Tight Control of Type 1 Diabetes: Recommendations for Patients

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Tight control of blood glucose levels and risk factors for cardiovascular disease (e.g., hypertension, hypercholesterolemia) can substantially reduce the incidence of microvascular and macrovascular complications from type 1 diabetes. Physicians play an important role in helping patients make essential lifestyle changes to reduce the risk of these complications. Key recommendations that family physicians can give patients to optimize their outcomes include: take control of daily decisions regarding your health, focus on preventing and controlling risk factors for cardiovascular disease, tightly control your blood glucose level, be cognizant of potentially inaccurate blood glucose test results, use physiologic insulin replacement regimens, and learn how to manage and prevent hypoglycemia. (Am Fam Physician 2006;74:971-8, 983-4. Copyright © 2006 American Academy of Family Physicians.)

▶ **Patient information:** A handout on type 1 diabetes, written by the authors of this article, is provided on page 983.

Randomized clinical trials[1-5] have demonstrated that tight control of blood glucose levels reduces the risk of microvascular and macrovascular complications in patients with type 1 diabetes; this is not true for patients with type 2 diabetes. Although many patients with type 1 diabetes may benefit from tightly controlling their blood glucose levels,[3] few do so.[6] The Diabetes Control and Complications Trial (DCCT)[4] showed that, compared with conventional therapy, intensive therapy significantly reduced the risk of retinopathy progression (4.7 versus 1.2 per 100 patient-years, number needed to treat [NNT] = three for 10 years) and clinical neuropathy (9.8 versus 3.1 per 100 patient-years, NNT = 1.5 for 10 years). In a long-term follow-up study,[4] the likelihood that a patient would experience a cardiovascular event was significantly lower in the intensive treatment group (0.38 versus 0.80 events per 100 patient-years). Thus, intensive therapy prevented one cardiovascular event for every 25 patients treated over a 10-year period in this relatively young group of patients.[4] Intensive therapy is not without risk, however. The risk of severe hypoglycemia and subsequent coma or seizure was significantly higher in the intensive therapy group (16.3 versus 5.4 per 100 patient-years).[3]

Recommendations for Patients

Physicians may provide patients with the following recommendations to help them tightly control their diabetes; a few of the recommendations may not be appropriate for patients with type 2 diabetes, even those who use insulin. *Table 1*[1-5,7-26] includes tips for controlling blood glucose levels and minimizing complications. These tips are consistent with consensus guidelines from the American Diabetes Association (ADA) and others (these tips are informed by my experience practicing tight control of type 1 diabetes for 50 years -S.H.).

TAKE CONTROL OF YOUR HEALTH

Tight control of type 1 diabetes requires patients to independently make daily decisions about diet, exercise, and insulin intake. Family physicians can encourage patients to proactively control their disease by teaching them how to properly adjust their insulin dosages and adopt lifestyle changes to reduce the risk of complications. Physician encouragement can effectively help patients change their behaviors.[7]

One randomized clinical trial[8] on immediate and delayed patient education and empowerment programs showed that

95 percent of patients who participated in the programs reportedly changed their diet, exercise regimen, and/or frequency of blood glucose testing. A1C levels, measured after patients completed the education programs, were more improved in patients who received immediate education compared with patients who received delayed education (-0.72 versus -0.04 percent, $P = .05$).

TABLE 1
Twenty Tips for Patients to Help Tightly Control Their Type 1 Diabetes

Take control of your health.[7,8]

Adopt multiple strategies to prevent the complications of type 1 diabetes.[9,10]

Eat a heart-healthy diet.[11-13]

Maintain a healthy weight.[14,15]

Exercise regularly.[16,17]

Meet your blood glucose goals as closely as possible.[1-5]

Test blood glucose level frequently and at critical times.[1-3]

Be wary of potentially inaccurate blood glucose readings.[18]

Use a rapid-acting insulin before each meal.[19-22]

Carry rapid-acting insulin syringes or pens.[23]

Take ultralong-acting insulin once per day.[24]

Know the onset, peak, and duration of your insulins.[23]

Learn the signs and symptoms of hypoglycemia and how to manage the condition.[23]

Always carry a source of sugar.[23]

Teach those in your life about hypoglycemia.[23,25]

Keep glucagon at home.[23,25]

Wear a medical alert bracelet or necklace.[23]

Recognize effects of stress on blood glucose levels and manage your stress level.[23]

Limit alcohol consumption to moderate amounts.[15,26]

Lead a normal life.[23]

Information from references 1 through 5 and 7 through 26.

