Glucose Gremlins of Wound Healing

Purpose: This educational activity is designed to help nurses in all care settings identify why patients with diabetes are more prone to develop wounds with complications such as chronicity and infection. Nurses will also gain enhanced skills in wound prevention measures and strategies to manage the care and education of a patient with a diabetic wound.

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Objectives

At the completion of this educational activity, the nurse should be able to:

- List three ways diabetes impairs wound healing.
- Recognize the importance of strict glycemic control in wound healing of the diabetic patient.
- Describe two reasons diabetic patients are at greater risk for infection.
- Identify nursing precautions necessary when caring for and educating patients with lower extremity neuropathic disease.

Requirements for Successful Completion:

1. Read the article.
2. Download and print the post test at http://nurseslounge.com/CEUs.html.
3. Complete the post test questions and program evaluation by circling the selected responses on the post test.
4. Fill out the registration form.
5. Send registration form, post test, and a check for $12.00 to:
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   The University of Texas at Arlington
   Box 19197
   Arlington, TX 76019-0197
6. A passing score is 80% to receive 1.0 Contact Hour. If you pass, your CE certificate will be forwarded to you. If you do not pass, you will be notified and may repeat the test once at no cost.
7. Send before March 15, 2011.

The news is everywhere. Diabetes mellitus in the United States is on the rise. The American Diabetes Association estimates that 7.8% of the population has been diagnosed with diabetes and 5.7 million people are not yet aware that they are diabetic. (1) We all know that obesity and the aging population are two factors that are contributing to increased prevalence. The complications of diabetes can cause a host of major chronic problems including retinopathy, nephropathy, neuropathy, ischemic heart disease, cerebrovascular disease, peripheral arterial disease and skin lesions. These problems can contribute to the chronicity and difficulty of healing wounds in the diabetic patient. This is where the "gremlins" get their reputation! Chronic non-healing wounds in an individual with diabetes can start from a seemingly innocuous source. The blister caused from an ill fitting shoe can ultimately cause the person to suffer the loss of the foot. Diabetics are at a 10 x greater risk for amputations. 60% of all non-traumatic lower limb amputations are attributed to diabetes. (1) Although lower extremity wounds are common sites for wound development in a diabetic, it is important to consider that any wound on a diabetic patient can more easily become infected and heal at a slower rate. Since diabetes has a deleterious affect on microcirculation, it can lead to an increase in surgical wound dehiscence. (4) And let's not forget about those pressure ulcers. Pressure ulcers in diabetic patients are also impaired and slow to heal too. (3) This presents a real challenge for all nurses caring for patients with diabetes. Is there anything that can be done to improve outcomes? As a nurse there is a great deal that we can do to improve prevention of these wounds and in some cases achieve a better outcome once a wound has started.

The Gremlin Effect

It may help to understand the normal progression of wound healing first.

Uncomplicated wound healing in the acute non-diabetic wound occurs in a predictable and orderly sequence. Hemostasis and inflammation start immediately upon injury and generally last for about 4- 6 days. During this time the clotting cascade will trigger a clot formation. This clot contains factors that release cytokines and growth factors. As inflammation continues, neutrophils and monocytes are called to the scene – they are a great internal rescue team! Neutrophils will digest bacteria and nonviable tissue and monocytes will transform into macrophages and are key for the transition to the proliferative phase. Days 4-14 are characterized by the proliferative stage where new epithelializaiton, angiogenesis, granulation tissue formation and collagen deposition occur. Maturation and remodeling will happen from day 8 through year 1 when collagen deposition and synthesis will eventually lead to scar maturation. (5) Actually it can be a pretty straightforward healing process.

On the other hand, the effects of diabetes mellitus are a well known complication affecting almost all stages of wound healing. Collagen synthesis and deposition are responsible for tensile strength in wound repair.

Table 1

Wound Cultures

- Remember to clean the wound well with sterile normal saline before swabbing the wound for culture.
- Avoid swabbing any necrotic or purulent exudate. The culture should come from clean tissue since that is wear the infection is located.

