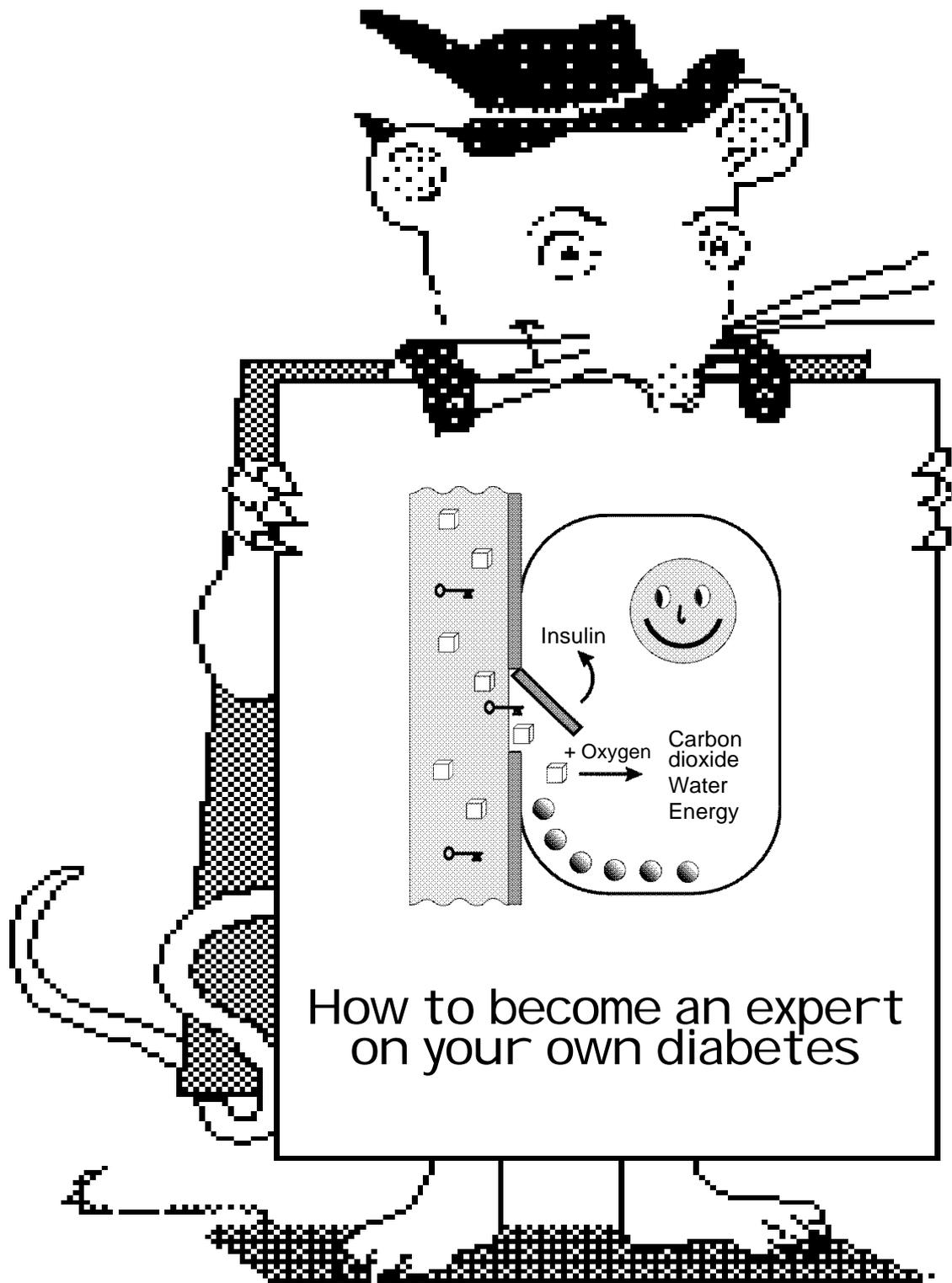


# INSULIN-DEPENDENT DIABETES

in Children, Adolescents and Adults





This book shows in a practical way what you need to know to be able to take good care of your diabetes. Having diabetes means that you need to know more about the disease than the average doctor, to be able to understand and take care of your illness in an appropriate way. This is necessary both to enjoy your life today, and to avoid and postpone late complications of diabetes. Modern research shows unambiguously that a lower mean blood glucose will lessen the risk of late complications. By reading this book you will learn how this can be accomplished through an intensive diabetes management.

Sometimes in this book I speak directly to you, the person with diabetes, and sometimes I address your family or parents. At other times there is even information for third parties, like the diabetes team members. When you are reading this book, just imagine that we are all together, sitting around a table, discussing diabetes. Remember that you run your own life - don't let your diabetes take over! Instead you can learn how to handle your diabetes in the different situations that life has to offer.

This book is applicable to children, adolescents and adults having insulin-dependent diabetes. It is also meant for teaching persons involved in diabetes and diabetes care, such as nurses, doctors, dietitians, teachers, child care staff and others.

The author is consultant pediatrician at Uddevalla Hospital in Sweden, specializing in diabetes.

The book was awarded the price for best pedagogical book by the Swedish Society for Diabetology in 1998.

You will find more information about the book at <http://www.piara.com/eng> and [http://www.childrenwithdiabetes.com/d\\_06\\_b00.htm#hanas](http://www.childrenwithdiabetes.com/d_06_b00.htm#hanas)

*The cover illustration shows how glucose enters into the cell with the help of insulin.*

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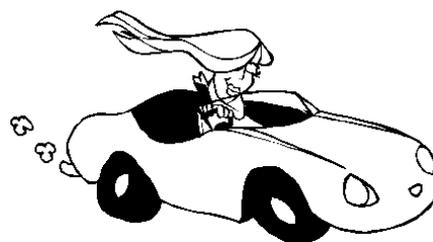
# Insulin treatment

The goal of all insulin treatment is to mimic the healthy pancreas' way of secreting insulin to the blood stream. Normally a small amount of insulin is constantly secreted during the day. After a meal a larger amount of insulin is secreted to take care of the glucose coming from the food.

Previously bovine (beef) and porcine (pork) insulin were used for all patients with diabetes. Nowadays mostly human insulin is used, i.e. insulin with a chemical structure identical to the insulin produced by the human pancreas. Human insulin is produced using gene technology or by semi-synthetic methods. Genetic engineering involves the insertion of human insulin-producing genes into a yeast cell or bacteria. In this way the yeast cells or bacteria are tricked into producing insulin instead of their own proteins.



## Regular short-acting insulin



### Production of human insulin

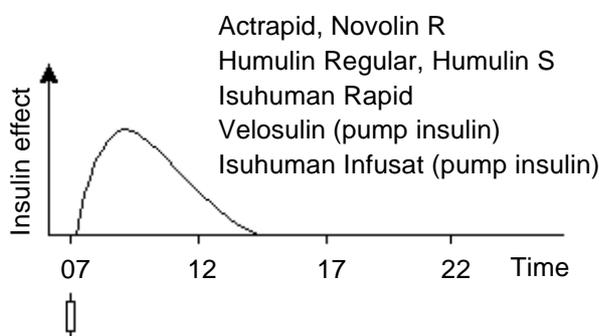
#### À Semisynthetic method:

Porcine insulin is changed enzymatically  
Velosulin  
Hoechst insulin

#### À Biosynthetical DNA-technology method

Production from baker's yeast  
Novo-Nordisk insulin  
except Velosulin

Production from coli-bacteria  
Eli-Lilly insulin



Regular short-acting insulin (also called soluble insulin) is given as a premeal bolus injection. It is also used to obtain a quick effect during times of hyperglycemia.

