

## CHAPTER 4

# MANAGEMENT OF TYPE 1 DIABETES IN ADULTS

### Author:

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### **4.1 Goals of Therapy**

#### **Initial Goals**

- Timely initiation of insulin therapy to relieve diabetic ketoacidosis if present.
- Relief of symptoms of hyperglycemia and metabolic instability.
- Education regarding glucose monitoring, self-administration of insulin, identification, avoidance and treatment of hypoglycemia, basic nutritional needs, effects of alcohol and exercise on blood glucose levels.

#### **Long Term Goals**

- Prevention of acute complications such as diabetic ketoacidosis and severe hypoglycemia.
- Prevention and reduction of the progression of chronic microvascular and macrovascular complications.
- Maintain life and quality of life, reduce mortality and morbidity.
- Maintenance of glycemic control as close to normal physiologic levels as possible while avoiding hypoglycemia, i.e. initiate and maintain intensive management where possible.
- Promotion of self care while providing a comprehensive health care support structure for the individuals with diabetes.
- Provision of advanced education on the effects of insulin, nutrition, illness, activity, and psychologic factors on glycemic control.
- Empowering individuals with type 1 diabetes to accomplish goals for lifestyle, meal planning, physical activity, occupation and family planning while maintaining appropriate glycemic control.
- Treat accompanying conditions.

### **4.2 Initial Assessment**

At the initial visit a complete history and physical examination should be performed.

#### **History**

##### ***New Onset Type 1 DM***

- Onset and duration of symptoms
- Symptoms of hyperglycemia: Polyuria, polydipsia, nocturia, weight loss, blurry vision, fatigue, skin infections e.g. candidiasis, folliculitis.
- Symptoms of ketoacidosis: Nausea, vomiting, abdominal pain, hyperventilation
- Medications
- Personal history of other autoimmune disorders
- Family history of Type 1 DM or other autoimmune disorders, premature cardiovascular disease, nephropathy
- Cardiovascular risk factors: Smoking, dyslipidemia, hypertension, family history
- Psychosocial history: Personal supports, occupation, shift work, lifestyle, education, financial supports,

use of alcohol and recreational drugs, driving, body image or history of eating disorder, depression, attitude toward health care

- Sexual and obstetric history: Use of birth control, plans for future pregnancy
- Diet and eating habits
- Physical activities

### ***Established Type 1 DM***

*In addition to above:*

- Insulin regimen: Type, dose, frequency, injection sites
- Monitoring: Method, frequency
- Record of glycemic control; A1C
- History of diabetes education and attendance at outpatient clinic
- Client's goals and objectives
- Self care behaviours (e.g. knowledge of sick day management)
- Symptoms of hypoglycemia, level of hypoglycemic awareness, treatment methods
- Frequency of severe hypoglycemia (needing the assistance of someone else to identify and treat)
- Frequency of insulin omission
- Frequency of episodes of diabetic ketoacidosis
- Frequency of hospitalizations due to DM
- Weight history, body image
- Complications of DM: Retinopathy, nephropathy, neuropathy, cardiovascular disease, infections, skin manifestations, sexual dysfunction

### **Physical Examination**

- General, injection sites, stigmata of dyslipidemia
- Height, weight, BMI, BP
- Head and neck: Eyes, oral cavity, thyroid
- Chest and cardiac, peripheral vascular (i.e., pulses, bruits)
- Abdomen: Rule out organomegaly
- GU: Rule out fungal infection
- Foot examination: Neurological - vibration sense, ankle reflexes, 10 gm monofilament sensation, vascular supply, deformities or ulceration and infection, nails, foot wear
- Skin: Diabetic dermopathy, injection sites
- Neurologic: Directed to symptoms

### **Investigations**

- Fasting or random glucose to confirm diagnosis in newly diagnosed
- Laboratory/capillary glucose monitor comparison
- Serum electrolytes in acutely ill or newly diagnosed
- Urine and serum ketones in acutely ill, or suspected diabetic ketoacidosis
- Serum creatinine
- A1C
- Liver enzymes in acutely ill, or if fatty liver suspected
- CBC in acutely ill or newly diagnosed
- Urinalysis for protein, sediment
- Urine microalbumin/creatinine ratio
- Timed urine protein, microalbumin, creatinine if screening microalbumin/creatinine positive

- Serum fasting lipids – cholesterol, triglycerides, HDL, LDL, may need to be repeated once glycemic control stabilized
- Arterial blood gases in suspected diabetic ketoacidosis

