EMERGENCY SURGERY IN THE SEPTIC DIABETIC PATIENT

Bradley Castellano, D.P.M.

Diabetic patients are often required to undergo emergency surgical procedures under compromised circumstances. Emergency surgery including incision and drainage of abscesses and amputations of gangrenous limbs are unfortunately relatively frequent situations which cannot be significantly delayed. Complicating medical problems must be corrected swiftly and efficiently so that the patient is able to withstand the stress of surgery. The surgical procedure should be well planned and initiated to insure the best result possible in the patient with impaired glucose metabolism. Fortunately, recent emphasis has been placed on limb salvage in the diabetic patient with lower extremity infection (1, 2).

PREOPERATIVE MANAGEMENT

Several complicating factors may exist in the diabetic patient scheduled for emergency podiatric surgery. These include coronary artery disease, nephropathy, and autonomic neuropathy (3).

Prompt preoperative assessment is necessary to determine the degree of compromise the patient suffers. Preoperative testing should usually include fluid and electrolyte assessment, urinalysis, electrocardiogram, and arterial blood gas values if pulmonary disease or respiratory derangement exists. Blood cultures are performed prior to surgery and may be repeated as necessary if recurrent or persistent sepsis and fever is present.

Blood Glucose Status

Diabetic patients suffering from severe infections generally have systemic alterations in their glucose and electrolyte status (4). It is important to determine the serum glucose as well as sodium, potassium, chloride, urea nitrogen, bicarbonate, and creatinine levels. The degree and severity of fluid and electrolyte imbalance will be dependent on the duration of the infectious process and on the type of diabetes (type I, insulin dependent or type II non-insulin dependent). Patients with type I diabetes tend to suffer from more rapid alterations in their fluid and electrolyte status (3). They tend to be ketosis prone with acidosis being the major complicating factor. Since septic patients often present in diabetic ketoacidosis (DKA) delay of the surgery will often be necessary. At least partial correction of the ketoacidosis will be necessary prior to initiation of surgery since such patients carry a significant increase in surgical mortality (5).

Fortunately, type I is a less frequently encountered class of diabetes. Septic patients with type II diabetes are less prone to acidosis and this is one of the main distinguishing characteristics between the two clinical classes (6). Significant alterations in the fluid and electrolyte balance occur insidiously in the type II diabetic patient. Type II patients tend to become dehydrated secondary to hyperosmolarity (7). Extremely high glucose levels often in excess of 800 mg/dl are often seen in these patients. Paradoxically these patients will usually require less insulin to reduce their hyperglycemia (3,7). On the other hand, fluid replacement takes precedence in stabilizing the hyperosmotic state. Rapid rehydration is necessary in the preoperative preparation (3,5,7).

SEPTIC PROCESSES

The infectious diseases which typically require emergency surgery can be categorized based on their anatomic location and by the bacterial agents responsible for the septic process. While in most instances the decision to treat an infection medically or surgically is a clinical judgement, some situations will dictate the need for rapid intervention. Understanding of the type of infectious process occurring in each individual patient and knowledge of the prognosis innate to each disease situation will be essential in the decision-making process.

Early surgical debridement will often be warranted in the diabetic patient for several reasons. One important reason for performing incision and drainage of the diabetic foot infection is to allow accurate identification of the pathogens involved (8). Several authors have discussed the need for acquiring an accurate culture of the wound in diabetic foot infections (8, 9). Poor correlation between superficial or sinus tract cultures with surgically obtained cultures validates this recommendation. In most cases accurate cultures of the deep tissues should be obtained prior to initiation of antibiotics.

Vascular Gangrene

Vascular gangrene is the result of an imbalance of nutritional demand and supply. If oxygen supply or nutrients are rapidly decreased by vascular occlusion or the supply is exceeded by increased metabolism, cell death and gangrene result. If no infection of the necrotic tissue occurs the gangrene remains dry and autoamputation of the extremity results. However, if infection of the necrotic tissue does occur then wet gangrene results and the disease process will usually continue with high mortality potential (Fig. 1). Surgical intervention is normally required when dry gangrene is transformed to wet gangrene. Vascular surgical consultation is often desirable to determine the level of the occlusive disease and the feasibility of vascular bypass.