ADOPT MULTIPLE STRATEGIES TO PREVENT COMPLICATIONS

Tight glycemic control can significantly reduce the risk of microvascular complications from type 1 diabetes. For example, a reduction in A1C from 10 to 7 percent is associated with a reduction in the risk of retinopathy from 0.5 to 0.1 percent.[27,28]

Patients can reduce their risk of cardiovascular disease (CVD) by learning to prevent and control other major risk factors (e.g., high cholesterol, hypertension).[9,10,29-32] Patients who smoke should quit to reduce the risk of CVD and microvascular complications. Family physicians should screen for these risk factors and help patients modify their lifestyles to reduce risks. Patients should keep their low-density lipoprotein (LDL) cholesterol level at less than 100 mg per dL (2.60 mmol per L),[33] with a therapeutic option of less than 70 mg per dL (1.80 mmol per L) for high-risk patients (e.g., those with known CVD).[34] Patients should maintain blood pressure levels of less than 130/80 mm Hg.[35] A daily aspirin regimen lowers coronary heart disease risk by 20 to 25 percent.[36]

Closely monitoring and treating patients with retinopathy reduces progression of microvascular complications. Diabetic retinopathy can be treated, and[37] tight glycemic control reduces its progression.[3] The ADA recommends that patients receive dilated eye examinations at least annually starting three to five years after the onset of type 1 diabetes.[25]

Early nephropathy can be detected by screening for microalbuminuria. Hypertension control,[37] tight blood glucose control,[3] and the use of angiotensin-converting

enzyme (ACE) inhibitors (regardless of blood pressure)[38] reduce the risk of progression.

EAT A HEART-HEALTHY DIET

Hypercholesterolemia and hypertension increase the risk of CVD, retinopathy, and nephropathy.[39,40] Approximately 90 percent of adults develop hypertension[41]; patients with diabetes generally develop the condition earlier in life.[42] More than 70 percent of American adults develop elevated cholesterol levels.[11] These risk factors are largely preventable, however.[40,41]

Patients should follow a heart-healthy diet to reduce blood pressure and cholesterol levels. Specifically, patients should limit their daily fat intake to 30 percent or less of calories, with less than 7 percent from saturated fat; limit their sodium intake to 1,500 mg or less per day; and eat at least 3 oz of whole grains, 2 cups of fruit, and 3 cups of vegetables per day.[11-13] Patients should only eat sweets in moderation. To slow the rapidly rising blood glucose levels caused by sweets, patients should eat them with other foods when possible and use rapid-acting insulin.[25] Bedtime and other snacks are largely unnecessary to raise blood glucose levels if a patient uses insulin, but they may be necessary if the patient's blood glucose level is low.

MAINTAIN A HEALTHY WEIGHT

The DCCT[14] demonstrated that tight control of blood glucose levels can cause weight gain and even obesity. Weight gain causes an increase in blood pressure, LDL cholesterol levels, and triglyceride levels and causes a decrease in high-density lipoprotein (HDL) cholesterol levels.[15] Weight gain also can lead to insulin resistance and can make glycemic control more difficult. Men should maintain a waist size of 40 in (102 cm) or less, and women should maintain a waist size of 35 in (88.9 cm) or less.[33] Patients should be reminded that food portion control and lower caloric intake plus regular physical activity are critical to avoid weight gain.

EXERCISE REGULARLY

Regular physical activity is especially important for patients with diabetes, because inactivity in these patients is associated with a two times higher risk of CVD.[16] Exercise improves glucose and HDL cholesterol levels, decreases stress, and helps normalize weight.[17] However, less than 20 percent of Americans get sufficient exercise.[32]

Patients should exercise for 30 to 60 minutes daily at an intensity of at least a brisk walk,[17] and they should be counseled on how to accommodate exercise's effect on blood glucose levels. Before exercise, patients can reduce their insulin dose or consume extra carbohydrates proportionate to the intensity and duration of their physical activities. Physicians should tell patients that insulin is absorbed and peaks faster during exercise, especially when injected into the leg.

