

# The Importance of Glycemic Control in Wound Healing

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**D**iabetes mellitus is defined as a cluster of metabolic disorders reflected by abnormal hyperglycemia that cause chronic microvascular, macrovascular, and neuropathic diseases.<sup>1</sup> Diabetes often goes undiagnosed because many symptoms seem harmless, including frequent urination, excessive thirst, extreme hunger, unusual weight loss, increased fatigue, irritability, and blurry vision. Unfortunately, these symptoms are anything but harmless and if unchecked over time, they will surely lead to future complications. For these reasons, having clear diagnostic criteria is imperative.

Diagnostic criteria for diabetes are based on the level of hyperglycemia that will lead to microvascular complications and, in particular, to retinopathy. In 2004, the American Diabetes Association<sup>2</sup> (ADA) published guidelines based on three cross-sectional epidemiologic studies that measured the glycemic level that significantly increased the risk of retinopathy. According to these guidelines, a diagnosis of diabetes can be made if a patient has fasting plasma glucose (FPG)  $\geq 126$  mg/dL (7.0 mmol/L) or a 2-hour post glucose load value of  $\geq 200$  mg/dL (11.1 mmol/L). Further epidemiologic studies<sup>3,4</sup> demonstrated a similar link between hemoglobin A1C (HbA1c) and increased risk of retinopathy. Based on these findings, the ADA presented their new diagnostic criteria in January 2010 (see Table 1).

## Classification and Prevalence of Diabetes

Diabetes mellitus is classified according to etiology. The ADA<sup>2</sup> defined several classes. Type 1, which accounts for 5% to 10% of people with diabetes, is mostly caused by immune-mediated beta cell destruction and is reflected by a complete deficiency of insulin. Type 2 diabetes accounts for 90% to 95% of cases. People with type 2 diabetes have a strong genetic predisposition for the disease. They may suffer from varying degrees of insulin resistance due to abnormal beta-cell function that can progress to some but not complete insulin deficiency. About 80% of people with type 2 diabetes are overweight or obese, one of the major causes of insulin resistance. Weight reduction and oral medications can improve insulin resistance and delay disease progression. Gestational diabetes mellitus (GDM) is defined as glucose intolerance that occurs in pregnancy; it affects ~4% of

**Table 1. Criteria for the diagnosis of diabetes\*<sup>5</sup>**

1. A1C  $\geq 6.5\%$ ; or
2. FPG  $\geq 126$  mg/dL (7.0 mmol/L); or
3. Two-hour plasma glucose  $\geq 200$  mg/dL (11.1 mmol/L) during 75-g glucose load; or
4. A random plasma glucose  $\geq 200$  mg/dL (11.1 mmol/L) with symptoms of hyperglycemia

\* Criteria 1–3 should be confirmed by repeat testing.

pregnant women in the US. Other types of diabetes (eg, maturity onset diabetes of the young [MODY]) are usually rare and associated with other genetic syndromes or disorders.

Currently, 285 million people worldwide (6.6% of the total world population) have diabetes.<sup>7</sup> It is projected that by 2030, this number will grow to 438 million or 7.8% of the population. In 2007, 23.6 million people (7.9%) in the US were estimated to have diabetes. Among them, 17.9 million were diagnosed with the disease while 5.7 million remained undiagnosed.<sup>6</sup> Every year, 1.6 million new cases of diabetes are diagnosed among American adults. In a May 2010 publication, the International Diabetes Federation<sup>7</sup> (IDF) reported the prevalence of diabetes among adults is the highest in North America and the Caribbean region followed by Europe and the Middle East. The lowest prevalence was noted in Africa and the West Pacific region. These trends are predicted to continue through 2030, which will present tremendous challenges for healthcare professionals dealing with diabetes all over the world.<sup>7</sup>

## How Blood Glucose Affects Healing

Patients with diabetes often have difficult-to-heal wounds. The initial barrier to healing is an increased blood glucose level, which causes cell walls to become rigid, impairing blood flow through the critical small vessels at the wound surface and impeding red blood cell permeability and flow. Impaired hemoglobin release of oxygen results in oxygen and nutrient deficits in the wound. A less-than-optimal immune function also contributes to poor wound healing in the patient with di-

