

Inpatient Management of Diabetic Foot Disorders: A Clinical Guide

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The implementation of an inpatient diabetic foot service should be the goal of all institutions that care for patients with diabetes. The objectives of this team are to prevent problems in patients while hospitalized, provide curative measures for patients admitted with diabetic foot disorders, and optimize the transition from inpatient to outpatient care. Essential skills that are required for an inpatient team include the ability to stage a foot wound, assess for peripheral vascular disease, neuropathy, wound infection, and the need for debridement; appropriately culture a wound and select antibiotic therapy; provide, directly or indirectly, for optimal metabolic control; and implement effective discharge planning to prevent a recurrence. Diabetic foot ulcers may be present in patients who are admitted for nonfoot problems, and these ulcers should be evaluated by the diabetic foot team during the hospitalization. Pathways should be in place for urgent or emergent treatment of diabetic foot infections and neuropathic fractures/dislocations. Surgeons involved with these patients should have knowledge and interest in limb preservation techniques. Prevention of iatrogenic foot complications, such as pressure sores of the heel, should be a priority in patients with diabetes who are admitted for any reason: all hospitalized diabetic patients require a clinical foot exam on admission to identify risk factors such as loss of sensation or ischemia. Appropriate posthospitalization monitoring to reduce the risk of reulceration and infection should be available, which should include optimal glycemic control and correction of any fluid and electrolyte disturbances.

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The implementation of an inpatient diabetic foot service should be the goal of all institutions that care for patients with diabetes. The objectives of this team are to prevent problems in patients while hospitalized, provide curative measures for patients admitted with diabetic foot disorders and to optimize the transition from inpatient to outpatient care. Pathways for the outpatient management of diabetic foot disorders are available; however, little has been written on the inpatient management of these disorders while patients are hospitalized. A multidisciplinary group was assembled

on the basis of their experience in treating patients with diabetic foot disorders and tasked with preparing a guideline to assist practitioners who care for hospitalized patients. Medical specialists (infectious disease, hospital medicine, and endocrinology), surgical specialists (podiatry, plastic surgery, and orthopedic surgery), diabetes educators, and nursing staff contributed to this article. Members were assigned to research and write on their areas of expertise using an evidence-based approach and incorporating their own expert opinions when a lack of evidence existed.

The lower extremity manifestations of diabetes are multifactorial, and the approach to treatment and prevention of complications should take each of the key factors into consideration. Physicians, surgeons, nurses and other staff play a central role in the management and screening of the inpatient with diabetes (1). Although the staffing of this team might vary from region to region, or even over time, the skill sets required remain constant. For patients with diabetes whose primary admission is not for a lower extremity wound, provisions should be made during the hospitalization to screen for diabetic foot complications and implement preventative care practices. Nondiabetic patients presenting with foot lesions, particularly if neuropathic and/or ischemic, should be screened for diabetes: foot ulcers and infection may be the presenting sign of diabetes.

Essential skills of an inpatient diabetic foot service

—Guidelines, pathways, and checklists should be in place to evaluate patients with diabetes who are hospitalized for any reason. Patients should have their shoes, slippers, and socks removed and their feet examined for the presence of ulceration, ischemia, infection, neuropathy, and Charcot neuroarthropathy (CN). Urgent consultations should be obtained with an appropriate specialist for patients manifesting systemic signs of infection, critical limb ischemia, soft tissue crepitation, or deep tissue gas seen on radiographs, or fractures or dislocations of the foot and ankle (2). Timely (albeit less urgent) consultations should be obtained for less severe infection, noncritical ischemia, noninfected foot ulcers, or unexplained swelling in the foot or ankle. All biomechanical and dermatological conditions should be evaluated. Foot deformity can increase friction and cause pressure points, and simple paronychia and fungal skin infections can be a precursor to more significant infection.

A process should be in place to reduce pressure on the heels of all inpatients with diabetes in order to prevent iatrogenic pressure sores of the heel (Fig. 1). Fitzgerald et al. (2) identified seven essential skills that might be required for an inpatient team caring for patients with diabetes.

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Figure 1—Photograph of a pressure-related heel ulcer in a hospitalized patient with diabetes. Friction against the bed in this neuropathic patient resulted in a full thickness ulcer.

