How to maintain glycaemic success in adolescents using CSII

Rebecca Thompson discusses how to engage with this often challenging group. Page 6.

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Sustaining long-term glycaemic control in CSII users

Peter Hammond, Consultant in General Medicine, Harrogate

In this issue of CSII Therapy Rebecca Thompson from University College London Hospitals discusses how to help adolescents using insulin pump therapy maintain the initial improvement in glycaemic control seen after the initiation of CSII, and Julie Brake from the Royal Liverpool University Hospital Trust considers how to use continuous glucose monitoring as a means of optimising insulin delivery to improve glycaemic control.

Both articles address a fundamental need for insulin pump therapy: it is well established in short-term studies that CSII delivers significant improvements in glycaemic control compared with multiple daily injections (MDI), with average reductions in HbA1c of around 0.5 to 1 percentage point (5.5 to 10.9 mmol/mol) (Bruttomesso et al, 2009). The challenge is to ensure that this improved control is sustained, and that for those people who either do not get any initial benefit from pump therapy, or whose control deteriorates back to baseline after a period of time, strategies are put in place to assist them in gaining or regaining benefit from the technology. It is probable that benefit can be achieved if obstacles are identified. If CSII is indicated to begin with, time and effort should be invested in working with the pump user rather than prematurely giving up on CSII and returning to MDI.

At Harrogate District Hospital we have recently reviewed the progress of all our current insulin pump users to determine whether improvements in HbA1c level have been sustained over time. Our data showed that a fairly stable reduction in HbA1c level is sustained over time. The data also showed the characteristic finding that the higher the baseline HbA1c level the greater the reduction in HbA1c level on switching from MDI to CSII; but also that for most people, their initial result is similar to the mean result, so it is possible to predict their long-term response to CSII on the basis of their initial response.

For those who do not respond initially or who lose the initial improvement in control, a strategy is needed to help them make more of their insulin pump therapy.

There are various areas to focus on with the pump user (Shetty and Wolpert, 2010). These include:

- Check infusion sites. Are there potential problems at the infusion site such as lipohypertrophy or lipoatrophy?
- Consider catheter problems. These could include kinking of the tubing or dislodgement and might indicate that a different type of infusion set is needed.
- Ensure the infusion sets are being changed frequently enough. Glycaemic control may drift for some people after 48 hours, and for most after 72 hours.
- Consider whether a different insulin might be more effective. The evidence is inconsistent but on an individual basis this may help to improve control.
- Add-on technology may help to identify problems. Pump downloads give information about frequency of priming a new infusion catheter, whether bolus doses are being missed, and whether bolus to basal ratios seem appropriate (just over 50% on average appears to be correct).
- Sensor augmentation may help to optimise insulin delivery as described in Julie Brake’s article (opposite).

Most people do well on insulin pump therapy and the improvements in glycaemic control are maintained over time, but it does take hard work and there are various ways we can help them to achieve this.

Periodic use of continuous glucose monitoring for education

Julie Brake, Diabetes Specialist Nurse, Royal Liverpool University Hospital Trust, Liverpool

It is clear that the key to optimal diabetes management is tight glycaemic control, which may be achieved with multiple daily fingersticks tests, good record-keeping of the results, and appropriate modification of the medication, diet, and exercise regimen. However, on occasion, fingerstick testing can miss parts of the day that significantly impact diabetes control, such as following meals, during and after exercise and overnight. The technology of continuous glucose monitoring (CGM) can overcome these limitations.

The author has always been interested in using CGM as a way to help people manage their diabetes either as a continuously used tool or as a one-off to identify times when treatment could be altered to improve diabetes control. This article describes how a new CGM service was planned and funded, how to use the graphs produced by CGM and the results of an audit of the service after 12 months.

Planning the service

It was agreed that CGM should be used in people with type 1 diabetes treated with intensive insulin therapy (basal–bolus regimen) and whose diabetes control does not appear to be improving despite regular review and ongoing management under the outpatient care of the diabetes centre. These individuals had received multiple consultations with both the DSN team and the diabetes specialist dietitians.

It was decided that 72-hour CGM should be used once in each person to see if areas for improvement could be identified and an associated management plan be agreed when the data were analysed in conjunction with a food, insulin and a lifestyle diary.

Funding

As the monitors can be expensive, obtaining funding can be difficult. Fortunately, in this case, a monitor was acquired via a research trial that had finished and the company donated the monitor to the department. In this respect there was no opportunity to research which CGM monitor would have best suited the service but on the positive side it was available for free.

