Modern strategies for management of glycaemia in type 1 diabetes

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Abstract

The last decade has seen significant advances in the management of type 1 diabetes. The usual management of type 1 diabetes involves 'physiological' basal bolus regimens with multiple daily insulin injections, but use of insulin pumps (continuous subcutaneous insulin infusion) is growing. Structured education programmes are of great importance in realizing the potential of the flexible insulin regimens that are now technically possible; these now offer patients with type 1 diabetes standardized support and education in counting carbohydrates (and perhaps fat and protein) and in adjusting doses for other behavioural factors. Evolution of continuous glucose monitors from being tools for 'forensic' retrospective monitoring to 'real-time' devices for continuous use has led to major interest in strategies for glycaemic control that involve insulin pumps linked to continuous glucose monitoring, with the hope that this will provide increasing automation of insulin delivery. Data from many devices — meters, pumps and continuous glucose monitors — are downloadable and can be analysed and/or shared with healthcare providers. In this chapter, we describe how modern glucose monitoring and insulin replacement can be used strategically together with education to manage glycaemia in type 1 diabetes.

Keywords Continuous glucose monitoring; continuous subcutaneous insulin infusion; hypoglycaemia; insulin pumps; islet transplantation; pancreas transplantation; structured education

What's new?

- Structured education gives patients freedom to adjust insulin doses to food and lifestyle
- Insulin pumps are increasingly popular although used by less than 10% of patients with type 1 diabetes in UK
- Continuous glucose monitoring is available but less established
- Insulin pumps and continuous glucose monitoring can be coupled, and may incorporate a 'threshold suspend' feature that may benefit those with intractable hypoglycaemia
- Pancreas and islet cell transplantation may give insulin independence but are reserved for those with complications and/or hypoglycaemia

Introduction

Many technical and healthcare changes have occurred over the last few years in type 1 diabetes mellitus (T1DM). New insulin analogues (engineered either to act more rapidly or be more long lasting) continue to be developed and have been widely adopted in T1DM. The combination of rapid-acting 'bolus' insulin given before meals and/or as *ad hoc* doses to correct high blood glucose values, with long-acting background insulin replacement (by convention termed 'basal' if delivered by insulin pump) allows patients to use more 'physiological' basal bolus insulin regimens (Figure 1). Insulin therapy and blood glucose monitoring are described in more depth in the article on Modern technologies for glucose monitoring and insulin replacement on pages 00—00 of this issue.

Structured patient education

The flexibility offered by modern variable insulin regimens presents a challenge for patients, who need to learn and use many self-management skills beyond simply checking blood glucose concentration and administering insulin. For example, many people with T1DM adjust doses of meal-time rapid-acting insulin depending on the carbohydrate content of food, meaning that they need training to count carbohydrates accurately. Evidence-based structured educational packages have emerged in the UK over the last decade. The largest and best established of these is the DAFNE programme (*D*ose *A*djustment *F*or *N*ormal *E*ating), described below, but a number of broadly similar smaller structured education programmes are also being used in UK services.

DAFNE is based on a patient education model developed in Düsseldorf. In a randomized controlled trial, DAFNE improved blood glucose control and patient well-being.[1] It was introduced as clinical service in the UK in 2002. By June 2014, there were 75

A 'basal bolus' insulin regimen with three bolus injections of rapid acting insulin (red) for meals with, in this case, once daily background insulin (blue)

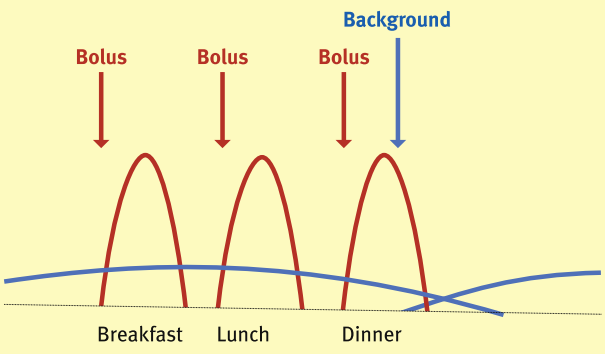

Figure 1

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centres in the UK and Ireland delivering DAFNE to 31,000 patients and growing at a rate of 4000–5000 per annum. It has also been adopted in Australia, New Zealand and Singapore. DAFNE continues to be effective with improved glycaemic and patient-reported outcomes.[2] Patients experience not only lower average blood glucose concentrations, reflected by lower HbA_{1c} values, but also less hypoglycaemia and improvement in their ability to detect a falling blood glucose sooner.

DAFNE and similar programmes provide education in skills required to self-adjust insulin doses, such as carbohydrate counting, adjustment for exercise/activity, illness, stress, alcohol, travel and the menstrual cycle (Figures 2 and 3). The DAFNE approach teaches patients to count carbohydrate intake in 10 g portions and then apply an individualized insulin:carbohydrate ratio to calculate prandial insulin. Other programmes may also use portions (for simplicity) or grammes of carbohydrate. DAFNE is delivered in group sessions over 5 days. In common with the Düsseldorf programme, DAFNE also has a supporting structure with a clear philosophy, written curriculum, processes for training and accrediting educators, quality assurance process including regular external peer review and audit of process and outcomes, with an anonymized database. Patient education also highlights the increasing role of non-medical staff as part of a multidisciplinary team approach, with specialist nurse educators and diabetes dieticians being highly trained and skilled in delivering and supporting education.