The listed brand names are examples of insulins. Ask your diabetes clinic to find out which insulins that are available in your home country.

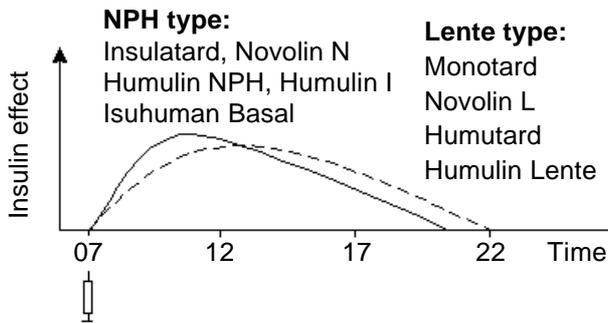
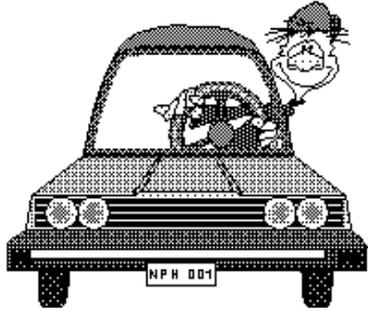
Short-acting insulin is pure insulin without any additives and is a clear liquid. It doesn't require stirring or mixing before usage. Different additives are used to make the insulin more long-acting, thus making the insulin cloudy. The cloudy part of the contents will sediment in the bottle or cartridge, and must be resuspended by turning over or rolling (but not shaking) 10 - 20 times before use.

### How to postpone the action of insulin

À **NPH insulin** Bound to a protein from salmon (protamin)

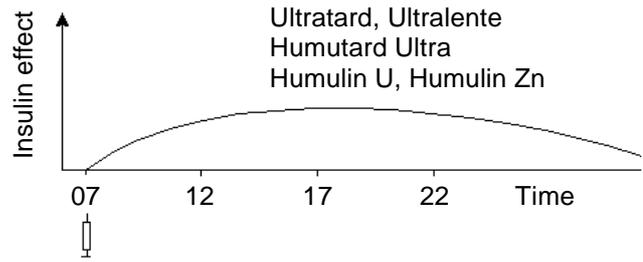
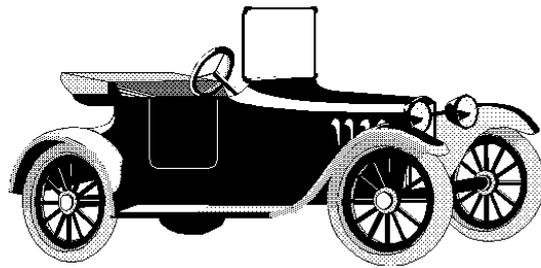
À **Lente insulin** Excess of free zinc.

## Intermediate-acting insulin



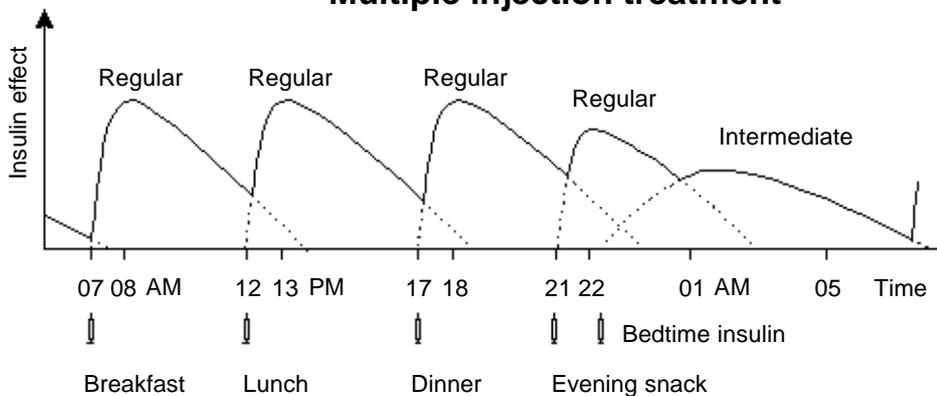
Intermediate-acting insulin is used as basal insulin when injecting twice-daily and as bedtime-insulin when using multiple daily injections. There are two different types: NPH insulin (—) and Lente insulin (-----).

## Long-acting insulin



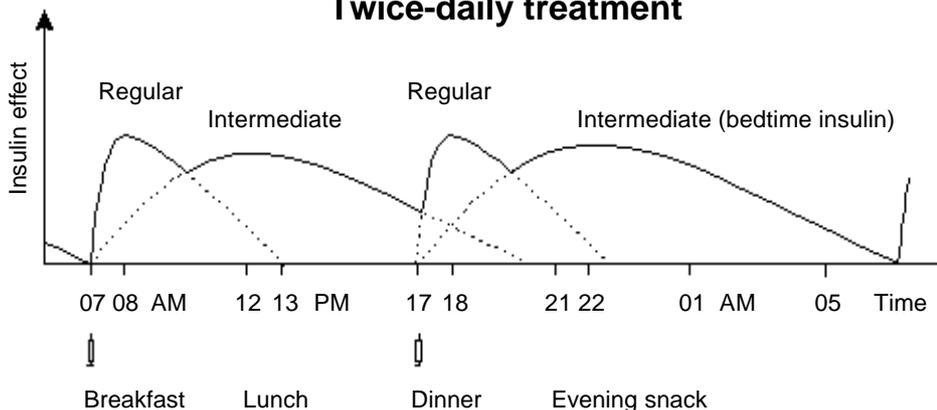
Long-acting insulin has effect during at least 24 hours. We use it mostly in combination with the direct-acting insulin analogue (Humalog). It is usually injected twice daily to give a basal insulin level in between meals and during the night.

### Multiple injection treatment



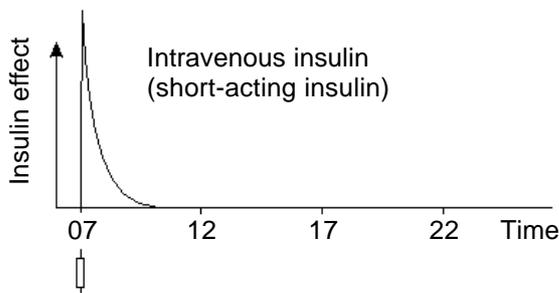
With 5 daily insulin doses (4 doses of short-acting insulin and 1 dose of intermediate-acting) the body's normal meal time insulin secretion is mimicked. The system is easy to understand as each insulin dose affects only one meal. Compare this insulin curve with the curve of a healthy person (top picture page 22).

