ISSN 1262-3636

Diabetes & Metabolism

Indexed in:
BIOSIS (Biological Abstract) - CABS - Chemical Abstracts - Current Contents: Life Sciences - EMBASE/Excerpta Medica - Medline (Index medicus) - Pascal (INIST/CNRS) - Research Alert - Science Citation Index - SCI Search.

ELSEVIER MASSON

Société francophone du diabète

Bi-monthly publication

February **2010** Vol. 36 **1**

63641

Available online at ScienceDirect www.sciencedirect.com
Elsevier Masson France EM|consulte www.em-consulte.com
Diabetes & Metabolism 36 (2010) 79–85

Position Statement

When to treat a diabetic patient using an external insulin pump. Expert consensus. Société francophone du diabète (ex ALFEDIAM) 2009

V. Lassmann-Vague [a,*], S. Clavel [b], B. Guerci [c], H. Hanaire [d], R. Leroy [e], G.A. Loeuille [f], I. Mantovani [g], M. Pinget [h], E. Renard [i], N. Tubiana-Rufi [j]

[a] *Centre médical Paul-Paret, 3, route de la Gavotte, Marseille, France*
[b] *Service de diabétologie, fondation Hôtel-Dieu, Le Creusot, France*
[c] *Service de diabétologie, hôpital Jeanne-d'Arc, Dommartin-les-Toul, France*
[d] *Service de diabétologie, hôpital Rangueil, Toulouse, France*
[e] *Service d'endocrinologie, diabétologie, hôpital privé La Louvière, Lille, France*
[f] *Service de pédiatrie, hôpital de Dunkerque, Dunkerque, France*
[g] *Service de diabétologie, hôpital Princesse-Grace, Monaco, France*
[h] *Service de diabétologie, hospices civils, Strasbourg, France*
[i] *Service de diabétologie, hôpital Lapeyronie, Montpellier, France*
[j] *Service d'endocrinologie et diabétologie, hôpital Robert-Debré, Paris, France*

Received 15 July 2009; received in revised form 22 September 2009; accepted 26 September 2009
Available online 13 January 2010

Abstract

For years, external insulin pumps have enjoyed proven efficacy as an intensive diabetes treatment to improve glycaemic control and reduce hypoglycaemia. Since the last ALFEDIAM guidelines in 1995, however, basal-bolus treatment using a combination of long- and short-acting insulin analogues have emerged and could challenge, at a lower cost, the efficacy of pumps using rapid-acting insulin analogues, considered the 'gold standard' of insulin treatment. Nevertheless, given its theoretical and practical advantages, some patients will derive more benefit from pump treatment. These cases have been carefully evaluated in the literature by a panel of experts appointed by ALFEDIAM to determine the indications for pump treatment. In patients with type 1 diabetes, persistent elevated HbA_{1c} despite multiple daily injections (MDI), and repeated hypoglycaemia and high glycaemic variability, represent the most validated indications. In patients with type 2 diabetes, pump treatment may be indicated in cases of MDI failure to achieve HbA_{1c} targets. Absolute contraindications are rare, and comprise severe psychiatric disorders, rapidly progressing ischaemic or proliferative retinopathy before laser treatment and exposure to high magnetic fields. Relative contraindications are mostly related to the patient's lack of compliance or inability to cope with the treatment, and need to be evaluated individually to clearly assess the benefit/risk ratio for the given patient. However, as these conditions are progressive, there should also be annual reassessment of the appropriateness of pump treatment. Specific education on pump treatment initially and throughout the follow-up, delivered by experienced medical and paramedical teams, are the best guarantees of treatment efficacy and safety.

Keywords: Insulin pump; Intensified treatment of diabetes; Basal-bolus insulin; SFD recommendations

Résumé

Quand traiter un patient diabétique par pompe à insuline externe ? Référentiel de la société francophone du diabète (ex Alfediam) 2009.

Pendant des années, le traitement par pompe à insuline externe a fait la preuve de son efficacité chez les patients diabétiques de type 1 et avec les analogues rapides de l'insuline a été considéré comme l'étalon-or des traitements par insuline. L'apparition des analogues lents de l'insuline qui, combinés aux analogues rapides réalisent un traitement basal-bolus par injections a remis en cause, à moindre coût, la supériorité de la pompe. Toutefois, en raison des avantages théoriques et pratiques de la pompe, certains patients vont tirer un bénéfice plus important de ce traitement. Ces situations qui permettent de définir les indications du traitement par pompe externe ont été évaluées par un groupe d'experts mandatés par la Société francophone du diabète (ex Alfediam), à la lumière de la littérature et de leur expérience. Chez les diabétiques de type 1, une

* Corresponding author. 90, traverse Fort-Fouque, 13012 Marseille, France. Tel.: +33620147228.
E-mail address: vague.veronique@wanadoo.fr (V. Lassmann-Vague).

