An introduction to insulin pump therapy

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Insulin pump therapy currently seems to be reserved for the few, yet many more type 1 diabetes patients could benefit from this delivery system. This review outlines the evidence for insulin pumps including patient selection and suggests more could be done to initiate their use.

Type 1 diabetes is an autoimmune disease characterised by autoimmune destruction of the pancreatic islet cells that produce insulin. Insulin is essential for the incorporation of glucose into muscle cells and for the storage of carbohydrates in the liver. A lack of this hormone results in rising blood glucose. Most patients with type 1 diabetes take at least four injections of insulin a day, a combination of short-acting analogue insulin with meals, and a long-acting analogue to provide a basal insulin – ie multiple daily injections (MDI).

Control of diabetes is monitored by measuring glycosylated haemoglobin (HbA<sub>1c</sub>). We know that achieving optimal control of diabetes reduces the development of diabetes-related complications that can include long-term complications such as renal failure and blindness. Optimal control is difficult to achieve and although some people will manage this with MDI, others will not, and insulin pump therapy may present an alternative option.

MDI therapy is associated with some physical limitations such as number of injections, but also there are physiological disadvantages. Once injected the long-acting insulin sits as a depot subcutaneously and is released over 12 to 24 hours irrespective of insulin requirements, which can lead to problems such as those arising at the time of exercise. It provides a flat profile, which physiologically is at odds with the rise in blood sugar in the early hours of the morning (dawn phenomenon). It is only practical to inject short-acting insulin as a single bolus with meals, which may not be appropriate for meals that are slowly absorbed or have a high fat content. That is not to say that insulin pump therapy is an easy alternative or perfect for everyone.

Insulin pump therapy, or continuous subcutaneous insulin infusion (CSII), is a method of insulin delivery that more closely resembles physiological insulin delivery. It is an increasingly utilised...
treatment for selected patients with type 1 diabetes as a means of achieving improved glycaemic control. It is not recommended for patients with type 2 diabetes.

NICE advises that insulin pump therapy should be started by a specialist hospital team with an interest in insulin pump therapy including a diabetologist, specialist nurse and dietician.

The mechanics of insulin pump therapy
An insulin pump is a mechanical device that delivers a constant small infusion of insulin that can vary hour by hour to meet individualised physiological needs. This is delivered via the pump through a cannula inserted subcutaneously. The cannula remains in situ for up to 72 hours and must then be changed.

Patients who go on to insulin pumps are trained in the calculation of insulin doses using carbohydrate counting. This is the process where a patient ‘counts’ how much carbohydrate is contained in the food they are eating, and calculates the insulin required for this meal. All foods containing carbohydrates will have an effect on blood sugar so need to be covered with the additional insulin dose, known as the bolus dose. At every meal the carbohydrate count is entered into the pump to give an additional dose of insulin.

All of the commercially available pumps are ‘smart pumps’ so they contain an on-board calculator that will calculate the amount of insulin required for any given carbohydrate value and also suggest a correction dose to restore the blood glucose back to the normal range if it is outside of this prior to eating. When a patient checks their finger-prick blood glucose this information is transmitted via Bluetooth to the pump. Smart calculators reduce the complexity for patients and allow more fine adjustment of insulin for a given carbohydrate load.

Insulin pumps also have ‘advanced features’. When a meal contains a large carbohydrate content or a mixture of carbohydrate, fat and protein, the absorption of this carbohydrate load is slower than it would be if eaten alone or in smaller quantities. An insulin pump can deliver a set bolus of insulin calculated for this carbohydrate load over a longer defined period of time to mimic normal physiology.

Additionally, insulin pumps have multiple functions to offer advantages to patients who exercise. The basal rate can be increased or decreased by a set percentage before, during or after exercise.

There have been a number of advances in insulin pump therapies. Patch pumps or tubeless pumps consist of a patch (reservoir of insulin and tiny pump) attached to the skin with the smart calculator and glucose monitor as a separate handheld device communicating by Bluetooth. This has the advantage of no long wires connecting the pump to the patient. The technologies to assist patients in managing their diabetes are progressing rapidly with the potential to end blood glucose monitoring, by using devices that measure the interstitial glucose in a semi-continuous manner and communicate directly with the pump.

