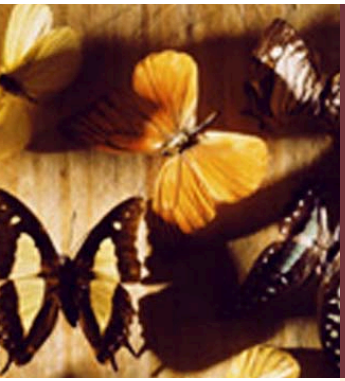
TYPE 2 DIABETES



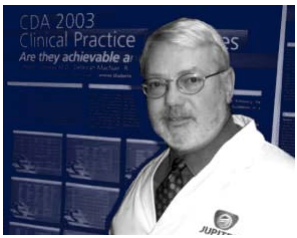
INSULIN TREATMENT

2009 UPDATE ON

"A HEALTHCARE PROFESSIONAL'S GUIDE TO TREATMENT"

BY **J. ROBIN CONWAY, MD**

www.diabetesclinic.ca



Author: Dr. Robin Conway

Note to readers The contents herein represent the opinions and clinical experience of the author. This booklet is not intended to be a comprehensive text on diabetes management, but rather a user-friendly guide to key management principles for use in the family practice setting. Healthcare professionals must consider the needs of their individual patients and use their clinical judgment when applying the information in this document. Readers who may be interested in more detail and references are referred to the most recent Canadian Diabetes Association clinical practice guidelines. In addition, physicians should consult the most recent version of the *Compendium of Pharmaceuticals and Specialties* for complete prescribing information and product monographs.

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TREATMENT - INSULIN

RATIONALE

At the time of diagnosis of diabetes when fasting plasma glucose exceeds 7 mmol/L or casual plasma glucose exceeds 11 mmol/L; it is estimated that the insulin producing ability of the pancreas has declined to 50% of normal. The UKPDS has shown us that the progressive decline in function of the pancreas continues at a rate of about 5% per year until 10 years after diagnosis there is minimal or no insulin production. The point at which insulin needs to be added to the treatment regime varies from one person to another but generally; if appropriate treatment and lifestyle changes are implemented, good glycemic control may be maintained with insulin production as low as 20% of normal (6-10 years after diagnosis). There comes a point; however, where introduction of exogenous insulin is required to prevent metabolic decompensation. Initially the use of insulin is fairly simple, one of many regimes can be used because precise replacement is not needed but only a correction of some of the insulin deficit. In the earlier stages; when glycemic control with A1c <7% (eAG 8.5 mmol/L) can no longer be achieved with oral hypoglycemics, CDA Guidelines recommend addition of basal insulin. As time goes on and endogenous insulin production declines still further to minimal levels; more precise insulin replacement regimes are needed including basal/bolus insulin.

INSULIN

Initial use of insulin can be considered in the patient with marked hyperglycemia (A1C > 9.0%) or metabolic decompensation at diagnosis. Many physicians and patients alike resist the initiation of insulin. It is important to overcome this barrier. Individuals who have had diabetes for >10 years most often need addition of insulin in order to achieve glycemic control. Patients who are not initially motivated should be encouraged to try insulin. Sometimes it may be preferable to introduce insulin as a temporary trial with the understanding that if the patient does not feel better on insulin, a return to previous treatment is acceptable. It is essential to explain the many benefits of good glucose control and to make insulin initiation as simple as possible. Even patients who are not physically able (such as nursing home residents) can do very well on insulin administered by a caregiver.

TREATMENT - INSULIN

If adequate control (A1C > 7.0%) cannot be maintained on oral agents alone, we should add insulin.

We have conventionally started by using an intermediate-acting insulin such as NPH (Neutral Protein Hagedorn) [Humulin or Novolin], administered at bedtime. We start with a modest dose (such as 10u or 0.2u/kg) and then titrate up the dose until we achieve normal fasting glucose levels (or until we get nocturnal hypoglycemia).

Alternatively we can use an extended long-acting insulin analogue (glargine [Lantus] or detemir [Levemir]), these insulins last 24 hours so they may be given at any time of the day (though the time should be consistent from one day to the next). The action profile of glargine is slightly longer than that of detemir, though from a clinical standpoint they are very similar though somewhat larger doses of detemir may be required. There is less risk of hypoglycemia using a long acting analogue.