After the initial acquisition of the meter, continuing funding was needed as there is a cost to the sensors, so although a business case was not prepared for the meter itself, a case was presented for the sensor cost and the healthcare professional time involved. Within this case, the potential savings that could be made from reduced outpatient attendance and reduced diabetes specialist nurse (DSN) and dietetic time as a result of people using CGM was presented. Financial support was offered with the caveat that the service was audited after 12 months to demonstrate the predicted savings.

CGM trend graphs

The various trend graphs from the CGM software show what has happened over the previous 3–24 hours and can show trends, which we and the people with diabetes who used the system found very useful.

The effects of exercise

The 3- to 6-hour trend graphs can show blood glucose patterns related to exercise or increased activity which could otherwise be missed. Checking the graph during and after such events will show when and how much blood glucose levels were affected.

Basal insulin

To assess overnight trends or basal insulin requirements, the 6- to 12-hour trend graphs are important (Figure 1). By looking at the trend graphs approximately 4 hours after the last mealtime bolus was given, the basal insulin dose can be determined. If the blood glucose level continues to drop or starts to rise after the mealtime bolus dose and the effect of food has worn off, the basal insulin probably needs adjustment as it is not keeping the blood glucose level stable until the next meal and a bolus insulin dose should be given. This trend graph can also demonstrate the effect of an evening
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snack before bed and if an additional bolus insulin dose is required.

In Figure 2, the blood glucose level is rising throughout the night from 2 am until 8 am. This indicates the need for a higher dose of overnight insulin. The individual in Figure 2 is currently using insulin glargine, so an increase in dose or consideration of a change to a twice-daily human insulin may be appropriate after discussion with the individual. Overnight increases in blood glucose levels were occurring in those who were anxious about stopping evening snacks when changed onto insulin glargine. The demonstration of the effect of this snack on overnight blood glucose levels was a great visual aid and provided further reassurance that evening snacks can be omitted or reduced without causing nocturnal hypoglycaemia.

Assessing for nocturnal hypoglycaemia
The 6- to 12-hour trend graphs can also identify nocturnal hypoglycaemia, which the patient may not be aware of. A number of studies have demonstrated nocturnal hypoglycaemia in people with type 1 diabetes that they were previously unaware of (Kaufman et al, 2001; McGowan et al, 2002; Woodward et al, 2009). However, there is some evidence that night-time readings from CGM can be 15% lower and be clinically significant because they could result in an inappropriate reduction of overnight insulin dose (McGowan et al, 2002). CGM reports of asymptomatic night-time hypoglycaemia may be spurious and should be interpreted with caution in people with tightly controlled type 1 diabetes (McGowan et al, 2002).

Assessing bolus insulin action
The 6- to 12-hour trend graphs can also be used to determine the action profile of rapid-acting insulin. Insulin action can vary from person to person, but it normally ranges from 2.5 to 6 hours (Sabbah et al, 2000). Remember that if the basal dose of insulin is not correct – either too high or too low – this can affect the accuracy to which the bolus insulin action can be predicted. To determine the action profile of the rapid-acting insulin, check to see how long it takes for the blood glucose level to stop decreasing and even out after giving insulin with a meal. This can be seen in Figure 3, in which the rapid-acting insulin action is approximately 3 hours.

Three-day graph
One of the advantages of the MiniMed system is the ability to place all three 24-hour graphs together on one screen. Even if over 72 hours the fingerstick readings appear erratic and without pattern, when they are overlaid, obvious trends generally appear, such as overnight dips, mid-morning peaks, prolonged episodes of hyperglycaemia every afternoon or forgotten doses of bolus insulin. This information, along with an individual’s lifestyle diary, provides sufficient information to adjust
their management plan to improve glycaemic control through either decreased HbA1c level or reduced hypoglycaemic episodes.

Effects of CGMS on diabetes management

The most frequent therapy adjustment by Sabbah et al (2000) was to increase the mealtime bolus dose and by Kaufman et al (2001) was to modify the type of long-acting basal insulin. However, with the current group of patients no significant change was made to any insulin therapy but rather changing their diet and timing of insulin injections resulted in significant and maintained reduction in HbA1c level (Brake, 2010).

