Insulin pump therapy – a new language

Traci Lonergan

The use of insulin pumps by people with diabetes, in particular type 1 diabetes, to deliver their insulin is becoming more prevalent. This article will support primary care providers to become more familiar with insulin pump basics, and learn the new language around insulin pump therapy.

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Article points

1. The advantages of insulin pump therapy include a more physiologically precise delivery of insulin and a greater likelihood of achieving optimal glycaemic levels without an increased risk of hypoglycaemia.
2. As well as the evidence of clinical advantages in the use of insulin pump therapy, improvements in quality of life for the user and their families has been recorded.
3. Insulin pump therapy is challenging for the user, and diabetes educators can assist by setting realistic expectations. It is not a suitable therapy for everyone with type 1 diabetes.

Key words

- Injection
- Insulin
- Pump
- Type 1 diabetes

The treatment regimen following a diagnosis of type 1 diabetes requires that insulin be administered subcutaneously, with the aim of achieving euglycaemia. In people with type 2 diabetes, insulin therapy may also be required when oral medication is insufficient for individuals to reach or maintain optimal blood glucose levels (BGLs). Insulin has historically been delivered via subcutaneous injection consisting of a basal insulin either once or twice per day and a rapid-acting insulin with three main meals. Insulin can also be delivered into the subcutaneous adipose tissue via continuous subcutaneous insulin infusion (CSII), through insulin pumps.

Insulin pumps have been available for some time and, with the advances in technology and improving ease of use, there are more people with type 1 diabetes of varying ages using an insulin pump to deliver insulin. Up to 10% of Australians with type 1 diabetes are currently using insulin pumps, and this figure is increasing (Xu et al, 2015).

In Australia, the National Diabetes Services Scheme currently only provides a subsidy to people with type 1 diabetes for the consumable products required for insulin pump therapy, such as reservoirs and infusion sets. People with type 2 diabetes cannot access this subsidy and, due to the prohibitive costs, there are very few people with type 2 using insulin pump therapy.

Multiple daily injections

Type 1 diabetes is a life-long and potentially life-threatening condition that requires constant management. The care of diabetes requires adherence to a complex daily regimen that balances nutritional intake with exercise and insulin administration, traditionally given in the form of multiple daily injections (MDI).

The dose of injected insulin often lacks specificity and absorption can be unreliable due to temperature or activity changes and using different injection sites with different absorption characteristics (Walsh and Roberts, 2012). A depot of long-acting insulin is injected under the skin either once or twice daily to cover the body's basal requirements. This basal insulin is to be absorbed gradually over 24 hours and there can be a variation in absorption by up to 25% from one day to the next (Walsh and Roberts, 2012).

The amount of lifestyle flexibility that can be achieved with MDI is directly related to the number of daily injections. This can be inconvenient for some and, for younger children, it can be inadvisable as MDI can be difficult for the family to administer on a daily basis. For the school-age child the midday injection can be problematic as most schools have policies where children are required to receive their insulin in the school office. This has children missing out on social time with their friends as well as compounding the feeling of appearing different (ISPAD, 2014). The result is that children, and particularly adolescents, will often omit this important dose of insulin, resulting in sub-optimal glycaemic levels and

Authors

Traci Lonergan, Clinical Nurse Specialist (Diabetes) at Launceston General Hospital; Youth Program Coordinator at Diabetes Tasmania, Launceston, Tas.

Page points

1. In contrast to multiple daily injections (MDI), an insulin pump can be programmed to deliver basal insulin to mimic the body's circadian rhythm, with the ability to change the basal rate every 30 minutes to match the changing requirements for basal insulin.
2. The insulin absorption is more consistent than MDI as only one site is being used.
3. Continuous subcutaneous insulin infusion via an insulin pump is more precise, reducing hypoglycaemia by as much as four times when compared to MDI.

increasing their risk for future long-term health complications of diabetes (DCCT/EDIC Study Research Group, 2016).

A regimen using long- and short-acting insulins mixed together and given twice daily has been used for younger children. The need for fewer injections with this regimen is more convenient, avoiding the need for administering a lunchtime injection. However it does mean that the effects of the different insulins are not clearly defined. That is, if the child's BGL is high or low, it is difficult to determine with any accuracy which insulin (the long- or short-acting) was responsible.