1262-3636/$ – see front matter © 2009 Elsevier Masson SAS. All rights reserved.
doi:10.1016/j.diabet.2009.09.002

HbA_{1c} élevée de façon répétée malgré les multi-injections, des hypoglycémies répétées, et une variabilité glycémique importante représentent les indications les plus validées. Chez le diabétique de type 2, en cas d'échec des multi-injections, un traitement par pompe peut être proposé. Les contre-indications absolues au traitement par pompe sont rares : maladies psychiatriques graves, rétinopathie ischémique sévère rapidement évolutive ou proliférante non traitée par laser, exposition à des champs magnétiques intenses. Les contre-indications relatives sont essentiellement liées au manque d'observance du patient ou à son incapacité à gérer ce traitement. Elles seront appréciées cas par cas afin d'évaluer le rapport bénéfices/risques pour chaque patient. Toutes ces situations peuvent évoluer, ce qui souligne l'importance de la réévaluation annuelle de la pertinence du traitement par pompe. Une éducation thérapeutique spécifique délivrée au sein d'un environnement médical et paramédical expérimenté garantit au mieux l'efficacité du traitement et la sécurité du patient.

Mots clés : Pompe à insuline ; Traitement intensifié du diabète ; Insuline basal-bolus ; Recommandations SFD

1. Introduction

Since the last recommendations for insulin pump treatment by *Association de langue française pour l'étude du diabète et des maladies métaboliques* (ALFEDIAM; French-speaking Association for the Study of Diabetes and Metabolic Diseases) in 1995 [1], rapid-acting insulin analogues have been developed and, when used in pumps, they appeared to be more efficient than human insulin, according to a review of the literature [2]. In addition, when long-lasting analogues were associated with short-acting ones, the so-called 'basal-bolus regimen', using multiple injections, became possible. With the exception of pump treatment, this regimen is currently regarded as the reference treatment. In comparison, external pumps theoretically have three advantages: the infusion is continuous; the basal dose rate is adjustable; and boluses can be given as frequently as necessary with no additional injections. This suggests that these two therapeutic methods need to be compared to determine which patients might benefit the most from which treatment.

The decrees published by *Le Journal Officiel* (Official Gazette of the French Republic) on 10 November 2000, 25 August 2006 and 17 December 2008 [3–5] specify guidelines for the management and refunding of pump treatment. The short-term costs of the treatment are greater than those based on multiple injections, but the improvements in metabolic control and quality of life easily counterbalance the extra costs. Thus, an expected short-term benefit of pump treatment might be a favourable benefit/risk ratio (concerning hypoglycaemic events) while, in the long run, patients may also benefit from the avoidance or slower development of complications linked to diabetes.

For this reason, a group of experts met at the request of ALFEDIAM to rigorously evaluate, based on the literature (see Table 1 for grading of the recommendations) and experience, the conditions under which a patient would most benefit from pump treatment, and to define the most relevant indications for this therapeutic method. This would also mean that the success of this treatment and the safety of the patient would be best guaranteed by such guidelines of good care as stated in such recommendations [3–5]. Being rigorous in terms of indications and contraindications as well as adherence to the rules of good care is the best way to deliver pump treatment with the optimal benefit/risk ratio for the patient and as the most cost-effective healthcare.

Table 1
Grading of recommendations.

Level of scientific evidence from the literature	Grade of recommendation
Level 1	A
Randomized controlled trials of high power	Established scientific evidence
Meta-analysis of randomized controlled trials	
Decision analysis based on well-conducted studies	
Level 2	B
Randomized controlled trials of low power	Scientific presumption
Non-randomized comparative studies, but well conducted	
Cohort studies	
Level 3	C
Case-control studies	
Level 4	
Comparative studies with major bias(es)	Low level of scientific evidence
Retrospective studies	
Case reports	
Descriptive epidemiological studies (cross-sectional, longitudinal)	

2. Treatment objectives

Recommendations for healthcare professionals define treatment objectives for diabetic patients as a composite of the following, while maintaining an optimal quality of life:

- HbA_{1c} concentrations;
- capillary blood glucose levels;
- frequency of hypoglycaemic episodes.