Surgical debridement of the infected part often involves simple amputation. Digits are most commonly affected and disarticulation at the metatarsophalangeal joint will often be curative. The level of amputation will be determined by the interface of necrotic and viable tissue. Debridement of all necrotic tissue is necessary and often the degree of involvement will be more extensive than appears at the surface. The surgeon should always be prepared to perform ray resection or even forefoot amputation if necessary.

Plantar Space Abscess

Several authors have indicated the significance of deep space infection of the plantar foot (10, 11). Diabetic patients appear to be at increased risk for developing this form of abscess. The entrance to the deep space is often an inconspicuous fissure between the digits which can occur with a tinea infection or ulcerated soft corn. This type of infection is often neglected for extended periods before the diagnosis of deep space abscess is made. The diagnosis is made on clinical examination. Fever and leukocytosis will usually, but not always be present. Evidence of edema of the medial arch which may have a convex rather than its normal concave configuration is indicative of central space infection. Erythema and calor of the foot will be present with all signs often extending into the dorsum of the foot. Often pain will be absent or localized at a site proximal to the foot. Proximal symptoms may indicate extension of the suppuration into the leg compartments. Medial or lateral leg compartments are the most commonly affected with the former being the most often involved (10, 11).

The spaces deemed significant as potential sites of abscess formation were well delineated by Grodinsky in two studies performed in 1929 and 1930 (12, 13). Three plantar spaces were identified: central, medial, and lateral (Fig. 2). The central space is the most often involved and is actually divided into four separate layers. The lateral and medial spaces are separated from the central space by thick intermuscular septa which extend from the plantar fascia to the metatarsals. The extension of infections along fascial planes in the foot and into the leg are quite predictable based on the course of the various tendons which traverse the plantar arch from the tips of the digits to the proximal leg.

The central space is located deep to the plantar fascia and flexor digitorum brevis muscle belly, inferior to the fascia covering the adductor hallucis and the interossei, lateral to the flexor hallucis brevis and medial to the muscle bellies of the flexor digiti quinti brevis and abductor digiti quinti. Traversing this space are the tendons of the flexor digitorum longus, flexor digitorum brevis and lumbricales. One or all of these tendons may become involved in the suppurative process and prox-

Fig. 1. Dry vascular gangrene can progress to wet (infected) gangrene necessitating surgical debridement. Digital amputation and incision and drainage of central space was required in this diabetic patient.

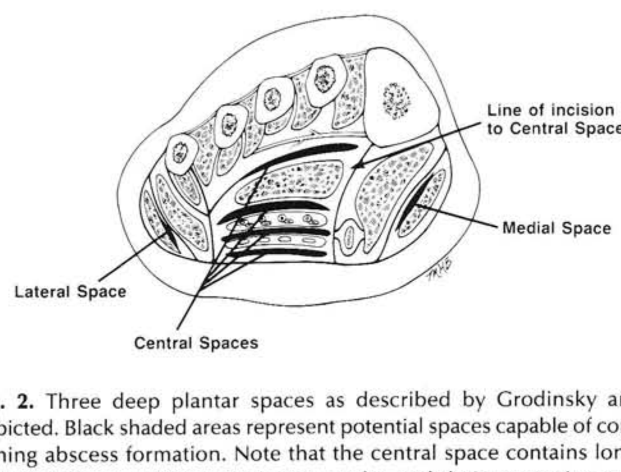

Fig. 2. Three deep plantar spaces as described by Grodinsky are depicted. Black shaded areas represent potential spaces capable of containing abscess formation. Note that the central space contains long flexor tendons as well as intrinsic muscles and their respective tendons. Infections can enter or exit foot by traveling along tendon sheaths and paratenon.

imal extension of infection occurs in form of necrotizing fasciitis, synergistic necrotizing cellulitis, or gas gangrene.