### **4.3 Initial Management**

- Intensive therapy using multiple daily injections of insulin or continuous subcutaneous insulin infusion has been clearly shown to delay the onset or slow the progression of long-term microvascular complications in patients with or without early complications.
- Most people with Type 1 DM should be encouraged to aim for optimal glucose levels using intensive therapy (see Table 4.1).
- However, an assessment of the individual’s willingness or ability to participate in an intensive insulin regimen must be made prior to initiating intensive therapy.
- A person with newly diagnosed Type 1 DM may go into a "honeymoon" or remission period shortly after insulin therapy is started. Because the extent of return of beta cell function varies, the insulin dose must be changed in response to blood glucose values. Stabilization usually occurs over 3 to 6 weeks after the diagnosis and initiation of therapy.
- Where appropriate support services are available and the individual is not in diabetic ketoacidosis, insulin therapy can be started as an outpatient.
- New onset diabetes in association with diabetic ketoacidosis requires admission to hospital for acute management and initiation of insulin therapy.

<b>TABLE 4.1 Recommended targets for glycemic control with Type 1 Diabetes</b>			
	<b>A1C</b>	<b>FPG/preprandial PG</b>	<b>2 h postprandial PG</b>
<b>Target for most patients</b>	≤ 7.0%	4.0 – 7.0	5.0 – 10.0

### **4.4 Insulin Regimens**

- The amount and type of insulin administered and the frequency of altering the dose will depend on the patient's clinical status, insulin sensitivity, stage of self-care knowledge and practice, and previous experience with insulin.
- The total daily dose of subcutaneous insulin in adults with Type 1 DM who are not acutely ill is usually approximately 0.5 unit/kg (0.62 ± 0.17unit/kg in the final year of the DCCT), however, the doses can vary depending on the individual’s insulin sensitivity. Adolescents are more insulin resistant often requiring 0.8-0.9 units/kg.
- Patients with newly diagnosed Type 1 DM who are not in DKA and who may still have some islet cell function may require a lower starting dose.

### **4.5 Intensive Diabetes Treatment Regimens**

- Intensive diabetes management aims at the achievement of normal or near normal glycemia in individuals with diabetes in the expectation that such metabolic control will prevent or delay the onset and/or progression of the microvascular complications of the disease.

- Intensive therapy usually results in a significant decrease in A1C and retards the development and progression of microvascular disease.
- The major adverse effects include increased incidence of severe hypoglycemia and weight gain.
- The DCCT reported that the risk of severe hypoglycemia was 3x on intensive versus conventional therapies. However with newer rapid acting insulin analogues, the rates of severe hypoglycemia on intensive therapy appear to be declining.
- The choice of regimen for intensive treatment is a personal one involving decisions regarding lifestyle, cost and convenience.
- In those with frequent severe hypoglycemia or hypoglycemia unawareness, blood glucose targets will have to be set at a higher level to ensure safety.
- In all regimens, however, frequent blood glucose monitoring (3 to 7 times per day) is an essential component both in helping to decide insulin dose and in preventing hypoglycemia.
- Intensification of diabetes management should be undertaken by health care teams with expertise in this type of treatment.

### **Components of Intensive Therapy**

- Accessible Diabetes Health Care Team with frequent contact between members.
- Comprehensive client education and maintenance of self care skills.
- A highly motivated individual with diabetes.
- A more intensive understanding of the interaction between food intake, physical activity and insulin dosage.
- MDI (multiple daily injections of insulin) or CSII (continuous subcutaneous insulin infusion).
- More frequent blood glucose monitoring.
- Self-adjustment of basal and bolus insulin regimens based on patterns.
- Frequent self-adjustment of insulin according to blood glucose levels and nutrient intake.
- Knowledge of carbohydrate counting.
- Knowledge of management of sick days.
- An appropriate exercise program and adjustment of insulin for exercise.
- Greater attention to the prevention, detection and treatment of hypoglycemia to avoid severe or recurrent hypoglycemia.

### ***4.6 Multiple Daily Injections (MDI or "Basal-bolus Regimen")***

- The most commonly employed approach to MDI is the administration of short or rapid-acting insulin before each meal (bolus insulin) and intermediate or long acting insulin at bedtime or intermediate insulin split twice per day (basal insulin).
- The dose of the meal insulin is adjusted according to the ambient blood sugar, the size of the planned meal and the exercise regimen.
- The use of the rapid-acting analogues insulin lispro and insulin aspart, have been proven more convenient, associated with better control of post-prandial hyperglycemia, less inter-meal hypoglycemia, and a tendency for better control.
- If the person has already been on insulin the existing total daily insulin dose should be used to calculate the MDI doses.
- Intermediate acting (NPH) or long acting (glargine or ultralente) is used for basal requirements and is usually 40% of the total daily dose.
- The remaining 60% of the dose is usually administered as boluses of rapid-acting insulin (lispro/aspart) or short acting (regular) insulin for meals.