Insulin pumps

An insulin pump is worn by the person and delivers small doses of fast-acting analogue insulin continuously via an infusion set which has a small, soft cannula that is inserted just under the skin. This infusion set is connected to the pump via thin tubing through which insulin travels, and is changed approximately every two to three days. The pump is programmed to deliver precise increments of basal insulin throughout 24 hours, and bolus insulin is given to cover meals and correct high BGLs back to target. In contrast to MDI, the pump can be programmed to deliver basal insulin to mimic the body's circadian rhythm, with the ability to change the basal rate every 30 minutes to match the changing requirements for basal insulin. It is common for up to five basal rates to be entered into the pump settings (Walsh and Roberts, 2012).

An insulin pump will deliver insulin in increments as small as 0.025 units every 3 minutes, which enhances absorption, thereby requiring less insulin administration overall (Walsh and Roberts, 2012). The insulin absorption is more consistent than MDI as only one site is being used. Rapid-acting or "bolus" insulin is injected up to three or more times per day to cover meals and sometimes snacks. As a result, CSII via an insulin pump is more precise, reducing hypoglycaemia by as much as four times when compared to MDI (Walsh and Roberts, 2012).

Insulin pump therapy

Basal

Insulin is delivered over 24 hours in increments as small as 0.025 units every 3 minutes. The rates can be set to reflect the changing metabolic requirements which affect BGLs throughout the day and night. Basal insulin typically makes up 40–60% of total daily dose (TDD).

Bolus

Insulin is delivered rapidly as a meal bolus to cover carbohydrate eaten or as a correction dose in response to a high BGL.

Bolus calculator

This is insulin pump software that calculates insulin doses using settings entered by the individual to cover carbohydrates eaten and correct BGLs back to their target. The bolus calculator decreases the risk of insulin stacking by tracking the amount of insulin still active from the last bolus.

Insulin to carbohydrate ratio

This is the amount of carbohydrate in grams that 1 unit of insulin will cover. Alternatively, this can be set in exchanges, where an exchange is equivalent to 15 grams of carbohydrate. This setting is used to calculate a meal bolus. An accurate insulin-to-carbohydrate ratio will ensure that the BGL will return to target within the time that the insulin is active, which is approximately 4 hours after a meal bolus is delivered. This is dependent on the BGL being in target pre-meal, and carbohydrate quantity in the meal being accurately calculated.

Insulin sensitivity factor

This determines how much a BGL is expected to drop after administering 1 unit of insulin. This setting is used to calculate a correction bolus to bring a high BGL back down to target.

Target range

An individualised BGL range can be set in the bolus calculator and will be used to calculate correction doses to keep the individual's BGL within this range.

Active insulin time

This setting tells the pump how long a bolus of rapid-acting insulin will actively lower BGL after the bolus has been delivered. The insulin action time of rapid-acting insulin is around 4.5 hours, although the active insulin time setting in the pump can be set for a shorter duration if required. This will allow the bolus calculator to deliver another bolus once the active insulin time that has been entered into the pump settings has elapsed.

Insulin on board

The active insulin time is used by the bolus calculator to calculate how much insulin is still active in the body from the last bolus. This is the amount of bolus insulin remaining from recent meal and correction boluses that is still actively lowering BGL within the active insulin time.

Insulin stacking

Once the first bolus of the day is given, insulin stacking will occur when another bolus is given within the time that the first bolus insulin dose is active, causing them to overlap. The bolus calculator in the pump will take into account insulin still on board to suggest a dose which will minimise the risk of insulin stacking and the resulting hypoglycaemia.

Total daily dose (TDD)

This is the total amount of units of insulin a person uses in a 24-hour period, including both basal and bolus doses. The TDD is used to calculate the basal rate, insulin-to-carbohydrate ratio and insulin sensitivity factor.

Advanced features

Basal patterns

Several basal profiles or patterns can be saved for use at different times when insulin requirements vary, such as on school days versus weekend days.

Temp basal

This feature allows the pump to deliver a specified temporary reduction or increase in basal rate for a set amount of time. It is important to note that different pumps will have different methods to set the temp basal, so familiarity with the pump being used is paramount when suggesting a change in basal rate using the temp basal function.

