of the blister to prevent infection.

A blister surrounding the wound may also occur post-operatively due to a contact dermatitis from the skin preparation agents, or agents applied to the dressings, from the Steri-strips or other tape applied to the skin, or from the application of a topical antibiotic to the wound. Many patients feel compelled to apply antibiotic ointments and creams to a wound following suture removal. There is a very high risk of a patient having contact sensitivity to an applied antibiotic, especially neomycin, the most common over-the-counter antibiotic available. This should be strongly discouraged due to increased risk of complications.

As wound dehiscence and necrosis can result from excess tension on the wound at the time of wound closure, surgical techniques may be necessary to alleviate tension on the wound.

Post-operative Infection

There are three required elements to produce a post-surgical infection—a receptive host, contamination by micro-organisms and a wound culture medium to support bacterial growth. The United States Center for Disease Control and Prevention report the post-operative infection rate for a clean, uncontaminated surgery to be 2.1%.

Skin provides a great barrier to invading bacteria. Once a portal of entry is established, bacteria can penetrate into the deeper layers where resistance is diminished. Infection in a closed wound is much more problematic than a superficial infection in an open wound (Figure 10 A-C). During the operative setting, contamination of the wound can occur from several sources including glove punctures, contamination of sterile draping and instrumentation, or ineffective skin scrub.

The length of the procedure may also play a role in the contamination of the wound with the infection rate almost doubling for every hour of operating time. So there appears to be no single factor that influences contamination of the wound. The physiologic state of the patient and the wound before and after the surgical procedure appear to be a more significant factor in developing a post-operative infection than contamination of the wound by bacteria.

Besides the overall health of the patient and contamination of the wound, the wound must provide a culture medium for the bacteria to flourish into a full post-operative infection. Ischemic or necrotic wounds provide an excellent medium for bacterial growth. These tissues lack sufficient oxygen and nutrients to cope with wound healing and the impending infection.

The necrosis may be due to des-

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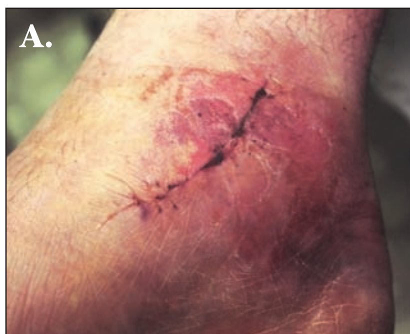

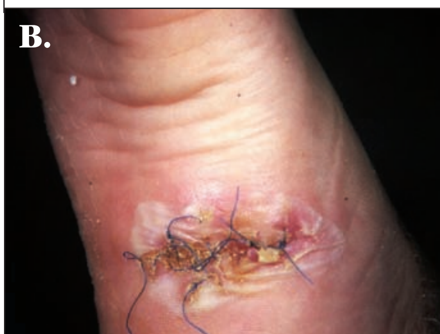

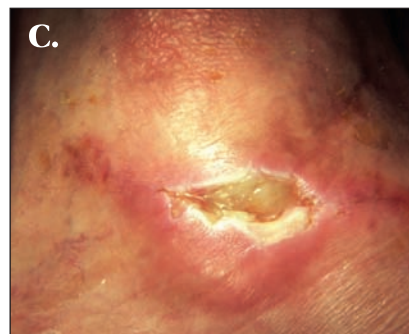

Figure 10: Infection. A) Closed space deep infection. The area was swollen, hot and erythematous. B) Superficial open wound infection. C) Superficial wound infection with maceration.

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ication of the wound, extensive electrocautery, rough handling of the tissue, prolonged tourniquet use, excessive edema, or high concentration of epinephrine. Foreign bodies or implants also provide a good culture medium for bacteria. Sutures, prostheses and fixation devices all locally decrease a host's resistance to bacteria.