### Twice-daily treatment



Before the introduction of the insulin pen in 1985 we mostly used twice-daily injections, mixing short-acting and intermediate-acting insulin. The advantage was fewer injections/day. The disadvantage however was difficulty in dosage adjustment due to changes in food intake or physical activity, or during intercurrent illness.

## Intravenous insulin



Short-acting insulin given intravenously has an extremely rapid action with a half life of only 3 - 5 minutes.

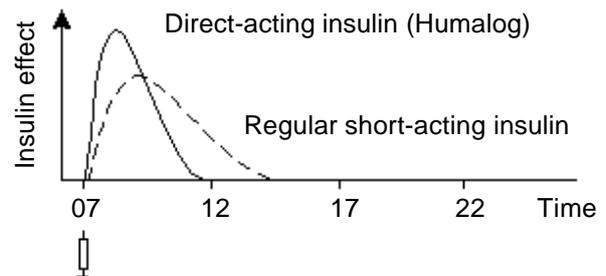
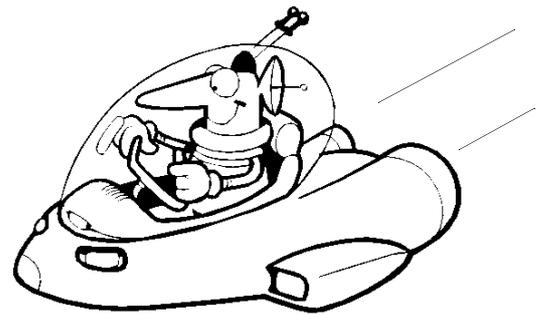
In intravenous insulin therapy the short-acting insulin is given directly into the blood stream. This treatment is given only in hospitals as an intravenous drip or in a motorized syringe. Since the half-time of insulin is very short, only about 4 min.<sup>152</sup>, the blood glucose will increase sharply if the intravenous insulin is stopped. When using intravenous insulin one must check the blood glucose every hour (even during the night) to monitor the correct dosage.

We use this type of insulin treatment at the onset of diabetes as an early and intensive insulin treatment. In this phase it may prolong the honeymoon phase and might preserve part of the insulin production for some time.<sup>364</sup> Intravenous insulin is often used during surgery or a complicated gastroenteritis with prolonged vomiting. It is also a practical method for determining the insulin requirements/24 hours, for example when starting up a subcutaneous pump therapy program.

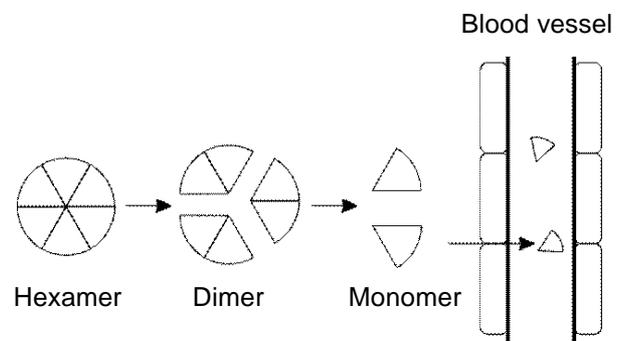
## Pre-mixed insulin

Pre-mixed insulin is today available in cartridges for insulin pens in different proportions of short-acting and intermediate-acting insulin of NPH type (Mixtard, Humulin Mix and Isuhuman Comb). However, we do not use these insulins very often since the proportions of the two insulins can-

## Direct-acting insulin (lispro)



The new lispro insulin (Humalog, henceforth referred to as direct-acting insulin) has a much more rapid action than regular short-acting insulin. You can inject it just prior to a meal and still get a good insulin effect at the time when the glucose from the food reaches the blood stream. However, the insulin effect might wane too quickly, causing the blood glucose to rise before the next meal. Because of this, basal insulin (intermediate- or long-acting) is usually given twice daily (see page 119).

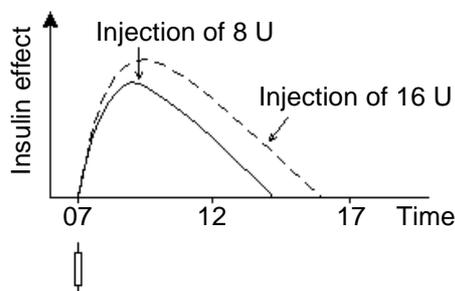


Insulin is always in the hexamer form when it is injected. It must then dissociate into dimers and monomers before it can pass between the cells of the blood vessel to enter the blood stream. The new direct-acting insulin (Humalog) dissolves much faster than regular short-acting insulin, thus making the time of action much faster.<sup>209</sup> Massage of the injection site can also enhance the dissociation, causing a faster absorption of the injected insulin.<sup>261</sup>

not be adjusted. If you change the dose you will get more or less of both types of insulin even if you only need more short-acting insulin, for example at meal-time.

## A larger dose lasts longer

A larger insulin dose will give a stronger insulin effect which also lasts for a longer time.<sup>182</sup> An exception to this is the direct-acting insulin (Humalog) which has the same time span of action even when the dose is increased.



*A larger insulin dose (dashed line) gives both a stronger and longer-lasting insulin effect.*

## Units

Insulin is administered in units, abbreviated U (international units). One unit of insulin is defined as the amount of insulin that will lower the blood glucose of a healthy 2 kg (4.4 pounds) rabbit that has fasted for 24 hours to 2.5 mmol/L (45 mg/dL) within 5 hours.<sup>337</sup> Quite a complicated definition, don't you think? Also see "How much does insulin lower the blood glucose level?" on page 106.

Today the most common insulin concentration is 100 units/ml (U-100). In many countries other concentrations are used, mostly 40 U/ml (U-40).

For the smallest children we often use 40 U/ml for low doses (less than 2 - 3 units) to be able to adjust in half units. There is an insulin pen available for 40 units/ml with  $\frac{1}{2}$  units increments (Diesetronic<sup>®</sup> D-pen 40/0.5). It uses a cartridge that is filled from insulin bottles. Some standard pens for insulin 100 /ml can be used for giving  $\frac{1}{2}$  units.

Disposable syringes can be practical to use if you need to change the insulin dose in very small increments. Syringes for 30 units (100 U/ml) can be used for adjusting doses with an accuracy of  $\pm 0.25$  units in the interval between 2.5 and 3.5 units.<sup>366</sup> However, they may be difficult to use for very small doses of 0.5 - 1 unit. In one study, in which parents were supposed to deliver 1.0 units of insulin, the actual dose varied between 0.6 and 1.3 units.<sup>76</sup> The variability was even greater when the dose was

administered by pediatric nurses. Syringes for U-100 insulin should not be used with U-40 insulin (risk of underdosage), nor should syringes for U-40 insulin be used with U-100 insulin (risk of overdosage).

