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An overview of insulin pump therapy

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Modern pump therapy is relatively new and different centres will have different criteria for its use. In the authors' experience, good glycaemic control can be achieved in most children and adolescents with type 1 diabetes through the use of insulin pump therapy.

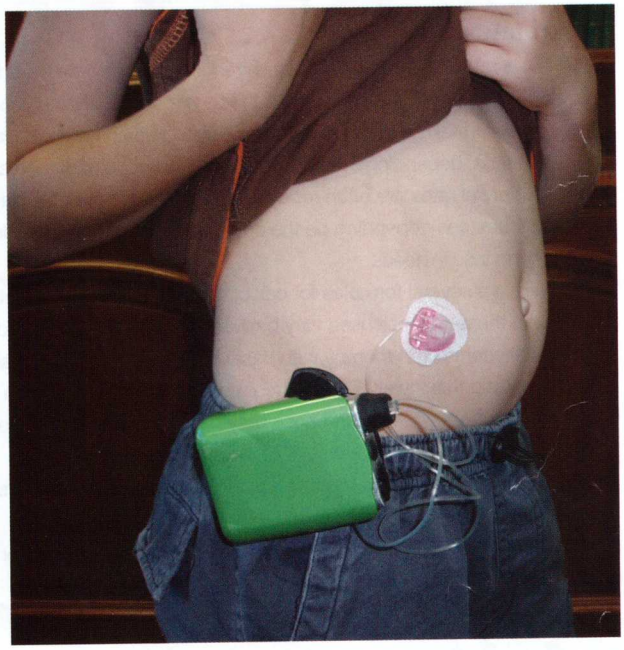

Figure. Insulin pump therapy is a good option for the long-term control of diabetes and reducing the risk of long-term complications in children and adolescents particularly.

What are insulin pumps?

An insulin pump is a compact computerised device that delivers small amounts of insulin under the skin. The pump is programmed to give background doses of insulin continuously depending on the individual's needs – the 'basal rate' (see the box on page 66 for explanations of terms used). The only insulins used with insulin pump therapy are the rapid-acting insulin analogues aspart, lispro and glulisine.

Each time the person eats he or she activates the pump to give a burst of insulin – a 'meal bolus' – to cover the amount of carbohydrate eaten. This meal bolus should be given before a meal or snack is eaten. An extra bolus – a 'correction bolus' – can also be given to treat a high blood glucose level.

Why use a pump?

The main benefits of using an insulin pump are:

- better metabolic control
- less hypoglycaemia
- better quality of life
- less glycaemic variation.

Recent studies of patients in Queensland have shown glycosylated haemoglobin (HbA_{1c}) values for patients under 18 years of age on conventional subcutaneous insulin regimens average 8.9%.[1]

The recommended international target for HbA_{1c} for all patients younger than 18 years is less than 7.5%. The mean HbA_{1c} for our patients in this age group over a four-year period on pump therapy is 7.3%. Both retrospective and randomised controlled trials have shown improvement in HbA_{1c} with insulin pump therapy.[2-5]

When (or in whom) is it used?

Patients of any age with type 1 diabetes are suitable for pump therapy. It is also sometimes used in patients with gestational diabetes and type 2 diabetes. We consider all children younger than 6 years should be using an insulin pump if possible. We encourage all patients and their families to consider the pump as the best option for long-term control of their diabetes and reduction of the risk for long-term complications. Many families in our practice are opting to commence pump therapy at the time of diagnosis.

Although good glycaemic control may be achieved with current insulin delivery devices by some adult patients with type 1 diabetes, children and adolescents rarely achieve this degree of control, partly because they are unable to sustain the commitment required. It is interesting to note that in adults with type 1 diabetes the highest use of pump therapy is by medical practitioners.

The basic requirements for people using pump therapy are:

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continued

Terms used in insulin pump therapy

Basal rate

The basal rate is the amount of insulin required in a day (delivered in tiny increments regularly throughout the day) to keep blood glucose within the normal range when fasting. Everyone has different basal insulin needs, depending on age, weight and duration of diabetes. Different basal rates are often required at different times of the day, these differences depending on the age of the patient and individual variation in insulin needs.