Self-monitoring blood glucose is an important component of insulin therapy.

Adding bedtime insulin to daytime oral agents

When lifestyle modifications and oral agents are no longer able to maintain A1C in the target range (A1C >7.0%), the addition of intermediate-acting insulin (NPH) or an extended long-acting insulin analogue (glargine [Lantus] or detemir [Levemir]) at bedtime may achieve better glucose levels in the morning, thereby decreasing glucose toxicity and allowing the daytime oral agents to be more effective. Frequently in type 2 diabetes, the highest glucose value of the day is the fasting value in the morning. This is primarily caused by overnight hepatic glucose production. The administration of exogenous insulin suppresses glucagon secretion and thereby decreases overnight glucose formation by the liver.

The **Dawn Phenomenon**, characterized by increased steroid levels (particularly growth hormone levels), further increases morning glucose levels.

Hepatic glucose production is sensitive to suppression by insulin. Thus, a small dose of insulin at night may suppress hepatic glucose output and achieve a lower fasting glucose level. The dose required at night to suppress hepatic glucose production is lower than the dose required to stimulate peripheral glucose uptake to treat postprandial hyperglycemia and is usually safe with little potential to cause hypoglycemia..

Advantages of bedtime insulin

Bedtime insulin is a good starting point for patients who may need multiple injections later, as it allows them to become comfortable with the injections and the concept of insulin adjustment to achieve a glycemic goal.
Other advantages include:

- **Safe**, less likely to cause overnight hypoglycemia (especially with glargine [Lantus] and detemir [Levemir])
- **Easy** to teach
- **Only** 1 injection/day
- **Only** small doses of insulin are needed, causing less weight gain
- Can be given by **insulin pen** (virtually painless, no mixing needed)

Bedtime insulin options

- Extended **long-acting basal insulin analogues** (insulin glargine [Lantus] or insulin detemir [Levemir]). These insulins have a virtually flat profile of action over 24 hours. Because of their prolonged activity, the injections may be given at any time of the day. It may be given whenever the oral medications are taken once a day in order to enhance adherence or to increase flexibility for other healthcare providers such as home-care nurses. Insulin glargine is available in a vial, cartridge (for the Autopen 24) or disposable Solostar pen. Levemir is supplied in cartridges that fit in the Novolin pen 4.
- **Intermediate-acting insulin** (Humulin-N, Novolin ge NPH) are available in vials, in 3 ml cartridges to fit in the proprietary pens of each of the insulin manufacturers or in disposable pens

General principles of bedtime insulin adjustment

Since hyperinsulinemia is associated with weight gain and increases risk of hypoglycemia, we want to use the smallest possible dose of insulin to achieve our objective of a normal fasting glucose level. We get a bigger bang for our buck by using a small dose of insulin at night to suppress overnight glucose production by the liver than by giving daytime insulin to increase glucose disposal.

Goal: To achieve stable fasting blood glucose values of 4.0 to 7.0 mmol/L

Dose: 0.1 to 0.3 units/kg or 1 unit/mmol/L of fasting blood glucose

Starting dose: 10 units of insulin administered just before bedtime. Some can get by with even smaller doses if insulin sensitive. In slim patients or those who live alone, I will often start with a dose of 6 units.

Self-monitoring: Patient should monitor fasting blood glucose daily.

Titration: Increase the dose by 1 or 2 units after 3 successive days of a fasting blood glucose > 7.0 mmol/L. Proceed slowly in trying to achieve the fasting target. Many patients have been hyperglycemic for a long time and may have hypoglycemic symptoms with glucose levels in the normal range (< 5.0 or 6.0 mmol/L). Take your time to correct hyperglycemia. Patients hate hypoglycemia. They feel terrible and simply will not adhere to insulin therapy if we push glucose levels down too fast. Patients gradually become accustomed to lower glucose levels and over time will develop tolerance for levels that previously made them feel hypoglycemic.

Reduce bedtime insulin dose by 2 units after an episode of nocturnal hypoglycemia or 2 successive days with a fasting glucose level < 4.0 mmol/L.