Pros and cons of insulin pump therapy
- Cost-effective in terms of quality-adjusted life-years (QALYs)
- Increased flexibility in lifestyle
- Increased freedom with food
- Reduced hypoglycaemia and glucose variability
- Possible 30–40% insulin dose reduction on initiation may help weight loss
- Assists in cases of severe needle phobia
- Benefits those with lipohypertrophy or lipoatrophy

Table 1. Pros and cons of insulin pump therapy

<table>
<thead>
<tr>
<th>Pros of insulin pump therapy</th>
<th>Cons of insulin pump therapy</th>
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<tbody>
<tr>
<td>• Cost-effective in terms of quality-adjusted life-years (QALYs)</td>
<td>• Costs between £2000–3000</td>
</tr>
<tr>
<td>• Increased flexibility in lifestyle</td>
<td>• Not all patient want to be attached to a machine 24 hours a day</td>
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<tr>
<td>• Increased freedom with food</td>
<td>• Psychological body image barriers, particularly with teenagers</td>
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<tr>
<td>• Reduced hypoglycaemia and glucose variability</td>
<td>• Concerns over pump failure</td>
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<tr>
<td>• Possible 30–40% insulin dose reduction on initiation may help weight loss</td>
<td>• Requires increased frequency of blood glucose monitoring</td>
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<tr>
<td>• Assists in cases of severe needle phobia</td>
<td>• Not always easy to change the infusion set</td>
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<tr>
<td>• Benefits those with lipohypertrophy or lipoatrophy</td>
<td>• Perceived increased risk of diabetic ketoacidosis among some patients</td>
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Which patients benefit from insulin pump therapy?
It is important to remember that many patients with type 1 diabetes will manage very well on MDI. Interventions that have been shown to improve glycaemic control in patients with type 1 diabetes include out-patient teaching programmes such as BERTIE (Beta cell Education Resources for Training in Insulin and Eating) or DAFNE (Dose Adjustment For Normal Eating), which teach patients self-management skills. All patients referred for assessment for insulin pump therapy must have had the opportunity to maximise their diabetes control using MDI and input from a specialist team. In some situations, however, progression to insulin pump may be appropriate. The pros and cons of insulin pump therapy are outlined in Table 1.

Problematic hypoglycaemia
Many patients with type 1 diabetes will struggle with persistently elevated HbA1c levels. Current guidelines recommend an HbA1c between 48 and 58mmol/mol. Aiming for tight glycaemic control may result in increased frequency of hypoglycaemia. Severe hypoglycaemia (requiring third party assistance) may occur in up to 40 per cent of patients with type 1 diabetes. Insulin pump therapy may allow reduced glucose variability, which can reduce the risk of hypoglycaemia and, therefore, increase confidence to improve overall control.

Continued disabling hypoglycaemia despite best attempts with multiple daily injections is a recommended indication for insulin pump therapy.

Persistent suboptimal diabetes control
Initiation of insulin pump therapy on average leads to a reduction in HbA1c of between 3.3 and 6.6mmol/mol. The greatest reduction in HbA1c is seen in those patients with a higher HbA1c at baseline. NICE advises insulin pump
therapy for patients with a HbA₁c above 69mmol/mol. This is the level at which insulin pump therapy is most cost-effective in terms of improvement in quality-adjusted life-years.⁹,¹¹

**Children and type 1 diabetes**

In paediatric care thresholds for insulin pump therapy are lower because many paediatricians see multiple daily injections of insulin as being impractical for children. This is supported by NICE for children under 12 years, although those over 12 should be treated with the same guidelines as adults.¹¹ Many paediatric centres in the UK now use insulin pump therapy as first-line treatment upon diagnosis of type 1 diabetes.⁹,¹²

**Pregnancy and insulin pump therapy**

Tight glucose control is advised at the time of conception and pregnancy to reduce pregnancy-related complications. Insulin pump therapy in pregnancy can help patients achieve optimal control. Any reduction in HbA₁c before and sustained during pregnancy increases the chance of a successful pregnancy. The risk of hypoglycaemia during pregnancy can be increased because of the intensive regimen to improve glycaemic control. Insulin pump therapy can reduce these episodes in pregnant patients.¹³

There are other circumstances in which insulin pump therapy may be advised, such as in patients with co-existing coeliac disease and in patients with complications such as gastroparesis.

**Conclusion**

Insulin pump therapy is an increasingly used method for managing type 1 diabetes. Evidence and guidelines support the use of insulin pump therapy, and have demonstrated improvements in both HbA₁c and quality-of-life measures.

Selection criteria for insulin pump therapy suggested in guidelines are useful in determining those patients most likely to benefit. The benefits and downsides to insulin pump therapy should be explained to patients to allow each individual to make an informed decision with a team experienced at commencing insulin pump therapy.

**References**


**Declaration of interests**

None to declare.

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