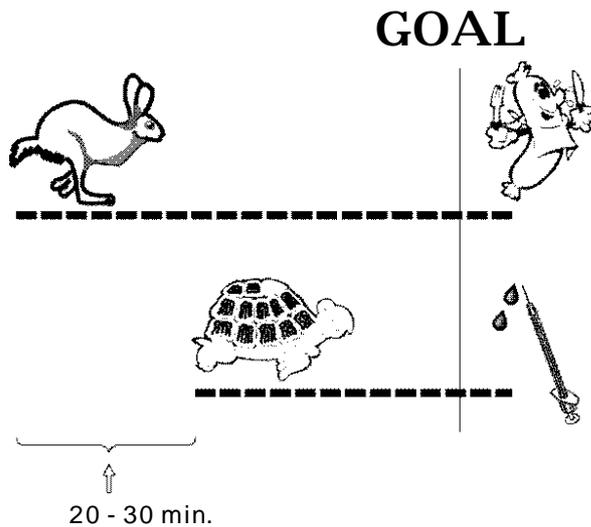
Insulin units are counted in the same way regardless of the concentration. A weaker insulin will give a faster absorption.<sup>157</sup> Insulin of 40 U/ml gives approximately 20 % higher insulin levels 30 - 40 minutes after injection compared to the same number of units of 100 U/ml.<sup>367</sup> Patients should be advised that the onset of the insulin effect will often be faster when switching from 100 U/ml to 40 U/ml.

## Twice-daily treatment

Twice-daily injections is the standard treatment for many patients with insulin dependent diabetes today. It has its advantages when the patient has a low total daily insulin requirement, as during the honeymoon phase, or if the patient, for various reasons, has difficulties in taking multiple injections. A twice-daily injection regimen usually results in a less flexible meal planning during the day. The afternoon dose of intermediate-acting insulin is often not large enough to cover the insulin requirements during the night, thus resulting in morning hyperglycemia. A large amount of intermediate-acting insulin daytime will increase the need of in between meal snacks.

## Multiple injection treatment

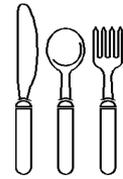
Multiple injection treatment has been used since 1984 and the first insulin pen was introduced in 1985. Many studies have shown that one can obtain a better glycemic control with this regimen.<sup>208</sup> However, patients using multiple injection treatment will not always obtain a better HbA<sub>1c</sub><sup>124,206</sup>, but will often experience positive psychosocial effects<sup>207</sup> as well as a freer life-style with greater flexibility in meal planning.<sup>204</sup> In studies more than 90 % of the patients have found multiple injections acceptable.<sup>208</sup> In the DCCT study (see page 220) the majority of patients on intensive treatment used multiple injections with syringes if not on insulin pumps. In 1987 we switched the patients in our clinic (aged 2 - 20 years) from twice-daily injections with syringes to multiple injection treatment with insulin pens. Only one patient was dissatisfied with this new regimen and switched back to twice-daily injections.



Since it takes 20 - 30 minutes for regular short-acting insulin to begin its action you must give the insulin a head start, otherwise the race will be very uneven. The carbohydrates from your meal will enter the blood stream first and give you a high blood glucose. The insulin will enter the blood stream later resulting in a risk of low blood glucose at snack-time and before the next meal. Taking the injection 30 minutes before the meal is most important at breakfast, however if you recognize these problems you should take the injection 20 - 30 minutes before all meals. The new direct-acting insulin (Humalog) has a very rapid action and can be given directly prior to the meal.

Today our policy is to use multiple injections already from the onset of diabetes with 4 - 5 injections of short-acting insulin as premeal boluses and an intermediate-acting insulin prior to bedtime. This regimen mimics the insulin secretion of a healthy pancreas better than a twice-daily regimen (see graphs on page 22 and 56).

In multiple injection treatment it is fairly easy for the person with diabetes and his/her family to understand which dose of insulin that affects a certain time of the day. This is quite essential since the goal of our diabetes education is that the patient and the family gradually assume increasing responsibility for their treatment, eventually becoming experts on their own diabetes.



## Premeal injections

Short-acting insulin (regular insulin) begins to act 15 - 30 minutes after a subcutaneous injection and begins its maximal effect after 1½ - 2 hours. The blood glucose lowering effect lasts for about 5 hours. This means that you should not wait more than 5 hours between your main meals and injections of regular insulin. Children and teenagers having a late evening meal will need a 4<sup>th</sup> injection of regular insulin, otherwise there will be a lack of insulin late at night before the bedtime injection has begun its action.

Remember that it takes 2 hours before the bedtime injection (of NPH type insulin) has any significant effect. This means that the time span between the last dose of regular insulin and the bedtime injection should not be more than 3 - 4 hours. If you for any reason prefer only 4 injections/day one alternative is to take a combination of short-acting and intermediate-acting insulin at the time of the evening meal. Mixing these insulins in one syringe or taking them as pre-mixed insulin is not an ideal method. If you inject in the thigh there is a risk of hypoglycemia early in the night from the short-acting component whereas if you inject in the abdomen there is a risk that the intermediate acting insulin will not last until morning.

There is no difference in effect between different brands of regular short-acting insulin. Direct-acting insulin (Humalog) gives a faster onset of action than regular short-acting insulin. The abdomen is the most common injection site for premeal injections (see page 93). If you take your regular premeal insulin in the thigh (or buttocks) you will probably need to add another 15 - 30 minutes to these time limits. The time limits given in this chapter refer to abdominal injections of regular short-acting insulin if not otherwise stated. If you use direct-acting insulin you must adjust the mentioned time intervals.

Your insulin depot from the bedtime injection will be almost gone in the morning. You should therefore give the morning injection of regular insulin at least 30 minutes before breakfast. Use a longer interval if your blood glucose is high and a shorter if it's low (see page 116).

**When should I take my premeal insulin?** (abdominal injections)

Meal	Regular short-acting insulin	Direct-acting insulin (Humalog)
Breakfast	At least 30 min. before	Just before the meal
Other meals	0 - 30 min. before (see text)	Just before the meal
Hypoglycemia at mealtime	Just before you eat	After the meal
High blood-glucose at mealtime	Wait 30 - 60 min. before eating	Wait 15 - 30 min before eating

**Can I take my injection just prior to the meal?**

To find out take the injection just prior to the meal and measure your blood glucose before and 1½ - 2 hours after the meal. The blood glucose should have risen 3 - 4 mmol/L (55 - 70 mg/dL) at the most. If it has risen more the effect of your regular insulin is too slow.

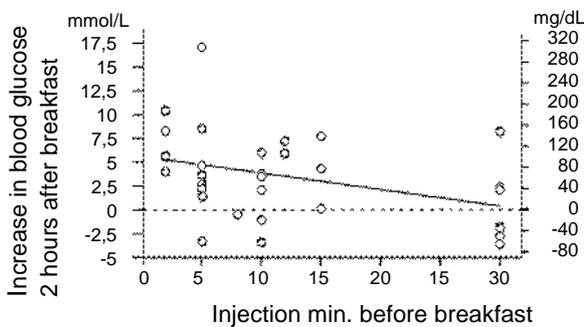
Try the same thing when you take your insulin 15 and 30 minutes before eating to find out which suits you the best. If the blood glucose is too high, even when you have taken the insulin 30 minutes before the meal, you will probably need a higher dose.