As severity of wound infection increases, the enhanced inflammatory response has a negative effect on wound healing. Proteolytic enzymes are released from the inflammatory cells, which speeds the resorption of buried sutures, decreasing wound support and increasing wound dehiscence. From the open wound, samples of the drainage can be collected for culture and sensitivity studies and gram stain.

Hypertrophic scars are usually symptomatic, thickened, raised, usually pigmented scars that do not extend beyond the margins of the wound.

As the culture may take a few days to return, empiric antibiotics may be started based on the gram stain findings, the location of the infection, and the most likely organisms found in that area. The first line of coverage is usually with an antibiotic that will cover Staphylococcus aureus until the laboratory cultures are available with confirmation of infecting organism.

It can be challenging to differentiate the early pathological process of an infection from the normal physiological response of post-operative inflammation. The signs and symptoms of early infection include severe pain unresponsive to strong analgesics, peri-incisional edema, erythema, and radiating heat.

This can be seen, however, with hematoma formation, acute gout, inflammation, tight dressings and tight casts. It is the additional signs and symptoms that develop with continued infection that aid in the diagnosis: fever, chills, night sweats, loss of appetite, red streaking and lymphadenopathy. These symptoms usually present later in the infection process.

Laboratory Testing

Laboratory testing can help confirm the presence of infection as well as the responsible organism(s). Culture and sensitivity is the standard of care for infection management to determine the bacteria and the appropriate antibiotic coverage. A complete blood count with an elevated neutrophil count and an elevated white blood cell count will also give suspect to an ongoing infection. Blood cultures are seldom necessary in cutaneous surgery due to the rarity of bacteremia or septicemia.

A variety of bacteria may be cultured from the post-operative infected wound, the most common being S. aureus. This is closely followed by S. epidermidis, which used to be thought of as a skin contaminant in the culture but is now becoming more virulent and is frequently the causative organism when implants are present. Staphylococcus infections are intensely erythematous, swollen, tender, with a localized abscess consisting of creamy thick pus (Figure 11).

Another common invading bacterium is B hemolytic group A streptococci. Streptococcus infections are intensely red with cellulitis and extreme warmth but no purulence is seen, only occasional serous drainage (Figure 12).

Streptococcus infections can dissolve fibrin clots and spread rapidly leading to septicemia if diagnosis is delayed. Gram (-) bacilli may also be isolated from an operative infection but is more rare in cutaneous surgery than the gram (+) cocci above. Escherichia coli, klebsiella, proteus, pseudomonas, enterobacter, and Serratia are the most common gram (-) bacteria.

Any bacteria can lead to a post-operative infection but based on the site of the infection and the local conditions, some organisms such as gram (-) rods, candida, and anaerobic bacteria are far less common in cutaneous surgery.

Prevention and Treatment

The best treatment for a post-operative infection is prevention. The surgeon must adhere to strict aseptic sterile protocol peri-operatively, as well as be on alert for any signs and symptoms post-operatively that may correlate with an insidious infectious process. Prophylactic antibiotics are universally accepted as a method to decrease the incidence of post-operative infections.

There is some controversy and little scientific data to substantiate when prophylactic antibiotics are best utilized and under which circumstances, but there are accepted anecdotal guidelines that many surgeons follow when considering antibiotic use. Prophylactic antibiotics are often instituted when a procedure involves the implantation of a foreign material such as a tissue graft, metallic screw or implant, or a surgical procedure that involves extensive dissection or prolonged wound exposure of over two hours.