We have added an eighth essential skill (Table 1). These skills provide a comprehensive framework for the treatment of patients with diabetes independent of specific medical or nursing specialty, and include the ability to stage a wound; assess for peripheral vascular disease, peripheral neuropathy, wound infection; debride a

wound; appropriately obtain wound cultures and select antibiotic therapy for infected wounds; plan for hospital discharge; and to prevent wound recurrence (Table 1).

Neurological evaluation at the bedside is aimed at detecting loss of protective sensation, using any of several validated techniques (the monofilament test, the neuropathy disability score, the Biothesiometer/vibration test, or the touch test) (3). Because depression is associated with neuropathy and indeed predicts first foot ulcer development, careful assessment of the patient's affect should be made by the medical team caring for the patient (4,5). This is particularly important because psychological distress may also impact wound healing (6). The presence of ischemia should be assessed initially by history and physical examination, i.e., symptoms of claudication and palpation of the dorsalis pedis and posterior tibial pulses, and supplemented by evaluation with a handheld Doppler if pedal pulses are absent. When more objective evaluation is needed, assessment of lower extremity perfusion by means of Doppler waveform analysis, toe pressure measurement, transcutaneous oxygen measurement or arterial duplex ultrasound is recommended. Information based on this might prompt more invasive vascular assessment, e.g., angiography, which may lead to open or endovascular intervention (3).

Proper staging/grading of the wound using a validated classification system that documents depth, presence of infection and presence of ischemia may reduce ambiguity (Table 2) (7). Diabetic foot ulcers (DFU) may be present in patients who are admitted for nonfoot problems, and these ulcers should also be evaluated by the diabetic foot team during the hospitalization. Noninfected foot ulcers should be debrided at the bedside, covered with a moist wound dressing, and protected by appropriate pressure offloading (redistribution). Offloading can be achieved by casting, removable boots, or postoperative sandals. Measurements should be obtained after debridement, and the characteristics of the wound (undermining, tunneling, and type of tissue at the base of the wound) should be recorded. Classification of wounds facilitates appropriate management (especially when different providers care for the patient over time) and has been shown to help predict wound outcomes (2,3).

Medical management of infection

—More than half of DFUs are clinically infected at the time of presentation (8–10). Recognizing the presence of infection in a DFU is crucial because infection is often the immediate precipitating event for a lower extremity amputation. Infection is diagnosed clinically by the presence of at least two signs or symptoms of inflammation or purulent

Table 1—Eight essential skills necessary for treatment and prevention of diabetic foot disorders in hospitalized patients

1. The ability to perform hemodynamic and anatomic vascular assessment with revascularization, as necessary using both physical examination and handheld Doppler evaluation. More objective testing of lower extremity perfusion by means of Doppler waveform analysis and toe pressure assessments may be indicated. Transcutaneous oxygen measurement and arterial duplex ultrasound may also prove useful to provide anatomic or regional perfusion. Information based on this might prompt more invasive vascular interrogation and possible open or endovascular intervention.
2. The ability to perform neurological workup using rapid assessment of this at the bedside should be performed using various validated techniques including the monofilament test, the neuropathy disability score, the Biothesiometer/vibration test, or the touch test.
3. The ability to perform site-appropriate deep culture technique (preferably tissue cultures or wound-based curettage) to direct antibiotic therapy from initial broad spectrum empiric therapy to more narrow spectrum, as required.
4. The ability to perform wound assessment and staging/grading of infection and ischemia using a suitably validated wound classification system describing depth, presence of infection, and/or ischemia that is understood by members of the team can assist in reducing ambiguity.
5. The ability to perform site-specific bedside and intraoperative incision and debridement to decompress limb-threatening abscesses nonviable tissue are cornerstones of care for a limb preservation team. Surgeons involved in this care should have knowledge and interest in this aspect of limb preservation.
6. The ability to initiate and modify culture-specific and patient-appropriate antibiotic therapy after an initial course of broad spectrum antibiotic therapy based on culture results and patient response. Knowledge of and interest in the antibiotic management of lower extremity infections are key skills associated with reducing complications and length of stay.
7. The ability to perform appropriate postoperative monitoring to reduce risk of reulceration and infection after hospital discharge to home, a rehabilitation unit, or a skilled nursing facility should be as seamless as possible. Ideally, elements of the same team that manages the inpatient care should oversee outpatient care and transition the patient into preventative care as the foot moves into “remission.”
8. The ability to provide basic foot care education during hospitalization and referral to a self-management education program.

Eight essential skills that are necessary for treatment and prevention of diabetic foot disorders in hospitalized patients. This table is modified from Fitzgerald et al. (2).