2.1. HbA_{1c}

The HbA_{1c} goal recommended for adults and children with type 1 diabetes is < 7.5% [6]. However, this target does not reflect any international consensus: the American Diabetes Association (ADA) recommends < 7% [7], whereas National Institute for Health and Clinical Excellence (NICE) [8] and International Society for Pediatric and Adolescent Diabetes (ISPAD) [9] have selected < 7.5%.

For type 2 diabetes, the HbA_{1c} goal recommended in France is < 6.5% or 7%, depending on the type of treatment [10].

2.2. Capillary blood glucose

- In both types of diabetes, postprandial capillary blood glucose goals are < 180 mg/dL after 1–2 h [11] or, more recently, < 140 mg/dL [12].
- In children, capillary blood glucose goals vary according to age, and are less strict in young children [13].
- During pregnancy, glycaemic goals are lower: < 95 mg/dL in the fasting state; and < 120 mg/dL postprandial after 2 h [7] in gestational diabetes.
- The ADA has no recommendations for glycaemic targets in pregestational diabetes.

2.3. Hypoglycaemia

As hypoglycaemia should be avoided as much as possible, glycaemic targets in the fasting state and before meals can be set at 70–120 mg/dL [14].

However, it is often difficult to reconcile these objectives, whatever the insulin regimen. Continuous subcutaneous insulin infusion (CSII) *via* an external pump, thanks to its flexibility, makes it easier to achieve these different objectives at the same time. However, the cost/benefit balance of the treatment should also be taken into account.

3. Results according to type of diabetes

3.1. Type 1 diabetes

- A 0.4–0.6% reduction in HbA_{1c} levels has been reported in three meta-analyses of trials comparing CSII with multiple daily injections (MDI) [15–17]. However, in four further studies [18–21] — three of which were randomized [18,20,21] — comparing CSII with MDI in adults using insulin glargine and short-acting insulin analogues, the benefit from pump therapy to the whole population was small. On the other hand, the higher the baseline HbA_{1c}, the greater the superiority of CSII over MDI, reaching an absolute difference of 1% in lowering HbA_{1c} in patients with baseline HbA_{1c} > 12% [22].
- In children, four trials — including one randomized study [23] — comparing CSII with MDI, and using glargine and short-acting insulin analogues, showed greater efficacy with CSII [23–26].
- A recent meta-analysis of trials, including patients at high risk of severe hypoglycaemia (> 10% patient-years), showed a significant reduction in severe hypoglycaemic events with CSII compared with MDI, the number of events being divided by 2.9 in randomized trials and by 4.3 in observational studies [27]. The higher the frequency of severe hypoglycaemic events at baseline, the greater the benefit of pump therapy.

  In studies that included patients not particularly prone to severe hypoglycaemia, and comparing an MDI regimen using glargine and short-acting insulin analogues with CSII, no difference was seen in the frequency of hypoglycaemic events. However, the small number of hypoglycaemic episodes reported in these studies, and their short duration, does not allow any firm conclusions to be drawn.
- In the paediatric population, numerous observational studies [28–31] have shown a reduction in the frequency of both severe and mild hypoglycaemic events with pump therapy compared with MDI, whereas randomized studies [32–34] could find no such differences. However, once again, it is difficult to draw any clear conclusions, as the frequency of hypoglycaemic events was low, and the duration of the studies was short.

  Nevertheless, two consensus reviews of the indications for pump therapy in children were based on these results [35,36].
- Glycaemic variability is reduced in CSII compared with MDI using various types of insulin [37], including glargine as the basal insulin [20], and the more marked the glycaemic variability, the greater the benefit with CSII [38].
- In recent studies, the following parameters of glycaemic control were concomitantly improved by pump therapy: HbA_{1c}, and frequency of hypoglycaemic events and ketoacidosis [26]; and HbA_{1c}, frequency of hypoglycaemic events and glycaemic variability [37].
- In those rare cases of insulin allergy, pump therapy has proved its efficacy in type 1 diabetes, according to one review [39].
- No controlled randomized trial used quality of life as a primary endpoint. However, a recent case-controlled, large-scale study [40] showed the benefit of CSII on quality of life, thanks to its greater flexibility in day-to-day life, less fear of hypoglycaemia and greater treatment satisfaction. In recent randomized trials including quality of life as a secondary endpoint, the results were better [21,37] or the same [23,32,33] with pump therapy *vs* MDI. These results, however, need to be confirmed. Also, as they are strongly related to device performance, the results may continue to improve as the technology is developed.