MEET YOUR BLOOD GLUCOSE GOALS AS CLOSELY AS POSSIBLE

It is important for physicians to provide patients with blood glucose goals. The ADA intensive treatment goals for blood glucose and A1C levels, which are similar to those established by the DCCT Research Group, are highlighted in *Table 2*.[25] To achieve these goals, patients may need counseling on how to appropriately balance their caloric intake, physical activity, and insulin doses throughout the day. This balance requires patients to learn how food, physical activity, and insulin affect their blood glucose levels. Blood glucose control also requires patients to start with basal insulin and use an insulin bolus at mealtime to mimic normal physiologic insulin levels. Physicians may refer a patient to a certified diabetes educator at the time of

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TABLE 2

ADA Recommendations for Blood Glucose and A1C Goals

Measurement	Goal
Preprandial blood glucose	90 to 130 mg per dL (5.0 to 7.2 mmol per L)
Postprandial blood glucose	Less than 180 mg per dL (10.0 mmol per L)
A1C level	Less than 7 percent

ADA = American Diabetes Association.

Adapted with permission from American Diabetes Association. Clinical practice recommendations 2005. Diabetes Care 2005;(28 suppl 1):S22.

diagnosis or if the patient is unable to meet his or her glycemic goals.

FREQUENTLY TEST BLOOD GLUCOSE LEVELS

Patients should assess fingertip blood glucose levels at least three times daily.[43] In addition, patients should test their blood glucose levels before and after exercising, before driving, and when they are uncertain if their blood glucose is at an appropriate level. Bedtime testing is especially important because nocturnal symptoms may go unnoticed, causing severe hypoglycemia. If a patient's blood glucose level drops below 100 mg per dL (5.6 mmol per L), he or she should eat a small snack.

> Patients with type 1 diabetes should use an insulin bolus at mealtime plus a long-acting insulin to mimic normal physiologic insulin levels.

Meters that measure glucose from a site other than the fingertip usually are reliable; however, nonfingertip testing 60 minutes after meals and after exercise has been shown to be less reliable than fingertip testing.[44] Therefore, the fingertip remains the recommended test site.

Continuous glucose monitoring systems can detect the frequency and severity of unrecognized hypoglycemic episodes; these systems are effective but expensive. A controlled crossover trial[45] showed that patients using continuous glucose monitoring systems had significantly lower A1C levels compared with control patients (-0.39 versus -0.1 percent).

BE WARY OF POTENTIALLY INACCURATE BLOOD GLUCOSE READINGS

Patients should be aware that inaccurate blood glucose readings potentially can occur because of faulty equipment or improper testing techniques. One study[18] concluded that faulty meters or test strips could provide grossly inaccurate readings. Patients can use a control solution to check the accuracy of their meters if they believe their equipment is not functioning properly. Physicians should suspect an inaccurate reading if a home blood glucose test is inconsistent with A1C testing. When an unexpectedly high or low reading occurs, patients should assess the presence or absence of symptoms before taking extra insulin or sugar.

USE RAPID-ACTING INSULIN BEFORE EACH MEAL

Rapid-acting insulin (e.g., lispro [Humalog], aspart [NovoLog], glulisine [Apidra]), taken shortly before eating, can effectively control postprandial blood glucose levels.[19-22,46] With a peak activity of about one hour, which is similar to normal postprandial blood glucose levels, rapid-acting insulin is more physiologic than regular insulin. The use of rapid-acting insulin is associated with fewer postprandial hypoglycemic episodes compared with regular insulin (about 3 versus 4 percent over six to 12 months). Studies have not yet demonstrated that rapid-acting insulin improves other clinical outcomes compared with regular insulin; therefore, other than the decreased risk of hypoglycemia from using insulin analogues instead of regular insulin, regular insulin can be substituted if cost is an issue.