- The basic dose of the insulin should be adjusted according to the results of blood glucose levels measured several times per day over several days. This is referred to as *pattern management*. The type and frequency of basal insulin should be individualized based on needs. Some people require basal doses split into a daytime and evening dose in order to optimize control.
- A *variable insulin dosing scale* (VIDS) should then be developed to guide insulin doses prior to meals. See Table 4.2 for example of a VIDS. See Section 4.8 for how to calculate supplements or correction doses. Supplements or corrections allow correction of glucose levels from out of target back into target.
- The VIDS must take into account the insulin sensitivity of the individual.
- More advanced knowledge of *carbohydrate counting* allows calculation of insulin to carbohydrate ratios for each meal which allows changes in insulin dosing based on anticipated changes in carbohydrate intake for that meal.

<p align="center"><b>TABLE 4.2 Sample VIDS (Variable Insulin Dosing Scale) for 70 kg person</b>  <b>TDD = .5 x 70 = 35 units approximately</b>  <b>We usually reduce the lunch meal bolus to start as insulin sensitivity typically increases as the day progresses</b></p>						
Glucose Level	Meal insulin – lispro or aspart					Basal Insulin NPH or glargine
	Breakfast	Lunch	Dinner	Snack		
≤3.9 Treat low first	-1	-1	-1	No	Yes	14 units at 10 pm
4.0-5.9	7	6	7			(another option would be to slit the NPH basal, give 30% or 4 units in am and 10 units at hs)
6.0-7.9	7	6	7			
8.0-9.9	+1	+1	+1			
10.0-11.9	+2	+2	+2			
12.0-13.9	+2	+2	+2	2		
14.0-15.9	+3	+3	+3	1	4	
16.0- 19.9	+4	+4	+4	3	5	
≥ 20	+5	+5	+5	4	6	
<b>Goal CHO/ meal</b>	35 g	50 g	80 g	0	20	If BG > 16 Test for ketones Follow sick day guidelines
<b>Insulin/CHO</b>	1:5*	1:7	1:10	1:10		

\* For 35 gm of CHO at breakfast, 7 units of insulin is required, therefore for an additional 5 gm of CHO, 1 additional unit of insulin is required.

#### **4.7 Continuous Subcutaneous Insulin Infusion (CSII or "Pump" Regimens)**

- A subcutaneous insulin pump administers small doses of regular, insulin lispro or insulin aspart continuously to provide preprogrammed basal insulin.

- At mealtime, or when so desired, a bolus of insulin can be instantaneously administered by the pump as indicated by the pump user.
- Pumps are now available which can aid in the calculation of insulin bolus doses based on insulin:CHO ratios and bolus corrections.
- In the conversion of existing subcutaneous insulin basal doses to pump basal doses, a reduction in the dose is sometimes required. It is advisable to reduce the basal insulin dose by 20%.
- For example, the basal dose of insulin in Table 4.2 would be given as 0.5 units per hour of lispro/aspart rather than 14 units of NPH and the meal time insulin doses of lispro/aspart would be similar.
- The basal insulin rates are adjusted as necessary to compensate for the Dawn phenomenon whereby insulin requirements increase in the early morning hours.
- To determine appropriate basal rates after initial dose calculations, glucose levels are monitored over several hours of fasting.
- The adjustment in the basal insulin infusion rate upwards (or downwards) is usually necessary 2-3 hours prior to required increase (or decrease) in insulin action to account for the pharmacokinetics of subcutaneous rapid acting insulin.
- Basal rates can be temporarily adjusted downwards to avoid hypoglycemia following exercise.
- Rapid-acting insulin analogues are usually used in the pump system because they are associated with improved post-prandial glucose control and fewer episodes of hypoglycemia as compared with regular insulin.
- There is considerable training involved in the use of the pump. In order to avoid diabetic ketoacidosis, users must be skilled at appropriate use of the pump and to trouble shoot when hyperglycemia occurs.
- Users must monitor blood glucose levels very frequently.
- There may be advantages to the use of the insulin pump beyond convenience and flexibility in some individuals particularly if AIC levels were suboptimal prior to pump initiation.
- At the present time, insulin pumps and supplies are costly and provincial health care plans and some private health care plans do not cover the cost of insulin pumps and supplies.
- The choice of an insulin pump for delivery of intensive insulin therapy at the present time remains a decision that must be carefully made by a clinician with knowledge of the pro's and con's of pump use and a well informed client.