Trauma-induced wounds are also considered contaminated due to exposure or vascularly compromised due to injury and represent a high-risk patient population for infection. A patient compromised by a heart condition or valvular defect, immunosuppressive agents or peripheral vascular disease is

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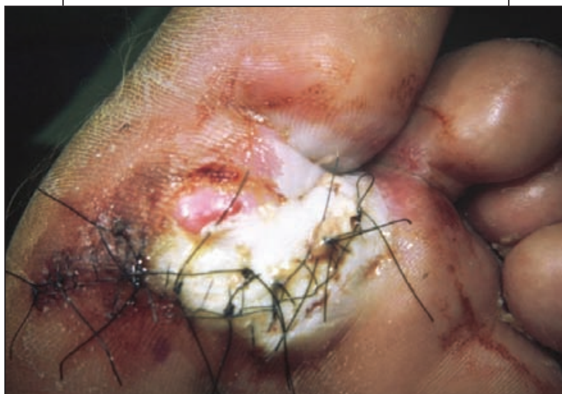

Figure 11: Staphylococcus infection with thick purulent drainage, maceration and erythema.

also at risk of a serious and potentially life-threatening post-operative infection and is frequently given a prophylactic antibiotic to try to avoid these complications. The controversy surrounding prophylactic antibiotic use continues with which antibiotic agent to select and the appropriate duration of antibiotic coverage.

Some general concepts are that the antibiotic must be in the tissues before the wound is opened and exposed, the antibiotic should be directed at the most likely causative organism and the duration of use could range from a single dose given pre-operatively to a continued regimen up to 24 hours post-operatively. Beyond 24 hours, there does not seem to be any enhanced protection to the patient. The most popular choice for prophylactic antibiotic agent is Cefazolin. Cefazolin is a first generation cephalosporin that is very effective as a prophylactic antibiotic due to relatively high serum levels, good bone penetration, long duration, good Staphylococcus coverage, some gram (-) coverage, and reasonable cost.

If a patient has true penicillin or cephalosporin allergy, clindamycin is a good alternative with excellent coverage against Staphylococcus, excellent tissue and bone penetration, and it is capable of penetrating the bacterial glycocalyx produced around foreign implants by S. epidermidis. Vancomycin has been very popular in the past and is often utilized in penicillin allergy patients; however, there has been some increasing concern regarding the development of vancomycin resistant strains of S. aureus and S. epidermidis.

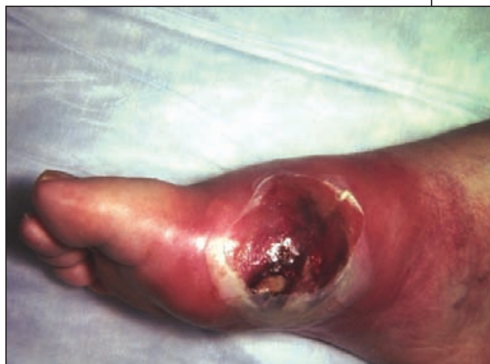

Figure 12: Streptococcus infection with intense spreading cellulites, increased local heat, swelling and minimal drainage.

With the diagnosis of infection emerging post-operatively, the surgeon must exclude multiple other diagnoses that may present similarly, including hematoma and severe inflammatory response. The patient with infection will usually present with constitutional signs of infection such as fever, chills, night sweats, lymphangitis and lymphadenopathy. Once the clinical diagnosis of infection has been made, the surgeon must act quickly and with purpose to avoid additional potentially more severe complications. Radiographs are usually obtained for a baseline to evaluate for any bone changes or possible gas in the tissues. If drainage is present, a gram stain is obtained and this is followed by a culture and sensitivity.

Empiric Antibiotics

Empiric antibiotics are frequently initiated even before a culture result is available to try to intervene early and decrease the spread of the infection. If the patient is to be taken to the operating room, the culture is repeated under sterile conditions and in the deeper tissues to obtain a more accurate identification of the organism(s) involved without skin contaminants.

> ***Some post-operative edema can be expected as part of the increased vascular permeability of the normal inflammatory process.***

Once the organism is properly identified, the empiric antibiotic can be replaced with the appropriate systemic antibiotic based on the sensitivities and the bacteriocidal action of the antibiotic with the least toxicity to the patient. This will usually be a parental antibiotic, but this can also be augmented with an oral antibiotic. In some infections, there may be a question as to the extent of the bacterial invasion in which case an MRI will show the extent and the exact location of abscess formation and early marrow changes that may indicate osteomyelitis.