Fibroblasts are responsible for the production of collagen. (2) The diabetic patient may have a diminished capacity for producing fibroblasts as well as having an abnormal morphology of the fibroblast itself. (6) Patients with diabetes also have been found to have impaired leukocyte function, inadequate migration of neutrophils and macrophages to the wound, along with reduced cell movement.(7) Their internal "rescue teams" do not respond! Since diabetes may cause problems with perfusion, diabetics are also at a high risk for microvascular disease. This means that the delivery of micronutrients at the capillary level can also be seriously impaired.(2)

Update and Background: Diabetes

Diabetes mellitus is diagnosed when a person's fasting plasma glucose is greater than 125 mg/dl. People with levels from 100-125 mg/dl are considered to be at an "impaired" fasting glucose and are actually more likely to develop diabetes even with no other risk factors. Now this has extended to patients with fasting plasma glucose levels at the high end of normal under 100 mg/dl. (8) Hyperglycemia alters vascular tissue at a cellular level causing oxidative stress and proinflammatory responses. Prolonged hyperglycemia is a major factor in the development of artherosclerosis in diabetes and accounts for almost 80% of all deaths among diabetics. (9) Hyperglycemia may also compromise natural antioxidant defenses such as vitamin C and vitamin E.

Perhaps most disturbing is that the effects of hyperglycemia are often irreversible and may persist even after normal glycemic levels are established. (10) Strict glycemic control is key in the prevention of complications. It is the single most critical focus for clinicians when patients with diabetes are hospitalized, and a very important message to get across to the diabetic patient. "A patient with average glucose levels of 200-250 mg/dl will have at least a two fold greater risk of developing retinopathy, neuropathy and nephropathy than a patient with average glucose levels of 150-160 mg/dl over the course of several years." (11)

Diabetes and Infections

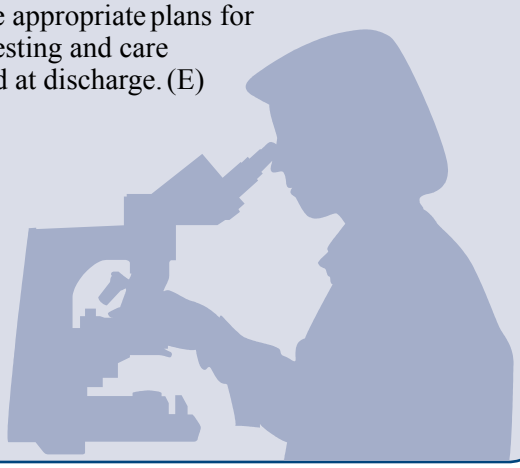
The explanation for why patients with diabetes are more prone to developing infections in not yet completely understood. One reason may be that bacteria are actually using the glucose present in the diabetic wound. Also, the body's natural defense system of neutrophils, macrophages and leukocytes are altered in diabetes. This enhances the susceptibility of

Table 2

The **American Diabetes Association** Position Statement on Standards of Medical Care in Diabetes 2008

Diabetes Care in the Hospital Recommendations

- All patients with diabetes admitted to the hospital should be identified in the medical record as having diabetes. (E)
- All patients with diabetes should have an order for blood glucose monitoring, with results available to all members of the health care team. (E)
- Goals for blood glucose levels:
  - Critically ill patients: blood glucose levels should be kept as close to 110 mg/dl (6.1 mmol/l) as possible and generally <180 mg/dl (10 mmol/l). These patients will usually require intravenous insulin. (B)
  - Non–critically ill patients: premeal blood glucose levels should be kept as close to 90–130 mg/dl (5.0–7.2 mmol/l; midpoint of range 110 mg/dl) as possible given the clinical situation and postprandial blood glucose levels <180 mg/dl. Insulin should be used as necessary. (E)
  - Due to concerns regarding the risk of hypoglycemia, some institutions may consider these blood glucose levels to be overly aggressive for initial targets. Through quality improvement, glycemic goals should systematically be reduced to the recommended levels. (E)
- Scheduled prandial insulin doses should be given in relation to meals and should be adjusted according to point-of-care glucose levels. The traditional sliding-scale insulin regimens are ineffective as monotherapy and are not recommended. (C)
- Using correction dose or "supplemental" insulin to correct premeal hyperglycemia in addition to scheduled prandial and basal insulin is recommended. (C)
- A plan for treating hypoglycemia should be established for each patient. Episodes of hypoglycemia in the hospital should be tracked. (E)
- All patients with diabetes admitted to the hospital should have an A1C obtained for discharge planning if the result of testing in the previous 2–3 months is not available. (E)
- A diabetes education plan including "survival skills education" and follow-up should be developed for each patient. (E)
- Patients with hyperglycemia in the hospital who do not have a diagnosis of diabetes should have appropriate plans for follow-up testing and care documented at discharge. (E)