If you use the new direct-acting insulin (Humalog) it should be normally injected just prior to the meal.

Ideally regular short-acting insulin is administered 30 minutes before all meals since the blood glucose is not affected until 30 minutes after an injection. However, at lunchtime some of the short-acting breakfast insulin still remains in your body and the same holds true for the other meals. Because of this, the 30 minute insulin “head start” is not as essential with other meals as it is with breakfast.

Children using small doses and having a thin subcutaneous fat layer will absorb the insulin faster and rarely need to wait 30 minutes before they eat<sup>271</sup> (provided the premeal blood-glucose isn't high). Taking insulin 30 minutes before each meal can lead to a difficult schedule for younger children with many interruptions of their daily activities. We

therefore recommend younger children to take their insulin just prior to the meals (except breakfast). Some children will however absorb the insulin slowly and individual advice on this point is necessary. Older children and teenagers will rarely experience problems taking the insulin 30 minutes before mealtime.



It is important to give the regular short-acting insulin 30 minutes before breakfast. In this study the blood glucose increased about 5 mmol/L (90 mg/dL) when the children took their insulin just prior to breakfast compared to less than 1 mmol/L (20 mg/dL) when taking insulin 30 minutes before the meal.<sup>344</sup>

If you inject regular insulin just before mealtime it is important that the food not be absorbed too quickly from the intestine. If so, the blood glucose will increase before the insulin reaches the blood stream. This can be achieved by drinking at the end of the meal. The gastric emptying rate will then be decreased, slowing the blood glucose response. Any fat content of the meal will also slow down the gastric emptying rate. For example ice cream made with milk products will give a slower rise in blood glucose than a popsicle. See the food chapter, page 143.

The blood glucose reading before the meal will indicate when it is appropriate to take the injection. If the blood glucose is high you should wait 45 - 60 minutes before eating. If you have a low blood glucose reading you should hold the injection until it is time to eat or wait 15 minutes at the most (see the table on page 107).

The new short-acting insulin analogue (Humalog) can be injected just before a meal and still give a good insulin effect at the time when glucose from the meal enters the blood stream. You must then

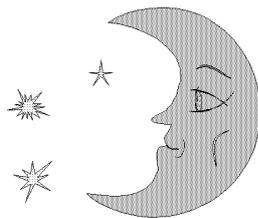
adjust the above mentioned time tables. With a high blood glucose prior to the meal you can try waiting 15 - 30 minutes before eating. If you have a low blood glucose you can try holding the insulin until after you have eaten. Most often Humalog is combined with twice-daily injections of basal insulin (intermediate- or long-acting, see page 118).

### Can I skip a meal?

A low level of insulin is needed in the blood even between meals to take care of the glucose produced by the liver. When using multiple injection treatment you must therefore take a low insulin dose even if you skip a meal. Half the ordinary insulin dose is usually enough, but you must try this out yourself. Intervals between meals and injections of regular insulin should not exceed 5 hours. Listen to your hunger signals and you will know when you must eat. You cannot skip a meal and also skip the snack a couple of hours later. If your blood glucose is low you must of course eat something.

If your blood glucose is above 15 mmol/L (270 mg/dL) you can try taking your ordinary dose and skip the meal or parts of it (does not apply to breakfast). Chewing gum or some vegetables might be a good alternative to relieve your feelings of hunger. Instead you can eat more at snack-time or at the next meal when the insulin has lowered the blood-glucose (also see "Temporary changes of insulin doses" on page 107).

### Bedtime insulin



The bedtime insulin injection is the most difficult dose to adjust. Although we do not eat during the night the body needs a low level of insulin throughout the night to take care of the glucose being produced by the liver. Usually we give an intermediate acting insulin of NPH type at bedtime. An insulin with longer effect (Ultratard, Ultralente, Humulin U, Humutard Ultra) may be a better alternative for some teenagers.

The bedtime insulin covers 1/3 of your 24-hour day and is in that sense the insulin dose that affects your HbA<sub>1c</sub> the most. High blood glucose readings dur-

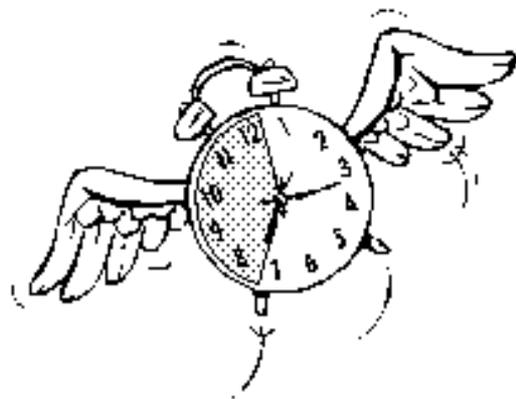
ing the night can give you a high HbA<sub>1c</sub> even if your glucose level during daytime is normal.

### When should I take the bedtime insulin of NPH type?

It is important to take the injection at the same time every night on week days. If you change the time from day to day it will be more difficult to see a pattern in your blood glucose readings. Since the most common problem is to get the bedtime insulin to last until morning (see graphs on page 113) we recommend taking the bedtime injection as late as possible, i.e. shortly before your usual bedtime. There is no use sitting up late, waiting to take your insulin injection. 11 PM can be a practical time for adults, for older children 10 PM is usually more practical. Younger children must take their evening injection earlier. A better alternative is to give the bedtime insulin when the child is asleep, which is easily done if the child has an indwelling catheter (Insuflon).

The dose of NPH insulin (Insulatard, Humulin NPH, Isuhuman Basal) taken in the evening will take effect after 2 - 4 hours and will usually last during 8 - 9 hours of sleep. Lente insulins (Monotard, Humutard) are a bit more long acting and give

### Can I change my meal times?



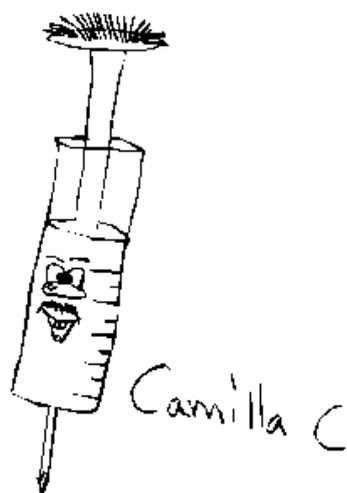
You can usually adjust your timetable for meals and injections with ± 1 hour. Just remember not to go over 5 hours between meals and injections of regular short-acting insulin if you don't use a basal insulin during the day. If you wait more than 5 hours between injections of regular insulin there is a risk of insulin deficiency.

maximal effect first after 4 - 5 hours. It is important to remember that smaller doses of insulin not only give less effect but also last for a shorter duration.

It is important to rotate the cartridge for insulin pens several times before injecting. The cartridge with NPH insulin contains a small glass ball that will help to mix the insulin crystals with the clear liquid.