Technetium-99 can also be utilized to evaluate depth of infection; however, false positive findings can be seen if bone work was performed intra-operatively. Almost all-post-operative infections will require antibiotic coverage, drainage of pus from the wound, and irrigation and debridement of any necrotic tissue. This is usually performed in the operative setting but can also be performed at bedside.

The wound is left open and may be closed later by delayed primary closure, or allowed to heal by secondary intention. The surgeon must closely monitor the changing status of the wound to be certain the infection is reacting appropriately to the intervention.

If the infection does not seem to be responding, there are many possibilities, such as that the wrong organism was isolated, there are other organisms involved not covered by the antibiotic, the antibiotic is not being delivered in adequate dosage or is not capable of penetrating the tissue infected, or a resistant strain of bacteria has emerged. The surgeon must evaluate these possibilities and alter the treatment plan to resolve the complicating infection. A patient will require reassurance and emotional support during the management of this turn of events.

Life Threatening Complications

As the surgeon and the patient enter the operating room theater, there are remote risks that exist in every case that fortunately are extremely rare. These are life-threatening events that could be irrevocable. Events such as anaphylaxis, cardiac arrhythmias, and seizures can all occur in any patient at any time and the operating room team members, including the surgeon, must be prepared to handle these complications. During a seizure that is usually brought on by a vasovagal event,

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Complications...

the patient must be protected from harm with the use of a bite stick and Trendelenburg position of the table to assist in oxygenation and blood flow to the brain. The patient is at significant risk of aspiration during the seizure as well as anoxia and brain damage so the airway must be maintained.

Anaphylaxis can occur with any medication given in the peri-operative setting. This includes the pre-operative prophylactic antibiotic, the medications given by the anesthesiologist for sedation or general anesthetic, or any local anesthetic injected during the case. The anaphylaxis requires immediate recognition and institution of treatment to prevent complete circulatory collapse. This initial treatment is usually epinephrine and fluids and the discontinuation of the medication, if identified. Although the surgeon may have a strong suspicion in some patients who are at risk of a cardiac event, in some cases, there is no warning.

The event may be a mild arrhythmia that was not previously diagnosed, but may also be a malignant arrhythmia that could lead to cardiac failure or arrest. A myocardial infarction is known to be more likely in the diabetic or obese population, but it can also occur in a healthy patient with an arrhythmia that occurs during the procedure, or from a reaction to a medication. Members of the operating room team must be certified in basic and advanced life support to allow for the best possible outcome in these calamitous events.

Conclusion

Through all the training and all the education, one aspect of surgery will remain true: complications can and do occur even to the best of surgeons with the best of intentions. Managing these complications efficiently and appropriately is our job, and when done correctly, will hopefully result in as minimal trauma to the patient as possible, and provide the best possible outcome. Denying that the complication exists or delaying aggressive appropriate treatment will usually result in more extensive complications and a loss of confidence by the patient. Being direct and forthright with the patient will usually provide for a more satisfied and trusting patient who will work with you to resolve the complication. ■

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EXAMINATION

See answer sheet on page 199.

1) Bleeding complications are:
- A) rare
- B) unusual
- C) common
- D) seen in most cases

2) When a blood vessel is cut, it:
- A) dilates
- B) constricts
- C) coagulates
- D) heals quickly

3) The surgeon should exercise caution in relying on the epinephrine to decrease bleeding after foot surgery because:
- A) induced vasoconstriction may mask the bleeding site until after closure
- B) it will cause tissue death
- C) excessive cyanosis usually occurs
- D) there is delayed healing and potential wound dehiscence

4) Christmas disease is also known as:
- A) von Willebrand's factor deficiency
- B) Hemophilia B
- C) disseminated intravascular coagulation
- D) December Factor Deficiency (DFD)