Infection of the central space usually occurs by one of three routes. Web space fissure or ulceration which becomes infected communicates with the small bursae overlying each of the lumbrical tendons (Fig. 3). The infection courses along the paratenon of the lumbrical tendon into the central space. The second route is through ulcerations beneath the metatarsal heads or in the pulps of the lesser digits. Long flexor tendons provide passage into the deep space when exposed to infection within the ulceration. Finally, deep space infections can result from puncture wounds to the plantar foot. Retained foreign bodies are often the source of such infections.

Surgical incision and drainage of the central space is warranted in the event of abscess formation. The technique utilized will be dependent on the vascularity of the involved limb, the integrity of the plantar skin, and the degree of extension of the infection. Simple amputation of the involved limb may be warranted if poor perfusion is present. This may be determined by numerous methods including transcutaneous oxygen, digital plethysmography, and ankle-arm indices to name a few. Digital necrosis should not be used to determine that entire foot amputation is required since occlusion of the plantar digital arteries alone may occur in the presence of deep central space abscess (10).

Deep space infection secondary to contiguous spread through a plantar ulceration will usually be drained through the plantar skin with primary excision of the ulceration. Longitudinal linear incision through the plantar fascia and flexor digitorum brevis muscle belly will provide adequate release of accumulated purulence and preserve the maximum amount of vascular structures (Fig. 4). Care should be taken to preserve the medial, lateral, and plantar arch arteries, all of which lie within the space between the flexor digitorum brevis and the adductor hallucis muscle bellies.

Long flexor tendons and metatarsophalangeal joints especially the one which lies directly above the original ulceration should be inspected for signs of suppuration. If the abscess was caused by a retained foreign body the object should always be retrieved.

In the event that the central space abscess is due to a minor fissure or ulceration of the toe web space a different approach than the one described above may be useful. When the plantar skin is intact a medial approach to the plantar space can be used to avoid a large plantar incision (Fig. 5). This approach preserves the plantar skin which may be needed as flap coverage in the event of

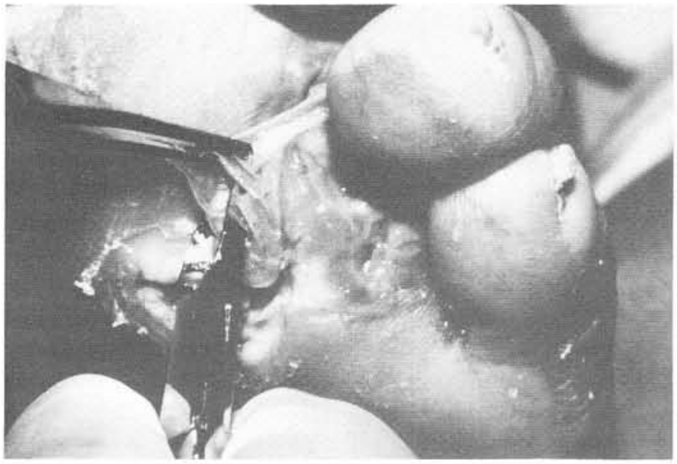

Fig. 3. Deep central space infections can result from digital web space infections or ulcerated soft corns.

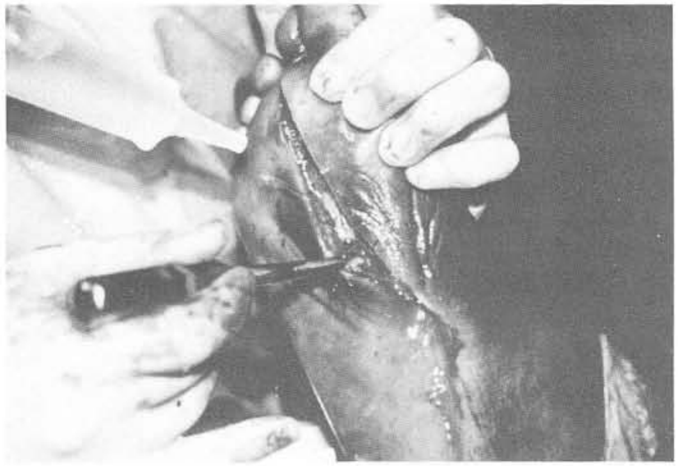

Fig. 4. Incision and drainage of central space requires opening through plantar fascia and flexor digitorum brevis muscle belly. Ulcerated plantar skin may be drained through incision made about ulceration itself. Copious irrigation is used as part of mechanical debridement of infected tissue.