3.2. Type 2 diabetes

The experience of external pumps in patients with type 2 diabetes is much more recent and limited. The results of four randomized studies comparing the insulin pump with MDI using rapid-acting analogues and NPH [41–43] or glargine [44] revealed that treatment with the pump had greater efficacy if the previous treatment had been intensified (to at least two injections per day), while quality of life was maintained or improved. A fifth study [45] showed sustained improvement of blood glucose with the pump used simply (without frequent adjustments) in association with antidiabetic oral agents.

The pump allows more predictable insulin uptake in patients with high insulin requirements and/or major insulin resistance [46,47], and probably offers desensitization in the rare cases of insulin allergy [39].

4. Indications for pump therapy

The indications for insulin pump therapy described in the 1995 ALFEDIAM recommendations [1] can now be updated in

the light of increased experience since then. Also, the text of the French *Journal Officiel* of 10 November 2000 [3], which covers the reimbursement of such treatment, states that "care is provided for type 1 or 2 diabetes that cannot be properly controlled through multiple insulin injections".

The purpose of the present update is to clarify the debate based on rigorous analysis of the literature and experience by an expert panel to allow grading of the new recommendations according to the level of scientific evidence and professional experience. This should help to better define the benefit/risk ratio for patients and the cost-effectiveness of the treatment. Of these indications, only a few are absolute, whereas the motivation of the patient (or parents in paediatric cases) is an essential consideration. It is crucial that physicians and patients take the time to carefully weigh the various factors, as this will limit the chances of failure.

4.1. Type 1 diabetes

4.1.1. HbA_{1c} persistently elevated despite intensified MDI

After intensification of healthcare by a multidisciplinary team and optimization of the patient's education, an HbA_{1c} persistently > 7.5% is an indication to initiate therapy by insulin pump. This treatment will be even more effective in patients with an elevated HbA_{1c} at baseline.

Grade A recommendation

4.1.2. Recurrent hypoglycaemia (severe or moderate, but frequent)

a. Incidence of severe hypoglycaemia (requiring the assistance of a third party): more than one episode per year;
b. Incidence of moderate hypoglycaemia: more than four episodes per week;
c. Inability to maintain HbA_{1c} target without increasing episodes as described in a or b.

Grade A recommendation

4.1.3. Marked glycaemic variability

Glycaemic variability from day to day or within the same day needs to be documented by a panel of parameters, including clinical (frequent hypoglycaemia) and biological (high HbA_{1c}) data, self-monitoring of blood glucose, index of variability (SD, MAGE, MODD) and/or continuous interstitial glucose monitoring using sensors.

Grade B recommendation

4.1.4. Variability of insulin requirements

The main advantage provided by the pump compared with MDI is the possibility of programming several basal rates to adapt insulin delivery according to varying needs throughout the day and to manage the dawn phenomenon.

Expert consensus

4.1.5. Treatment with MDI results in good metabolic control, but undermines the patient's social/professional life

This includes people who are shift workers, business travellers — especially those who must deal with 'jetlag' — participants in competitive sports activities, and have variable times for sleeping and eating.

Expert consensus

4.1.6. Planned or current pregnancy

Before and during pregnancy, excellent glycaemic control is of vital importance. If not achieved by MDI, then pump therapy may be considered in accordance with the previously mentioned indications.

Given the increased risk of ketoacidoses during pregnancy and the subsequent risk to the fetus, an individualized risk/benefit analysis upon initiation of pump therapy is required.

Expert consensus

4.1.7. Specific indications in children and adolescents

All indications for adult patients are equally valid for children and adolescents, although incremental indications may result on consideration of:

- glycaemic instability in very young children;
- pain and/or needle phobia;
- practical reasons limiting the feasibility of MDI;
- nocturnal hypoglycaemia;
- very low insulin requirements (especially at night) in very young children;
- neonatal diabetes or very early onset of diabetes.

In such cases, consider the pump as the first-line therapy.

Expert consensus

4.1.8. Insulin allergy

Grade C recommendation

4.2. Type 2 diabetes

As the use of pump therapy in type 2 diabetes is much more recent, the following recommendations are based on limited experience only.