CGM has also been used as a therapeutic tool to decrease the incidence and magnitude of hypoglycaemia (Schiaffini et al, 2002; Garg et al, 2004; Weintrob et al, 2004). In the current study, the results of the CGM showed previously unrecognised blood glucose excursions in all participants. Seven suffered unrecognised nocturnal hypoglycaemia, with an average of two asymptomatic nocturnal and early morning hypoglycaemic events per person.

Prolonged periods of hyperglycaemia (blood glucose values greater than 14 mmol/L for 5 hours) were also recorded in three people. At 3-month follow-up, mean HbA1c levels had reduced from 8.8% (73 mmol/mol) to 8.2% (66 mmol/mol; P=0.028).

This improvement was a result of lifestyle and diet modification rather than changes to therapy. Mean HbA1c levels at 12, 24 and 36 months were 8.2% (66 mmol/mol; P=0.009, compared with baseline), 8.0% (64 mmol/mol; P=0.009) and 7.5% (58 mmol/mol; P=0.004), respectively.

The information about direction, magnitude, duration, frequency, and causes of fluctuations in blood glucose levels that can be obtained by CGM is simply not available with intermittent blood glucose monitoring. Many of the people in this study had previously partaken in many consultations with the DSN and dietitian with no significant improvement in HbA1c level. Although the cost effectiveness of using CGM was not statistically analysed, the people in this study improved their control after only one joint appointment with the DSN and dietitian after CGM had been performed.

Conclusion

The most important use of CGM is to facilitate adjustments in therapy, be it insulin or lifestyle, to improve glycaemic control, quality of life or both. CGM provides the tools to:

- Identify glycaemic excursions.
- Help educate and motivate people with diabetes.
- Assess individuals using data that are reliable and accurate.
- Identify the interactions between meals, exercise, medication and insulin on blood glucose values, and educate people with diabetes using the data presented as a graph.

Individuals can better understand the cause-and-effect relationship between daily activities and their blood glucose levels, which may have profound effects on both their self-monitoring and way of living.

CGM can document the time spent in the normal, low, and high blood glucose ranges, which may be more valuable than an HbA1c level. For some people, a decreased amount of glycaemic instability alone, even without any improvement in HbA1c, might represent an improved outcome.

“By using CGM, individuals can better understand the cause-and-effect relationship between daily activities and their blood glucose levels, which may have profound effects on both their self-monitoring and way of living.”


Adolescents and pump therapy: Maintaining success

Rebecca Thompson, Nurse Consultant – Paediatric & Adolescent Diabetes, University College London Hospitals NHS Trust, London.

Diabetes is increasing in the adolescent population with over 22,000 people under the age of 17 years in England diagnosed with the condition (Diabetes UK, 2010). Of these, 97% have type 1 diabetes (Diabetes UK, 2010). Managing the demands of diabetes in daily life can be challenging for adolescents, with currently only 14.5% of children in the UK achieving the recommended level of glycaemic control (NHS Information Centre, 2011). Healthcare professionals are therefore tasked with finding ways of helping young people and their families cope with the demands of diabetes and improving outcomes for these individuals.

CSII at University College London Hospital

The team at University College London Hospital (UCLH) NHS Trust has initiated insulin pump therapy in over 180 children and young people. This has required the development of a structured pathway that incorporates the trial of a pump, structured education in the form of “pump school” for the adolescent and their carers and planned, frequent follow-up (Thompson, 2008).

Children and young people using CSII at UCLH have consistently lower HbA1c values than those using multiple daily injections (MDI) (see Table 1).

Extrapolating data for 2010 into age groups shows that adolescents on pumps (13–19 years old) achieve better HbA1c levels than adolescents treated with MDI (median HbA1c level 8.4% [68 mmol/mol] compared with 8.9% [74 mmol/mol]). Compared with the National Diabetes Audit dataset, 36% of this adolescent population using CSII achieved an HbA1c level of <7.5% (<58 mmol/mol).

Maximising education

Diabetes education needs to be adaptable and personalised so that it is appropriate to each individual’s age, stage of diabetes, maturity and lifestyle and delivered at a pace to suit individual needs. Adolescence is a transitional time where a young person might be expected to learn to take responsibility for some tasks, with some shifting and shared responsibility for decision-making between the young person and their parents or carers. Therefore, education will need to be provided for both the young person and his or her parents.

Initial education at UCLH is given over 2 days and involves a comprehensive explanation of pump functioning, programming, troubleshooting, infusion site care, managing day-to-day experiences such as exercise, hypo- and hyperglycaemia and their prevention and emergency actions. This is delivered using powerpoint presentations, button- pushing sessions, scenario discussions and problem solving. Two age-matched young people are invited to each school, which not only facilitates peer learning but also, perhaps more importantly, provides an opportunity for young people to realise that they are not alone in living with diabetes.