Patients may benefit from instruction on how to count carbohydrates to accurately determine how much insulin to take. Patients typically need 1 unit of insulin per 10 to 15 g of carbohydrates. If the patient's blood glucose rises above the recommended level, a supplemental dose should be taken to restore the level to 100 mg per dL. One unit of short-acting insulin typically reduces blood glucose levels 20 to 60 mg per dL (1.1 to 3.3 mmol per L), depending on insulin sensitivity; the level of reduction can be estimated by dividing 1,800 by the daily insulin dosage.[47]

ALWAYS CARRY RAPID-ACTING INSULIN SYRINGES OR PENS

Patients should always carry rapid-acting insulin to accommodate flexible meal and snack times or in case additional doses are needed.[23] Repeated use of plastic syringes does not increase the risk of infection if the needle is recapped after each use.[48] Patients may choose to carry insulin pens, although they cost more than syringes. Some highly motivated patients may prefer an insulin pump, which is more difficult to use, for optimal physiologic insulin replacement. Pumps cost more than syringes or pens.

USE GLARGINE ONCE DAILY IF YOU DO NOT USE AN INSULIN PUMP

Patients who do not use insulin pumps may consider using glargine (Lantus) as their basal insulin (typically 16 to 24 units). If a patient does not use basal insulin, blood glucose levels can become unstable during the night and between short-acting insulin doses. Glargine slowly releases insulin over 24 hours, causing more physiologic basal insulin levels. Insulin pumps create the same effect,[49] maintaining stable blood glucose levels between meals.

Glargine is absorbed more consistently than intermediate-acting insulins and has no peak action time, reducing the risk of hypoglycemia. A study[24] that compared glargine insulin with insulin isophane suspension (neutral protamine Hagedorn) in patients with type 1 diabetes showed that symptomatic hypoglycemia was less common in patients who used glargine (39.9 versus 49.2 percent over one month, $P = .02$).[24] Data are lacking regarding the effect of glargine on other clinical outcomes (e.g., macrovascular complications, mortality) in patients with type 1 diabetes compared with other long-acting insulins.

KNOW THE ONSET, PEAK, AND DURATION OF YOUR INSULINS

Patients should know how rapidly their insulins take effect, when they peak, and how long they are active (*Table 3*[18]). Each type of insulin has distinct advantages and disadvantages. Rapid-acting insulin controls postprandial blood glucose more effectively than regular insulin; however, too much rapid-acting insulin can cause a rapid onset of hypoglycemia, giving the patient less time to recognize the symptoms.

Intermediate-acting insulin remains active longer than other insulins but has a slower onset, its peak action is not related to mealtimes, and it can cause hypoglycemia if eating is delayed or if physical activity is increased. Because intermediate-acting insulin peaks many hours after it is administered, patients must eat meals at set intervals to avoid hypoglycemia. The disadvantages of intermediate-acting insulin outweigh the advantages of tight blood glucose control.

LEARN THE SIGNS AND SYMPTOMS OF HYPOGLYCEMIA AND HOW TO MANAGE THE CONDITION

Soon after diabetes is diagnosed, patients with hypoglycemia typically experience adrenergic symptoms (e.g., shakiness, palpitations, nervousness, unexplained diaphoresis, hunger). After many years, especially if a patient experiences recurrent hypoglycemia, neuroglycopenic symptoms (e.g., fatigue, slow speech or movement, confusion, irrationality, irritability, weakness, blurred vision, pallor, twitching, headache) predominate. Symptoms of hypoglycemia can be as subtle as slight fatigue or as dramatic as a feeling of imminent collapse.

Hypoglycemia normally does not require hospitalization. Patients instead should immediately eat or drink something that contains sugar; overtreatment can cause an

TABLE 3

Onset, Peak, Duration, and Cost of Insulins

Type of insulin	Onset	Peak (hours)	Duration (hours)	Cost*
Rapid-acting				
Aspart (NovoLog)	5 minutes	1 to 2	3 to 4	$84
Lispro (Humalog)	5 minutes	1 to 2	3 to 4	78
Lispro pen	5 minutes	1 to 2	3 to 4	31 (3 ml)
Regular insulin injection	15 minutes	3 to 4	6 to 8	46
Intermediate-acting				
Insulin isophane suspension (neutral protamine Hagedorn)	1 hour	6 to 8	12	35
Insulin zinc suspension (Lente)	1 hour	6 to 8	12	33
Long-acting				
Glargine	1 hour	None	24	75
Glargine pen†	1 hour	None	24	30 (3 ml)

*—Estimated cost to the pharmacist for one 10-mL vial based on average wholesale prices in Red book. Montvale, N.J.: Medical Economics Data, 2006. Cost to the patient will be higher, depending on prescription filling fee.