The efficacy of structured educational packages in children/adolescents with T1DM has not yet been established.

Continuous subcutaneous insulin infusion ('insulin pumps')

With continuous subcutaneous insulin infusion (CSII), a rapid-acting insulin is pumped in constantly as a basal insulin replacement via an indwelling subcutaneous infusion cannula, self-inserted typically into abdomen, buttock, thigh or arm. Patients can then use the pump to deliver an insulin bolus to cover meals and/or corrections for high glucose values as needed (Figure 4). Typically, every 3 days, the infusion set is removed and a fresh set inserted at a different site.

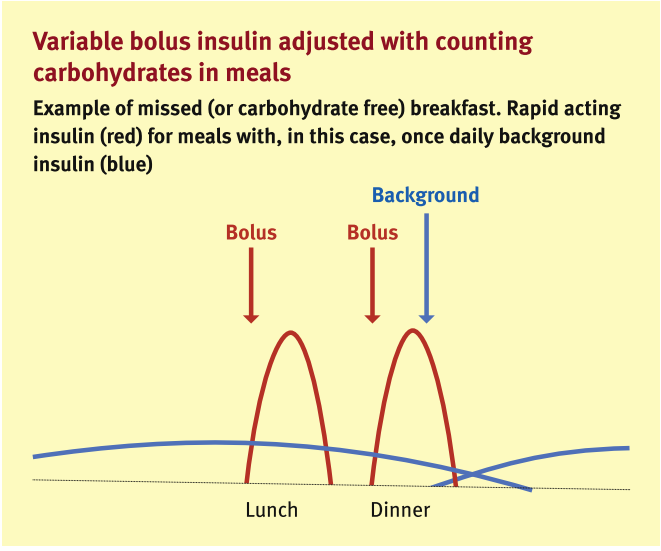

Figure 2

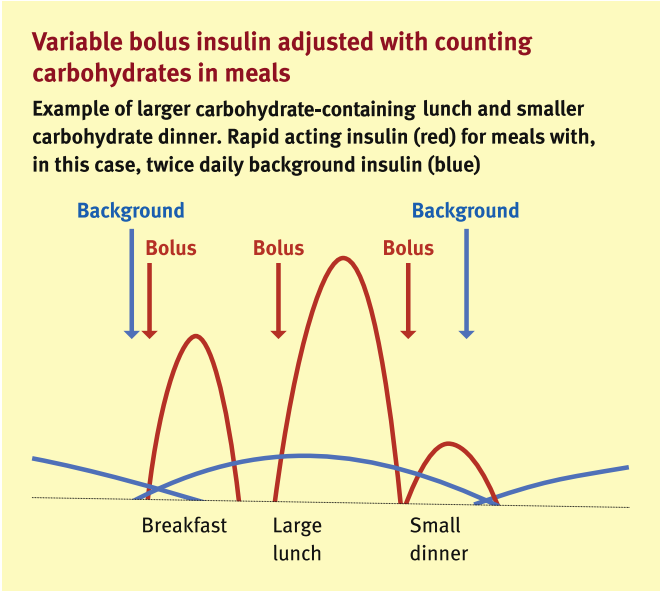

Figure 3

Early CSII models were cumbersome and unreliable but the last decade has seen increased uptake in many developed countries in both children and adults. Used judiciously, CSII can improve glucose control[3] but they are more complex technically and medically and thus unlikely to replace injections as standard treatment for insulin-requiring diabetes in the near future.

Particular advantages of modern pumps over multiple daily injections are:

- The ability to pre-programme variable basal insulin delivery – useful for patients with marked circadian variability in insulin requirements.
- Temporary basal rates, where basal insulin delivery can be adjusted for a defined period of time – especially useful for lowering insulin delivery with unplanned or unexpected activity to reduce risk of hypoglycaemia.

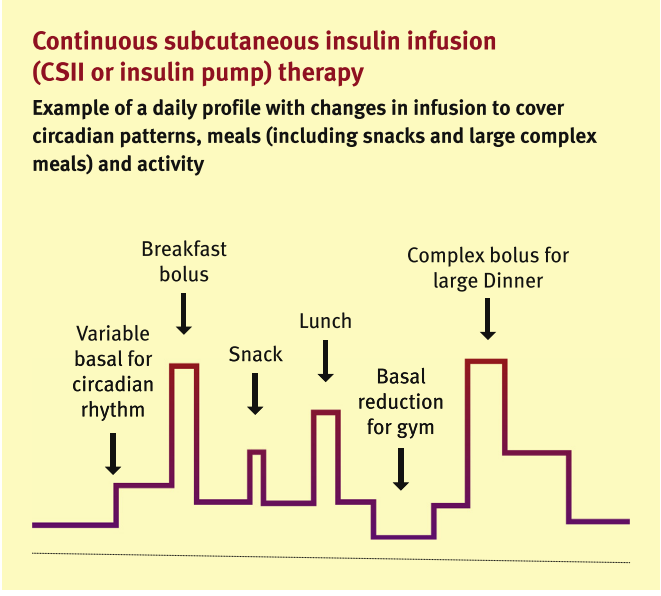

Figure 4

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