Combination bolus

The user can specify how they want to deliver a bolus. The whole bolus can be delivered over a specified amount of time or the bolus can be split with part of the bolus being delivered immediately and part-delivered over time. The user will specify the percentage split and time to deliver. This is referred to as a combo bolus if using an Animas pump, or a dual or square wave bolus if using a Medtronic pump.

Advantages of insulin pump therapy

There are many advantages in using an insulin pump. Due to the more physiologically precise method of insulin delivery, it is easier to achieve optimal glycaemic levels whilst retaining a flexible lifestyle. The DCCT (Diabetes Control and Complications Trial) showed that a decrease in HbA_{1c} was associated with an increase in the risk of hypoglycaemia. Insulin pump users, however, are more likely to have a decrease in HbA_{1c} without the increased risk of hypoglycaemia (Coleman, 2008), a reduced risk of diabetic ketoacidosis (DKA) and less severe hypoglycaemia (Walsh and Roberts, 2012). Insulin absorption variability is reduced from 25% with MDI to 3% on insulin pump therapy due to the small increments of insulin delivered, single site use and elimination of the unpredictable absorption of long-acting insulins (Walsh and Roberts, 2012).

Temporary basal rates can be used to increase insulin delivery during illness or decrease insulin delivery during or after exercise to prevent hypoglycaemia. Temporary basal rate adjustments can be made easily and spontaneously. Using the insulin pump bolus calculator, doses can be calculated to match the carbohydrates eaten, and calculate correction doses to bring down high BGLs whilst minimising insulin stacking.

Use of CSII in paediatrics is useful, particularly in children with fickle eating habits, common in young children. While on injected insulin, the

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3. Insulin absorption variability is reduced from 25% with multiple daily injections to 3% on insulin pump therapy due to the small increments of insulin delivered, single site use and elimination of the unpredictable absorption of long-acting insulins.

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1. The need for regular self-blood glucose monitoring is paramount whilst on insulin pump therapy and this must be stressed to families and children before continuous subcutaneous insulin infusion (CSII) is considered.
2. Healthcare providers must also recognise that the primary reason for the transition to CSII for the person with diabetes may not be optimisation of blood glucose levels, but improved lifestyle and quality of life.
3. The increase in uptake of insulin pumps to deliver insulin has introduced a new language for healthcare professionals to become conversant with.

young person with diabetes is required to adhere to a more rigid eating schedule dictated by the insulin they have on board at any given time. Conversely, a child on an insulin pump may eat a greater variety of foods at whatever time and in whatever quantities they please, matching their boluses to the food, which eliminates a stressor from the family dynamic.

As well as evidence of clinical advantages of CSII, the improvements in quality of life for insulin pump users and their families cannot be denied. The person can sleep in without the restriction of a regimen that can increase the risk of hyperglycaemia or hypoglycaemia. They can engage in activities more spontaneously and still be able to adjust their insulin with shorter notice than when on MDI, and without the need to eat carbohydrates when they are not hungry.

Injecting in public is no longer an issue and, for children with diabetes, the lunchtime bolus at school can either be administered by the child if they are competent, or built into the basal program for younger children (Walsh and Roberts, 2012).

Implications for practice

Diabetes educators can assist families by preparing them for the challenges of initial insulin pump use and providing them with realistic expectations. Initially, CSII requires a process of re-education that can prove challenging, especially the skill of accurate carbohydrate counting if this has not already become part of their diabetes management. The need for regular self-blood glucose monitoring is paramount whilst on insulin pump therapy, and this must be stressed to families and children before CSII is considered. Whilst the clinical advantages are undeniably important, healthcare providers must also recognise that the primary reason for the transition to CSII for the person with diabetes may not be optimisation of BGLs, but improved lifestyle and quality of life. This aspect is just as important for a person with diabetes and CSII should be accessible to all for whom it is assessed as suitable therapy. Insulin pump therapy is not for everyone, however, and a discussion prior to considering CSII will assess whether a person with diabetes has realistic expectations and whether they possess the level of commitment required to manage their diabetes with CSII.

Conclusion

As the incidence of type 1 diabetes increases, the likelihood of seeing clients in the primary care setting who are using insulin pumps increases. Whilst the management of insulin pump therapy has been the domain of diabetes educators, paediatricians and endocrinologists, the need for specialist care far outweighs the resources that are available to service this growing demand. It is time to become familiar with insulin pump basics and learn the new language around insulin pump therapy. ■

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