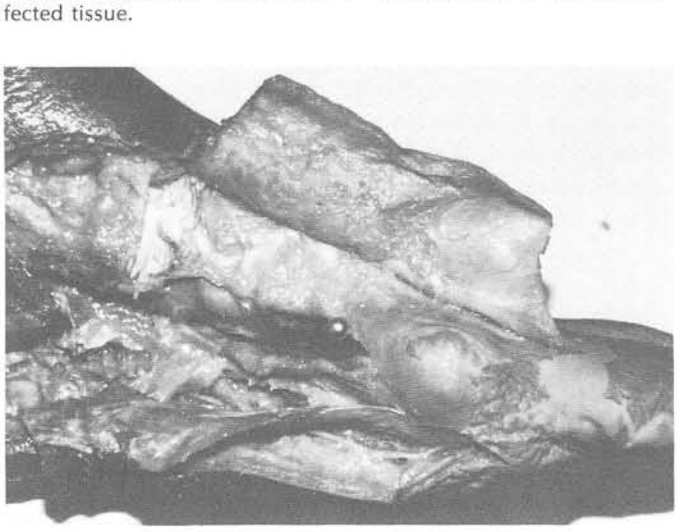

Fig. 5. Silver headed pin marks medial entrance into plantar space. Line incision courses between flexor hallucis brevis muscle belly and first metatarsal. This incision spares plantar skin which may be required in later reconstruction.

transmetatarsal or LisFranc amputation. The incision is made medially at a level just plantar to the first metatarsal shaft (10,12). Dissection is carried between the muscle belly of the flexor hallucis brevis and the first metatarsal. A fascial septa extending between the plantar fascia and the first metatarsal periosteum will be encountered and opened sharply in the same line as the original incision. The deep central plantar space will be exposed and blunt dissection can be used to explore for pockets of purulence within the various layers of the central space. Necrotic tissue within the deep space and toe web is aggressively excised when found. Copious irrigation with normal saline or antibiotic solution can then be used to complete the debridement. The wound is packed open and bandaged with sterile gauze.

Medial and lateral deep space infections occur less frequently than central space infections. They usually result from extension of infection through an ulcerated bunion or tailor's bunion (Fig. 6). The spaces are located between the short flexors and the abductor muscle bellies of the respective ray. Drainage of the abscesses is performed from medial or lateral incision as indicated, irrigated, and dressed as described above.

Antibiotics are begun immediately after obtaining a deep culture and biopsy of suspected osseous involvement. Empiric therapy will usually be broad spectrum since numerous organisms have been implicated in deep space infections. Clinical evidence of anaerobes, i.e., mal odor and stat gram stain to determine the presence or absence of gram positive or gram negative organisms, will be useful in the selection of appropriate therapy. In general, severe infections require aggressive use of antibiotics and combination therapy with extended spectrum penicillin or cephalosporin or clindamycin and an aminoglycoside. The use of toxic antibiotics at therapeutic levels should not be avoided when amputation is the alternative.

Cellulitis

Cellulitis is a spreading infectious process which tends to travel along fascial planes. The tissue plane most frequently effected is the superficial fascia. Cellulitis can be caused by numerous bacterial agents and the clinical presentation is dependent on the type of organism involved. The most common form of cellulitis is caused by group B streptococcus and is known as erysipelas. This appears as flat, indurated, erythematous edema of the extremity with well demarcated borders. Erysipelas is usually treated adequately with antibiotics alone and surgical incision and drainage is indicated only in more advanced cases. Some forms of cellulitis are more destructive and aggressive in nature and will, therefore, require rapid surgical intervention.

Combinations of various bacterial organisms have been shown to cause forms of cellulitis. The relationship of the various organisms can be exclusive or synergistic in terms of the mechanism of the infectious process. Synergistic infections are generally more virulent and aggressive than single agent infections. However, this is not always the case as will be discussed.