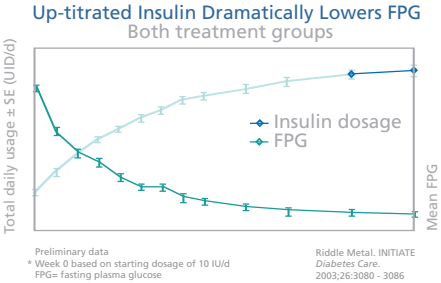
Once a stable average fasting glucose level of 4.0 to 7.0 mmol/L has been achieved for or a month or so, turn your attention to the pre-lunch, pre-supper and pre-bedtime glucose levels. If these are normal, then we have achieved our goal.

If the patient has normal fasting values, but develops daytime or evening hypoglycemia, reduce the sulphonylurea or the meglitinide. These drugs cause insulin release from the pancreas and may cause hypoglycemia (although this is rare with repaglinide or nateglinide, as these are taken only with meals). Metformin, TZDs or acarbose on their own do not cause hypoglycemia. If daytime hyperglycemia persists despite full therapeutic doses of appropriate oral agents, we have to consider adding daytime insulin or discontinuing oral agents and using insulin alone.

After a month on a low (introductory) dose of insulin, if the patient is comfortable, is willing and is monitoring well, give instructions on how to self-adjust their insulin dose according to self-monitored fasting blood glucose levels (see sample patient instructions on p. 27). Insulin requirements are rarely static, so the patient really needs to become familiar and comfortable with insulin adjustments.

If these measures do not achieve control (A1C <7.0%) after 3 months, referral to a diabetes clinic or endocrinologist should be considered.

Set limits on insulin adjustments. Remember that some patients will not respond adequately because of profound insulin resistance and will need more frequent insulin therapy. It is not wise to increase insulin doses indefinitely. Patients should not increase the insulin dose to more than 30 units without first reviewing their diary with the physician. Some patients do need large doses, but beware of overnight hypoglycemia with high blood glucose levels in the morning.



HYPOGLYCEMIA

Make sure that the patient is aware of the symptoms of hypoglycemia and how to treat it. The CDA and several pharmaceutical companies have charts describing hypoglycemic symptoms. If patients suspect hypoglycemia, they should always confirm it with capillary testing, and record the results in their diary. (See page 31 for treatment of hypoglycemia.)

Overnight hypoglycemia with high blood glucose levels in the morning

If you see increasing fasting levels despite increases in bedtime insulin, the patient may be having undetected hypoglycemic reactions during the night. To confirm, have the patient set an alarm clock for 3:00 AM for a few nights and instruct them to check the capillary glucose level (and record in the diary). If the value is low (< 4.0 mmol/L), the bedtime insulin dose should be reduced or the patient should be switched to an extended long-acting insulin such as glargine (Lantus) or detemir (Levemir).

How to adjust your bedtime insulin dose

I have given you a prescription for: _____

I am giving you a small dose of evening insulin to prevent your blood glucose (sugar) from going too high during the night, so that you will have a normal blood glucose level when you get up in the morning. It is safe and rarely causes low blood glucose (hypoglycemia).

It is very important to measure your blood glucose with your blood glucose meter. You should do this at bedtime before you take your insulin, and in the morning before you eat breakfast. While you are adjusting your insulin, you should also measure and record (in your glucose diary), readings before lunch and supper as often as possible.

- **Start** with a dose of 10 units of insulin at bedtime. (or at any convenient time if you are using Lantus or Levemir, time should be consistent from day to day).
- **Measure** your blood glucose every morning before breakfast.
- **If your before-breakfast** glucose value is higher than 7.0 for 3 days in a row, you should increase your bedtime insulin dose by 2 units (that is: from 10 units to 12 units).
- **Whenever you have** a glucose level higher than 7.0 for 3 days in a row, you will increase your bedtime insulin by 2 units.
- **You should consider** testing your blood glucose at 3:00 am occasionally to ensure you are not having low overnight blood glucose levels.
- **Do not go above** a daily dose of 30 units of insulin without discussing with me. Your goal is to achieve before-breakfast glucose levels between 4.0 and 7.0 mmol/L.
- **If you have** a low blood glucose (hypoglycemic) reaction during the night, decrease the bedtime insulin dose by 2 units.
- **If you have** a before-breakfast glucose reading below 4.0 for 2 days in a row, decrease the bedtime insulin dose by 2 units.