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**Table 2. Summary of glycemic recommendations for non-pregnant adults with diabetes****AACE 2007<sup>10</sup>**

- A1C  $\leq$ 6.5%
- Fasting plasma glucose concentration  $<$ 110 mg/dL
- 2-hour postprandial glucose concentration  $<$ 140 mg/dL

**ADA 2010<sup>5</sup>**

- A1C  $<$ 7.0%
- Preprandial capillary plasma glucose 70–130 mg/dL (3.9–7.2 mmol/L)
- 1–2 hour postprandial capillary plasma glucose  $<$ 180 mg/dL ( $<$ 10.0 mmol/L)

abetes. When blood glucose levels are persistently elevated, chemotaxis and phagocytosis are compromised.<sup>8</sup> Chemotaxis is the process by which white cells are attracted to the site of an infection; phagocytosis is the ingestion of bacteria by white cells. Both processes are important in wound infection control. Diabetic infections take longer to heal because of delayed macrophage introduction and diminished leukocyte migration, which causes a prolonged inflammatory phase in the wound healing cascade.<sup>9</sup> Protein-calorie malnutrition and the resultant body composition changes are additional considerations in wound healing. Patients with diabetes often have a progressive loss of lean body mass, which is replaced with metabolically inactive fat mass.

The increase in morbidity and mortality rates for patients with diabetes is mostly related to progressive macro- and microvascular complications, including failure of wounds to heal. It is estimated that 15% of all patients with diabetes will develop foot ulcers and 84% of them will end up with lower-leg amputations.<sup>10</sup>

A multidisciplinary approach to clinical management is required to improve wound healing rates and reduce the risk of amputations. The Foot Care Specialists at Boston Medical Center in Boston, MA, developed a patient care algorithm<sup>11</sup> for patients outlining three possible patient categories: patients with non-limb-threatening wounds, patients with limb-threatening wounds, and septic patients. For all three categories, patient care includes clinical evaluation of the wound and general patient evaluation. This is followed by standard local wound care that includes offloading, debridement, dressing changes, and infection management plus applicable adjunctive therapies including nutritional care; glycemic control is the first and foremost goal, making medical nutrition therapy (MNT) an important part of diabetes management. The treatment of comorbidities, controlling edema, and physical and emotional therapy round out the treatment plan. These protocols have been proven to be effective in the treatment and healing of wounds and in reducing the risk for amputation.<sup>11</sup>

Although no specific glycemic targets are set for wound healing, the importance of sustained blood-sugar control was demonstrated in a recent 12-week, multicenter, randomized

clinical trial.<sup>13</sup> Clinical and laboratory data for 411 patients with diabetes were evaluated to study the association between HbA1c and wound healing in diabetic foot ulcers. Statistical regression results of this study showed that patients with elevated glucose levels (as reflected by HbA1c) over 12 weeks of wound care had 15% decreased odds of healing for every 1% increase in HbA1c. Glycemic targets for patients with diabetes are presented in Table 2. Nutrition plays a major role in improving patients' glycemic control for wound healing; MNT should be included in every plan of care.

### Nutrition for Wound Healing in Patients with Diabetes Mellitus

The basic diet for people with diabetes is well-balanced and carbohydrate/calorie-controlled, designed to control glucose levels and weight and minimize the risk of other comorbidities in otherwise healthy persons. The registered dietitian's (RD) role is to evaluate the patient's needs and individualize the diet to achieve normoglycemia as well as other treatment goals such as lipid (to prevent macrovascular risks) and blood-pressure control.<sup>5</sup> Since 2002, MNT for patients with diabetes has been covered under Medicare Part B<sup>14</sup> as well as by most private insurance plans.<sup>5</sup> Wound care practitioners who treat patients with diabetes should determine whether the patient has received MNT and refer the patient to a nutrition professional if needed.

The components of MNT for diabetes were established by strong evidence-based studies and trials<sup>5</sup> but as of today no specific evidence-based guidelines exist for MNT to support wound healing in patients with diabetes. Two recently published review articles<sup>14,15</sup> use the ADA Standards of Medical Care to come up with nutrition recommendations for wound healing in patients with diabetes. The American Association of Clinical Endocrinologists<sup>12</sup> (AACE) also established some evidence-based MNT guidelines for people with diabetes and addressed some specific recommendations for wound healing. Based on these articles, the following are some practical nutrition recommendations.