5) The late sequela of post-operative bleeding is the formation of:
- A) microhemorrhagic blebs under the skin
- B) fibrinogen deficiency in the subcutaneous tissue
- C) hemosiderin defects
- D) hematoma within the closed tissue space

6) Wound dehiscence is related to all of the following complicating events except for:
- A) hematoma formation
- B) edema
- C) superficial or deep infection
- D) late suture removal

7) Debridement for wound necrosis of a skin flap is performed early only if:
- A) infection is present
- B) the edges dehisce
- C) the flap is cyanotic
- D) seroma formation is present

8) The early post-operative inflammatory response serves all of the following purposes, except:
- A) initiate a massive humoral and phagocytic assault on tissue invaded by bacteria
- B) mobilize necrotic tissue factor to help with phagocytosis
- C) localize and isolate the reactive area and prevent the spread of bacteria
- D) provide the initial clean up by removing bacterial debris and dead tissue

9) The preferred method of treatment of fracture blisters is to:
- A) apply even compression for 48 hours
- B) inject a small amount of local anesthetic with cortisone
- C) aspirate or drain under sterile conditions
- D) remove the roof of the blister to prevent infection.

10) Which of the following is not one of the three required elements to produce a post surgical infection?
- A) a receptive host
- B) contamination by microorganisms
- C) a wound culture medium to support bacterial growth
- D) poor peripheral circulation

11) As the severity of a wound infection increases, the enhanced inflammatory response that occurs has:
- A) a negative effect on wound healing
- B) no effect on wound healing
- C) a positive effect on wound healing
- D) none of the above

12) In a post-operative infection, the first line of coverage is usually with an antibiotic that will cover:
- A) Streptococcus pyogenes
- B) Staphylococcus aureus
- C) Staphylococcus epidermidis
- D) B hemolytic Streptococcus

13) Which of the following is not a gram (-) bacteria:
- A) Klebsiella
- B) Clostridium
- C) Proteus
- D) Pseudomonas

14) The most popular choice for prophylactic antibiotic agent is:
- A) Cephalexin
- B) Cefotetan
- C) Cefdinir
- D) Cefazolin

15) Endothelial cell destruction occurs following extensive surgi-

Continued on page 198

Continuing Medical Education

EXAMINATION

(cont'd)

cal dissection and may take how long to repair?

A) 1-2 months
B) 1-2 weeks
C) 1-2 days
D) 1-2 hours

16) The United States Center for Disease Control and Prevention reports the post-operative infection rate for a clean, uncontaminated surgery to be what percent?

A) 2.1%
B) 4.2%
C) 8.4%
D) 16.8%

17) Staphylococcus epidermidis:

A) is never implicated in implant infections
B) used to be considered a contaminant bacteria
C) is usually found in deep wound cultures
D) cannot be regarded as a primary cause of infection

18) In a post-operative infection, Technetium-99 scan can be utilized to evaluate what?

A) the depth of the infection
B) the type of infection
C) the number of bacteria present
D) the spread of bacteria into the osteotomy site

19) During a seizure, brought on by a vasovagal event, the patient must be protected from harm by:

A) administering an epinephrine injection
B) providing CPR immediately
C) fitting the patient with a bite stick
D) placing the patient in a reverse Trendelenburg position

20) Anaphylaxis in surgery can occur with any of the following, except:

A) the prophylactic antibiotic given before surgery
B) the increased saturated nasal oxygen flow
C) the medications given by the anesthesiologist for sedation
D) the general anesthetic agent

See answer sheet on page 199.

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2.	A	B	C	D	12.	A	B	C	D
3.	A	B	C	D	13.	A	B	C	D
4.	A	B	C	D	14.	A	B	C	D
5.	A	B	C	D	15.	A	B	C	D
6.	A	B	C	D	16.	A	B	C	D
7.	A	B	C	D	17.	A	B	C	D
8.	A	B	C	D	18.	A	B	C	D
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