Devices for insulin administration

The incidence of diabetes is increasing dramatically in the UK, mainly due to the rise in type 2 diabetes, associated with an increase in obesity and decrease in physical activity. Type 2 diabetes is progressive and initially requires the patient to make changes in lifestyle and take oral hypoglycaemic agents. The patient may eventually require insulin therapy because of gradual beta cell failure. Evidence from the UK Prospective Diabetes Study (1998) showed that improving blood glucose levels reduced or delayed the progression of diabetes complications. This has led to a greater use of insulin pens, and the development of novel devices for use by patients with manual dexterity or visual problems.

There are four main UK manufacturers of insulin, each producing many insulins and devices, which accounts for the bewildering number of insulins and pens available in the British National Formulary. However, the variety of devices offers people with diabetes choice, convenience and effective methods for the delivery of insulin.

Syringes  Syringes are popular with many insulin users. They are lightweight and those who have administered insulin for a long time may prefer to continue with this device. Patients may have to use a syringe as they are using insulin that is only available in vials. Syringes are also suitable for patients who like to mix variable proportions of short and long-acting insulin in a twice-daily regime. This would not be possible with an insulin pen.

Syringes are available in three sizes: 0.3ml (30 units), 0.5ml (50 units) and 1ml (100 units). The two smaller sizes are available on the drug tariff with 8mm or 12.7mm needles, the 1ml size with 12.7mm needles only.

Reusable pen devices  Reusable pen devices (Fig 1) hold the insulin in a cartridge and measure out the required dose, so are convenient to use. They are free on the drug tariff or from a diabetic nurse specialist. Most brands of insulin used with the pens are available in 3ml (300 unit) cartridges.

Some reusable pens have novel features. For example the Optipen, for use with Aventis insulin, has a digital display which shows the insulin dose the patient has chosen, which remains on the display for several minutes after administration. The Innovo pen, used with Novo Nordisk insulin, retains details of the last dose given and how many hours since it was administered. It can also be incorporated into the InDuo blood glucose meter (Fig 2) so the two devices can be carried together.

The NovoPen PenMate conceals the needle and injects the insulin dose automatically. This can be used by patients who cannot insert needles into their skin. This device is attached to the NovoPen and is used with Novo Nordisk insulin (Fig 2).

Pens are mainly used to administer insulin that is identical to human insulin but there is a limited selection of animal insulins available that can be used with another make of pen called the Autopen.

Disposable pens  Disposable pens (Fig 3) offer the most expensive method of injecting insulin, but can save costs by maintaining patient independence and improving concordance with treatment. For example, they reduce the need for support from a district nurse and lower the cost of treating any symptoms resulting from poorly controlled diabetes.

Complete pens containing 3ml (300 units) of insulin are available on the drug tariff. The patient attaches a needle and the pen is ready for use. When the pen is empty, the needle should be disposed of safely and the pen thrown away with household rubbish. Disposable pens are not available for use with animal insulins.

The Optiset pen can be preset so is useful for people who can inject but have poor vision. Older people requiring two visits a day from a district nurse may prefer this device so they can maintain independence.

The Innolet pen, which can be used with Mixtard 30 and Insulatard, looks like an egg timer with a large circular dosage face and dial which is useful for someone with visual problems or poor manual dexterity.

Both disposable and reusable pens deliver a maximum dose in the range of 40–70 units of insulin and may be of limited use for patients requiring large doses.

Insulin pen needles  Insulin pen needles are available on the drug tariff in 5mm, 6mm, 8mm, 10mm and 12.7mm sizes. There are many brands and it is vital to test compatibility between pen and needle. Insulin pen needles are designed for single use, but many patients choose to reuse them.

Needle length is important as insulin has to be injected into subcutaneous fat rather than the intradermal layer or muscle. Subcutaneous fat has a relatively poor blood supply so insulin will be absorbed from it over several hours. Injecting insulin into muscle, which has a rich blood supply, often results in sudden hypoglycaemia as the insulin is absorbed too quickly. Intradermal injections are painful and can cause a localised itchy rash.

Very short needles are particularly useful for injecting into lean limbs or for patients who are unable to perform the recommended pinch-up technique, for example someone with arthritis of the fingers, or someone with a

Non-injection devices  The mhi-500 is the one device available in the UK for delivering insulin without a needle (Fig 4). The patient loads up the required dose of insulin (or mix of insulins) from a 10ml vial. The nozzle is pressed against the skin in the same sites that are used for conventional insulin injections.

Insulin is forced at speed and pressure into the subcutaneous layer through the nozzle when the discharge button is pressed. Although not pain-free, this device may be useful for people reluctant to use needles. It recently became available on the drug tariff and has the advantage of reducing the risk of needlestick injuries.

Insulin pumps  Insulin is produced from the beta cells, in people who do not have diabetes, in response to prevailing blood glucose levels. This results in a slow continual basal supply that maintains fasting blood glucose levels at about 3.5–5mmol/l.

After a carbohydrate load, for example after a meal, the blood glucose level starts to rise steeply, stimulating the beta cells to give a burst of insulin which prevents the blood glucose from rising much higher than 8mmol/l. As the blood glucose drops again several hours after the meal, there is less stimulation of the beta cells so less insulin is produced. This positive feedback process prevents hypoglycaemia (low blood glucose) or hyperglycaemia (high blood glucose) from occurring.

Insulin pumps provide the closest mechanism for achieving this fine control. The pump (about the size of a pager) delivers a continuous infusion of insulin via a cannula into the injection site. The patient can programme this hourly basal dose to adjust to varying insulin requirements such as exercise or illness. Boluses of insulin are delivered by pressing a button on the pump, and can be titrated according to carbohydrate portion size. Generally, patients require about 1 unit of insulin for every 10 grams of carbohydrate; the bigger the meal, the bigger the dose of insulin given, mimicking the delivery of insulin in someone without diabetes.

There are two insulin pumps available in the UK: Disetronic and MiniMed. Pumps cost about £2,000 and there are monthly costs of consumables of about £70. The cost means that the pump is not accessible to many people. New guidance from the National Institute for Clinical Excellence recommends insulin pump therapy as one option for people with type 1 diabetes provided that multiple dose insulin therapy has failed and the patient is able and willing to use it (NICE, 2003).

The future  Despite the wide choice of devices, there are still problems with insulin administration. Many patients miss injections and have a poor insulin injection technique (Partanen and Rissanen, 2000). The search continues for a mechanism that is easy and painless to use and mimics the action profile of insulin produced by people without diabetes.

Insulin cannot be given orally, leading to research into alternative delivery sites, including rectal administration. Most are inconvenient or ineffective. Inhaled insulin is the most promising area, with availability expected in the next few years. The insulin is inhaled via a similar mechanism to that used by people with asthma, but much bigger doses are required than by injection to achieve a therapeutic dose. Inhaled insulin could replace the quick-acting insulin given with meals, but patients would still need to inject a daily dose of insulin to maintain normal blood glucose levels between meals.

Conclusion  There are many devices for administering insulin. The one used depends on patient choice, visual and manual dexterity, type of insulin used, regimen and, in the case of pumps, cost. All devices need to be used correctly to ensure effective delivery and achieve normal glycaemia. Evidence suggests that this does not always happen, which drives the search for more convenient, easy-to-use mechanisms.

![Image of insulin infusion devices]

1. Reusable insulin pen devices
2. NovoPen PenMate (left) and the InDuo blood glucose meter for use with Novo Nordisk insulin
3. Disposable insulin pen devices
4. The mhi-500 needle-free insulin device