diabetic wounds to bacterial infections. In animal studies where a non-diabetic wound was inoculated with Staph aureus, it caused a non-significant delay in wound healing. In contrast, when the diabetic wound was inoculated it led to a higher rate of infection and increased co-infection with endogenous bacterial strains. These wounds also showed a significant delay in healing/reepithelialization at the wound edges. The most common organisms found in diabetic wounds are Gram-positive cocci such as Staphphylococcus aureus. The effectiveness of administration of antibiotics may be affected by the condition of the vasculature of the patient. Poor blood supply will hinder the distribution of the antibiotic into the tissue. Surgical intervention to revascularize affected areas may be necessary to achieve healing. This is true particularly in relation to wounds in the foot. (13)

Major Impact

The most common of all diabetic wounds occur on the lower extremities. We all need to recognize that patients can easily have a wound and not even be aware of it! They are caused from neuropathy, musculoskeletal abnormalities and peripheral arterial disease.

Peripheral neuropathy can be classified as sensory neuropathy, motor neuropathy and autonomic neuropathy. Sensory neuropathy usually starts with pain and eventually leads to loss of protective sensation and lack of awareness of pain and temperature change. It is easy to see how a person

with sensory neuropathy could injure themselves and not realize it! If a person with normal sensation is experiencing pain with the shoes they are wearing, they might remove the shoes and not wear them again. However, if there is no pain, a person may wear the shoes and walk in them all day until a wound is present. Motor neuropathy can ultimately lead to muscle atrophy and effect the normal movement of the foot. With this neuropathy you see deformities such as hammer toes and claw toes making the foot more susceptible to wounding. Autonomic neuropathy can cause a decrease in sweating, loss of temperature regulation and abnormal blood flow in the soles of the feet. This can make the foot dry and cracked allowing wounds to form more easily. (2)

Peripheral neuropathy can cause musculoskeletal abnormalities in the ankle and foot of diabetic patients causing deformities such as ankle joint eqinus and Charcot's foot. These malformations can lead to a loss of the natural fat pad located beneath the metatarsal heads. Ulcers and calluses can form due to repetitive trauma of pressure and friction over the deformed prominences. Any callus formation causes a significant increase in pressure to the tissue directly beneath it. Neuropathic ulcers are often seen on the tops and tips of toes and plantar aspect of the foot. They may be dry or draining and surrounded by a thick callus with a clear margin. They may appear to be superficial. However, it is not uncommon for these wounds to tunnel to the bone with resulting osteomyelitis. An MRI is usually ordered to evaluate and diagnose infection present in the bone. It is important that calluses be debrided to prevent this build up of pressure. Patients should follow up with routine outpatient visits to keep the calluses trimmed. All diabetics should have annual foot exams. This is even more reason to so carefully assess all surfaces of the lower extremities on diabetics when are admitted to our care.

As discussed previously, the microvasculature of the diabetic patient can be affected with artherosclerotic plaque buildup. Ischemic diabetic wounds from peripheral artery disease are less common that neuropathic ulcers but they can be much more serious. Often there is insult added to injury with infection and neuropathy present as well. It should come as no surprise that these patients are at a much greater risk of amputation. If the wound is infected, it must be aggressively treated with a combination of antibiotic therapy and removal of all necrotic and devitalized tissue. The vascular surgeon will probably be consulted in these cases. Sometimes surgical debridement with subsequent revascularization will save a limb. However, for some patients it may unfortunately be a losing battle.

For our nursing care, it is important to remember that if an ischemic wound is not infected and is covered with a dry, intact eschar, it is best to keep it that way. It seems contrary to everything learned in school. After all, doesn't bacteria breed in necrotic tissue? In this case the eschar is actually protecting from the invasion of bacteria into the tissue. Many protocols for this type of wound advocate leaving the wound dry and painting the eschar with povidone-iodine swabs. If the wound changes and there is evidence that it may be infected, then a consult for debridement may be in order.