## When should I take the long-acting injection?

These Lente type insulins (Ultratard, Ultralente, Humulin U, Humutard Ultra) are made long-acting by binding the insulin to large crystals. They begin their action around 4 hours after the injection, give a peak effect after 8 - 18 hours and can still give some effect after 24 hours. Because of this very long action you should take the injection earlier in the evening, e.g. at the evening meal or often already at dinner-time. The timing is very individual and you will need to experiment to find out which suits you best. You should take at least 30 - 40 % of the total 24-hour insulin dose as long-acting insulin to get a good basal insulin effect. Remember that you also have an insulin effect into the next day with these long-acting insulins. With high doses of long-acting insulin it is optimal to divide the dose and take half in the morning and half before dinner or at the evening meal. If you use direct-acting insulin (Humalog) for premeal injections you will also need to divide the long-acting basal insulin into two injections.



Since long-acting insulins act over more than 24 hours it is important not to change the dose more often than 1 - 2 times per week.

Lente insulins are not available in cartridges for insulin pens. The reason for this is that the insulin is in crystal form and the crystals will break if a glass ball is used in the cartridge for mixing.

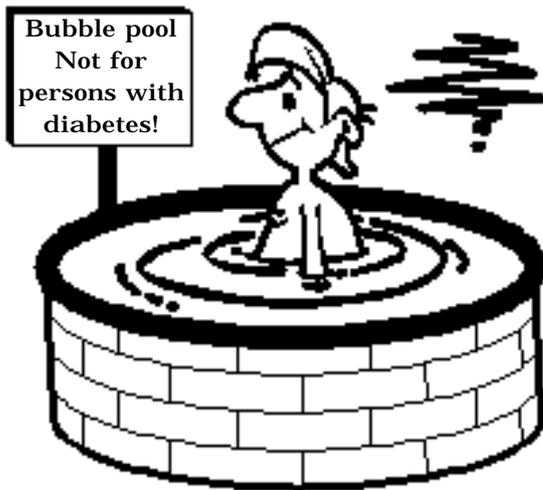
## Mixing insulins

Insulin of NPH type (Insulatard, Humulin NPH, Isuman Basal) can be mixed with both regular short-acting insulin and direct-acting insulin. If, however, you mix insulin of Lente type (Monotard, Humutard, Ultratard or similar) with short-acting insulin you will lose part of the short-acting effect. This is due to an excess of zinc in the Lente insulin that binds to the short-acting insulin and flattens the peak of action, making it more long-acting.<sup>46,183</sup> If you prepare the mixture from vials stored in the refrigerator<sup>317</sup> and if you inject directly after mixing in the syringe this problem seems to be less pronounced. If you use long-acting insulin (Ultratard, Ultralente, Humulin U, Humutard Ultra) together with short-acting insulin in a multiple injection treatment these should preferably be taken as separate injections. It is also not a good idea to use Lente insulins in indwelling catheters (Insufion) for the same reason. However, direct-acting insulin (Humalog) seems to be an exception to this rule. Mixing Humalog and Ultralente did not change the peak action when injected within 5 minutes of mixing.<sup>33</sup>

## Depot effect

If only intermediate- or long-acting insulin is used, a depot of insulin is formed in the subcutaneous fat tissue, corresponding to about 24 hours of insulin requirements.<sup>53</sup> The larger the share of intermediate- or long-acting insulin you use, the larger the depot will be. When using multiple injection treatment with regular short-acting insulin the depot will correspond to about 12 hours of insulin requirements.<sup>53</sup> When changing the dose of bedtime insulin the size of the insulin depot makes it necessary to allow for 2 - 5 days of adjustment before achieving a new equilibrium (see "Basic rules" on page 110).

The disadvantage of a large insulin depot is that the insulin effect will vary from day to day. The disad-



You may feel sad and disappointed when you see a sign like this, maybe even feel like you have the plague. The reason for the warning is that insulin will be absorbed faster when the skin is heated by the hot water. This might cause a hypoglycemia. If you are aware of this phenomena and have taken proper precautions you can take your bubble bath without worrying.

If you have a diabetic foot ulcer or nerve damage you should talk this over with your doctor or foot therapist before taking a bubble bath since hot water will soften the skin on your feet and increase the risk of infection.

vantage of a small insulin depot is that little or no extra insulin is stored in your body. The depot functions like a “spare tank” in that the extra insulin stored in your body can be used when a lack of insulin arises, for example if you forget an injection. If your insulin needs are increased (e.g. when having an infection) or if you forget an insulin injection you are more susceptible to insulin deficiency (ketones in the urine, nausea or vomiting). With pump therapy only short-acting insulin is used resulting in a very small depot of insulin. If the insulin supply is stopped or blocked symptoms of insulin deficiency will develop within as little as 4 - 6 hours (see page 129).

## How accurate is my insulin dose?

A correctly used insulin pen will give a very accurate insulin dose with an error of only a few percent. However, the effect of a given insulin dose also depends on a number of other factors. A variability of as much as 25 % in insulin effect may exist for the same dose given to an individual at the same site, whereas the variability approaches 50 %

## Factors influencing the insulin effect

- Ä** **Subcutaneous blood flow**  
(increased blood flow will give a faster insulin absorption).  
  
Increased by Heat, e.g. sauna, bubble pool or fever.<sup>182</sup>  
  
Decreased by Cold, e.g. a cold bath.<sup>41</sup> Smoking (constriction of the blood vessels).<sup>233,236</sup> Dehydration.<sup>182</sup>
- Ä** **Injection depth** Faster absorption after an intramuscular injection.<sup>157,403</sup>
- Ä** **Injection site** See page 93 An abdominal injection will be absorbed faster than a thigh injection. The absorption from the buttocks is slower than the abdomen but faster than the thigh.
- Ä** **Insulin antibodies** Can bind the insulin resulting in a slower and less predictable effect.
- Ä** **Exercise** Increases the absorption of short-acting insulin even after the exercise is ended, particularly if the injection is given intramuscularly.<sup>155,236</sup>
- Ä** **Massage of the injection site** Increased absorption, probably due to a faster breakdown of the insulin.<sup>261</sup>
- Æ** **Subcutaneous fat thickness** A thicker layer of subcutaneous fat gives a slower absorption of insulin.<sup>191,367</sup>
- Ç** **Injection in fat lumps (lipohypertrophies)** Slower<sup>434</sup> and more erratic absorption of insulin.
- È** **Concentration of the insulin.** 40 U/ml is absorbed faster than 100 U/ml.<sup>157</sup>

when the same dose is given to two different individuals.<sup>182,195</sup>

## Insulin absorption

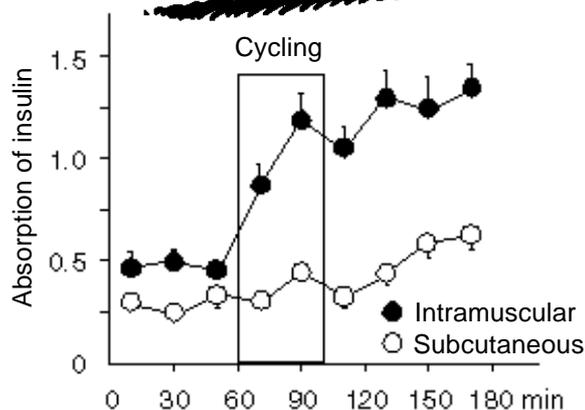
The absorption of insulin from the injection site can be influenced by a number of factors. Heat will increase the absorption. If the room temperature increases from 20° to 35° C the absorption of short-acting insulin will increase by 50 - 60 %.<sup>236</sup> A 85° C sauna bath will increase the absorption by as much as 110 %! In other words, there will be a risk of hypoglycemia if you inject short-acting insulin shortly before the sauna bath. A hot bath (42° C) in a bubble pool may double the insulin level in your blood while a cold bath (22° C) will decrease the absorption of insulin.<sup>41</sup> Massage of the injection site for 30 minutes gave higher insulin levels and lower blood glucose, both with short-acting,<sup>261</sup> and long-acting insulins.<sup>41</sup>