Table 2—University of Texas Diabetic Wound Classification incorporating depth, presence or absence of infection, and presence or absence of ischemia

	Grade 0	Grade 1	Grade 2	Grade 3
Stage A	No open lesion	Superficial wound	Tendon/capsule	Bone/joint
Stage B	With infection	With infection	With infection	With infection
Stage C	Ischemic	Ischemic	Ischemic	Ischemic
Stage D	Infection/Ischemic	Infection/Ischemic	Infection/ischemic	Infection/ischemic

Adapted from Oyibo et al. (7).

secretions. Diabetic foot infections (DFI) should be classified according to their severity, using one of the similar validated systems devised by the Infectious Diseases Society of America (IDSA) or the International Working Group on the Diabetic Foot (Table 3) (11).

Hospitalization is rarely required for mild infections and for only some of the patients with a moderate infection (defined as those with >2 cm surrounding erythema or infection that penetrates deeper than the subcutaneous tissue). Hospitalization is appropriate when a moderate infection is accompanied by limb ischemia or not responding to outpatient treatment. Patients with severe (grade 4) infections (those accompanied

by fever, leukocytosis, or severe metabolic perturbations) should be hospitalized. The most recent guidelines of the IDSA define severe infection as the presence of local infection associated with signs of systemic inflammatory response syndrome (11). (Table 3) Although patients with diabetes can present with systemic signs of infection (fever, nausea, vomiting, anorexia, malaise, loss of glycemic control, etc.), they may not mount a robust systemic response (12–14). Correction of an abnormal white blood cell count or hyperglycemia should be tracked during hospitalization to help monitor the response to treatment (15). In most studies hyperglycemia is associated with poor wound healing and it is likely

Table 3—Diabetic Foot Infection Classification Schemes: IDSA/International Working Group on the Diabetic Foot

Clinical description	IDSA	IWGDF
Wound without purulence or any manifestations of inflammation	Uninfected	1
≥2 manifestations of inflammation (purulence or erythema, pain, tenderness, warmth, or induration); any cellulitis or erythema extends ≤2 cm around ulcer, and infection is limited to skin or superficial subcutaneous tissues; no local complications or systemic illness	Mild	2
Infection in a patient who is systemically well and metabolically stable but has ≥2 cm; lymphangitis; spread beneath fascia; deep tissue abscess; gangrene; muscle, tendon, joint, or bone involvement	Moderate	3
Patient who demonstrates signs of systemic inflammatory response syndrome manifested by ≥ of the following: Temperature >38°C or <36°C Heart rate >90 bpm Respiratory rate >20 breaths/minute or PaCO ₂ <32 mmHG White blood cell count >12,000 or <4,000 cells/microliter or ≥10% immature cells (bands)	Severe	4
Systemic toxicity may also present with anorexia, chills, hypotension, confusion, vomiting, acidosis, hyperglycemia, and/or azotemia. The presence of critical limb ischemia may increase the level of severity.		

Diabetic foot infection classification system according to the IDSA and International Working Group on the Diabetic Foot (IWGDF). The two classifications are virtually identical. Adapted from Lipsky et al. (11).

that its correction would increase the likelihood of a favorable outcome (16). Plain film radiographs of the foot and ankle should be obtained to assess for bone destruction, deformity, foreign body, or soft tissue emphysema. The presence of soft tissue gas on radiographs, abscess or extensive gangrene should alert the team that prompt surgical intervention is required (Figs. 2 and 3).

A team approach to management is optimal in patients with DFI in order to increase the likelihood of limb salvage (2,17,18). The initial evaluation should identify and correct any glycemic, fluid, and electrolyte or metabolic disorders, consulting with specialists as necessary. Patients with a DFI require a thorough examination of the foot, basic blood tests such as complete blood count, serum chemistries, and inflammatory markers (erythrocyte sedimentation rate and/or C-reactive protein). When deep soft tissue or bone infection is suspected, additional imaging (magnetic resonance in preference to nuclear medicine studies) may be helpful. Those with suspected limb ischemia should undergo further noninvasive vascular evaluation, although urgent treatment of deep infection takes immediate precedence. Surgical consultation should be sought for patients with infections that are deep, extensive, or accompanied by osteomyelitis or limb ischemia (19). The presence of crepitus (or subcutaneous gas on radiographs), bullae, ecchymosis, or skin necrosis suggest a necrotizing soft tissue infection, which represents a surgical emergency (20) (Figs. 2 and 3).

