

Insulin pumps in hospital: a guide for the generalist physician

Kate Evans

ABSTRACT – An increasing number of people with type 1 diabetes mellitus are using insulin pump therapy, also known as continuous subcutaneous insulin infusion therapy (CSII). Most patients using pumps are safest remaining on CSII if admitted to hospital, unless incapacitated. This review provides the generalist physician with a framework to guide the management of such patients, although one should always seek specialist diabetes advice where available.

KEY WORDS: Type 1 diabetes mellitus, insulin pump, continuous subcutaneous insulin infusion therapy

Introduction

Consider the following scenarios. A doctor from the emergency department telephones you, the on-call physician, for advice: a young man with type 1 diabetes mellitus (T1DM) has been admitted with suspected diabetic ketoacidosis (DKA). He is wearing an insulin pump: what should the doctor do? Or perhaps it is a midwife calling: a patient with T1DM and using an insulin pump user is in labour; what should the midwife do? Or maybe it is the surgical FY1 doctor: one of the patients for the theatre list the next day has an insulin pump; what should the doctor do?

What should you advise?

If this question causes you a flutter of anxiety or uncertainty, you would not be alone. Most non-diabetes specialists will have encountered few users of insulin pumps. In most regions of the UK, fewer than 5% of the T1DM population use pump therapy, although numbers are increasing. A higher rate of pump use (>20%) is seen in more affluent healthcare environments, such as the USA (at least among those with insurance), and it is predicted that pump usage rates in the UK will increase to 10–15% of all adults with T1DM. Although some diabetes centres offer ‘pumpers’ extended-hours telephone support in addition to the 24-h technical support available from pump manufacturers, few hospitals have the luxury of an on-call diabetologist and, inevitably, out-of-hours queries such as those outlined above will be directed to the duty medical team. This article sets out to provide the generalist with a straightforward guide to managing a hospitalised patient with an insulin pump.

Kate Evans, consultant physician

Plymouth Hospitals NHS Trust, Plymouth, UK

Insulin pumps: an overview

What is an insulin pump?

Insulin pump therapy, also known as continuous subcutaneous insulin infusion therapy (CSII) is used in patients with T1DM to improve glucose control and/or reduce the risk of hypoglycaemia.^{1,2} It was first introduced over 30 years ago,³ although early pumps were bulky and prone to technical problems. Modern insulin pumps are portable and discrete (being similar in size to a mobile phone), and utilise smart technologies, such as Bluetooth transmission of capillary glucose level from glucometer to pump, and the ability to download pump data to a computer for analysis. However, contrary to the hopes of many individuals with T1DM, the pump is not a fully automatic ‘artificial pancreas’ and requires a high level of user involvement. For pump terminology, see Table 1.

Pump therapy entails infusion of short-acting insulin (typically NovoRapid or Humalog) from a reservoir within the pump via plastic tubing into a fine-bore cannula placed in the subcutaneous tissue. The cannula is typically sited on the abdominal wall (Fig 1) although other areas can also be used, and needs to be changed every 3 days. The cannula can be inserted by hand or by utilising a purpose-designed device. In most models, the needle component of the cannula is removed after insertion, leaving a very fine plastic tube sitting in the subcutaneous tissues. CSII delivers insulin in two patterns: a pre-programmed continuous background insulin infusion (the rate usually varies over the 24-h period), with additional insulin boluses for food or to correct hyperglycaemia. People using CSII do not take any additional long-acting insulin: both

Table 1. Insulin pump terminology.

Basal rate	The constant background insulin infusion, measured in units/h. Rates are variable between individuals and across a 24-h period. Some individuals have different basal profiles for different days (eg work versus rest days)
Bolus insulin	Insulin to cover carbohydrate intake. Different bolus delivery patterns available to reflect differing meal types (or issues with gastric emptying)
Insulin sensitivity factor (ISF; ie correction dose)	Individualised ratio: allows calculation of a correction dose expected to reduce blood glucose level by X mmol/l (eg if ISF = 2.5, 1 unit should reduce blood glucose by 2.5 mmol/l)
Insulin:carbohydrate ratio (ICR)	Individualised ratio: allows calculation of prandial insulin dose required for any food (pump user needs to measure and/or estimate carbohydrate content). Typical ICR 1:10 = 1 unit/10 g carbohydrate