If you have any problems or questions, please check the information on the web site (www.diabetesclinic.ca) or call me at: _____

For emergencies outside office hours, call: _____

Adding basal is not enough

If, despite achieving a normal fasting glucose with adjustment of NPH or long acting analogue insulin, there is consistent hyperglycemia at certain times of the day, we can alter our insulin therapy to correct these hyperglycemic periods. One technique is to add a single injection of short acting insulin analogue (aspart, glulisine or lispro) with the largest meal of the day. This technique is known as **basal plus** and is a good way to start intensification when basal is not enough.

Premixed insulins

Some physicians have a comfort level with premixed insulins. These insulins are usually used twice daily. For example, a 30/70 human insulin mixture (Humulin 30/70 or Novolin GE 30/70) is given as 2/3 of the total daily dose in the morning and 1/3 with supper. The usual insulin dose is about 0.5 to 1 units/kg. For dose adjustment, concentrate on correcting the highest blood glucose value of the day. This can be accomplished using a dose-adjustment formula (for example, increase the dose by 2 units if blood glucose is >10.0 mmol/L for 2 or 3 days in a row).

If morning glucose is high, we increase the evening premix dose.

If evening glucose is high, we increase the morning premix.

If despite adjustment of morning dose, we have hypoglycemia in the daytime or A1c is still above target of <7% then it may help to add a small dose of premix with the midday meal (start with about 6u). An alternative would be to change to a 50/50 analogue premix such as Humalog Mix 50 with each meal.

Premixed insulins include the following:

- Humulin or Novolin ge 30/70 (30% regular and 70% NPH);
- Humalog Mix25 (25% rapid-acting insulin analogue [lispro] with 75% Humulin-NPL [NPL, an intermediate-acting insulin]) or Humalog Mix 50; (50% rapid-acting insulin analogue [lispro] with 75% Humulin-NPL [NPL, an intermediate-acting insulin])
- Novomix 30 (30% rapid-acting insulin analogue [aspart] and 70% intermediate-acting insulin analogue (neutral protamine aspart [NPA]).

A potential problem with premixed insulins given at suppertime is that the intermediate-acting component (NPH, NPL or NPA) peaks about 7 or 8 hours after administration. This peak may therefore occur at around 2:00 am, when insulin needs are lowest, and may cause nocturnal hypoglycemia, or may not supply enough insulin to cover the dawn phenomenon from 4:00 to 8:00 am. If either of these is a problem, we can give a rapid-acting insulin analogue (such as insulin aspart [Novorapid]), insulin glulisine (Apidra) or insulin lispro [Humalog] with supper and the intermediate-acting or long acting insulin at bedtime. This is known as a **Basal Plus** technique and is a good start to intensifying insulin to MDI.

BASAL/BOLUS

Frequently, a more logical approach is a basal/bolus method (also known as intensive management or multiple daily injections [MDI]) in which a short-acting (bolus) insulin (aspart [NovoRapid], glulisine [Apidra] or lispro [Humalog]) is given with each meal, and a longer-acting (basal) insulin (NPH, glargine [Lantus] or detemir [Levemir]) is given once or twice a day to maintain a constant basal insulin level. This is described in more detail on page 29.

Adjusting oral agents

If, despite achieving a normal fasting glucose with bedtime NPH and maximal therapeutic doses of appropriate oral antihyperglycemic medications, there is still hyperglycemia before lunch and supper, we will likely need to go on twice-daily or intensive insulin treatment. Again, the most logical treatment is MDI. I counsel other physicians that if they are going to learn only one way of giving insulin, this is the one to learn. Oral agents, certainly the sulphonylureas, may be discontinued at this point, as the patient is receiving exogenous insulin support round the clock. In practice, I have found that sometimes in the very insulin resistant individuals if on rosiglitazone (Avandia), pioglitazone (Actos) or metformin (Glucophage, Glumetza), continuing on these medications decreases the total dose of insulin required for control. We need to be cautious when giving insulin together with a TZD (glitazone), as this combina-

tion may increase the risk of fluid retention or CHF. This combination is approved in the US, but is not an approved indication in Canada and there is a Health Canada warning about this combination. As this is an "off-label" use of TZDs, remember to inform the patient and note in the chart.