**Calories.** Wound healing consumes energy usually in the form of carbohydrates and fats. However, because of the stress response in wound healing, protein often is misused for energy, especially in cases involving low caloric intake. To prevent the loss of lean body mass, sufficient energy supply must be provided, and caloric requirements may be increased up to 25 to 30 calories/kg daily.<sup>15,16</sup>

**Carbohydrates.** Carbohydrates are the main and first source of cellular energy during wound healing. They also help in fibroblast movement and increase white blood cell activity to boost immune response.<sup>16</sup> The American Dietetic Association, the ADA, and AACE are all in agreement that the daily carbohydrate intake to maintain good glycemic control should be 45% to 65% of total daily calories.<sup>5,12</sup> In wound healing, this amount of carbohydrate will ensure that enough carbohydrate calories are provided in order to prevent oxida-

tion of protein for energy. Carbohydrates should be evenly distributed throughout the day to prevent fluctuations in blood sugar. For people with uncontrolled diabetes a low carbohydrate diet (about 130g/day) is frequently recommended along with exercise and pharmacotherapy<sup>5</sup>; however, this amount of carbohydrate may not be sufficient to promote wound healing. Thus, it is necessary to closely monitor the patient's blood sugar levels during the process of wound healing and modify the carbohydrate intake as needed.<sup>14</sup>

People with diabetes should be able to identify the carbohydrates in their diet by becoming familiar with exchange lists, carbohydrate counting, or the glycemic index/load method.<sup>14,15</sup> The role of the RD is to conduct a thorough patient assessment and evaluate ability to learn one or more of these methods. For people using the basal-bolus insulin regimen, the best approach is the carbohydrate counting method, which also provides more flexibility in food choice.<sup>5,12</sup>

**Fiber.** Fiber also plays a role in glucose management; daily goals of 25 to 50 g/day or 15 to 25 g/1,000 kcal should be emphasized.<sup>12</sup>

**Protein.** Protein is a major component of collagen synthesis; insufficient amounts can slow the rate as well as the quality of wound healing. Any type of trauma to the body can increase the need for protein; this requirement is even higher in cases of sepsis or stress. Wound healing requires 1.5 to 2 g/kg of protein per day, but this may vary depending on the wound type and the patient's kidney function.<sup>5,12,16</sup>

**Fat.** Total dietary fat should generally be <30% of daily calories. Monounsaturated fatty acids and n-3 polyunsaturated fatty acids have beneficial effects on the lipid profile and play a major role in membrane structure and function. These types of fat should comprise most of the daily fat intake for people with diabetes and wounds.<sup>5,12,16</sup>

Saturated fats should be limited to <10% of daily calories and <300 mg/day of cholesterol.<sup>12</sup> In patients with diabetes, LDL-C level should be maintained at <70 mg/dL to prevent risk of cardiovascular disease.<sup>5</sup> To achieve this level, saturated fat consumption should be limited to <7% of daily calories and cholesterol should be limited to less than 200 mg/day.<sup>12</sup>

**Vitamins and minerals.** A daily multivitamin should be considered for patients with diabetes with chronic or nonhealing wounds. Although some sources recommend additional supplementation of vitamins A and C and zinc, evidence is limited to support this practice for wound healing in patients who are not deficient.

**Fluids.** The elevated metabolic needs during wound healing may cause dehydration, which could be even more severe in uncontrolled diabetes. In order to maintain proper hydration status, water intake should range from 1,500 to 2,000 mL/day.<sup>16</sup> A general rule for provision of fluids calls for providing 1 mL per calorie consumed.

## Practice Points

- Many cases of diabetes are undiagnosed. Watch for signs

and symptoms of insulin resistance and diabetes, particularly in overweight patients with nonhealing wounds.