Meleney's Cellulitis

Meleney described a synergistic form of cellulitis in which Staphylococcus aureus and anaerobic Streptococcus produced a relatively indolent form of infection (14). This form of cellulitis was described as primarily involving the skin and subcutaneous tissues with only late involvement of deeper fascial planes. Treatment with conservative debridement and appropriate systemic antibiotics is usually curative.

Synergistic Necrotizing Cellulitis

Synergistic necrotizing cellulitis is an aggressive infectious process involving aerobic gram negative organisms and anaerobic streptococcal and/or bacteroides species. Approximately 75% of patients presenting with this form of infection are diabetic. The infection may follow an amputation in which incompletely debrided necrotic tissue remains. However, the perineum was the area most frequently involved in the original report by Stone and Martin (15). The lower extremity was the second most frequently involved carrying a 75% mortality rate.

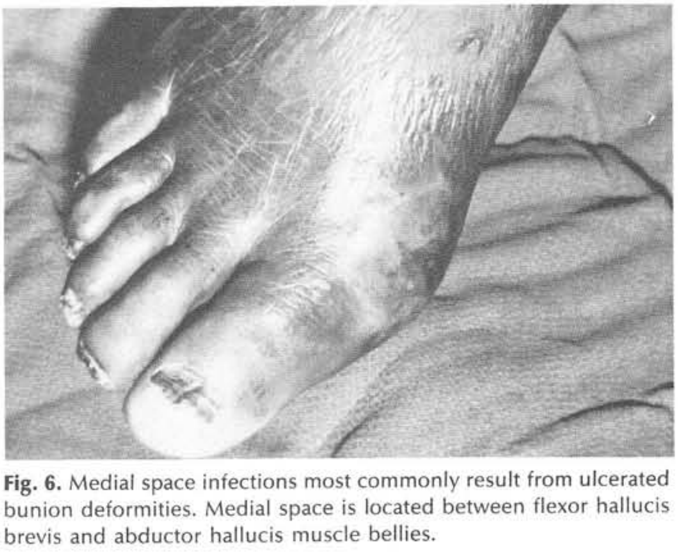

Fig. 6. Medial space infections most commonly result from ulcerated bunion deformities. Medial space is located between flexor hallucis brevis and abductor hallucis muscle bellies.

The clinical presentation which typically accompanies synergistic necrotizing cellulitis is somewhat unique. However, overlap with other clinical entities can obscure the diagnosis. Gas formation may or may not be present. Profound systemic toxicity as well as pain is usually present. The patient is moderately febrile 100 to 102 degrees and leukocytosis is also usually present. When the infection involves the lower extremity it will be markedly edematous. Skin ulcerations drain a thin, reddish brown fluid which is foul smelling. "Dish-water" pus is the name used to describe this form of purulence. Unlike clostridial gangrene the skin overlying the infection is not extensively involved in the necrotic process.

Treatment for this disorder must be aggressive since high mortality accompanies the septic process. As previously stated the septic patient will often present with significant fluid and electrolyte imbalance as well as hyperglycemia. These metabolic derangements should be at least partially corrected prior to surgery. Pro-longed delay is not recommended since the patient will not improve significantly until the infected portion of limb has been removed. High dose intravenous antibiotics may be required prior to the surgery in this situation and superficial cultures may be all that can be obtained prior to their institution. Debridement of all involved tissue requires amputation of the infected extremity at a distance significantly proximal to the site of obvious involvement. Below-knee, above-knee, and even hip disarticulation have been described. Intra-operatively the infection will be found to travel along deep fascial planes with myonecrosis present. Deep aerobic and anaerobic cultures are performed and intravenous antibiotics begun immediately if they were not instituted prior to the surgery. The antibiotic spectrum should cover anaerobic streptococci, bacteroides, and the enterobacteriaceae family.

Clindamycin in combination with an aminoglycoside is one effective regime, however, the organisms which tend to cause synergistic necrotizing cellulitis are notoriously resistant and careful attention should be given to the individual sensitivities.

Following debridement the wound is packed open and the patient placed on wound drainage isolation. The dressing is changed daily to monitor the wound for persistent infection. Further surgical debridements may be required and the first few dressing changes are usually performed in the operating room under sedation or general anesthesia.

