

Insulin Pump Guidebook



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Glossary

It is recommended that you familiarise yourself with all the terms in this glossary as these terms will be used throughout this guidebook.

| | |
|-------------------------------------|---|
| Apidra | Insulin glulisine, a rapid-acting insulin for bolus coverage |
| Basal Insulin | Background insulin coverage to control blood glucose throughout the day and night, even when fasting. This usually refers to intermediate- or long-acting insulin |
| BG | Blood glucose or blood sugar |
| Bolus Insulin | Refers to short- or rapid-acting insulin to cover mealtime glucose rise from carbohydrate consumption (meal bolus) and to correct for high BG levels (correction bolus) |
| Carbohydrate (carb) counting | Carbohydrates which include sugars and starches, are one of the main nutrients found in food and drinks. Carbs affect your BG more than other nutrients and is usually counted in grams (g) or by carb portions |
| Diabetes Mellitus (DM) | A metabolic disease that is characterised by either decreased insulin sensitivity or the inability of the pancreas to produce insulin |
| DKA | Diabetic ketoacidosis: A serious complication of diabetes mellitus (DM) that occurs when the body produces high levels of blood acids called ketones. This usually occurs when blood glucose has been too high for too long and is life-threatening |

| | |
|-----------------------------|--|
| HbA1c | Glycated haemoglobin, the average blood glucose level over a 2-3 month period |
| Hyperglycaemia | High BG |
| Hypoglycaemia (hypo) | Low BG of less than 4 mmol/L |
| ICR | Insulin to Carbohydrate Ratio: This estimates the dose of insulin for the amount of carbohydrates (g) consumed. For example, if your ICR is 1:10 g, you will require 1 unit of rapid-acting insulin for every 10 g of carbohydrate |
| Insulatard | Isophane insulin, an intermediate-acting insulin for basal coverage |
| ISF | Insulin Sensitivity Factor or Correction Factor: This estimates how much one unit of rapid-acting insulin will lower blood glucose. For example, if your ISF is 1:3 mmol/L, 1 unit of rapid-acting insulin will lower your blood glucose by 3 mmol/L |
| Lantus® | Insulin glargine, a long-acting insulin for basal coverage |
| Levemir® | Insulin detemir, a long-acting insulin for basal coverage |



Lipodystrophy

Small lump or dent in the skin that forms when a person repeatedly injects insulin into the same spot. Avoid injecting into sites with lipodystrophy as it results in erratic insulin absorption. Always rotate insulin injection sites to avoid lipodystrophy

MDI

Multiple daily insulin injections – these are insulin injections taken 4-5 times per day and includes 2 different types of insulin (long-acting or basal insulin and rapid-acting or bolus insulin)

Novorapid®

Insulin aspart, a rapid-acting insulin for bolus coverage

Type 1 Diabetes Mellitus (T1DM)

A metabolic disorder that occurs because of little or no insulin production from beta cells in the pancreas

TDD

Total Daily Dose of Insulin: This is the total amount of insulin (both basal and bolus) that is used in a 24-hour period (1 day)

Notes

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CHAPTER 1: INTRODUCTION

Welcome to insulin pump therapy! This guidebook aims to support you in your journey with insulin pump therapy.

Beginning insulin pump therapy involves a steep learning curve. In this book, we have covered topics which are essential components of successful insulin pump use. This book, together with continuous education from your healthcare team, should provide you with complete working knowledge of insulin pump therapy. Each chapter in this book begins with learning objectives which outline what you should learn.



By starting on insulin pump, your doctor and healthcare team have identified that you already understand the basics of diabetes mellitus (DM) management and are ready to embark on this next step of your DM journey.