Keeping a Close Eye

Surgical wounds and pressure wounds should be watched especially closely in the diabetic patient. Surgical wounds may be slower to heal and need to be monitored for any signs of dehiscence. Diabetic patients may not display the overt signs of infection. Your first clue may be a wound that is just not healing on a normal trajectory. Granulation tissue and reepithelialization are the signs to look for in a healing wound. Pressure wounds and other chronic wounds of diabetics may seem "stalled". The wound may look red and clean but there is no healthy granulation tissue in the wound bed and the wound edges do not have new epithelium forming. Non healing wounds should be reported to the physician or a wound care nurse for further evaluation. Cultures may need to be obtained. A few key steps for successful and effective obtaining of wound cultures are listed in Table 1.

The potential for post-operative wound infections with diabetic patients is a particular challenge today with the major increase in outpatient surgeries, resulting in the patient going home with family care. Thorough patient and family education on checking wounds, knowing what to look for, will be critical parts of the discharge process.

Although the prevention of all wounds in the diabetic may not be possible, it is possible to better the odds. There should be a team effort from health care providers in the care of the diabetic patient. Besides the primary physician and nurse, and in some cases an endocrinologist, others who might be consulted are the Registered Dietician, Nutritionist, Podiatrist, Vascular Surgeon, Certified Diabetic Educator, Certified Wound Care Nurse, Orthotist, Pedorthist and Certified Foot Care Nurse. The American Diabetes Association provides vast resources for the patient as well as the health care professional providing valuable advice and the most up to date scientific research. The ADA also provides standards of care for hospitalized patients with diabetes. (Table 2)

The Reality

Nurses are looked to and relied on by their patients to give them trustworthy advice. A newly diagnosed person with diabetes mellitus is no doubt stressed and worried about how their life will change. I have heard people say things to the effect, "Oh, diabetes! That's the disease where you lose your feet." It is good nursing practice to empower the person with knowledge that will help them manage and prevent future problems. It is probably impossible to over teach someone with a new diagnosis of diabetes. Repetition is an important aspect of learning. Besides, so much is forgotten or simply not heard, when a person is nervous, stressed and not feeling up to par. There are also the patients that have been living with diabetes for many years and are tired of dealing with it. They may be angry and noncompliant with therapy. These patients can be frustrating to the nurse caring for them. Regardless, the nurse must attempt to reengage the patient and encourage them to be an active partner in their care. There

may be barriers and problems to compliance that the patient will share if they feel the nurse is empathetic and will listen.

The importance of tight glycemic control and scrupulous foot care can simply not be overemphasized. Diabetic foot ulcers are the most common wound complications for a diabetic. In Table 3, we have listed some helpful guidelines and recommendations to share with your colleagues and patients.

Take on the Challenge of Defeating Glucose Gremlins!

There are all sorts of hurdles for us and our diabetic patients to overcome in the care and prevention of diabetic wound complications. Wounds may develop infections even with best of care. Diabetic feet may develop deformities regardless of careful daily inspection and routine annual foot examinations. There are seemingly endless research studies and clinical trials all attempting to cure and treat the complications of diabetes. The amount of information available over the internet and in bookstores is overwhelming. It is easy to imagine how lost a person diagnosed with diabetes could feel. The key is education and heightened awareness of the potential for wounds and delayed wound healing. Nurses take on challenges every day! Hopefully this information will help you to help your patients feel more confident, less alone with their concerns, and achieve better outcomes in the care of diabetic wounds.

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Table 3:

Care Guidelines

*All patients with diabetes should have an annual comprehensive foot exam.

*People with neuropathy should wear well-fitting shoes with adequate cushioned soles. It is important that the toes have enough room and are not crowded in any way by the shoe. Leather athletic shoes are often ideal. People with foot deformities may need shoes with extra wide toe boxes. When there are extreme deformities such as Charcot foot, the patient may need to have custom molded shoes made.

* Educate the patient to look inside the shoes before placing them on their feet to make sure there are no objects in them. A small stone or twig left behind in a shoe can be the beginning of a nasty wound.

*Advise them to avoid sandals and open toed shoes and to never walk barefoot inside or out.

*Socks should always be worn with shoes and natural fibers are best.

* Toenails should be trimmed straight across and may be filed with emery board. Cuticles and thickened skin should not be removed by cutting. Nail care may need to be performed by a healthcare professional.

*Feet should be inspected daily for any blisters, abrasions or areas discoloration. Remind them to use their hands to manually palpate the feet for any abnormally warm spots or rough areas they may not be able to see. It may be necessary for the patient to use a mirror or have a friend or family member to inspect the feet for them.

*Heating pads are never a good idea and can lead to serious burn injuries.