4.2.1 Failure of intensified MDI regimen (at least 2 injections/day)

4.2.2 Patients with insulin resistance or very high insulin requirements

Expert consensus

4.2.3 Pregnancy (mother has type 2 diabetes)

While this situation appears more frequently in clinical practice, the therapeutic value of the insulin pump has yet to be established. Indications may be similar to those outlined in 3.2.1 and 3.2.2.

Expert consensus

4.2.4 Insulin allergy

Grade C recommendation

4.3. Other indications

4.3.1. Major perturbations of glycaemic control in extreme and/or long-term pathophysiological situations

- Diabetes and parenteral nutrition
- Secondary diabetes (for example, following interferon treatment)
- Lipoatrophic diabetes
- Association with insulinopenic state and major insulin resistance

4.3.2. Outlook

Forthcoming indications might include pump therapy as a first-line treatment upon diagnosis of diabetes or as a way to improve patients' quality of life. Likewise, in line with technical innovations, guidelines differentiating the use of intraperitoneal implantable insulin pumps *vs* external insulin pumps need to be established.

5. Contraindications for pump therapy

Both absolute and relative contraindications depend on the patients, their environment and/or the pump itself, and refer to situations in which pump therapy is not effective and/or dangerous to the patient.

All contraindications are based on expert consensus.

5.1. Absolute contraindications

5.1.1. Severe psychiatric illness

This includes the parents in cases of children with diabetes.

5.1.2. Severe, rapidly progressive or proliferative retinopathy

Any treatment aiming to rapidly normalize glycaemia is contraindicated in these patients prior to laser treatment.

5.1.3. Regular exposure to strong magnetic fields

Strong magnetic fields such as those emitted by magnetic resonance imaging (MRI) machines can cause pumps to overdeliver insulin.

5.2. Relative contraindications

These situations require careful evaluation of the benefits/risks related to pump therapy. Expert teams in charge of the decision-making process should be experienced with pump therapy, and include physicians, nurses, dietitians and psychologists.

5.2.1 Suboptimal adherence to diabetes treatment

This includes patients who fail to visit their doctor regularly, neglect blood glucose self-monitoring and do not test for ketone bodies. For children, this includes families who are unable to get to an appropriate medical institution within 3 h due to logistical/geographical reasons, or those who have difficulties reaching their parents.

5.2.2 Suboptimal acceptance of treatment by the patient

Indeed, the patient's motivation and cooperation are essential for the success of pump therapy.

5.2.3 Poor hygiene and participation in violent sports

Such patients have the risk of causing localized infection or bleeding at the site of infusion.

5.2.4 Sensory (particularly visual) or gestural impairment (physically handicapped)

5.2.5 End-stage renal failure and the risk of acidosis

This situation indicates the need for capillary surveillance for ketonaemia.

5.2.6 Living in extremely cold or heated environments for professional or personal reasons

These situations (experienced by patients who are, for example, cooks and refrigeration workers) can lead to insulin inactivation.

5.2.7 Underwater diving (as a sport or profession)

Pumps are water-resistant, but not waterproof, so their submersion in water is not recommended.

5.2.8 Participation in extreme sports

This requires great caution and precise insulin dose adjustments on a case-by-case basis.

For most relative contraindications, it is extremely important to increase the frequency of checking for blood glucose and capillary ketonaemia or ketonuria to avoid diabetic ketoacidosis.

6. Need for ongoing evaluation of appropriate pump treatment

The patient, physician and technology may all change. Certain transient indications may be acceptable, but what was once the correct indication may become adverse or a contraindication. This emphasizes the need for continuous reevaluation of the patient, his theoretical knowledge and everyday ability to manage the pump treatment, and requires careful verification of the patient's metabolic control, quality of life and satisfaction. Making such an assessment at each medical consultation with the diabetologist, and at each annual check-up with the mutidisciplinary medical and paramedical team of the initiating centre, allows every patient to appreciate the benefits and risks of pump treatment. Regular patient evaluation, motivation and observation are the three main points for achieving success with this mode of treatment.

6.1. Criteria for interruption of pump treatment

6.1.1 Carelessness (or parents' carelessness towards their diabetic child) or non-compliance with the following conditions

- Insufficient frequency of blood glucose determinations and testing for ketone bodies
- Insufficient and irregular follow-up
- No annual check-up

6.1.2 Misuse of treatment

Making wrong dose adjustments that are ineffective or even dangerous.