Let us list down what you know about how you manage your DM

- 1) Name of my basal insulin and usual dose: _____
- 2) Name of my bolus insulin and usual dose: _____
- 3) My total daily dose (TDD) of insulin (add up usual basal dose and all bolus insulin doses): _____
- 4) My target blood glucose (BG): _____
- 5) My most recent HbA1c: _____
- 6) My target HbA1c: _____
- 7) My Insulin to Carbohydrate Ratio (ICR): _____
- 8) My Insulin Sensitivity Factor (ISF) or Correction Factor: _____
- 9) How many times per day I check my BG: _____
- 10) My frequency of hypoglycaemia (low BG) (number of times per week):

- 11) My symptoms of hypoglycaemia: _____
- 12) Who is involved in my care team (you may include your family members, friends, healthcare team): _____



CHAPTER 2: PUMP THERAPY – HOW DOES IT WORK?

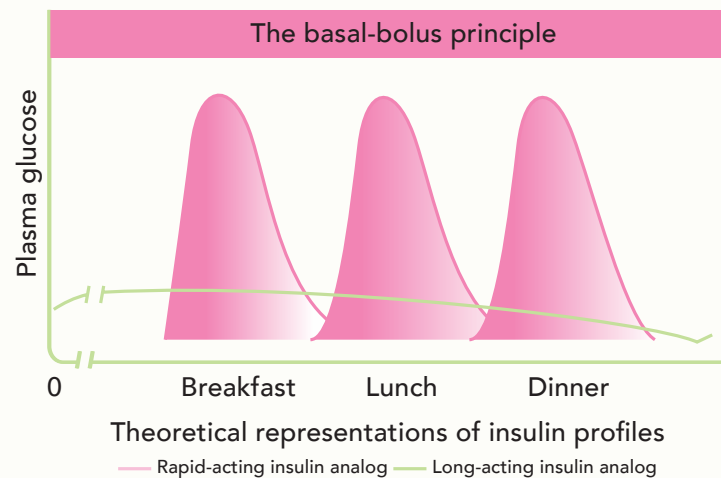
Learning Objectives:

1. Learn different component parts of an insulin pump
2. Understand how insulin pump therapy differs from multiple daily insulin injections
3. Learn the benefits of insulin pump therapy
4. Understand why your healthcare team may have recommended insulin pump therapy for you
5. Understand and familiarise with common pump terminology



2.1 What is an Insulin Pump?

A person with DM on insulin therapy has to take insulin as close as possible to the way insulin is delivered by the pancreas. You may currently be on multiple daily injections of insulin (MDI) that is injected 4-5 times per day.

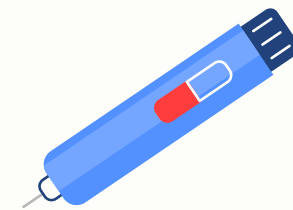


MDI include 2 different insulin types:

- **Basal insulin (usually Lantus®, Levemir® or Insulatard)** - This is a long-acting insulin that has a slower onset of action and is given once or twice daily as it can stay in the body for a longer period of time, usually between 14 hours to up to 24 hours. The dose of this insulin is usually fixed but it can be adjusted for sick days, stress or physical activity. Basal insulin covers your insulin needs in between meals and throughout the night, even when fasting. More explanation on this can be obtained in the *Pump Terminology* section of Chapter 2, Page 21.
- **Bolus insulin (usually Novorapid®, Apidra or Humalog)** - This is a rapid-acting insulin that works very quickly and needs to be injected before each meal. It will start to work ('onset of action') within 15 minutes after the injection, has its maximum glucose lowering effect at about 1-2 hours ('peak action') and stops lowering glucose levels within 3-5 hours ('duration of action'). The dose of this insulin will depend on the amount of carbohydrates in your meal and your blood glucose (BG) level before the meal.

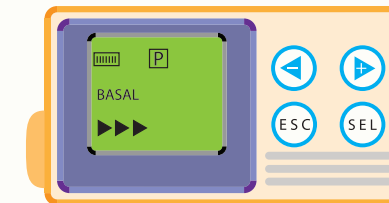


Insulin vial and syringe



Insulin pen

By adjusting your bolus insulin doses based on your meals (carbohydrate portions), BG levels and physical activity, you are trying to match your insulin requirements as closely as possible to what your body needs.



An insulin pump is a battery-operated insulin delivery device about the size of a pager that closely mimics the action of the pancreas in delivering insulin. The pump infuses rapid-acting insulin just below the skin and is usually worn on the abdomen, buttocks or hip.