ICR = insulin:carbohydrate ratio; ISF = insulin sensitivity factor.

background and bolus insulin are delivered by the pump. The basal infusion rates are pre-programmed by the patient or his/her diabetes specialist, but can be adjusted by the touch of a button. Basal insulin will continue to run until the insulin cartridge is empty. Insulin boluses are delivered as required under the patient's direction; most pumpers make use of an inbuilt 'bolus calculator', which utilises known variables for that individual (insulin:carbohydrate ratio, insulin sensitivity and target blood glucose range) in conjunction with situation-specific data (current capillary glucose level, estimated carbohydrate intake and time since last insulin bolus). The pump and tubing can be removed for up to 1 h leaving the cannula *in situ*, for example for swimming, bathing or contact sports, such as boxing or rugby. Some pumps are waterproof and, therefore, can be kept on for prolonged aquatic pursuits.

Who might use an insulin pump, and why?

Insulin pump therapy can be considered for adults with T1DM who have problematic hypoglycaemia (eg hypoglycaemia unawareness or severe hypoglycaemic episodes requiring third-party assistance) and/or inability to achieve target glycaemic control despite best efforts.² Before deciding on CSII as a treatment option, the patient should have tried multi-dose insulin (MDI) therapy with analogue insulins, undertake frequent self monitoring of capillary glucose and be proficient at carbohydrate counting (ie able to estimate the carbohydrate load of foods). Insulin pumps require a high level of self care, are more labour intensive than MDI (at least to begin with) and have a greater potential for problems if used incorrectly; therefore, they are only suitable for motivated, appropriately educated individuals who engage with their diabetes healthcare team. The greatest improvement in glycaemic control when changing from MDI to CSII is seen in those patients with the worst control pre-pump⁴ but even individuals who do not see much change in their haemoglobin A_{1c} show improved quality of life scores.¹ In the UK, the use of CSII is subject to National Institute for Health and Clinical Excellence (NICE) guidance;² current criteria do not include using CSII in patients with type 2 DM.

What can go wrong and what to do about it?

People using CSII do not take any additional long-acting insulin. Therefore, any interruption to insulin delivery from the pump (eg if the tubing has an air block or the cannula is kinked or dislodged) results in immediate insulin deficiency. Hyperglycaemia and DKA can develop quickly, unless the problem is identified and rectified, for example by re-siting the cannula, refilling the insulin reservoir, changing the tubing, or by starting alternative insulin, such as an intravenous infusion. Technical problems with the pumps can occur; the pump manufacturing companies offer round-the-clock telephone support and are typically able to provide a replacement pump within 24 h if required. All patients using pumps are advised to retain a supply of their pre-pump insulin for use in an emergency situation, for example, in case of pump failure or damage.



Fig 1. Insulin pump. Paradigm Veo insulin pump shown with glucose sensor and mini-link transmitter. Reproduced with permission from Medtronic.

The insulin pump patient in hospital

People with T1DM are frequently more skilled at glucose management and insulin dosing compared with non-specialist healthcare professionals. Medication errors relating to insulin are common during a hospital admission for someone with diabetes, associated with a high incidence of severe hypoglycaemia.⁵ Therefore, it is usually best for the patient to continue to self manage their diabetes using the pump, except in a few circumstances: if unconscious, confused or incapacitated; if in DKA; or if undergoing a major procedure under general anaesthesia lasting >2 h and likely to miss more than one meal. Shorter procedures might not need any change in the patient's usual insulin therapy.

If a patient is unable to manage their pump for whatever reason and no specialist advice is immediately available, the pump should be removed and a conventional intravenous insulin infusion started (unless the patient is hypoglycaemic). CSII can be restarted once the patient has recovered.

