Review Article

Treatment of patients with type 1 diabetes – Insulin pumps or multiple injections?

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ARTICLE INFO

ABSTRACT

In theory, the continuous subcutaneous insulin infusion (CSII) has a few advantages over the multiple daily insulin injections (MDI) that should lead to improved glycemic control and lower risk of hypoglycemia. In practice, both treatment regimens allow for adequate control of glycemia. The objective of this review is to discuss the most important factors contributing to this situation. We made a comprehensive evidence-based review of the factors affecting effectiveness of CSII and MDI, with a special attention to algorithms for insulin dose adjustments and the automatic bolus calculators. Regardless of the treatment regimen that is used a few different interdependent factors influence the final result of the intensive insulin therapy. These factors comprise: patients' education, attitude, emotional stability and compliance, and careful analysis of the treatment results by a physician establishing the appropriate rate of basal insulin infusion or the basal dose of insulin and adjusting insulin doses to: the meals, the planned physical activity and the actual and target glucose levels. Our study implies that good glycemic control in patients with type 1 diabetes requires not only a thorough patient education and complying with medical recommendations, but also an individual determination of therapy goals and ways of achieving them. That is why, regardless of the treatment method that is applied, it is the choice of appropriate algorithms and adjusting them to the patient's way of life what allow for achieving pre-specified therapeutic goals. Technical means such as automatic bolus calculators might supplement but they cannot replace patients education and compliance.

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1. Introduction

Since the release of the Diabetes Control and Complications Trial (DCCT) [1] results, the treatment of patients with type 1 diabetes has intensified, with multiple daily insulin injections (MDI) or the use of an insulin pump. Both treatment regimens allow for adequate control of glycemia. The appropriate titration of the daily insulin dose, skilful dosage of the basal insulin or the basic insulin delivery, adjusting doses to the meals by calculating the carbohydrate equivalents or to the exercise level, the use of correction doses – all these elements of treatment influence the results. Most patients with type 1 diabetes require the use of insulin analogues [2].

It is still a matter of debate, which patients should be treated with the insulin pump and whether treatment with continuous subcutaneous insulin infusion (CSII) is superior to the MDI in terms of the level of glycemic control that can be achieved.

The American Diabetes Association (ADA) presented its position regarding both advantages and disadvantages of insulin pumps [3]. The former encompass elimination of frequent injections, precise dosage, decrease of the glucose levels' fluctuations, easier bolus administration, easier adjustment of insulin doses to different meal times. In many patients there is an improvement in glycemia control described by the glycated hemoglobin A1c (HbA1c) concentration, and a reduction in severe hypoglycemia episodes. Another advantage is more foreseeable effect of the basal infusion than after an injection of a prolonged-release or long-acting insulin. Changes in the basal infusion rate allow for exercising without the need of an extra high-carbohydrate meal. Disadvantages – according to ADA – encompass increase of a body weight, possibility of ketoacidosis in case of a catheter slip, treatment costs, problems linked with permanent pump presence and a need of long-term, repeated education.

Recapitulating, in theory treatment with CSII has a few important advantages over MDI that should result in the improved glycemic control and lower risk of hypoglycemia. However, no proof of these theoretical advantages was found in numerous, randomized clinical trials conducted to date [4]. The objective of this review was to identify and characterize the most important factors contributing to this situation.

2. Glycemic control in patients treated using CSII and MDI regimens

An analysis performed in 2012 by Yeh et al. [5] showed that neither in children nor in adults differences occurred in the effects of treatment, either measured by the number of severe hypoglycemia episodes or by HbA1c, between MDI and CSII treatments. Recent publications do not confirm earlier reports indicating possible benefits of the insulin pump use [6,7]. An introduction of long-acting insulin analogues to diabetes treatment further reduced possible differences in treatment results between patients treated with MDI and those treated with CSII. Boli et al. have compared, although in a small group, the effect of starting treatment with insulin pump or with

peakless insulin analogue glargine in patients treated previously with NPH insulin. This trial showed no significant differences in the improvement of glycemic control, or the number of hypoglycemic episodes, and at the same time indicated that the cost of treatment with insulin pump was 3.9 times higher. However, it must be stressed that wider introduction of continuous glucose measurements in patients with type 1 diabetes improves treatment results in terms of HbA1c and hypoglycemic episodes, especially at night [8,9].

3. Factors affecting effectiveness of CSII and MDI treatments

Persons who treat the pump as a device and not a panacea for diabetes, achieve better glycemic control. Daily self-control, realistic approach to the use of the pump, emotional stability – all these elements affect the course of treatment [10].

Publicizing standards for 2014 the ADA presented its position regarding treatment of patients with type 1 diabetes and commented on the effects of intensive insulin therapy [11]. In the published standards of care for patients with diabetes we read:

''Recommended therapy for type 1 diabetes consists of the following components: (1) use of MDI injections (three to four injections per day of basal and peri-prandial insulin) or CSII therapy; (2) matching of peri-prandial insulin to carbohydrate intake, pre-prandial blood glucose, and anticipated activity; and (3) for most patients (especially if hypoglycemia is a problem), use of insulin analogues There are excellent reviews available that guide the initiation and management *of insulin* therapy to achieve desired glycemic goals. Although most studies *of* MDI versus *pump* therapy have been small and *of* short duration, a systematic review and meta-analysis concluded that there were no systematic differences in A1C or rates *of* severe hypoglycemia in children and adults between the two forms *of* intensive *insulin* therapy.''

One may ask, why treatment with CSII, which is as close as possible to the natural, physiological insulin secretion, offers no marked improvement in glycemic control as compared with multiple insulin injections. One may also ask, how many patients really make the most of the possibilities offered by the pump.

Decreasing glucose level fluctuations in many cases depend on adjusting insulin doses to the meals and the planned physical activity. It requires appropriate patients' education, both at the start of the treatment and during yearly re-education courses. For example, the Polish Diabetes Society recommends spending 9–15 h on initial education course and repeating it every year at 7 to 14-h course [12]. An adequate glycemic control depends also on the patient's dexterity in calculating carbohydrate exchange. Results of a questionnaire conducted among patients with type 1 diabetes showed that most of them had no refresher course in a very long time and had significant difficulties in calculating carbohydrate exchange. In patients with long-term diabetes (i.e. over 10 years)