Infected wounds should be cultured, preferably by obtaining tissue samples during any surgical procedure or by tissue biopsy or wound base curettage. Bone cultures are optimal for detecting the pathogen in osteomyelitis, but blood cultures are only necessary for those with a severe infection as defined by the IDSA/International Working Group on the Diabetic Foot (PEDIS) classifications scheme (Table 3). Appropriate deep culture technique is important because the results direct antibiotic therapy, enabling clinicians to alter their initial broad-spectrum empiric regimen to more narrow-spectrum antibiotic coverage (11). Initial therapy must usually be parenteral and empiric, based on the likeliest pathogens and their probable antibiotic susceptibility patterns (21). A broad-spectrum antibiotic regimen is recommended for severe infections, covering staphylococci, streptococci and commonly



Figure 2—Photograph of patient with a severe, limb-threatening necrotizing diabetic foot infection.

reported gram-negative pathogens. Where the likelihood is more than minimal of infection with methicillin-resistant *Staphylococcus aureus*, *Pseudomonas aeruginosa*, extended-spectrum β -lactamase-producing gram-negatives, or obligately anaerobic bacteria, antibiotics effective against these organisms should be considered. No one agent or regimen has shown superiority in treating DFIs, but those with demonstrated efficacy include β -lactams (penicillins and cephalosporins), glycopeptides (e.g., vancomycin), carbapenems, linezolid, clindamycin, and fluoroquinolones (22). The ability to appropriately initiate and then modify antibiotic therapy, based on culture results and clinical response



Figure 3—Plain film radiograph demonstrating subcutaneous gas on the dorsum of the foot.

is important (11). Proper antibiotic management of lower extremity infections reduces complications and length of stay (23). Infectious diseases specialists should be consulted when cultures yield multiple or antibiotic-resistant organisms, the patient has substantial renal impairment, or the infection does not respond to appropriate medical or surgical therapy in a timely manner.

Discharge planning should be initiated when the signs and symptoms of infection are clearly responding to treatment (resolution of the local and systemic signs of infection and improvement in white blood cell count). Most patients can be transitioned from parenteral to oral antibiotic therapy to complete a course of therapy as outpatients. Patients or caregivers may need training on how to apply dressings and offloading devices, and therapy for glycemic control will often need adjustment. It is important to arrange for timely outpatient follow-up with the appropriate provider(s) prior to hospital discharge. Even when managed at specialized centers, about half of patients hospitalized for DFI undergo a lower extremity amputation within a year (24). Glycemic control often requires a plan different from the prehospitalization regimen. Smoking cessation should be strongly recommended to the patient (15).

Surgical management of infections

—Some patients with moderate infections, and virtually all patients with severe infections, will require some type of surgical intervention. A limb preservation team must be able to perform bedside and intraoperative incision and debridement to decompress limb-threatening abscesses and debride nonviable tissue. Surgeons involved in this care should have knowledge and interest in this aspect of limb preservation (25). If insufficient blood flow to the extremities impairs delivery of antibiotics or oxygen, revascularization should be done as soon as the major infection has been adequately addressed. In this regard, prompt drainage of infection with or without partial foot amputation takes priority over revascularization.

With the exception of a limb or life threatening infection, it is best to optimize the patient's medical condition prior to surgical intervention. It is usually best not to delay needed surgery while monitoring the response to antibiotic therapy. If a delay in operative intervention is likely, appropriate deep cultures should

be obtained before starting broad-spectrum antibiotics. Although surgery for soft tissue infections may need to be done urgently or emergently (especially for necrotizing or gas-forming infections), resection of infected bone (if needed) can usually be undertaken electively (26). Available evidence does not support the benefits of most available adjunctive treatments, although some patients may benefit from treatment with negative pressure wound therapy (27), granulocyte colony stimulating factors (28) or hyperbaric oxygen therapy (29). A recent systematic review has reported that interventions in wound healing, with the possible exceptions of hyperbaric oxygen therapy and negative pressure wound therapy, are not guided by high level evidence due to the lack of controlled studies and poor methodological quality (30).