Hypoglycaemia

Hypoglycaemia *per se* is not a reason to remove the pump, unless prolonged or profound, or in the presence of coexisting pathology. For those patients who are conscious and able to manage their pump, hypoglycaemia should be treated as usual with rapid-acting carbohydrates (eg dextrose tablets or Lucozade™). Follow up with complex carbohydrates is not usually needed because patients using pumps have no long-acting insulin to contend with. For those patients with hypoglycaemia who are unconscious or otherwise incapacitated (Fig 2), their hypoglycaemia should be treated with intravenous dextrose or intramuscular glucagon, as well as by disconnecting the pump. Once normoglycaemic, insulin should be restarted, either via CSII if the patient is now alert and able to self manage, or using an alternative regimen (eg variable rate intravenous (IV) insulin infusion (VRIII) or subcutaneous MDI insulin). As described

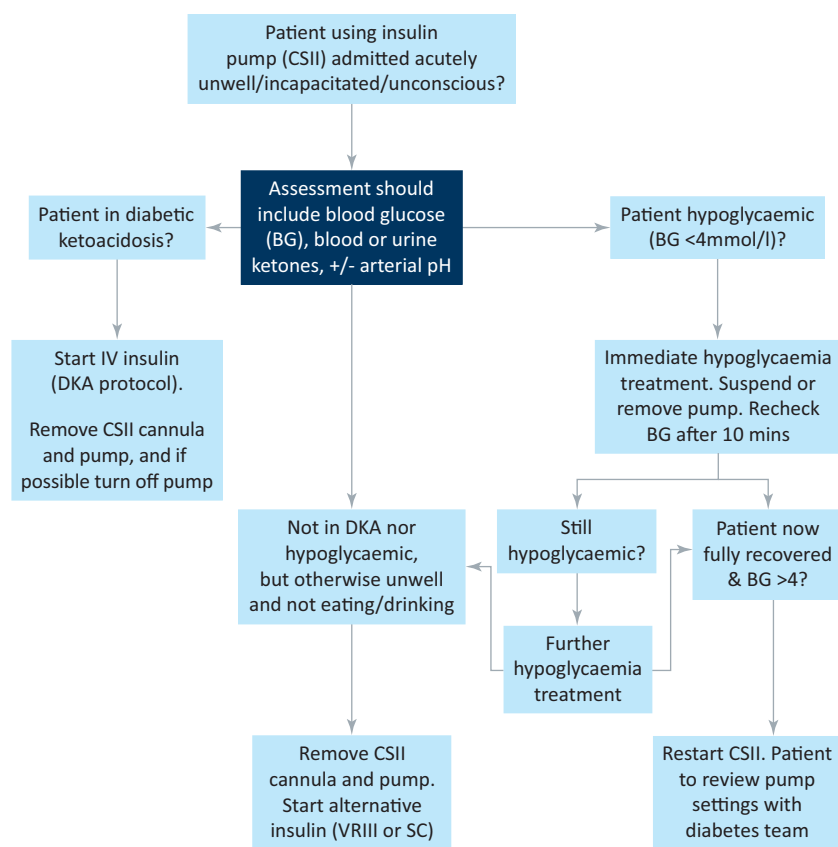


Fig 2. Pump management in the acutely unwell patient. BG = blood glucose; CSII = continuous subcutaneous insulin infusion therapy.

above, this is necessary to prevent the otherwise rapid development of DKA. Following on from a hypoglycaemic episode, the pump infusion rates might need adjustment, especially if there is a pattern of recurrent hypoglycaemia. The most appropriate course of action is to seek advice from the specialist diabetes team.

Diabetic ketoacidosis

The altered tissue perfusion in DKA affects insulin absorption, making CSII unreliable. CSII should be temporarily discontinued in patients with DKA (Fig 2). The cannula should be removed and the pump detached, then standard DKA treatment protocol should be followed. CSII can be restarted once the DKA has resolved. All patients should have specialist diabetes input to review their pump settings, which might need adjusting to prevent subsequent DKA, and to reinforce the 'sick day rules'.⁶

Pump patients and surgery

There are national guidelines for the peri-operative management of diabetes,⁷ but because there are few data on the use of CSII during surgery, recommendations for pump users are based on expert opinion.⁸ Fasting is not usually a problem when on CSII;