6.1.3 Occurrence of acute situations

Two or more episodes of diabetic ketoacidosis with no medical explanation, or more frequent severe hypoglycaemic episodes than with MDI.

6.1.4 Significant increase of HbA_{1c} levels over therapeutic goals

6.1.5 Patient's reluctance to use the insulin pump and desire to stop treatment is so strong that it leads to complaints

6.1.6 Occurrence of contraindications

6.2. Relative failures

The following conditions require reinforcement of education about the therapy:

- Recurrent skin infections at the infusion site
- Localized lipohypertrophic reactions at the same site
- Infrequent replacement of catheter
- Inappropriate adjustment of insulin doses
- Misuse of pump equipment

6.3. Transient interruptions

Transient interruption of pump treatment is usually necessary in hospitalized patients without a diabetologist present, with diseases that cause the patient to be unable to care for himself and by patient's request (during the summer holidays, for instance).

7. Conclusion

The indications and contraindications for insulin pump treatment have been summarized in this review. Ultimately, however, the motivation of the patient, and specific education at the time of treatment initiation and follow-up, delivered by experienced medical and paramedical teams, are the best guarantees of its efficacy and safety.

Conflicts of interest

None.

References

[1] Lassmann-Vague V, Guerci B, Hanaire-Broutin H, Leblanc H, Renard E, Thervet F, et al. Pompes à insuline (pompe portable à perfusion sous-cutanée d'insuline). Diabetes Metab 1995;21:371–7.

[2] Hanaire H, Lassmann-Vague V, Jeandidier N, Renard E, Tubiana-Rufi N, Vambergue A, et al. Treatment of diabetes mellitus using an external insulin pump: the state of the art. Diabetes Metab 2008;34:401–23.

[3] Arrêté du 10 novembre 2000 modifiant le titre 1er du tarif interministériel des prestations sanitaires et relatif aux systèmes actifs pour perfusion à domicile. J.O nº 268 du 19 novembre 2000, page 18 410. http://www.legifrance.gouv.fr.

[4] Arrêté du 17/07/2006 relatif à la modification de la nomenclature relative aux pompes à insuline externes, portables et programmables inscrites au chapitre 1er du titre de la liste des produits et prestations remboursables prévue à l'article L. 165-1 du Code de la Sécurité sociale. http://www.legifrance.gouv.fr.

[5] Arrêté du 11 décembre 2008. Journal officiel du 17 décembre 2008. http://www.legifrance.gouv.fr.

[6] Haute Autorité de santé (HAS). Diabète de type 1 de l'adulte. Guide affection longue durée, juillet 2007. www.has-sante.fr.

[7] Standards of medical care in diabetes—2008, American Diabetes Association. Diabetes Care. 2008;31(Suppl. 1):S12–54.

[8] Insulin treatment. National Collaborating Centre for Chronic Conditions. Type 1 diabetes: diagnosis and management of type 1 diabetes in adults. Quick reference guide. NICE website: www.nice.org.uk.

[9] Bangstad HJ, Danne T, Deeb LC, Jarosz-Chobot P, Urakami T, Hanas R. International Society for Pediatric and Adolescent Diabetes (ISPAD) clinical practice consensus guidelines 2006–2007. Pediatr Diabetes 2007;8:88–102.

[10] Agence française de sécurité sanitaire des produits de santé. Haute Autorité de santé. Traitement médicamenteux du diabète de type 2. Recommandations de bonnes pratiques, Novembre 2006. http://afssaps.sante.fr/pdf/5/rbp/reco_diabete_2006.pdf.

[11] Standards of Medical Care in Diabetes. Diabetes Care 2004;27:S15–35.

[12] Ceriello A, Colagiuri S. International Diabetes Federation guideline for management of postmeal glucose: a review of recommendations. Diabet Med 2008;25:1151–6.

[13] Standards of Medical Care in Diabetes—2009. American Diabetes Association. Diabetes Care 2009;32(Suppl. 1):S13–61.

[14] Haute Autorité de santé (HAS). Diabète de type 2 de l'adulte. Guide affection longue durée, novembre 2007. www.has-sante.fr.

[15] Pickup J, Mattock M, Kerry S. Glycemic control with continuous subcutaneous insulin infusion compared with intensive insulin injections in patients with type 1 diabetes: meta-analysis of randomized controlled trials. BMJ 2002;324:705–8.