Serial debridements until a clean wound is obtained may be necessary to assess the need for further resection or amputation. Staging of surgical intervention has been demonstrated as an effective strategy for acutely infected limbs (31–33). Pre- and postdebridement cultures of deeper tissues are useful for tracking the effectiveness of the debridement procedure (34,35). In addition to obtaining deep cultures during the debridement, specimens of bone and soft tissue for histological and pathological analysis can also be helpful. Some patients who are receiving antibiotics may not yield a positive culture, but pathological examination (particularly of the bone) may demonstrate changes of acute and chronic osteomyelitis. The goal of debridement is to drain abscesses and remove all infected and devitalized tissue until there is only normal tissue colors of red (muscle), white (bone, tendon, ligament) and yellow (fat) remaining. Painting the wound and injecting sinus tracts with blue dye provides a visual guide to identify contaminated tissue requiring debridement. Serial debridements may be necessary to achieve a clean wound base due to the presence of biofilm, antibiotic resistant bacteria, immunocompromised status, or a compromised blood flow state. When the wound is clean and the bacteria are either absent or adequately covered, plans can then be made for secondary reconstruction and closure.

After the debridement is performed, the wound should be copiously irrigated with fluid, and postdebridement deep tissue cultures should be taken. If high pressure pulsatile lavage is used for irrigation, care

should be taken to avoid further tissue injury and dissemination of the infection beyond the involved area. If the wound is clean, negative pressure wound therapy may be used to accelerate healing (27,36). If there is concern that the wound is still not clean, packing of the wound with moist sterile gauze (wet to dry dressing changes) allows for mechanical debridement.

Management of fractures and dislocations—Individuals with diabetes who sustain foot and ankle fractures have increased morbidity and worse outcomes than patients without diabetes (37–40). Adverse outcomes are related to both predisposing factors leading to fracture and the impaired ability to support healing from insult or injury. Patients with diabetes are more likely to be both vitamin D deficient and have poor bone quality (41,42). Bone quality and strength in patients with diabetes may be diminished due to numerous factors, including chronic hyperglycemia and microvascular disease (43). Neuropathic patients are at risk for developing gait instability due to impairment of proprioception and balance. The frequent presence of visual impairment combined with decreased balance and proprioceptive feedback increases the potential for stumbling and falling, leading to fracture in bone that is incapable of tolerating otherwise subpathological forces.

Several key factors may be responsible for impaired wound and fracture healing in patients with diabetes, although acute wound closure in experimentally induced human wounds does not appear to demonstrate significant delay in healing (44). Patients with diabetes have low levels of upregulating growth factors that promote neovascularization and the recruitment of pluripotential cells and may have impairment in recruitment of circulating white blood cells to the wound (45,46).

As a result of these metabolic aberrations, the end result is delayed soft tissue and bone healing, failure of orthopedic hardware and propensity for developing infection. Unique to the neuropathic individual is the potential for a seemingly trivial injury to initiate the process leading to the development of CN. Surgery is a form of trauma, and operative treatment of fractures, revascularization or debridement of infection can also initiate a CN event although the exact incidence is unknown. Mounting evidence suggests

that in this patient population trauma, often trivial, leads to the release of specific cytokines that upregulate osteoclasts to absorb bone (41). This bony absorption, in a patient who already has impaired bone quality and loss of protective sensation, may be the impetus for the development of CN (41,47). Early findings of CN include unilateral foot and/or ankle swelling, erythema, and warmth, and many patients are misdiagnosed at this stage as having infection, gout, or thrombophlebitis (48). The absence of a foot wound in a patient with signs of inflammation should prompt the clinician to consider CN, especially in the absence of signs of a systemic response to infection.

The treatment of ankle fractures in neuropathic individuals is fraught with complications, resulting in increased potential for catastrophic outcomes leading to amputation, severe deformity, and disability (39,40). Rigid internal fixation with augmented methods of achieving stability is indicated in even minimally displaced fractures due to the high risk of progression to the development of CN (49,50). The evidence available on managing fractures in the foot is not as clear, as it is difficult to distinguish between an acute foot fracture in a neuropathic patient and an acute presentation of CN (41). These patients should be treated on an individual basis, attempting to distinguish among acute fracture, neuropathic fracture, and the initial presentation of CN.

Medical management of the hospitalized patient with diabetes—Patients hospitalized with diabetic foot disorders typically have significant comorbidities, and management of concurrent cardiovascular disease, renal disease, anemia, and hyperglycemia is critical. Usually these patients are managed by a general internist or hospitalist, and appropriate consultative services such as cardiology, nephrology, infectious diseases, and endocrinology should be available. Although the optimal intensity of inpatient glucose control remains in some dispute, there is an emerging consensus, supported by two recent guidelines, one focused on intensive care unit (ICU) care (51), the other on non-ICU settings in inpatient care (15). Both guidelines are the result of input from representatives of major key organizations involved in the inpatient care of DM.