The skin temperature is also important. In a study the same insulin injection gave twice the concentration in blood after 45 minutes when a skin temperature of 37° C was compared to that of 30° C (same room temperature).<sup>367</sup> In the same study persons with thicker subcutaneous fat layer (10 mm) had lower insulin levels than those with a thin subcutaneous fat layer (2 mm). Also see "Where do I inject the insulin?" on page 92.

### If the child won't finish his/her meal.

As a parent you are only too aware how much your child will eat of a certain dish. It is a good idea to read through the school menu in advance and discuss what he or she does not like and what can be eaten instead. Smaller children are especially unpredictable as to how much they will eat at the time when the insulin is given. If the child eats less than anticipated there will be a risk of hypoglycemia. It is not ideal to give insulin after the meal, but in this situation it might be the best alternative, especially if you use direct-acting insulin (Humalog). You can also try giving insulin corresponding to a smaller meal first and then give the rest of the insulin if the child eats a normal sized meal after all. If the child uses an indwelling catheter (Insuflo) the extra injection does not create a problem.

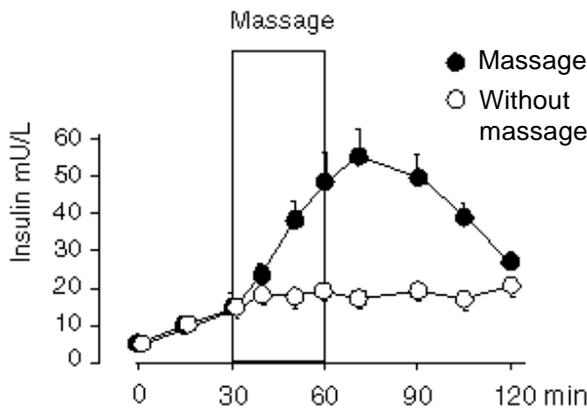
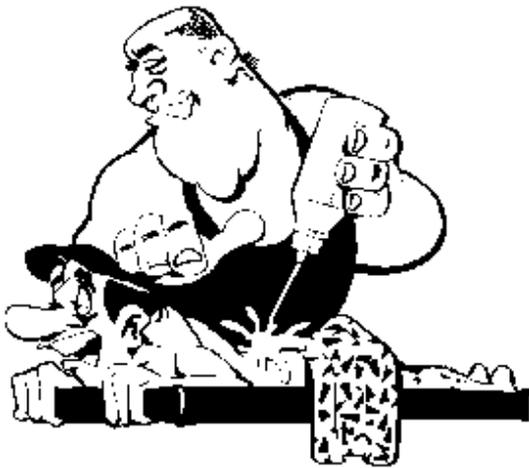
A child with good glycemic control will often have a well balanced opinion of how much he or she needs to eat. If the blood glucose is high the child will not be as hungry as usual and will not need to eat as much. (see "Hungry or full?" on page 152).



*After an injection in your thigh muscle the absorption rate will increase considerably when you exert the muscles in your legs. The insulin (10 U) was given at 0 minutes. After an injection in the subcutaneous fat you will only see a slight increase in the absorption rate, probably due to the subcutaneous insulin depot being "massaged" by the moving muscles.<sup>156</sup>*

You can compensate if the child has had more or less than usual to eat when it is time for the next snack. If the child has had a small lunch, schedule the snack a bit earlier and give the child a little more at that time (perhaps something extra tasty if his or her appetite has been bad).

If the child eats less while using twice-daily injections you should decrease the dose of short-acting insulin (Actrapid, Humulin Regular, Humalog) but give the same dose of intermediate-acting insulin (Insulatard, Monotard, Humutard).



Massaging the injection site will increase the absorption of insulin considerably.<sup>261</sup> The insulin (10 U) was given at 0 minutes. You can utilize this if you want a particularly rapid insulin effect, for example with a high blood glucose level with ketones in the urine. Give the injection site a thorough rubbing for 15 - 30 minutes and you will find that the effect of the insulin is much faster.



Sometimes it is difficult to know if a small child will finish a meal. It may then be better to give a smaller insulin dose before the meal to avoid the situation where you will have given a full dose of insulin and the child refuses to eat. An alternative, especially if you use direct-acting insulin (Humalog), is to give the injection after the meal. If the child has an indwelling catheter (Insuflon) it is easy to give half the insulin dose before the meal and then add a few units after, depending on how much the child eats.

### À Forgotten premeal injection (multiple injection treatment)

Take the same dose of regular short-acting or direct-acting insulin or decrease it by a unit or two, if you remember immediately after you have eaten. If an hour or 2 have lapsed you can try taking about half the dose of regular short-acting insulin or, even better, a dose of direct-acting insulin (Humalog). If a longer time has passed add a few units to your next meal injection, but not until you have measured your blood glucose level.

## What should I do if I forgot to take my insulin?

You can try the following suggestions if you have had diabetes for some time and are well acquainted with how the insulin you inject works. ***If you are even slightly unsure you should contact the hospital or diabetes clinic.***

### À Forgotten bedtime injection (multiple injection treatment)

If you wake up before 2 AM you can still take your bedtime insulin, but you should decrease the dose by 25 - 30 % or 1 - 2 units for every hour that has passed since the normal time of injection. If less than five hours remain before waking, measure your blood glucose and take an injection of regular short-acting insulin (*not* Humalog). You can try a dose of regular insulin with half the number of units of your normal bedtime injection of intermedi-

ate-acting insulin. However, never inject more than one unit per 10 kg of body weight at one time.

If you wake up with high blood sugar, nausea and ketones in the urine you have symptoms of insulin deficiency. Take 0.1 U/kg (0.5 U/10 pounds) body weight of short-acting insulin (regular or even better Humalog) and measure your blood glucose again after 2 - 3 hours. If your glucose level does not decrease take another dose of 0.1 U/kg (0.5 U/10 pounds) body weight. **If you still are feeling sick or if you vomit you should immediately contact the hospital.**

### **Â** **Forgotten injection with twice-daily treatment**

Take the same dose or decrease the regular short-acting part by 1 or 2 units if you remember immediately after having eaten. If you remember after an hour or two you can try decreasing the regular part to about half and the intermediate part by about 25 %. If you remember your injection even later, measure your blood glucose before the next meal and take only regular short-acting insulin at this meal.