The picture in Figure 2.1 below shows the basic components of an insulin pump.



Figure 2.1 The basic components of a traditional insulin pump and its component parts

Insulin pump component parts

- **Reservoir** - Used to hold the insulin that you will need for 2-3 days
- **Battery** - Powers the insulin pump
- **Infusion set** - The plastic tube that goes from the pump and leads to the site on the back of your abdomen where the insulin is stored. The cannula (C) that passes through the skin and sits in the fatty tissue under the skin. The infusion set must be changed every 2-3 days to prevent clogging and infection as well as to ensure consistent insulin absorption.
- **Cannula** - Tiny flexible tube placed into your body and delivers insulin from the infusion set to the fatty tissue under the skin.
- **Adhesive** - Holds the infusion set in place.
- **Tubing** - The tubing brings insulin from the pump (either the reservoir or the infusion set). There is a disconnect mechanism that allows you to temporarily set the pump and tubing aside for situations such as bathing, swimming, contact sports and driving, while leaving the cannula (C) in place.

2.2 Different types of insulin Pumps

There are various types of insulin pumps available, although not all may be available in Singapore as yet.

- 1) **Traditional insulin pumps** - These are as described and shown in Figure 2.1.
- 2) **Insulin patch pumps** (Figure 2.2) - Patch pumps are worn directly on the body and have a reservoir, pumping mechanism and infusion set made a small case and do not usually have tubing. Patch pumps are usually controlled wirelessly by a separate device (remote control) that instructs the pump to deliver insulin for meals.



Figure 2.2 Patch pump

Insulin patch pumps are often combined with a continuous glucose monitor (CGM) and your basal insulin every 2-3 minutes based on your CGM glucose readings. These pumps are able to suspend insulin delivery before a hypoglycaemic event happens and automatically resume insulin delivery after glucose levels recover to safe levels. Some smart pumps are also able to increase basal insulin delivery when BG is high. All these additional functions help to keep BG within your target range with fewer highs and lows.



Figure 2.3 Smart pump

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2.3 Using an Insulin Pump with a Continuous Glucose Monitor (CGM)

A continuous glucose monitor (CGM) is a small sensor which you wear at the back of your upper arm or in the abdomen (Figure 2.8). It measures the amount of glucose in the interstitial fluid that surrounds your body cells. Therefore, the sensor glucose will not exactly match finger-prick blood glucose as there is an expected small time delay in the BG change, especially when BG is fluctuating rapidly e.g. after eating or exercising.

The CGM records your BG level continuously throughout the day and night. You can find out your BG levels by viewing the sensor using a CGM reader or your mobile phone installed with the required mobile application. The CGM readings are particularly helpful in providing insights to BG trends when used together with an insulin pump in the trial stage or when adjusting overnight basal rates.

Some CGMs are combined with insulin pumps to enable the insulin pump to adjust insulin rates based on the CGM readings. For more information, please refer to Figure 2.9.

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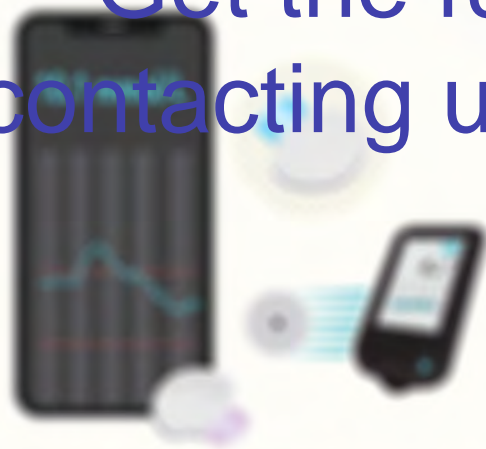


Figure 2.8 Continuous Glucose Monitor (CGM) may be used to provide insights to BG trends when using an insulin pump.