The consensus is that although hypoglycemia is to be avoided, the major

goal should be correction and avoidance of hyperglycemia. Both guidelines set preprandial glycemic targets at 140 mg/dL for the majority of patients (15,51). The American College of Physician guideline, which has not reviewed all of the more recent randomized studies, recommended glucose of >140 mg/dL and a target range of 140–200 mg/dL in critically ill patients (52). In the non-ICU inpatient setting there are now 19 studies (9 randomized and 10 observational) to support this conclusion. A meta-analysis and systematic review of the 19 studies concludes that although intensive glycemic control in the inpatient setting is not associated with a significant effect on the risk of death, myocardial infarction, or stroke, it is associated with a decreased risk of infection (53). The evidence is strongest in surgical settings. There is now unequivocal evidence from randomized studies that hyperglycemia in hospitals is associated with adverse outcomes (15,53,54). There is also earlier evidence that hyperglycemia is associated with impaired wound healing (55,56). There is, however, an association between intensive insulin therapy and an increased incidence of hypoglycemia, leading both recent guidelines to avoid glucose levels under 100–110 mg/dL. Although fear of hypoglycemia has limited some efforts at reducing hyperglycemia, the lack of association of hypoglycemic events during therapy for hyperglycemia suggests that severe hypoglycemia may be merely a marker for more serious underlying disease (55).

Insulin is the preferred agent for reducing glucose levels in hospitalized patients (53). In patients with increased insulin resistance, such as those with sepsis, infection, or in the perioperative period, insulin needs are often greatly increased even in the presence of reduced or absent caloric intake. There is strong evidence that the use of sliding scale insulin regimens as monotherapy without basal insulin, is inappropriate and leads to poorer outcomes and increased hyperglycemia (54). Either basal/bolus insulin algorithms with supplemental or correction doses of intravenous insulin (i.e., sliding scale) may be required. In some cases the use of continuous, variable insulin infusions with appropriate algorithms are most appropriate, particularly with critically ill patients, those in the perioperative period, and in some patients with uncertain oral intake or very variable or large insulin requirements.

The normal outpatient insulin dosage often needs to be modified in patients while hospitalized. While in some cases the outpatient dosage may be reduced, patients with severe physical stress such as sepsis secondary to a foot infection, typically require increased insulin to achieve glycemic control (15). Factors which may alter dosing in hospital settings include factors that may reduce insulin dosage, such as reduced caloric intake, worsening renal failure, increased age, or marked weight loss. Factors that may increase insulin requirements include severe hyperglycemia and/or ketosis, infection, fever, severe pain, myocardial infarction, surgical procedure, or corticosteroid therapy.

For noncritically ill patients with type 2 DM, one guideline suggests as a dosing regimen for insulin therapy (15):

0.2–0.3 units/kg body weight for patients aged ≥ 70 years of age and/or an estimated glomerular filtration rate < 60 mL/min

0.4 units/kg body weight for patients not meeting the criteria above who have glucose levels 140–200 mg/dL

0.5 units/kg body weight for patients not meeting the criteria above when the glucose levels are 201–400 mg/dL

In each case, 50% of the insulin should be given as long-acting insulin as a basal dose and 50% as nutritional doses using short-acting insulin (15). Frequent reassessment is required throughout the hospitalization due to potential changes in clinical status as a result of cessation of food intake or worsening renal failure. It is important that there be a hospital-wide effort to provide education and training for the team responsible for the glycemic control of the patient, including a nurse-based hospital-wide program to initiate treatment of hypoglycemia and to prevent its occurrence (15).

Perioperative management

—Patients hospitalized with diabetic foot problems frequently require surgery, which induces a period of heightened physiologic stress requiring a systematic and comprehensive approach to appropriately assess, and where possible mitigate, risk. Patients with diabetes have an equivalent risk of myocardial infarction to those known to have atherosclerotic coronary disease (57). Ischemic heart disease is frequently asymptomatic in persons with diabetes, and diastolic heart failure is highly prevalent (58–61). Despite the increased incidence of cardiac disease and its attendant risks, considerable evidence suggests that noninvasive cardiac testing or revascularization fails to reliably lower this risk before noncardiac surgery, particularly in diabetes patients receiving appropriate β -blockade and lipid-lowering (statin) therapy (62–64).