If you have forgotten the afternoon injection and remembered in the evening you must take a smaller dose of intermediate acting insulin before going to bed. A little more than half should be enough but you must test this with blood glucose controls. You



*If you are out dancing remember that this is also exercise. Don't forget to eat something during the evening. Because of the exercise you will probably not need an extra meal injection, that is if you are not planning on staying up very late. You may also need to decrease your bedtime injection by 2 - 4 units to avoid hypoglycemia if you have been dancing a great deal.*

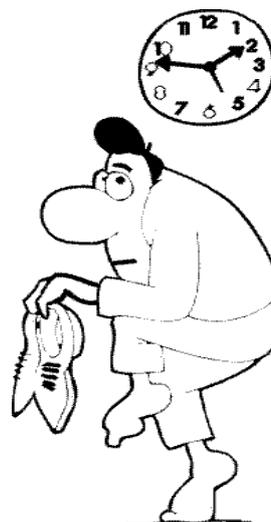
will probably also need an injection of short-acting insulin at your evening meal. Try the same dose (or a few units less) than the short-acting part of your afternoon injection. You should check your blood glucose at night to avoid hypoglycemia.

### **Can I sleep in on weekends?**



Sure, you can sleep a while longer on weekends. One hour extra is rarely a problem and usually you can sleep in two hours as well. Some persons with diabetes who experience problems with high morning blood glucose (see page 115) will find it difficult to sleep longer since their glucose level may rapidly rise during the morning hours. In some families this is solved by parents giving an early morning injection. The child or teenager can then sleep in an hour while their blood-glucose starts to decrease before having breakfast.

If you stay up late at night and plan to sleep in late in the morning you should take your bedtime insulin when you go to bed. It will then last the duration of a normal nights sleep including the extra hours in the morning.



*If you stay awake very late (2 - 3 AM) you will need another injection of premeal insulin (and food) late at night. Remember not to give the injections of regular short-acting insulin more than five hours apart.*

However, if you plan to have an early breakfast you should decrease the bedtime dose as the night will then be shorter than usual. Otherwise there is a risk of hypoglycemia when your breakfast insulin starts working.

If you have a late breakfast your lunch will usually also be a little late since you are not as hungry at your normal lunchtime. In this way your whole day will be shifted and you will usually have no problem spreading your meals evenly over the day. Just remember that the time between the injections of regular short-acting insulin should not exceed five hours.

When switching between summertime and wintertime you need only adjust your watch. You do not need to gradually adjust the time for meals and insulin injections.

## What if I stay awake all night?

Staying up all night is not common practice, but it is sometimes necessary when one is an adolescent or young adult. An 18 year old boy with diabetes worked as a travel guide and was required to stay awake all night in the bus on the way to a ski resort. Also during long flights one will often remain awake for a long time passing through time zones (see "Passing time zones" on page 208).

If you stay awake all night you should not take your bedtime insulin. Instead you inject regular insulin and eat every 4<sup>th</sup> or 5<sup>th</sup> hour. Adjust the dose according to how much you eat (compare the size of your meal with your usual lunch/dinner or evening meal). You should not use the amount of insulin taken at breakfast for comparison because more insulin is commonly needed for breakfast (see "Distribution of insulin doses" on page 105).



### Birthday parties

It is very important for a child with diabetes to be able to take part in birthday parties or school parties

without being embarrassed about having diabetes. In my opinion a person with diabetes should learn how to handle whatever food is served at a party instead of bringing their own "diabetes food". It is often a good idea to call before the party and arrange for something to drink with artificial sweeteners and request that there be not too many "goodies" served. At most parties the children receive a bag of candy at the end to take home, which suits the child with diabetes well.

Nowadays the food served at birthday parties is not as sweet as it used to be. Often there is just cake or ice cream on the menu and then perhaps hamburgers or hot dogs. Try giving an extra unit of insulin with the birthday cake.

Often children run around a lot at a party and it is quite possible that a child will manage very well without extra insulin. Check blood glucose and urine tests when the child comes home. Write the results down in a diary and you will be better prepared for the next party.

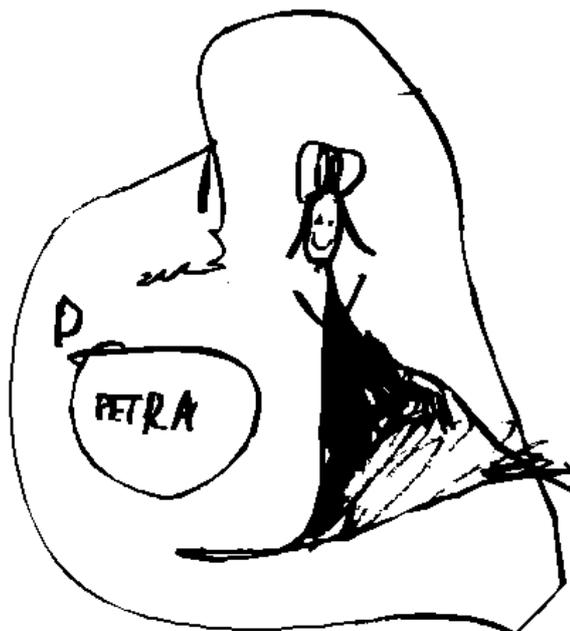
The best time for a party at the day care center is during snack time. Always make sure there is something to drink with artificial sweetener for children with diabetes. A good idea is to have a package of "light ice cream" in the refrigerator. The staff is usually very obliging for the small extra arrangements needed to accommodate a child with diabetes. Sometimes you might need to give an extra unit of insulin if, for example, a birthday cake is served (see above).

When going to an adult party many types of cookies, cakes and other sweet things are often served. The child will then need extra insulin to be able to pick and choose from all that is served. Try to find some kind of compromise here, for example only a few cookies or a little bit of cake (and if needed one or two units of insulin extra). It usually does not work out very well if you eat a lot of everything offered at a party. And do tell grandmother (who is only looking out for their grandchild's best) that so called "sugar free" cookies or "diabetes cookies" are not a very good alternative. They are not at all free from sugar and many children find them repugnant.

Of course the procedure will depend on how often you go to parties. Once in a while you can certainly make an exception and accept some sweets or a piece of cake when offered. But if you make exceptions every week they are not exceptions anymore and your HbA<sub>1c</sub> will probably be affected.

## Insulin at school or day-care centers

Sometimes it is difficult to get help with insulin injections at a day care center or to get the teacher to remind the child to take their insulin at school. The staff has no formal obligation to give injections when needed, but it is often possible to find a teacher or someone working in the school cafeteria who will help. At some larger schools where many pupils have diabetes they often meet at lunchtime, to eat together, and someone from the staff can help them if needed.



## Sleeping away from home



Children truly enjoy staying over night at a friend's home. As a parent of a child with diabetes one is of course worried when faced with such a request. It is easy to assume an overprotective attitude if you don't feel secure about how to deal with this situation. It is important that the friend's parents are familiar with how and when a child should take his/her insulin and how to treat hypoglycemia. A good idea is to write down a list for the child with when and how much insulin should be taken depending on blood glucose measurements. Don't forget to leave your telephone number if you will be out for the night.