†—The authors do not recommend glargine pens because the insulin cartridges are sold separately from the device that holds them, this device only is available in physician offices and not in pharmacies, and the devices are difficult to use.

Adapted from Havas S, Mayfield J. Self-control: a physician's guide to blood glucose monitoring in the management of diabetes. Leawood, Kan: American Academy of Family Physicians, 2004.

ongoing cycle of hyperglycemia, followed by hypoglycemia. Four to 8 oz of juice or soda is recommended for initial treatment of hypoglycemia, followed by a fingertip blood glucose test 15 to 20 minutes later to assess the need for further treatment.

Physicians should assure patients that hypoglycemia is an anticipated complication of tight glycemic control despite the best precautions.[3] Patients can be taught to recognize and treat early symptoms of hypoglycemia and to learn from each episode (e.g., how to reduce the chances of recurrence). Severe hypoglycemia can be fatal.

Fortunately, the availability of more physiologic long- and rapid-acting insulins has reduced the incidence of severe hypoglycemia. Patients with frequent hypoglycemia and those who are less aware of hypoglycemic symptoms should raise their short-term blood glucose goals to improve hypoglycemia awareness.

ALWAYS CARRY A SOURCE OF SUGAR

Because food is not always readily available, it is important for patients to carry a source of sugar (e.g., a vial of sugar, glucose tablets, candy) with them in case they become hypoglycemic, particularly if they are tightly controlling their blood glucose levels.

EDUCATE THOSE IN YOUR LIFE ABOUT HYPOGLYCEMIA

The patient or physician can teach persons who have frequent contact with the patient about the symptoms of hypoglycemia, how to treat the condition, how to overcome the patient's occasional hypoglycemia-induced confusion, and the importance of remaining calm during an episode. If the patient needs assistance, they should simply provide him or her with a source of sugar. Patients usually recover quickly; if not, additional sugar can be given.

KEEP GLUCAGON AT HOME

If extreme hypoglycemia inhibits a patient from eating or drinking safely, a single injection of glucagon (1 mg intravenously or subcutaneously) typically will restore consciousness within five to 10 minutes.

WEAR A MEDICAL ALERT BRACELET OR NECKLACE

A medical alert bracelet or necklace stating that the patient has diabetes can alert others that hypoglycemia may be causing unusual behavior, seizure, or coma. This may help the patient receive appropriate treatment faster. Patients can purchase medical identification bracelets or necklaces online.

MANAGE STRESS LEVELS

Physical and psychological stress can cause counterregulatory hormone (e.g., cortisol, epinephrine) elevations, which increase insulin resistance and gluconeogenesis. Depression has been associated with a significant increase in glycemic control difficulties.[50]

Patients may not recognize symptoms of hypoglycemia if they are distracted by stress. Patients should increase the frequency of blood glucose testing if they are stressed and should adjust their insulin and food intake accordingly. Physical stress (e.g., infection) also can cause blood glucose levels to rise.

LIMIT ALCOHOL CONSUMPTION

Excessive alcohol consumption increases the incidence of hypertension and stroke[12,26] and inhibits the liver from releasing glucose, exacerbating hypoglycemia. Patients should limit alcohol consumption to one to two drinks per day and focus on maintaining a normal blood glucose level when drinking alcohol.

LEAD A NORMAL LIFE

Patients with diabetes should be reassured that they can do virtually anything those without diabetes can do as long as they maintain glycemic control. Family physicians can significantly influence their patients' outlooks on living with diabetes by educating them and encouraging them to take control of their health.

Helping Patients Apply Recommendations

The previous recommendations focus on the key educational messages that patients with diabetes need to know. Taking the time to explain these recommendations, instead of simply providing written materials, may ben-

efit patients. These discussions can increase patients' satisfaction and understanding and benefit their future health. For patient education programs, newsletters, and journals on type 1 diabetes, go to the ADA Web site at http://www.diabetes.org.

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