therefore, being 'nil by mouth' does not necessarily mean removal of the pump or the need for IV insulin, especially if the starvation period is likely to be short. Most patients will be able to manage their pump post sedation or post anaesthesia as safely as any patient using standard insulin therapy and are more likely to achieve stable glucose control. Hence, it is not necessary to admit day-case patients overnight for VRIII simply because they manage their diabetes by CSII. However, some patients will feel unable to self-manage following the procedure and should discuss this with their diabetes pump team in advance. They might require alternative management, such as prior conversion back to MDI insulin, or hospital admission for IV insulin. For minor procedures (ie expected to eat and/or drink within 2–3 h) under general anaesthetic or sedation, the pump can remain *in situ*. Pre-procedure, the patient should ensure that: their cannula is sited away from the operative site and is accessible to the healthcare team; the pump contains new batteries; the insulin reservoir is full; and capillary glucose is in the acceptable range pre-procedure (ie 4–12 mmol/l). The theatre team must monitor the patient's capillary glucose levels at least hourly, and start VRIII if any reading is greater than 12 mmol/l. Post procedure, a correction dose might

be required, and possibly a temporary increase in basal rates to counteract the stress response to surgery. For any major surgical procedure, where a prolonged period of fasting is expected, CSII should be stopped and replaced by VRIII until the patient is sufficiently recovered and eating again. An overview of pump management for elective procedures under sedation or anaesthesia is shown in Fig 3.

Peripartum pump management

The use of pumps in pregnancy is increasing (see Fig 4 for management of insulin pumps during labour), although there is no clear evidence of improved glycaemic control or reduced perinatal mortality rates;⁹ this might simply reflect a lack of data rather than a lack of benefit. Maternal hyperglycaemia during labour and at the time of delivery increases the risk of neonatal hypoglycaemia – maintaining stable maternal blood glucose levels minimises this risk. In most cases (including elective Caesarean delivery), this is best achieved by continuing CSII rather than by converting to VRIII (Fig 4). If the mother-to-be (or her partner) does not feel confident managing the pump during labour, or if blood glucose levels are not appropriately controlled, then VRIII should be started instead. Following delivery, insulin requirements typically drop rapidly, and women are advised to revert to pre-pregnancy basal infusion rates to minimise their risk of hypoglycaemia.

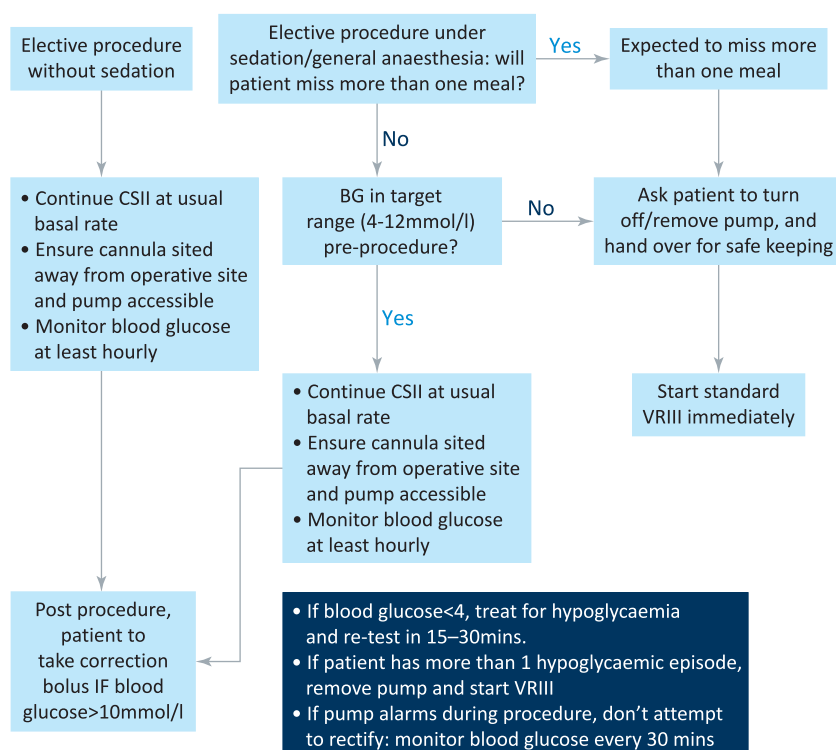


Fig 3. Pump management for elective procedures under sedation or anaesthesia.

BG = blood glucose; CSII = continuous subcutaneous insulin infusion therapy; IV = intravenous; VRIII = variable rate intravenous insulin infusion.