#### ***4.8 Supplements or Correction Bolus Insulin***

- Individual sensitivity to insulin varies widely.
- The TDD of baseline insulin to vary from 0.5 units per kg (or less) to 1.0 unit per kg (or more).
- Severe hyperglycemia causes a state of increased insulin resistance.
- Doses for correcting hyperglycemia need to be calculated taking the total daily insulin requirement and insulin sensitivity of the individual into account.
- Various methods of calculating supplemental or correction boluses have been suggested.
- '1500 Rule' has often been used to calculate a supplement or correction bolus for insulin pump therapy and has been adopted by several practitioners. Evidence to support this equation is lacking and the calculation has been tested only in persons with excellent metabolic control who are using an insulin pump.
- This equation has been modified to the "1700 to 1900" rule
- Using the '1700 to 1900' Rule in Canada means converting to a '**Rule of 100**' in order to take into account conversion from conventional to SI units used in Canada.
- In order to calculate the person's correction factor, divide 100 by the TDD. The correction factor represents what 1 unit of insulin is expected to lower the BG by in mmol/L

- For example, if the TTD is 35 units, the correction factor =  $100 \div 35 \text{ units} = 2.8 \text{ mmol/L/per unit of insulin}$ . Therefore 1 unit of insulin is expected to lower the BG by 2.8 mmol/L. If the glucose level was 13 and the target glucose was 6, the person would take  $7 \text{ mmol/L} \div 2.8 \text{ mmol/L/unit} = 2.5 \text{ units}$
- The use of this formula must always be re-evaluated in the context of how it works. Clients are encouraged to always review the pattern of their glucose levels to determine if correction factors or boluses are working appropriately.
- Another similar and commonly used method of calculating correction boluses at our institution is to add 10% of the usual baseline bolus insulin dose required for a particular meal for each 2 mmol/L increment above the target BG level. This is usually calculated for the patient and written in the VIDS so that the patient does not have to do the calculation, see the above VIDS. See Table 4.2 Sample VIDS.
- For example, if the target glucose level is 6 mmol/L and the person normally takes 7 units for that meal, but the BG is now 14, the calculated correction is done as follows :
- At 14 the BG is four (4) 2 mmol/L increments above the upper target range of 6.
- 10% of 7 is .7 ; Multiply  $.7 \times 4 = 2.8 \text{ units}$ . One would expect 2.8 units (rounded up to 3 units) to bring the glucose down from 14 to 6.
- If the individual is not using an insulin pump, then doses are rounded off. Some pen devices do allow for  $\frac{1}{2}$  unit increments of insulin delivery.

#### **4.9 Adjustments for Exercise**

- Lowering the dose of insulin will have the most effect during the time of the exercise
- If exercise will be done after a meal, the dose of rapid or fast acting insulin should be lowered by 20 to 50% for moderate activity and 50% for strenuous activity.
- If rapid insulin is being used, a dose reduction is only required if the exercise takes place within the first 2 to 3 hours after the injection
- BG should be done before, after and possibly during exercise to determine the appropriate change in insulin dose or food intake the next time the activity is done.
- Prolonged activity can have a delayed BG lowering effect. If this occurs, reductions in basal insulin are required.
- See Chapter 15 for more on exercise.

#### **4.10 Conventional Diabetes Treatment Regimens**

- The majority of individuals with Type 1 DM should be encouraged to participate in *intensive insulin regimens* however, there are some individuals, because of motivational or compliance issues, lack of resources, or inability to participate in intensive educational programs must be managed with so called conventional insulin regimens or BID insulin regimens.
- The so called *conventional regimen* consists of one or two (usually two) injections of intermediate acting and short or rapid-acting insulin per day.
- Approximately  $\frac{2}{3}$  of the total daily dose is given before breakfast:  $\frac{2}{3}$  of it as intermediate acting,  $\frac{1}{3}$  as short/rapid acting. The remaining  $\frac{1}{3}$  of the total daily dose is given in the evening,  $\frac{2}{3}$  as intermediate acting and  $\frac{1}{3}$  as short or rapid-acting.
- The doses are usually modified based the patterns of the blood glucose levels over several days and in those who do not monitor frequently enough, empiric adjustments are made based on the A1C.
- Although there is generally less self-adjustment of insulin in conventional regimens, clients should be encouraged to add elements of intensive diabetes management where appropriate.