Other carers

There needs to be consideration given to other individuals who might support the adolescent in their day-to-day life, in addition to parents. Diabetes can impact on secondary school life in many ways. Consideration might need to be given to having to move around the school campus, so testing equipment and emergency supplies may need to be in the school bag; having many different teachers over the course of one day and the potential for peer pressure and bullying.

Staff within secondary school do not need to be competent in using all the advanced features on the pump. However, they do need to have the appropriate knowledge of what the pump is (not a mobile

<table>
<thead>
<tr>
<th>Year</th>
<th>Treatment</th>
<th>Multiple daily injection (% [mmol/mol])</th>
<th>CSII (% [mmol/mol])</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>Multiple daily injection</td>
<td>9.7±0.2 [83±2.2]</td>
<td>8.6±0.3 [70±3.3]</td>
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<tr>
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<td>Multiple daily injection</td>
<td>9.2±0.2 [77±2.2]</td>
<td>7.6±0.2 [60±2.2]</td>
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<td>2006</td>
<td>Multiple daily injection</td>
<td>9.2±0.2 [77±2.2]</td>
<td>7.6±0.2 [60±2.2]</td>
</tr>
<tr>
<td>2007</td>
<td>Multiple daily injection</td>
<td>9.7±0.2 [83±2.2]</td>
<td>7.7±0.1 [61±1.1]</td>
</tr>
<tr>
<td>2008</td>
<td>Multiple daily injection</td>
<td>9.6±0.2 [81±2.2]</td>
<td>7.9±0.1 [63±1.1]</td>
</tr>
<tr>
<td>2009</td>
<td>Median 9.5 [80]</td>
<td>Median 7.9 [63]</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>Median 8.6 [70]</td>
<td>Median 7.9 [63]</td>
<td></td>
</tr>
</tbody>
</table>

Table 1. Mean HbA1c level of children at University College Hospital London treated with multiple daily injections compared with CSII.
phone to be confiscated); treatment of hyperglycaemia (especially before sport and exams) and hypoglycaemia (hypoglycaemia treatment does not fit well with rules about not eating in class).

One or two key individuals from the school are invited to attend the pump school with the young person. This is followed up by the completion of a school medical management plan and the invitation to attend annual “diabetes in school” workshops. The 3-hour workshops are held in the first week of the new academic term, with a focus on how diabetes can impact on cognitive function and performance, together with a practical “hands-on” session.

Maintaining engagement
Many studies of insulin pump therapy have demonstrated a significant decrease in HbA1c level but often this effect is not maintained. This might be attributed to an adolescent being given a new gadget to play with or the initial intensive attention and support from the healthcare team (Jones, 1992). Once the novelty wears off or the support becomes less intensive, a rise in HbA1c level is seen. The goal is obviously to maintain the initial reduction.

The adolescent period is notoriously challenging, both for parents and healthcare professionals. For education to be most effective, it needs to be a continuous process and be repeated as required (Swift, 2009), and when combined with psychological approaches, can achieve engagement, motivation and long-term change (Hampson et al, 2001).

The evaluation of ongoing learning requirements led to the development of annual “pump expert education days” for all young people using insulin pumps and their parents. The programme is developed by the families and the day facilitated by the diabetes team. Families have the opportunity to get together and share successful solutions that they have found to address common challenges in the day-to-day management of diabetes.

In practice, many diabetes healthcare professionals have expressed the challenge of engaging adolescents, particularly those who are not managing their diabetes well. It has been suggested that the psychological approaches of motivational interviewing and solution-focused therapy are beneficial in diabetes, helping to engage young people and consequently improve their glycaemic control (Viner et al, 2003; Channon et al, 2007; Wang et al, 2010).

In an effort to optimise the helpfulness of conversations, the nursing team integrates these psychological approaches into routine conversations on the phone or in face-to-face conversations in the clinic. Young people and their families are invited to focus on how moving to CSII improves abilities and use of resources in self-management, including how to recognise trends in blood glucose levels and how these relate to management of basal and bolus insulin doses.