Necrotizing Fasciitis

Necrotizing fasciitis is a form of diffuse spreading infection of the skin and subcutaneous tissues. Despite the implications in the name, this form of infection does not tend to infect the deep fascia or the muscle compartments (16, 17). The course of necrotizing fasciitis is less rapid than clostridial gas gangrene or synergistic necrotizing cellulitis. Aerobic bacteria are the most commonly identified organisms and the infection is typically polymicrobial. The lack of anaerobic bacteria seems to contribute to the less aggressive nature of this infectious process.

Clinical and laboratory diagnosis of necrotizing fasciitis is made by the presence of ascending deep infectious process. Skin ulceration is the usual portal of entry and an insidious onset of symptoms is normally related. Moderate to high leukocytosis will be present, but the patient may be only mildly febrile. The ulceration will usually be draining purulence and the immediately surrounding skin may appear necrotic (Fig. 7). The skin distant to the infection is often intact and viable despite the underlying dissecting infection. Moderate to marked edema is usually present and pain is also variable in presentation but is fairly constant. Diabetic patients may relate discomfort in the proximal leg only due to profound distal neuropathy.

The treatment of necrotizing fasciitis requires the combination of surgical incision and drainage as well as high dose antibiotics aimed at the organisms specifically involved. Limb salvage is a very real opportunity in this situation since massive necrosis is not usually present in necrotizing fasciitis. Debridement of necrotic tissue is performed and fascial planes inspected along the course of the infection. Deep space infections which progress to leg involvement are usually located in the central space and travel into the posterior leg space between the deep posterior muscle group and the superficial muscle group traveling within the sheaths of the long flexor tendons (Fig. 8). All involved spaces and tendon sheaths must be incised and drained adequately if limb salvage is to be successful.

Gas Gangrene

Infections in diabetic patients with associated crepitance or radiographic evidence of tissue emphysema (gas) carry a particularly ominous prognosis with regard to limb salvage and even patient mortality (15, 18). However, evidence of gas-forming infection does not preclude the possibility of limb salvage and steps should be taken to identify the true extent to which the limb is endangered. The prognosis will depend on the organisms involved, the degree of necrosis present, and on the individual situation of the patient being treated. Though the term gas gangrene tends to implicate clostridial infection and its associated syndrome most gas gangrene associated with diabetic foot infections is a

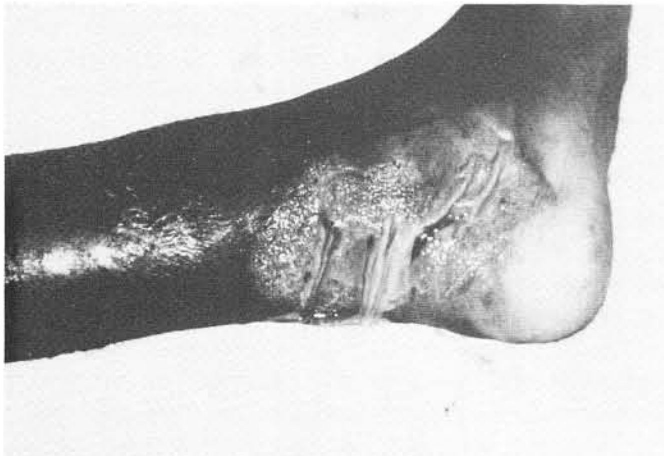

Fig. 7. Necrotizing fasciitis results from aerobic mixed infections. Despite severe appearance of this infection simple incision and drainage with later delayed primary closure resulted in no appreciable tissue loss.