[16] Weissberg-Benchell J, Antisdel-Lomaglio J, Seshadri R. Insulin pump therapy. A meta-analysis. Diabetes Care 2003;26:1079–87.

[17] Jeitler K, Horvath K, Berghold A, Gratzer TW, Neeser K, Pieber TR, et al. Continuous subcutaneous insulin infusion versus multiple daily insulin injections in patients with diabetes mellitus: systematic review and meta-analysis. Diabetologia 2008;51:941–51.

[18] Bolli GB, Capani F, Home PD, Kerr D, Thomas R, Torlone E, et al. Comparison of a multiple injections treatment with once daily insulin glargine basal insulin and meal-time lispro, to continuous subcutaneous insulin infusion: a randomized, open, parallel study. Diabetes 2004;53(Suppl. 2):A107–8 [Abstract].

[19] Lepore M, Pampanelli S, Fanelli C, Porcellati F, Bartocci L, Di Vicenzo A, et al. Pharmacokinetics and pharmacodynamics of subcutaneous injection of long-acting analog glargine, NPH insulin, and ultralente human insulin and continuous subcutaneous infusion of insulin lispro. Diabetes 2000;49:2142–8.

[20] Hirsch IB, Bode BW, Garg GS, Lane WS, Sussman A, Hu P, et al. Continuous subcutaneous insulin infusion (CSII) of insulin aspart versus multiple daily injections of insulin aspart/insulin glargine in type 1 diabetic patients previously untreated with CII. Diabetes Care 2005;28:533–8.

[21] Bruttomesso D, Crazzolara D, Maran A, Costa S, Dal Pos M, Girelli A, et al. In type 1 diabetic patients with good glycemic control, blood glucose variability is lower during continuous subcutaneous insulin infusion than during multiple daily injections with insulin glargine. Diabet Med 2008;25:326–32.

[22] Retnakaran R, Hochman J, DeVries JH, Hanaire-Broutin H, Heine RJ, Melki V, et al. Continuous subcutaneous insulin infusion versus multiple daily injections. The impact of baseline A_{1c}. Diabetes Care 2004;27:2590–6.

[23] Doyle EA, Weinzimer SA, Steffen AT, Ahern JAH, Vincent M, Tamborlane WV. A randomized, prospective trial comparing the efficacy of continuous subcutaneous insulin infusion with multiple daily injections using insulin glargine. Diabetes Care 2004;27:1554–8.

[24] Alemzadeh R, Palma-Sisto P, Parton EA, Holzum MK. Continuous subcutaneous insulin infusion and multiple dose of insulin regimen display