In the patient without unstable cardiac conditions (i.e., recent myocardial infarction or unstable angina, decompensated heart failure, significant untreated rhythm disturbances, or severe aortic stenosis), available evidence suggests that proceeding to necessary surgery without a delay for additional cardiac testing is generally appropriate (65). Patients receiving oral antidiabetic medications should have these held for 24 h prior to surgery. Intravenous insulin is optimal in the immediate perioperative period for type 1 diabetes, as well as for many type 2 diabetic patients undergoing major procedures and should typically be continued until a patient

resumes eating (66,67). When subcutaneous insulin is used, long-acting analogs (e.g., glargine and detemir) may be given at usual dose the evening before surgery, but the dose should be reduced if the patient's typical fasting blood sugars are lower than 90–100 mg/dL. Patients receiving intermediate acting insulin (e.g., NPH) should receive 50% of their usual dose on the morning of surgery, and short/rapid acting insulin (e.g., regular or lispro) should be withheld. Current data do not permit definitive recommendations regarding optimal postoperative glycemic control goals, but targeting premeal blood glucose values of < 140 mg/dL and random values of < 180 mg/dL as recommended for the majority of hospitalized patients by a recent American Diabetes Association position statement is reasonable (68).

Diabetes education and discharge planning

—The inpatient team should aim to seamlessly perform appropriate postoperative monitoring to reduce risk of reulceration and infection after hospital discharge to home, a rehabilitation unit, or a skilled nursing facility. This begins with having nursing professionals integrally involved on the diabetic foot team. Ideally, elements of the same team that manages the inpatient care should oversee transition to outpatient care for preventative measures as the foot moves into “remission”. In addition, to nurses familiar with diabetes education, the inpatient team should include a dietitian who can provide nutritional assessments and further education on the importance of ideal body weight and diabetes management. Continued optimal glycemic control will improve the probability of successful wound healing. As with the foot care service, care coordination for glycemic control is also necessary.

Optimal outcomes in patients with diabetes require patients to be knowledgeable about their disease and its complications and able to provide appropriate self-care to achieve treatment goals. Most patients will be responsible for self-management after a hospital stay, making it critically important for nurses to provide education on diabetes self-management concepts, including foot care during the patient's hospitalization. The Joint Commission and American Diabetes Association recommend that inpatient programs specifically include patient education because this provides the foundation for self-care. Patients who do not receive education are more likely to develop a major complication

Table 4—Goals of inpatient diabetic foot service

1. Provide comprehensive evaluation of the foot and ankle for hospitalized patients with diabetes with special attention directed at identifying neurovascular deficits.
2. Provide a thorough risk assessment to prevent iatrogenic complications during hospital admission such as decubitus heel ulcers.
3. Provide treatment for nonurgent diabetic foot problems such as noninfected DFUs.
4. Provide definitive treatment for soft tissue and bone infections, arranging for appropriate medical and surgical consultations as needed.
5. Identify critical limb ischemia and arrange for appropriate diagnostic testing and vascular consultation.
6. Provide definitive treatment for fractures and dislocations of the foot and ankle, with the ability to diagnose patients at high risk for complications from these injuries (patients with peripheral neuropathy and/or diabetic neuroarthropathy).
7. Coordinate medical management of comorbid conditions such as cardiovascular disease, renal disease, and glycemic management in the inpatient setting using appropriate consultants.
8. Coordinate discharge planning, patient education, and outpatient follow-up care.

and incur higher diabetes-related hospital costs, while those who do can improve HbA_{1C} levels, reducing risk for DM-related foot problems (69). Foot care education is strongly associated with various improved outcomes, including reduced foot complications and amputation rates (70). Although hospitalization offers an opportunity to educate diabetic patients, teaching during a hospital stay can be challenging given that inpatients are ill and have competing demands, such as scheduled diagnostic and therapeutic procedures. Nevertheless, a hospital admission for a diabetes-related foot problem provides a unique “teachable moment” because patients may be motivated to prevent further problems.

Even though staff nurses have competing demands and limited time for education, it is essential that they address key diabetes content areas, i.e., nutrition, activity, medication taking and monitoring, and risk reduction. During the assessment, nurses gather information about a patient’s experiences, knowledge, technical skills, beliefs, and support systems. Nurses can identify educational gaps (e.g., nutrition understanding) and use hospital team resources for educational support (e.g., the dietitian). By careful observation and teaching, nurses can also play a pivotal role in reducing the risks of in hospital complications such as decubitus heel ulcers.