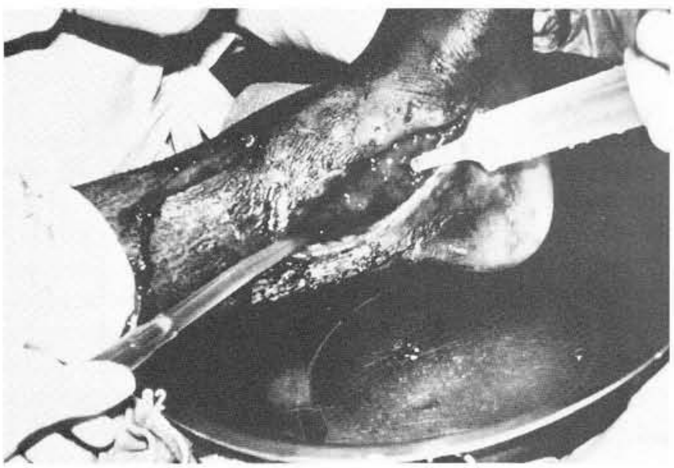

Fig. 8. Opening of medial leg with debridement and irrigation of wound depicted in figure 7. Posterior leg space infection can result from extension of central space infections along flexor digitorum longus tendon. Hallux plantar infections can travel along flexor hallucis longus tendon giving similar presentation.

non-clostridial. Additionally, differentiation of clostridial and non-clostridial gas gangrene has important therapeutic significance.

Clostridial Gas Gangrene

Clostridial gas gangrene represents a critical infectious process associated with hypoxia of the tissue. It is classically associated with trauma; however, clostridial gas gangrene is not exclusively a post-traumatic consequence (19). Recent literature has described numerous cases of clostridial gas gangrene not associated with trauma or contaminated surgery (20, 21). Diabetic patients have an increased risk of developing gas gangrene, but the non-clostridial type is much more common (22). Therefore, the determination of the true clostridial infection becomes an important clinical diagnosis.

The diagnosis of clostridial gas gangrene is largely based on the clinical presentation. The infection is a rapidly progressive process typically with a course of less than three days. Initial presenting signs and symptoms include increased wound pain disproportionate to the degree to the wound appearance. Profound edema without significant erythema. Tachycardia and mental changes disproportionate to the fever present. Later, more classical signs include purplish to grey discolored wound with rapidly extending edema and erythema. Brown, thin liquefaction necrosis and hemorrhagic bullae complete the late findings (23).

Since clostridial gas gangrene carries such a grave prognosis for the limb and the patient rapid diagnosis is essential. Gram stain indicating the presence of gram positive rods associated with the typical clinical signs and symptoms should be considered clostridial until proven otherwise. The presence of gram positive rods alone, however, does not constitute unequivocal clostridial infection since the organisms are part of the normal flora of the gastrointestinal tract and skin of healthy individuals. Compromised patients with hypoxic tissues are at increased risk of developing this form of infection and a high index of suspicion is important if early diagnosis is to be made. Paradoxically, gas formation is not a pathognomonic finding in clostridial gas gangrene and occurs late in the presentation. Since numerous organisms produce gas the presence of clostridia cannot be considered diagnostic of this form of gangrene.

Treatment of clostridial gas gangrene requires a combination of medical and surgical intervention. Neither antibiotics nor surgical debridement alone can prevent the progression of clostridial gas gangrene. Both antibiotics and surgical excision of the infected tissue remain the cornerstones of adequate therapy. Altemeier and Fullen described a widely used classification system of clostridial gas gangrene infections (24). Hart et al later modified this classification system to be used as a guideline for the initiation of therapy in suspected clostridial infections. The classification system modification described four categories of clostridial infection. Category I is clostridial myonecrosis. Category II is represented by primary organ involvement only. Category III is localized clostridial cellulitis and category IV clostridial wound contamination only. The method of treatment is based on the category to which the infection corresponds. Categories I and II require both surgical and antibiotic treatment. Categories III and IV were felt to be treatable with antibiotics alone. However, the authors admit that controversy exists as to whether category III infections also require surgical intervention (23).

Debridement of wounds affected by clostridial gas gangrene is considered a surgical emergency. Amputation of the limb at a considerable distance above the site of infection will usually be necessary in late cases. Wide incision and drainage combined with copious lavage may be acceptable in class III wounds only. Muscle tissue which is in any way devitalized or discolored must be excised. Careful hemostasis and removal of any hematoma formation has been stressed. Finally the wounds are packed open and daily dressing changes begun. Hyperbaric oxygen is felt to be a useful adjunct to the above therapy.