2.4 Benefits of Insulin Pump Therapy

Insulin pump therapy has been shown to have the following benefits:

- 1) Improved BG control
 - Studies have shown that people started on insulin pump therapy combined with proper training and support usually improve their HbA1c levels.
- 2) Reduced episodes of low BG episodes (hypoglycaemia)
 - Studies have also shown that people who experience frequent hypoglycaemia before insulin pump therapy are generally able to reduce the frequency of hypoglycaemia, particularly severe hypoglycaemia.
- 3) Better quality of life due to more flexibility
 - Being on an insulin pump provides you with greater flexibility as you will be able to better manage your basal insulin requirements on the go. This gives you more flexibility with meals and activity levels.

How do I know if insulin pump therapy is right for me?

- 1) The pump allows you to deliver insulin. Delivering insulin is more precise than injecting insulin into your body.
- 2) The insulin pump allows you to deliver very precise amounts and sets on both your basal and bolus insulin.

2.3 Differences Between Multiple Daily Injections (MDI) and Insulin Pump Therapy

Table 2.1. The differences between MDI and insulin pump therapy are listed below.

| | MDI | Insulin pump therapy |
|-----------------------------|--|--|
| Type of insulin | Usually 2 different types: 1 basal insulin and 1 rapid insulin | Requires only 1 type of insulin (rapid-acting insulin) which acts as both basal and bolus insulin |
| Number of injections | Requires 4-6 injections a day | Can usually be managed with the pump and changed every 2-3 days. This will depend on insulin needs day |
| Basal insulin | Needs to be manually topped with insulin at bedtime for basal insulin and some meals | No need to top up with insulin at bedtime. Basal dose may be delivered by pressing a few buttons or using a remote control |
| Meal insulin | Needs to top up insulin at the beginning of each meal plus the amount to deliver insulin injections | More accurate |
| | Calculation of bolus insulin for meals and correction may require complex timing calculation, use of apps, tools or additional devices | It does bolus automatically with the pump and the user calculates of bolus insulin |

| | MDI | Insulin pump therapy |
|-----------------------|---|---|
| Basal insulin | Changes in basal insulin needs in the course of the day or special occasions advised Insulin that has been injected cannot be reversed | Basal insulin can be turned off or reduced at any time by the pump if the needed More flexible able to set temporary basal rates, suspend boluses and other use of functions to suit your needs. Changing needs (e.g. stress, increasing physical activity, etc) |
| Meal insulin | Needs to remember to top up basal insulin at specific times of the day | Basal insulin is constantly delivered by the pump |
| Meal problems | Can be difficult remembering to top up insulin at the right time Can be difficult to know how much insulin to top up | Can only be discontinued for short time Can be programmed to deliver 2 levels increase or decrease of insulin depending on time |
| Site problems | Needs to be careful to rotate injection sites | Can be programmed to deliver insulin over a long period of time or adjust amount of insulin |
| Site problems | Handwritten notes about insulin needs of injection sites | Site can become irritated from the infusion set, infections and infections can happen if the set is not being or inserted regularly |
| Learning curve | Less complicated to learn | Changes initial learning curve to adjust pump use to the pump |
| Cost | Generally more affordable | May be more costly |
| Future outlook | Needs to keep track of log of insulin administered and CG readings | May be equipped with data management system for more precise and adjustment |

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As the pump only uses rapid acting insulin, there will be a quick rise in glucose levels within 2 hours if insulin infusion is interrupted. As such, insulin infusion should not be suspended/ stopped for more than 1 hour without checking your BG.

Good practices will enable safe use of the insulin pump and avoid potential problems:

- Check BG regularly, minimum 4 times a day (before meals and at bedtime)
- Never ignore a high BG level (> 16 mmol/L). Check for ketones if BG > 16 mmol/L persistently.
- Never ignore a low BG level (< 4 mmol/L) and keep fast acting carbohydrates, for example, 2 sweets that sugar-free or half a can of sweetened drink (e.g. fruit juice) nearby to treat hypoglycaemia.
- Refresh BG after a low or high BG reading to ensure BG levels return to the target range.