Remember

- **Don't give up until** A1C is in the target range of < 7.0%
- Normal fasting or preprandial glucose is 4.0 to 6.0 mmol/L.
- Talk to your patients about their diet and exercise habits and encourage improvements.

INTENSIVE INSULIN THERAPY

Intensive insulin therapy requires the discontinuation of some oral agents and the initiation of multiple daily insulin injections (MDI) in order to closely mimic the healthy body's basal and bolus insulin secretion patterns. Metformin is usually maintained. Secretagogues (Sulphonylurea or Meglitinides) are usually discontinued. By the time that we require intensive insulin therapy, there is usually very little functioning beta cells in the pancreas so TZD (rosiglitazone or pioglitazone) and incretin therapies are usually discontinued as they require functioning beta cells in order to be effective. If there is significant insulin resistance a TZD (rosiglitazone [Avandia] or pioglitazone [Actos]) may be maintained, but with caution because of the increased risk of fluid retention if these are given together with insulin. (Note: TZD + insulin is not an approved indication in Canada.)

Basal insulin

Insulin is involved in glucose transfer across cell membranes in order to provide the energy required for living. Thus, we need some constant supply of insulin to provide glucose to the tissues for the activities of staying alive (breathing, heartbeat, brain activity, etc). This constant supply is known as basal insulin. In

type 1 diabetes, where there is no endogenous insulin production, about 50% of daily insulin needs are for basal insulin. In type 2 diabetes, where there is some endogenous insulin, basal needs may be lower.

A fairly continuous basal insulin release is desirable. Exogenous basal insulin needs can be supplied by:

- An extended long-acting insulin (glargine [Lantus] or detemir [Levemir]) given once a day. With virtually constant insulin action over a 24-hour period, these insulins provide the closest to an ideal basal insulin supply. Since these insulins have no activity peak, they also cause less hypoglycemia than NPH.
- An intermediate-acting insulin (NPH) given twice a day.

Bolus insulin

Postprandially, insulin removes glucose from the blood and stores it as glycogen and fat. Insulin is needed to reduce postprandial hyperglycemia and increase peripheral glucose utilization. This is known as bolus insulin. In the person with type 2 diabetes, we often see postprandial hyperglycemia, as the pancreas may not be able supply enough insulin to provide for postprandial needs.

Postprandial hyperglycemia can be treated by giving a rapid-acting insulin analogue (aspart [Novorapid]), glulisine [Apidra] or lispro [Humalog] with meals. These insulin analogues have an onset of action in 10 to 15 minutes, peak in 60 to 90 minutes, and have a duration of action 2 to 4 hours.

In an intensive insulin regimen of Multiple Daily Injections (MDI), aspart [Novorapid], glulisine [Apidra] or lispro [Humalog] is given with meals in a dose to balance the carbohydrate content of the meal. Dosage varies according to the amount of carbohydrate eaten.

The insulin may be taken just before the meal, with the meal, or even just after the meal. The goal is to achieve normal 2-hour postprandial values. The carbohydrate-to-insulin match can be judged by a capillary glucose measured 2 hours after the meal.

Calculating basal and bolus needs

Usual total insulin dose is about 0.5 to 2 unit/kg of body weight divided into 50% basal and 50% bolus insulin. The bolus insulin dose is dynamic and changes with carbohydrate intake ± a high glucose correction according to premeal glycemia.

A typical bolus dose would be 1 unit for each 10 to 15 g of carbohydrate in the meal, +1 unit if premeal glucose is > 8.0 mmol/L, +2 units if > 10.0 mmol/L, +3 units if > 12.0 mmol/L etc. This regimen rapidly lowers postprandial glucose levels and reduces total insulin dose to the minimal effective and required dose. There is no excess insulin hanging around all day to stimulate appetite and weight gain, there is also less risk of hypoglycemia as bolus insulin is given only with meals, and the action of the insulin closely parallels the glycemic response to the food.