There are several formulae for calculating the starting basal rate for pump therapy; those used vary between centres but most children and adolescents start therapy with basal rates of 0.25 to 0.4 units/kg/day although a lower dose is often required in the honeymoon period. This partial remission phase of type 1 diabetes sometimes commences within days or weeks of the start of insulin therapy and may last for weeks to months. During this period the patient's insulin requirements are low, with a total daily dose less than 0.5 units/kg. Basal rates can be altered temporarily for exercise or illness, i.e. temporary basal rate.

Meal bolus

A meal bolus is the amount of insulin that on injection gives a stable glucose level two hours after a meal or snack. It is determined by the insulin to carbohydrate ratio (see below), which is programmed into the pump. The entering into the pump of the amount of carbohydrate being eaten at a meal 'instructs' the pump to deliver a bolus of insulin to match the carbohydrate amount.

Insulin to carbohydrate ratio

The insulin to carbohydrate is the ratio of insulin injected for amount of carbohydrate consumed; for example, a ratio of 1:30 means one unit of insulin is given for 30 g of carbohydrate. The ratio differs with patient age (Table).

Carbohydrate counting

Often called carb counting, carbohydrate counting is the amount of carbohydrate (CHO) measured in either 'grams of CHO' or 'exchanges' (equivalents of 15 g CHO); for example, one slice of bread = 15 g, one piece of fruit = 15 g.

Correction bolus

A correction bolus is the amount of insulin required to correct elevated blood glucose levels outside the target range. It can be given with a meal bolus or at other times. The usual blood glucose range is 4.0 to 8.0 mmol/L. We set our target at 4.0 to 5.5 mmol/L.

If used with a meal bolus, modern insulin pumps will add extra insulin for high blood glucose and subtract insulin for low glucose levels.

Correction factor or insulin sensitivity factor (ISF)

The correction factor is the number of mmol/L the blood glucose level will fall after one unit of insulin is administered. For example, for a correction factor of 5, one unit of insulin will lower blood glucose by 5 mmol/L, and applying this in an example, if the blood glucose level is 16 mmol/L and the target is 6.0 mmol/L, the pump will give two units of insulin.

Individual patients have different bolus ratios for meals and corrections. We usually start with a guideline developed in the Yale Diabetes Centre (see the Table; personal communication: Ahern JAH. Danbury Pediatric Diabetes Program, Yale University School of Medicine). These doses are estimates; they are usually not precise for any individual patient and will need to be adjusted. Other centres continue to use the '500' and '100' rules to determine insulin to carbohydrate ratios and ISF, respectively.

Table. Starting ratios for meals and blood glucose correction*

Age (years)	Meal ratio (unit of insulin/g of carbohydrate)	Correction factor or ISF (unit of insulin/mmol per L of glucose)
2 and younger	1/45	1/16.5
3 to 5	1/45	1/11
6 to 8	1/30	1/10
9 to 11	1/22	1/8
12 to 13	1/15	1/5.5
14 and older	1/10	1/4
Adult	1/10	1/4

* Personal communication: Ahern JAH. Danbury Pediatric Diabetes Program, Yale University School of Medicine, New Haven, USA.
ABBREVIATION: ISF = insulin sensitivity factor.

Continuous glucose monitoring systems (CGMS)

These systems measure blood glucose levels through continuous measurement of glucose levels in interstitial fluid. Sensors inserted subcutaneously in the abdomen are usually worn for up to six days and record glucose values every five minutes, enabling insight to blood glucose levels over the whole 24 hours. A continuous glucose monitoring system may be integrated into the pump (real time) or used as a separate device.

Carbohydrate-free periods

Carbohydrate-free periods are time blocks when no carbohydrate is eaten and are designed to assess basal rates. During these periods, blood glucose levels are measured every two hours. Only one time period in any day needs to be carbohydrate-free (e.g. breakfast to morning tea, lunch to afternoon tea or dinner to supper), and other foods (e.g. cheese, meats, chicken) may be eaten during these periods.