similar patterns of blood glucose excursions in pediatric type 1 diabetes. Diabetes Technol Ther 2005;7:587–95.
[25] Schiaffini R, Ciampalini P, Spera S, Cappa M, Crino A. An observational study comparing continuous subcutaneous insulin infusion (CSII) and insulin glargine in children with type 1 diabetes. Diabetes Care 2003;26:1142–6.
[26] Jakisch BI, Wagner VM, Heidtmann B, Lepler R, Holterhus PM, Kapellen TM, et al. Comparison of continuous subcutaneous insulin infusion (CSII) and multiple daily injections (MDI) in paediatric type 1 diabetes: a multicenter matched-pair cohort analysis over 3 years. Diabet Med 2008;25:80–5.
[27] Pickup JC, Sutton AJ. Severe hypoglycaemia and glycemic control in type 1 diabetes: meta-analysis of multiple daily insulin injections compared with continuous subcutaneous insulin infusion. Diabet Med 2008;25:765–74.
[28] Danne T, Battelino T, Kordonouri O, Hanas R, Klinkert C, Ludwigsson J, et al. A cross-sectional international survey of continuous subcutaneous insulin infusion in 377 children and adolescents with type 1 diabetes mellitus from 10 countries. Pediatr Diabetes 2005;6:193–8.
[29] Hanas R. Selection for and initiation of continuous subcutaneous insulin infusion. Proceeding from a workshop. Horm Res 2002;57(Suppl. 1):101–4.
[30] Weinzimer SA, Ahern JH, Doyle EA, Vincent MR, Dziura J, Steffen AT, et al. Persistence of benefits of continuous subcutaneous insulin infusion in very young children with type 1 diabetes: a follow-up report. Pediatrics 2004;114:1601–5 [Erratum in: Pediatrics 2005;115:518].
[31] Tubiana-Rufi N, de Lonlay P, Bloch J, Czernichow P. Remission of severe hypoglycemia incidents in young diabetic children treated with subcutaneous infusion. Arch Pediatr 1996;3:969–76.
[32] Wilson DM, Buckingham BA, Kunselman EL, Sullivan MM, Paguntalan HU, Gitelman SE. A two-center randomized controlled feasibility trial of insulin pump therapy in young children with diabetes. Diabetes Care 2005;28:15–9.
[33] Fox LA, Buckloh LM, Smith SD, et al. A randomized controlled trial of insulin pump therapy in young children with type 1 diabetes. Diabetes Care 2005;28:1277–81.
[34] Dimeglio LA, Pottorf TM, Boyd SR, France L, Fineberg N, Eugster EA. A randomized, controlled study of insulin pump therapy in diabetic preschoolers. J Pediatr 2004;145:380–4.
[35] Phillip M, Battelino T, Rodriguez H, Danne T. Use of insulin pump therapy in the pediatric age-group. Diabetes Care 2007;30:1653–62.
[36] Kapellen TM, Heidtmann B, Bachmann J, Ziegler R, Grabert M, Holl RW. Indications for insulin pump therapy in different age groups-an analysis of 1567 children and adolescents. Diabet Med 2007;24:836–42.
[37] Hoogma RP, Hammond PJ, Gomis R, Kerr D, Bruttomesso D, Bouter KP, et al. Comparison of the effects of continuous subcutaneous insulin infusion (CSII) and NPH-based multiple daily insulin injections (MDI) on glycaemic control and quality of life: results of the 5-nations trial. Diabet Med 2006;23:141–7.
[38] Pickup JC, Kidd J, Burmiston S, Yemane N. Determinants of glycemic control in type 1 diabetes during intensified therapy with multiple daily insulin injections or continuous subcutaneous insulin infusion: importance of blood glucose variability. Diabetes Metab Res Rev 2006;22:232–7.
[39] Radermecker RP, Scheen AJ. Allergy reactions to insulin: effects of continuous insulin infusion and analogues. Diabetes Metab Res Rev 2007;23:348–55.
[40] Nicolucci A, Maione A, Franciosi M, Amoretti R, Busetto E, Capani F, et al. Quality of life and treatment satisfaction in adults with type 1 diabetes: a comparison between continuous subcutaneous insulin infusion and multiple daily injections. Diabet Med 2008;25:213–20.
[41] Wainstein J, Metzger M, Boaz M, Minuchin O, Cohen Y, Yaffe A, et al. Insulin pump therapy vs. multiple daily injections in obese type 2 diabetic patients. Diabet Med 2005;22:1037–46.
[42] Raskin P, Bode BW, Marks JB, Hirsch IB, Weinstein RL, Mc Gill JB, et al. Continuous subcutaneous insulin infusion and multiple daily injection therapy are equally effective in type 2 diabetes. Diabetes Care 2003;26:2598–603.
[43] Berthe E, Lireux B, Coffin C, Goulet-Salmon B, Houlbert D, Boutreux S, et al. Effectiveness of intensive insulin therapy by multiple daily injections and continuous subcutaneous infusion: a comparison study in type 2 diabetes with conventional insulin regimen failure. Horm Metab Res 2007;39:224–9.
[44] Herman WH, Ilag LL, Johnson SL, Martin CL, Sinding J, Al Harthi A, et al. A clinical trial of continuous subcutaneous insulin infusion versus multiple daily injections in older adults with type 2 diabetes. Diabetes Care 2005;28:1568–73.
[45] Labrousse-Lhermine F, Cazals L, Ruidavets JB, Hanaire H, GEDEC Study Group. Long-term treatment combining continuous subcutaneous insulin infusion with oral hypoglycaemic agents is effective in type 2 diabetes. Diabetes Metab 2007;33:253–60.
[46] Pouwells MJ, Tack CJ, Hermus AR, Lutterman JA. Treatment with intravenous insulin followed by continuous subcutaneous insulin infusion improves glycaemic control in severely resistant type 2 diabetic patients. Diabet Med 2003;20:76–9.
[47] Lalej-Bennis D, Selam JL, Fluteau-Nadler S, M'Bemba J, Reach G, Sorel G, et al. Extreme insulin resistance: clinical management by external subcutaneous insulin infusion. Diabetes Metab 1997;23:533–6.