The primary focus of the education should be to address what the patient perceives to be the most critical area needing attention and to help the patient to prioritize self-care plans. In the case of a patient hospitalized for foot problems, the information and skills necessary to assure proper attention to foot care have high priority. The nurse should strategically seek opportunities to educate patients throughout the hospital stay. Skills can be evaluated and reinforced with routine procedures, including blood glucose testing and injections. Nursing tasks offer an opportunity for demonstration of skills by the patient and/or caregiver. Return demonstration during wound care procedures and dressing changes, provide teachable moments for the patient and caregiver.

It is unrealistic to expect that comprehensive diabetes education beyond the delivery of basic skills can be provided during a stressful hospital admission. Therefore, the nurse needs to assist in the coordination of a discharge transition plan that includes appropriate follow-up with an outpatient education program

visit, preferably at an outpatient site staffed by members familiar with the inpatient diabetic foot team.

We recognize that assembling an interdisciplinary team of specialists may be difficult in certain hospital environments (Table 4). The leader of the team can be from any specialty, with the major asset being a passion for this type of work. Strategies for success include incorporating both the administrative and professional components of the hospital (Table 5). Hospital administrators will become enthusiastic supporters if the team can demonstrate a reduction in hospital length of stay. Even a modest one-day shorter hospital stay can translate into a reduction in hospital costs. Professional staff members will support this concept if improved outcomes can be demonstrated such as a reduction in major amputations. Major amputations may be associated with increased mortality, decreased function, and increased cardiac demands. One of the most effective ways to promote the inpatient management of the diabetic foot disorders is through medical education. Hospitals

with large departments may provide an opportunity to speak at subspecialty conferences such as infectious disease, endocrinology, plastic surgery, vascular surgery, orthopedic surgery, and podiatry. Both clinicians and administrators need to understand the epidemiology and profoundly negative impact that diabetic foot disorders have on patient outcomes. The mortality of patients presenting with an acute CN event or DFU is surprisingly high (71). In fact, the 5-year mortality of patients with newly diagnosed DFUs is nearly 50% and carries a worse prognosis than breast cancer, prostate cancer, or Hodgkins lymphoma (72). A paradigm shift in our thinking is necessary to improve outcomes of patients with diabetic foot disorders, and we should strive to emulate the contributions made in centers that specialize in trauma, burns, stroke, and cardiology. Time equates to tissue loss, and prompt intervention in patients with diabetic foot disorders may preserve limbs and restore function.

In conclusion, hospital admission in patients with diabetes is unfortunately commonplace. Foot complications in

Table 5—Secrets for success in establishing an inpatient team for management of diabetic foot disorders

Involvement of both hospital administration and professional staff is paramount.
It is more important for the leader of the inpatient diabetic foot service to be knowledgeable and passionate than to be from a particular medical specialty.
Strive for multidisciplinary involvement. The exact make-up of the multidisciplinary team may vary from hospital to hospital based on the size and capability of the hospital. Specialties involved may include
Primary care physicians
Hospitalists
Endocrinologists
Infectious disease specialists
Radiologists
Podiatry
Orthopedic surgery
Plastic surgery
Vascular surgery
Nursing
Diabetes educators
Physical therapists
Orthotists
Case management/social service
Educate emergency department personnel on the importance of prompt consultation for patients with diabetic foot infections and neuropathic fractures.
Outcomes of treatment should be monitored and communicated to the medical staff through organized continuing medical education.
Hospital staff (physicians, nurses, educators and therapists) should be educated on the morbidity and associated premature mortality of patients who develop diabetic foot disease (ulcers, infection, neuropathy, and CN).
Make the patient and their family a part of the team.
Have a coordinated outpatient facility to provide a transition for appropriate continuing care after discharge.

this already impaired population constitute a major danger to the overall well-being of the patient and to the fiscal capacity of a health system. Consideration for development of effective, systematic, interdisciplinary teams that focus on skills for inpatient management should be a priority in these complex patients. The goals of this interdisciplinary team should be to provide comprehensive evaluation, thorough risk assessment, definitive treatment, and coordination of discharge planning in patients with diabetes who are hospitalized for foot problems. Prevention of foot problems in patients with diabetes who are hospitalized for unrelated causes should also be a priority.

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