Insulin action time

Insulin action time is the time period the pump will block administration of further correction boluses after administration of a correction dose of insulin.

continued

Useful resources

- *SPIN: A Straightforward Program for Insulin Pump Newcomers*. 2010. Department of Paediatric Endocrinology, John Hunter Children's Hospital, Newcastle, NSW. Available from: Kathy.Hodge@hnehealth.nsw.gov.au
- *The Carbohydrate Food Guide, 3rd edition*. 2009. By Deb Foskett and Marie-Claire O'Shea. Available from: info@mcdietitians.com.au
- *The Traffic Light Guide to Food: Carbohydrate Counter, 7th edition*. 2009. By Tania Bennett, Katie Booth, Sharon Youde S. Diabetes Education Centre, Royal North Shore Hospital, Sydney, NSW. Available from: orders@diabetesnsw.com.au

- wanting to use the pump
- able to afford the cost ($8000 or basic health insurance pays full cost)
- willing to test blood glucose levels five or six times a day
- willing to learn carbohydrate counting.

How is it used?

Insulin pumps are worn externally day and night and the subcutaneous infusion set needs replacing at least every three days. Once the diabetes team has programmed the pump, the patient (or his or her parents) only has to enter into the pump the amount of carbohydrates about to be eaten and any blood glucose level estimations. The algorithm in the pump then determines the appropriate insulin dose and the pump dispenses it.

We have observed that the average child or adolescent eats carbohydrates at least six to 10 times a day. This frequency helps explain why, even with subcutaneous basal bolus injections three times a day, many children and adolescents cannot achieve adequate control without pump therapy.

What needs monitoring?

For good glycaemic control, at least four blood glucose level estimations a day are necessary in patients using pumps to administer insulin. Those patients not using pumps to administer insulin also perform four such measurements a day.

The amount of all carbohydrates being consumed must be entered into the pump. Particular care should be taken with sick days and high blood glucose values (13 mmol/L or above), with testing for blood ketones and immediate action to correct high glucose values if this occurs.

What are the common problems with pump usage?

The more common problems encountered with insulin pump therapy are:

- **Lack of compliance.** As with other therapies for patients with diabetes, lack of compliance with insulin pump therapy will result in poor glycaemic control. Although some centres have reported deterioration in glycaemic control with time, a recent study from Spain reports that with continued team support excellent HbA_{1c} levels can be maintained for at least five years in adults using insulin pump therapy.[6] We have seen similar results with our patients.
- **Problems with the infusion set.** The usual problem is kinking of the tubing, which results in rapid elevation of blood glucose levels (within 2 hours). If the elevation of glucose is not detected and corrected, it will result in diabetic ketoacidosis (usually in 6 to 8 hours).
- **Failure to enter the amount of carbohydrates being eaten into the pump.** Four missed boluses per week results in an HbA_{1c} elevation of 1.0%.
- **Failure to measure blood glucose values or enter them into the pump.** The pump is then unable to correct elevated blood glucose values, resulting in poor glycaemic control.
- **Failure to change the cannula every three days.** This results in inflammation causing local infections and scarring at the site. It also slows insulin delivery, resulting in a decrease in glycaemic control after three days.

Important precautions

Patients using insulin pumps should always carry spare infusion sets and batteries. They also need to have available alternative means of administering insulin (pens or needles) and supplies of their basal insulin analogue and their rapid-acting insulin analogue for use if there is a mechanical problem with their pump.

Further information

Some useful resources for patients and also GPs are listed in the box on this page.

Conclusion

Although not all patients will decide on insulin pump therapy to treat their diabetes, the number of patients using insulin pumps is rapidly increasing. Therefore every GP should be familiar with the basics of this type of therapy. MT

References

A list of references is available on request to the editorial office.

Further reading

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Steck AK, Klingensmith GJ, Fiallo-Scharer R. Recent advances in insulin treatment of children. Pediatr Diabetes 2007; 8 Suppl 6: 49-56.

This article is for general information purposes only; the diabetes team caring for the patient should be consulted before any changes are made to a patient's pump management and settings.

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