- Those who can, should learn to modify short or rapid-acting insulin based on glucose level prior to breakfast and supper, and to adjust insulin for carbohydrate intake and planned activity.

#### 4.11 Insulin Types

There are different types of subcutaneous insulin available in Canada. An inhaled short acting insulin used in experimental trials may be available in the future. Subcutaneous insulin can be administered by needle and syringe or by pen devices.

Insulin Type and Action	Brand Name
<b>Rapid-acting</b> Onset: 10–15 min Peak: 60–90 min Duration: 4–5 h	Humalog <sup>®</sup> (insulin lispro) NovoRapid <sup>®</sup> (insulin aspart)
<b>Fast-acting</b> Onset: 0.5–1 h Peak: 2–4 h Duration: 5–8 h	Humulin <sup>®</sup> -R Novolin <sup>®</sup> ge Toronto
<b>Intermediate-acting</b> Onset: 1–3 h Peak: 5–8 h Duration: up to 18 h	Humulin <sup>®</sup> -N Humulin <sup>®</sup> -L Novolin <sup>®</sup> ge NPH
<b>Long-acting</b> Onset: 3–4 h Peak: 8–15 h Duration: 22–26 h	Humulin <sup>®</sup> -U
<b>Extended long-acting</b> Onset: 90 min Duration: 24 h	Lantus <sup>®</sup> * (insulin glargine)
<b>Premixed</b> A single vial contains a fixed ratio of insulin: % rapid- or fast-acting to % intermediate-acting insulin	Humalog <sup>®</sup> Mix25 <sup>™</sup> Humulin <sup>®</sup> (20/80, 30/70) Novolin <sup>®</sup> ge (10/90, 20/80, 30/70, 40/60, 50/50)

#### 4.12 Diet

See Chapter 3.

#### 4.13 Exercise

See Chapter 15.

#### **4.14 Monitoring**

For detailed review see Chapter 10.

##### **Ketones**

Individuals with Type 1 DM should be familiar with a method to test for ketones in the urine or serum ketones. The urine or serum should be tested for ketones if there is significant or prolonged hyperglycemia (blood glucose greater than 15 mmol/L) or an intercurrent illness.

##### **Self-Monitoring of Blood Glucose**

All individuals with Type 1 DM should self-monitor blood glucose (see Chapter 10).

##### **Record Keeping**

- A record of self-monitored glucose should be kept to allow the members of the diabetes health care team, to observe and recognize patterns of glucose levels in order to make appropriate adjustments in insulin, food and activity regimens.
- Computer programs available with some glucose meters can replace manual logging of results but down-loading of data must be done on a regular basis to allow appropriate and timely reflection on results.
- Changes in diet, activity, intercurrent illness should be recorded and hypoglycemia documented.

##### **Glycosylated Hemoglobin/A1C**

- The level of glycosylated hemoglobin or A1C is accepted as the best measure of long-term glucose control in patients with diabetes. Normal values vary from lab to lab according to the assay used.
- Consistently high values indicate poor control and warrant a review of the treatment regimen.
- Values within the normal range might indicate unrecognized hypoglycemia, particularly at night.
- Glycosylated hemoglobin (A1C) should be measured every three months.
- Some hemoglobinopathies can interfere with the usual glycosylation of hemoglobin. The A1C may therefore not accurately represent glycemic control. In these cases, the fructosamine level may be used to monitor overall glycemic control.

#### **4.15 Hypoglycemia**

See Chapter 12.

#### **4.16 Education**

- Education in the use of insulin, recognition, treatment and prevention of hypoglycemia, meal planning, dietary components, exercise and making appropriate changes in the treatment regimen to achieve optimum blood glucose levels is the most important aspect of the management of diabetes.
- All persons with Type 1 DM should be referred to a program providing comprehensive diabetes education. Periodic follow-up and updating is as important as the initial education.

#### **4.17 Ongoing Management**

- Frequency of visits is tailored to optimize control and prevent complications, typically every 3-4 months for very stable individuals, more frequently in poorly controlled subjects and during pregnancy.
- Often the responsibility for care is shared between the patient, the primary care physician and the specialist, and therefore a system of communication between all health care providers and the diabetes health care team is vital to assure a complete and coordinated approach to care and management.

- At each visit:
    - Interval history, review of results of glucose monitoring, and discussion of A1C and other relevant lab data
    - Physical examination: BP, weight, foot examination, other physical examination tailored to symptoms
    - Complication prevention and surveillance (see Chapter 16)
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