Can sensors and continuous glucose monitoring help?
There is a recognised correlation between the frequency of blood glucose monitoring and HbA1c level. Increased frequency of testing has been shown to be significantly associated with better metabolic control, with a drop of 0.27% for one additional test per day for young people using pump therapy (Ziegler et al, 2011). However, in the author’s experience, many young people find it difficult to perform or maintain frequent blood glucose testing, citing fear of the potential results, inconvenience or the belief that “knowing how they feel” means testing is unnecessary.

Sensor-augmented insulin pump therapy is now available and has been demonstrated to reduce HbA1c levels, with significant effect if worn more than 6 days per week (Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group et al, 2008). The STAR 3 (Sensor-Augmented Pump Therapy for A1C Reduction) study also showed that increased frequency of sensor use was associated with greater reduction in HbA1c level. When comparing sensor-augmented pump therapy to MDI in children and young people, sensor-augmented pumps enabled a higher percentage of children to achieve recommended HbA1c targets (44% as opposed to 20%) (Bergenstal et al, 2010).

There are challenges in translating this evidence into practice. In addition to the financial constraints in purchasing sensors, many young people have expressed reluctance to be continually attached to an additional piece of technology, however small.

The diabetes team at UCLH have found scheduled use of sensors helpful to optimise pump therapy. Young people are taught both the practical sensor insertion and sensor download interpretation in group training sessions. It is requested that they then wear and upload a sensor prior to each routine clinic appointment. In the absence of sufficient blood glucose measurements, a sensor download can provide an invaluable snapshot. This allows more effective consultations, identification of problem areas and making more aggressive changes to insulin settings.

Changing insulin doses
Diabetes might not be a priority in a young person’s life, when it competes with peer relationships, attendance at school, extracurricular activities and exams. Keeping up with increased insulin requirement in young people can be challenging if adolescents reschedule and cancel their appointments, resulting in extended periods of time between reviews.

For those young people who are seeing a rise in HbA1c level, it can be helpful to start again and recalculate both basal rates and ratios using an anticipated total daily dose for their weight. Pump history screens can provide valuable
information. Using pump rules such as the “100 rule” and “300 rule”, in conjunction with average total daily doses and basal to bolus proportions, can help healthcare professionals advise on insulin alteration.

In addition, insulin pumps that provide data on the average number of bolus doses per day can highlight those young people who are struggling to give insulin with food. This information can help to provide an honest starting point for conversations with a young person and their family about improving glycaemic control.

Conclusion
With support and education, adolescents using insulin pump therapy achieve lower HbA₁c levels than those treated with MDI. Offering ongoing education, involving families and carers, integrating psychological approaches into conversations, scheduled use of sensors and accessing data within the pump memory on a routine basis can all help to maintain this improvement.


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CSII THERAPY Digest

Summaries of data presented at the 71st Scientific Sessions of the American Diabetes Association 2011, 24–8 June, San Diego

POSTER

HbA₁c reductions sustained in STAR-3 study

1 The results of a 6-month crossover continuation of the STAR 3 (Sensor-Augmented Pump Therapy for AIC Reduction) randomised controlled trial were reported.

2 Participants who had previously been assigned to multiple daily injections (MDI) began using sensor-augmented CSII.

3 HbA₁c level in the crossover group reduced from 8.3% (67 mmol/mol) to 7.6% (60 mmol/mol) after device training and 12 months of use (P<0.001).

4 HbA₁c levels in the group originally using sensor-augmented CSII remained reduced throughout the 6-month continuation phase.

5 Increased sensor wear was significantly associated with greater HbA₁c reductions in the crossover group (P<0.001).

6 Rapid reductions in HbA₁c were experienced by participants moving from MDI to sensor-augmented CSII therapy.


POSTER

Less hyps with low-glucose suspend feature

1 Use of the low-glucose suspend (LGS) feature (where insulin is suspended automatically at a prespecified low glucose value) was assessed in 935 people.

2 Participants used the Paradigm® Veo™ insulin pump on a total of 49 867 patient-days and the LGS feature was used 82% of the time.

3 Most (65%) of LGS episodes lasted ≤30 minutes and 11% lasted ≥115 minutes.

4 In a subset of 278 people with continuous sensor wear for 3 months, the percent of sensor glucose values <2.8 mmol/L was 0.92% when using LGS and 1.33% when not using LGS (P<0.001).

5 The percent of glucose values >13.3 mmol/L was 11.28% using LGS and 11.65% when not using LGS (P=0.023).

6 Use of the LGS feature was concluded to be associated with less hypo- and hyperglycaemia than when not using the LGS feature.