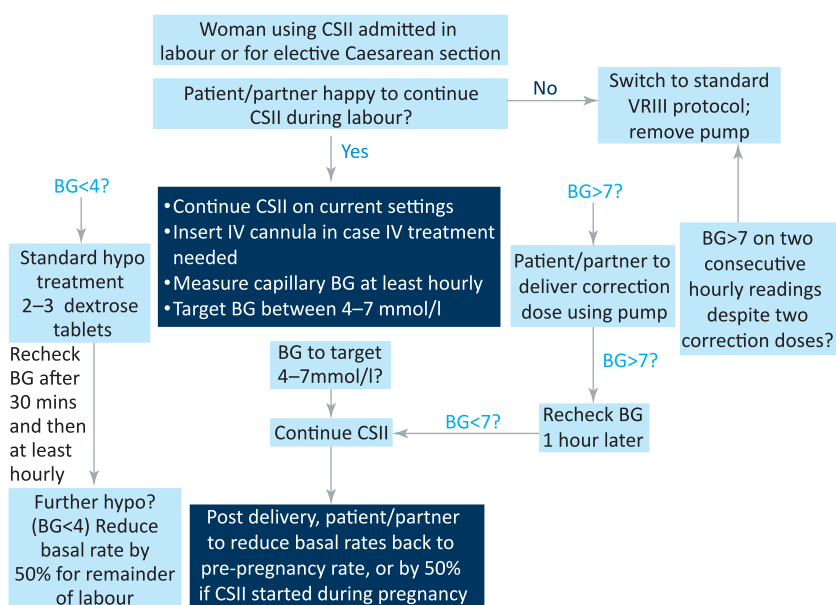


Fig 4. Management of insulin pumps (CSII) during labour. BG = blood glucose; CSII = continuous subcutaneous insulin infusion therapy; IV = intravenous.

Summary

Most patients using insulin pumps are safest continuing to use their pump as their form of blood glucose control when admitted to hospital, unless incapacitated. The increasing use of CSII by patients with T1DM makes it likely that non-diabetologists will have a 'pump encounter' in the future. Although this review provides the generalist physician with a framework to managing such patients, one should always seek specialist diabetes advice when available.

References

- 1 Misso ML, Egberts KJ, Page M *et al*. Continuous subcutaneous insulin infusion (CSII) versus multiple insulin injections for type 1 diabetes mellitus. *Cochrane Database Syst Rev* 2010;1:CD005103.
- 2 National Institute for Health and Clinical Excellence. *Continuous subcutaneous insulin infusion for the treatment of diabetes mellitus*: Technology Appraisal Guidance 151 (review of Technology Appraisal Guidance 57). London: NICE 2008.
- 3 Pickup JC, Keen H, Parsons JA, Alberti KGMM. Continuous subcutaneous insulin infusion: an approach to achieving normoglycaemia. *BMJ* 1978;1:204-7.
- 4 Pickup JC, Sutton AJ. Severe hypoglycaemia and glycaemic control in type 1 diabetes: meta-analysis of multiple daily insulin injections versus continuous subcutaneous insulin infusion. *Diabet Med* 2008;25:765-74.
- 5 National Diabetes Inpatient Audit, 2011. www.ic.nhs.uk/diabetesinpatientaudit [Accessed 28 March 2013].
- 6 Diabetes UK, 2009. www.diabetes.org.uk/Guide-to-diabetes/Living_with_diabetes/Illness/ [Accessed 28 March 2013].
- 7 Dhatariya K, Flanagan D, Hilton L *et al*. *Management of adults with diabetes undergoing surgery and elective procedures: improving standards*. London: NHS, 2011.
- 8 Boyle ME, Seifert KM, Beer KA *et al*. Guidelines for application of continuous subcutaneous insulin infusion (insulin pump) therapy in the perioperative period. *J Diabetes Sci Technol* 2012;6:184-90.
- 9 Farrar D, Tuffnell DJ, West J. Continuous subcutaneous insulin infusion versus multiple insulin injections for pregnant women with diabetes. *Cochrane Database Syst Rev* 2007;3:CD005542.

Address for correspondence: Dr K Evans, Department of Endocrinology and Diabetes, Plymouth Hospitals NHS Trust, Derriford Hospital, Derriford Road, Plymouth PL6 8DH. Email: Kate.evans6@nhs.net