If an adequate carbohydrate-to-insulin match is established (i.e. 2-hour postprandial glucose levels are normal), but the glucose level consistently rises from the 2-hour postprandial level to the next premeal level, the patient is not producing sufficient basal insulin and will need supplemental basal (long-acting) insulin.

Patients on intensive insulin therapy should see a dietitian to learn carbohydrate counting in order to match insulin dose to actual food intake and should keep detailed monitoring records in their diary.

Insulin delivery devices

Insulin pens are the simplest injection devices. Starting insulin with syringes adds another level of complexity of treatment to a patient who is already facing enough challenges. In my practice, I supply the patient with the first cartridge and recommend a fixed insulin dose until the first follow-up visit. The insulin pen contains 3 cc (300 units) of insulin. The cartridge of insulin that is in use and the pen do not need to be refrigerated. Get the patient to put the cartridge in the pen and attach the needle under supervision. One should always try to observe the patient giving the first insulin injection so that any potential problems can be noted and dealt with. In the office, a reduced dose of 2 or 3 units may be given to observe the technique. Alternatively the

patient can be referred to a Diabetes Education Centre or Pharmacy for insulin instruction.

I usually start with a dose of 10 units of insulin at bedtime and instruct patients to bring the pen back at the first follow-up visit in 28 to 30 days. A quick glance at the cartridge will tell us whether we have a adherence problem, since there should be only enough insulin left for 1 or 2 injections. When we have determined that the patient is comfortable and compliant with taking the insulin, we can deal with changing cartridges, storage of extra cartridges, dosage titration etc.

Changing pen needles

Needles should be changed each time an injection is given. They are Teflon coated and almost totally painless. However, the Teflon coating wears off after the first use and injections become progressively more painful. At least for the first month, the needle should be changed each time so the patient doesn't dread the injection. People with diabetes frequently re-use needles. The incidence of infection is very low, but being single-use devices, re-use can't ethically be suggested. Needles must be changed when cartridges are changed. Alcohol swabs are probably not needed.

Coverage by provincial plans and formularies: In Ontario, long acting analogues glargine (Lantus) and detemir (Levemir) are covered on the provincial formulary as well as the short acting analogues aspart (Novorapid) and lispro (Humalog). Insulin pens are usually available through the insulin companies free of charge and may also be obtained at Diabetes Education Centres or pharmacies.

Patient information

The Canadian Diabetes Association as well as insulin companies have educational material and videos on pens and insulin administration. It is important to allow the patient time to get comfortable with the injection, monitoring, and needle and cartridge changing.

TREATMENT - HYPOGLYCEMIA

HYPOGLYCEMIA

Hypoglycemia is defined by: 1) autonomic or neuroglycopenic symptoms; 2) a plasma glucose < 4.0 mmol/L; and 3) symptoms responding to the administration of carbohydrate.

The severity of hypoglycemia is defined by clinical manifestations:
Mild: autonomic symptoms are present and patient can self-treat
Moderate: autonomic and neuroglycopenic symptoms are present and patient can self-treat
Severe: patient may be unconscious or require assistance (plasma glucose is typically < 2.8 mmol/L)

Symptoms of hypoglycemia

Autonomic	Neuroglycopenic
Trembling	Difficulty concentrating
Palpitations	Confusion
Sweating	Weakness
Anxiety	Drowsiness
Hunger	Vision changes
Nausea	Difficulty speaking
Tingling	Headache
	Dizziness

The most common symptoms are sweating, hunger and trembling.

- All patients on insulin or insulin secretagogues should be counselled about their risk factors for hypoglycemia, and the recognition, prevention and treatment of drug-induced hypoglycemia.
- Since hypoglycemic unawareness may develop with increased frequency of hypoglycemia, the frequency of such episodes should be minimized (< 3 episodes/week).
- If A1C < 7.0% cannot be achieved without frequent hypoglycemia, refer to a diabetes specialist.

TREATMENT - HYPOGLYCEMIA

Treatment of hypoglycemia

In adults, **mild or moderate hypoglycemia** should be treated by the oral ingestion of 15 g of carbohydrate, preferably as glucose or sucrose tablets or solution. **Severe** hypoglycemia in a conscious adult should be treated by oral ingestion of 20 g of carbohydrate. Patients should wait 15 minutes and retest blood glucose. If glucose remains < 4.0 mmol/L, retreat with another 15 g of carbohydrate. Continue this cycle until glucose is in the normal range.