*Keep feet clean and dry and use moisturizing cream on the feet, avoiding the spaces between the toes.

*A foot soak to soften the skin on the feet is not advised because it removes the body's natural oils and can actually cause the feet to become even drier and lead to cracks and fissures. If a callus cannot be gently filed away, a professional should be consulted. Calluses can be removed with a scalpel by a podiatrist, wound or foot care specialist. *Patients should never attempt to chemically remove or use a blade to remove their calluses.

* Important to emphasize that smoking cessation, weight and diet control, hypertension management and control of hyperlipidemia are all important factors in the prevention of complications.

Registration Form and Test for **ContinuiningEducation**

"Glucose Gremlins of Wound Healing"

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Objectives:
At the completion of this educational activity, the nurse should be able to:

1. List three ways diabetes impairs wound healing.
2. Recognize the importance of strict glycemic control in wound healing of the diabetic patient.
3. Describe two reasons diabetic patients are at greater risk for infection.
4. Identify nursing precautions necessary when caring for and educating patients with lower extremity neuropathic disease.

How to Earn One Contact Hour:
1. Read the article.
2. Complete the post test questions and program evaluation by circling the selected responses on the post test.
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Registration Information:
Name: _____
Address: _____
City/State/ZIP: _____
State(s) of Licensure: _____
Telephone Number: _____
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Post Test Questions for Continuing Education Credit

Please circle your response for each question

1. Diabetes impairs wound healing by all the following except:
   a. Diminished capacity for producing fibroblasts
   b. Impaired leukocyte function
   c. Impaired vascular perfusion
   d. Low hemoglobin
2. The most important critical focus in the prevention of complications in the diabetic patient is:
   a. Always wear tennis shoes
   b. Strict glycemic control
   c. Eliminate carbohydrates from the diet
   d. Daily foot soaks
3. All the following are routine precautions for diabetic patient with lower extremity neuropathic ulcers except:
   a. Trim toenails straight across
   b. Annual comprehensive foot exam
   c. Use heating pad to warm cold feet
   d. Always wear shoes inside and outside
4. What is increasing the prevalence of diabetes in the U.S.?
   a. Obesity
   b. Alcoholism
   c. Aging population
   d. Both a and c
5. 5. Diabetes mellitus is diagnosed when a person's fasting plasma glucose is greater than:
   a. 90 mg/dl
   b. 125 mg/dl
   c. 175 mg/dl
   d. 200 mg/dl
6. The effects of hyperglycemia can be:
   a. Easily reversed
   b. Permanent
   c. Energizing
   d. Helpful in wound healing
7. Infections are more prevalent in diabetic wounds because:
   a. Bacteria are using the glucose in the cell
   b. The body's natural defense mechanism is altered
   c. Poor blood supply to wound from altered vascularization
   d. All of the above
8. The most common diabetic wounds are located:
   a. Face and neck
   b. Abdomen
   c. Hands and fingers
   d. Lower extremities
9. Which statement is true about peripheral neuropathy?
   a. What the patient can't feel won't hurt them.
   b. Muscle atrophy and musculoskeletal abnormalities may occur.
   c. The feet will stay silky smooth.
   d. Calluses are nature's little protective shields.
10. When obtaining a wound culture, always remember:
   a. Never rinse the wound with sterile normal saline first.
   b. Get as much pus on the swab as possible
   c. Obtain the culture from clean tissue
   d. Have the physician do it.

Program Evaluation

Strongly Disagree Strongly Agree

Objective 1 was met.
1 2 3 4 5

Objective 2 was met.
1 2 3 4 5

Objective 3 was met.
1 2 3 4 5

Objective 4 was met.
1 2 3 4 5

The article was effective as a learning resource/tool.
1 2 3 4 5

The objectives were relevant to the overall purpose.
1 2 3 4 5

The activity met your expectations.
1 2 3 4 5

List two ways that you will integrate what you learned in this activity into your practice and/or work environment: _____
_____
_____
_____
_____
_____
_____
_____

The following were disclosed:
Requirements for successful completion
Yes No
Conflicts of interest
Yes No
Commercial support
Yes No
Non-Endorsement of Products
Yes No
Off-label use
Yes No
Did you perceive any bias that was not disclosed in this activity?
Yes No
If Yes, please describe_____ _____
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State the number of minutes it took you to read the article, complete the test and evaluation
_____min