Antibiotic therapy is the second vital component in the treatment of clostridial gas gangrene. The drug of choice is penicillin G and 10 to 24 million units IV per day have been recommended. Only true penicillin allergic patients should receive alternate therapy and sensitivity testing is suggested when allergic history is reported since alternative antibiotics are significantly inferior. Patients with true penicillin allergy can be given tetracycline 2-4 gms IV per day (25). Other antibiotic regimes include clindamycin, chloramphenicol and erythromycin. Finally, the importance of distinguishing between clostridial and non-clostridial gas gangrene is particularly relevant with respect to the choice of antibiotics since resistance to penicillin G is high among the organisms which tend to cause the later type of infection.

Non-clostridial Gas Gangrene

Non-clostridial gas gangrene is considerably more prevalent than is the clostridial variety. Bessman and Wagner found only one clostridial infection in 49 patients with gas gangrene (22). Fortunately, non-clostridial gas gangrene appears to carry a significantly better prognosis than does clostridial type (23). Since synergistic necrotizing cellulitis exhibits gas formation in approximately 25% of the cases overlap exists between these two entities (15).

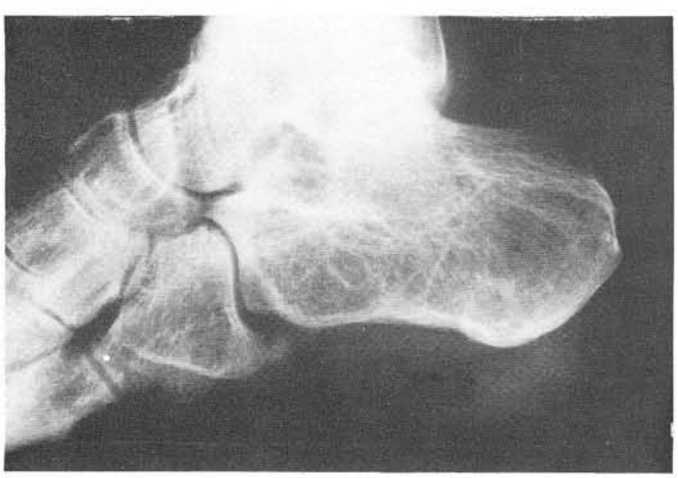

Fig. 9. Plantar ulceration of heel resulted in this gas producing abscess. Although, culture results were negative for anaerobic organisms the feculent odor and gas formation supported coverage for these organisms.

Organisms which have been implicated in non-clostridial gas gangrene include staphylococcus, enterococcus, the enterobacteriaceae family, aerobic and anaerobic streptococci, and bacteroides to name a few (15,22,23). Generally these are polymicrobial infections and surgical incision, drainage, and debridement will be combined with broad spectrum antibiotic coverage until definitive culture results are obtained. Although this is considered a serious infection in the diabetic patient more conservative debridement usually can be performed with successful eradication of the infection (Fig. 9).

DISCUSSION

Diabetic patients have a 15 times greater risk of lower extremity amputation than non-diabetic individuals (26). The majority of these amputations are performed for the eradication of infected gangrenous tissue. The level of amputation has traditionally remained at the extremes of the lower extremity, with the majority of the amputations being either digital or above the knee (26). Recently, however, the emphasis has been turned toward more conservative amputations with a resurgence of the midfoot amputation (1,2,11).

The level of amputation if any, can usually be determined based on two factors: the extent of vascular disease and the extent of proximal necrosis caused by the infection. Vascular consultation to determine the ability of the affected extremity to heal a conservative amputation is usually in order. However, gross degrees of error in determining amputation levels have been described in the literature despite numerous vascular evaluation techniques including clinical judgement (27). Therefore, if the extent of tissue necrosis fails to extend into the rearfoot the patient should usually be given the opportunity to heal a more conservative amputation. Kucan and Robson reported 40% maintenance of biped ambulation despite bilateral partial foot amputation with minimum follow-up of three years (28). Since approximately 50% of diabetic patients with below knee or higher amputation will have a similar procedure performed within two years on the contralateral limb it does appear that conservative approaches are warranted (29).

Rapid and accurate diagnosis with aggressive removal of infected tissue are necessary if limb salvage is to be successful. Understanding and differentiation of the specific infectious processes will be helpful in determining the proper surgical and medical treatment of the diabetic foot infection.

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