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3.6 Possible Indicators for Insulin Pump Therapy

Insulin pump therapy may be considered if you have:

1. Recurrent episodes of hypoglycaemia (or hypoglycaemia a high level of self-management)
2. Not achieving target HbA_{1c} level despite a high level of self-management
3. Rise in BG levels early in the morning ('dawn phenomenon')
4. Wide fluctuations in BG despite intensive multiple daily injections of insulin
5. Requiring very small amounts of insulin (high insulin sensitivity)
6. Wanting to conceive a baby (pre-conception) or pregnancy

3.7 Tips on how to be a successful Pump user

To benefit the most from an insulin pump and to use the pump successfully, it is advisable to do the following:

1. **Learn as much as you can** about how your insulin pump works and practice the steps of changing the infusion set. This includes learning all the insulin pump function buttons and how to troubleshoot when problems arise.

2. Frequent BG monitoring

To improve your BG control while on insulin pump therapy, you will need to check BG at least 4 times per day (before you wake up, before each meal and at bedtime). Other times of the day in which BG checks are recommended include when you feel hypoglycaemia, unwell, before exercise or before driving.

3. Learn carbohydrate counting

Learning to count the carbohydrates in your meals helps you to determine how much bolus insulin to deliver through the pump.

4. Check your pump site daily

As the insulin pump requires a catheter to be inserted under the skin for 2-3 days, there is a risk that skin infections can occur. As long as correct procedures are followed, skin infections should be rare but can be unpleasant and dangerous if they do happen.

5. Pump in concert with your healthcare team

As you start your pump journey, you will need to work with your healthcare team to determine your pump settings. You will need to adjust your insulin pump settings as you learn more about your insulin sensitivity and how your body reacts to insulin. Your healthcare team should guide you through this process.

3.8 Goals of starting Insulin Pump Therapy

People choose to start an insulin pump therapy for different reasons. Why did you choose to start an insulin pump therapy? There will be some of your reasons here:

1. _____
2. _____
3. _____
4. _____
5. _____



During the course of some of our insulin pump users...



Living with the "roller coaster" DM

Living with the roller coaster DM is a 30-year-old man with T1DM, who is active, works outdoors, and has a BMI of 27. He has a long history of using insulin pumps and has been using a pump for 15 years. He has a long history of using insulin pumps and has been using a pump for 15 years. He has a long history of using insulin pumps and has been using a pump for 15 years.

Running for pregnancy

The 30-year-old man is a runner and is looking to start a family. He has a BMI of 27 and is looking to start a family. He has a BMI of 27 and is looking to start a family. He has a BMI of 27 and is looking to start a family.



Cycling to keep fit

When 30-year-old man starts his new T1DM he runs 30 miles a week. He continues to keep active by cycling long distances 3-4 hours a week with a group of cycling buddies. Despite his love affair of cycling, unfortunately, over time his HbA1c has risen to 10% in recent years. He is keen to continue to active lifestyle and prevent hypoglycaemia after his long cycles. He has also noticed that he has had some of the usual symptoms of hypoglycaemia and has had symptoms after 12-14 days after 5-7 months. He wants an insulin pump therapy which helps him to reduce the frequency of hypoglycaemia and enable him to maintain his active lifestyle with variable basal rates for his long cycling rides.



2.2 Pump Terminology

Some important pump terms are explained in this section.



Basal insulin

Basal insulin is the background (continuous) production of insulin from the beta cells in the pancreas. It is the minimum amount of insulin needed to keep the body's glucose levels stable throughout the day and night. Basal insulin requirements are unique and are affected by many different factors such as hormones, stress and physical activity. An insulin pump delivers basal insulin continuously but in small amounts to act as the basal insulin and the rate of the delivery is matched to your body's needs. Any interruption in the pump delivery of basal insulin could result in hyperglycaemia within a few short hours and can result in DKA.

The basal rate is typically 40-50% of your total daily dose of insulin (TDD) (insulin). Together with your pump/healthcare team, you will learn to program initial basal rates into your pump. It is not unusual to require more than one basal rate since your body may require different amounts of insulin at different times of the day. These initial rates will need to be assessed once you begin pump therapy (Refer to Chapter 3.1, Page 26). The goal is to set a basal rate that will keep your BG stable without the need for extra insulin or food.

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