- Request a HbA1c test for patients with risk factors for and symptoms of diabetes. Certain patients who have blood glucose levels in the normal range when a finger stick test is performed may have high levels at other times of day. HbA1c provides a broader, longer-range picture.
- Diet management must be individualized to each patient's comorbid conditions and ability and readiness to adhere with protocols.
- Diet control is no longer simply controlling "sugar." The goal of a diet is to control the entire metabolic syndrome, including obesity, dyslipidemia, and hypertension.
- Portion size is key. Portions should be weighed with a food scale, not estimated, until the patient can demonstrate accuracy.
- A multidisciplinary approach should be used to reinforce the importance of controlling blood glucose during wound healing.
- Progressive resistance exercise can offset lean body mass loss and increase the body's anabolic drive.
- Ask patients about their dietary habits. Recommend consumption of three meals and one to two snacks daily.
- Explain the importance of taking medications (oral drugs and/or insulin) before meals or at set times as prescribed by the physician.
- Provide guidelines for treating hypoglycemia.
- Refer patients to an RD for individualized nutrition guidance. Remember this is a covered benefit for patients with diabetes.

## References

1. Lebovitz HE, ed. *Therapy for Diabetes Mellitus and Related Disorders*. 4th ed. Chicago, IL: American Diabetes Association; 2004:5-7.
2. American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care*. 2004;27(suppl 1):S5-S10.
3. International Expert Committee. International Expert Committee report on the role of the A1c assay in the diagnosis of diabetes. *Diabetes Care*. 2009;32:1327-1334.
4. American Diabetes Association. Diagnosis and classification of diabetes mellitus. *Diabetes Care*. 2010;33(suppl 1):S62-S69.
5. Standards of Medical Care in Diabetes—2010. *Diabetes Care*. 2010;33(suppl 1):S11-S61.
6. National Diabetes Information Clearinghouse (NDIC). National Diabetes Statistics, 2007. Available at: <http://diabetes.niddk.nih.gov/dm/pubs/statistics/#allages>. Accessed August 30, 2010.
7. International Diabetes Federation. Diabetes and impaired glucose tolerance—global burden: prevalence and projections, 2010 and 2030. Available at: [www.diabetesatlas.org/content/diabetes-and-impaired-glucose-tolerance](http://www.diabetesatlas.org/content/diabetes-and-impaired-glucose-tolerance). Accessed August 30, 2010.
8. Kenshole AB. Wholistic care of the person with diabetes. In: Krasner DL, Rodeheaver GT, Sibbald RG. *Chronic Wound Care: A Clinical Source Book for Healthcare Professionals*. 3rd ed. Wayne, PA: HMP Communications; 2001:584.
9. Kane DP. Surgical repair in advanced wound caring. In: Krasner DL, Rodeheaver GT, Sibbald RG. *Chronic Wound Care: A Clinical Source Book for Healthcare Professionals*. 3rd ed. Wayne, PA: HMP Communications; 2001:404.
10. McLennan SV, McGill MT, Twigg SM, Yue DK. Improving wound-healing

- outcomes in diabetic foot ulcers. *Expert Review of Endocrinology and Metabolism*. 2007;2(9):205-213.
11. Gibbons G, Locke C. Peripheral arterial disease. In: Lebovitz HE, ed. *Therapy for Diabetes Mellitus and Related Disorders*. 4th ed. Chicago, IL: American Diabetes Association; 2004:514-526.
  12. Rodbard HW, Blonde L, Braithwaite SS, et al, and the AACE Diabetes Mellitus Clinical Practice Guidelines Task Force. American Association of Clinical Endocrinologists medical guidelines for clinical practice for the management of diabetes mellitus. *Endocr Pract*. 2007;13(suppl 1):1-68.
  13. Cook EA, Cook JJ, Henao M, et al. The importance of sustained glycemic control during wound healing. Oral session presented at Foot Complications, American Diabetes Association Scientific Sessions. Orlando, FL. June 2010. Available at: <http://ww2.aievolution.com/ada1001/index.cfm?do=abs.viewAbs&abs=12889>. Accessed August 30, 2010.
  14. Collins N. Diabetes, nutrition, and wound healing. *Adv Skin Wound Care*. 2003;16(6):291-294.
  15. Grieger L. Nutrition and wound care. *Today's Dietitian*. 2009;11(8):12.
  16. Life Extension. Trauma and wound healing: the therapeutic role of nutrition. Available at: [www.lef.org/protocols/health\\_concerns/trauma\\_02.htm](http://www.lef.org/protocols/health_concerns/trauma_02.htm). Accessed August 30, 2010.

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