C A U T I O N: Do Not Over-treat hypoglycemia.

Severe hypoglycemia with unconsciousness or inability to take oral carbohydrate should be treated with 1 mg glucagon subcutaneously or intramuscularly. Caregivers or support persons should call for emergency services and the episode should be discussed with the diabetes healthcare team as soon as possible. Since the person with severe hypoglycemia is unable to self-treat, it is very important to train the spouse, a family member or support person to administer glucagon.

Patients on **MDI or insulin pumps** should have glucagon available for administration by a support person if they are unconscious or unable to take oral carbohydrate. Support persons at home or at work should be taught when and how to administer glucagon by injection (for further details, see www.diabetesclinic.ca).

Capillary glucose monitoring should be done 15 minutes after glucagon injection and the recommendations above for moderate hypoglycemia should be followed to prevent repeated hypoglycemia. Once the hypoglycemic episode has been treated, the person should have their usual meal. A snack including 15 g carbohydrate and a protein source should be taken if a meal is more than 1 hour away.

One should always consider the cause of the hypoglycemia. For example, the risk of recurrent hypoglycemia may remain until the peak action of an intermediate- or long-acting insulin has passed.

R e m e m b e r
PREVENTION is the best treatment.

MONITORING OF GLYCEMIC CONTROL

Glycated hemoglobin (A1C)

A1C should be measured approximately every 3 months to ensure that glycemic goals are being met or maintained.

A1C goal < 7.0%

Self-monitoring of blood glucose (SMBG)

All patients, who are able, should be taught how to self-manage their diabetes, including SMBG. The benefits of SMBG include improved A1C, avoidance of hypoglycemia, and increased lifestyle flexibility. These benefits are enhanced when patients are willing to adjust their food intake, exercise activity and medications in response to blood glucose values. SMBG also empowers patients to make their own choices to achieve glycemic control.

SMBG goals for most patients

Before meals	After meals
4.0 – 7.0 mmol/L	5.0 – 10.0 mmol/L

Frequency of SMBG

The frequency of SMBG should be tailored to the patient's level of glycemic control and type of therapy. In the stable type 2 diabetes patient meeting targets, a daily capillary glucose measurement may be sufficient. For the patient on intensive management, measurements need to be made at least before each meal, as the insulin dose will be dependant on the premeal glucose level as well as the amount to be eaten. Daily testing is recommended, asking the patient to vary the time of testing, sometimes measuring fasting or before meals or sometimes testing 2 hours after meals. Both fasting as well as postmeal testing should be done, since the treatment of fasting hyperglycemia (which represents a beta cell defect), and postprandial hyperglycemia (which represents insulin resistance and is a potent predictor of CV mortality) may be different.

Accuracy of SMBG

At least annually (and whenever indicators of glycemic control do not match meter readings), a correlation between the glucose meter and a laboratory plasma glucose should be done. Ask patients to take their meter when they go to have lab work done. Have them check their capillary glucose within 5 minutes of getting the lab glucose tested and write the result in their diary. When they come in to review the lab work, the correlation with the meter can also be reviewed. If the meter and lab value are more than 20% apart, the meter should be checked with a test solution of known glucose concentration provided by the meter manufacturer (the pharmacy can usually do this). If the discrepancy persists, the patient should contact the meter manufacturer or pharmacy, which will generally provide a replacement meter. All modern meters offer accuracy and reproducibility, so the patient should choose the meter that works best for him or her. Inaccuracies are most commonly due to failure to correctly code for the strips or outdated strips.

Ketone testing

Diabetic ketoacidosis (DKA) can occur in patients with type 2 diabetes. If all the following conditions are present, patients should consider ketone testing:

1. Acute illness, and
2. Preprandial blood glucose levels > 14.0 mmol/L, and
3. Symptoms of DKA (nausea, vomiting, abdominal pain).

While urine tests for ketones may be used, it is preferable to use a meter that tests levels of beta-hydroxybutyric acid (e.g. Precision Extra).

NOTES

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