ORIGINAL ARTICLE

Insulin Pump Therapy in Children and Adolescents with Type 1 Diabetes: Improvements in Glycemic Control and Patients' Satisfaction - Hospital UKM Experience

H L Ooi, MBBS (Malaya), MRCPCH (UK), L L Wu, MBBS (Malaya), MRCP (UK), MRCP (Ire), DCH (Lon)

Paediatric Endocrine Fellow, University Kebangsaan Malaysia Medical Centre, Paediatric Department, Jalan Yaacob Latif, Bandar Tun Razak, Cheras, 56000 Kuala Lumpur, Malaysia

SUMMARY

Hospital UKM (Universiti Kebangsaan Malaysia) introduced the use of insulin pump therapy in children and adolescents with Type 1 Diabetes in Malaysia in April 2004. This study aims to evaluate the effectiveness of pump therapy and its impact on metabolic control among patients from our institution. Insulin pump therapy resulted in sustainable improvement in glycemic control throughout the six years of treatment with reduction in HbA1c in the first two years of pump use was statistically significant. The BMI SDS showed an increase trend but the changes before and after pump use was insignificant. There is also high level of treatment satisfaction reported among our insulin pump patients.

KEY WORDS:

Insulin pump, Type 1 Diabetes, glycosylated hemoglobin (HbA1c), body mass index standard deviation scores (BMI SDS)

INTRODUCTION

Type 1 Diabetes is one of the most common chronic diseases in childhood with 480,000 children estimated affected globally [1]. The incidence is increasing at 3% per year and annually 76,000 children aged under 15 years old develop Type 1 Diabetes worldwide [1]. Despite the huge number of patients, only about one-third of them have HbA1c below 8%[2]. Therefore it is of utmost important to achieve good glycemic control via intensive diabetes management to reduce the long term microvascular complications shown by the Diabetes Control and Complications Trial (DCCT)[3] and its follow-up Epidemiology of Diabetes Interventions and Complications (EDIC) study [4]. Both multiple daily injections of insulin and insulin pump therapy are effective tools in achieving intensive diabetes management. Insulin pump was available since the late 1970s but was widely used in paediatric patients mainly after year 2000 [5]. A tremendous amount of data has also shown that intensive diabetes management with insulin pump is a durable and effective mean of optimizing glycemic control in pediatric patients and improving their quality of life [6]. Hospital UKM pioneered the use of insulin pump therapy in children and adolescents with Type 1 Diabetes in Malaysia since April 2004. There is careful selection of patients who are motivated, knowledgeable about carbohydrate counting and willing to do home blood glucose monitoring at least four times a day. Parents must be able to pay for the pump and monthly maintenance cost, as the health authority currently does not fund the insulin pump treatment. This study aims to evaluate the effectiveness of pump therapy and its impact on metabolic control among our patients with Type 1 Diabetes. This will be the first available data for our local context.

MATERIALS AND METHODS

This was a retrospective cohort study where we reviewed 22 patients with Type 1 Diabetes started on insulin pump therapy between April 2004 and December 2009 from our institution. 4 patients were excluded from this study. One had subcutaneous insulin resistance, two did not attend the clinic regularly and one patient was switched back to multiple insulin injections due to self manipulation resulting in hypoglycemia. 18 patients were enrolled and all of them were initially on multiple daily injections of long and short acting insulin. The main indications of pump therapy included patients' or parents' preferences, poor glycemic control, glycemic variability with hypoglycemia and wanting a more flexible lifestyle. Patients were admitted for pump initiation and all used the Medtronic pump. There were no other changes in the diabetes management (general counseling, dietary management) apart from a change from multiple daily injections to pump therapy. Data on background characteristics e.g. gender, age of diagnosis of Type 1 Diabetes, duration of Diabetes, age of initiation of insulin pump therapy and duration of pump treatment were recorded from patients' medical files.

The annual mean HbA1c before and after pump therapy were compared with HbA1c at the start of treatment. HbA1c was measured using the DCCT-equivalent ion exchange HPLC (High Performance Liquid Chromatography) method (Adams Arkray) with normal range being 4.4-6.4% in our centre. Similarly the annual mean weight and height of patients before and after treatment were also recorded. The annual mean body mass index (BMI) was calculated based on formula BMI = weight (kg)/ height(m)^2 . The body mass index standard deviation scores (BMI SDS) were derived using the Epi Info programme based on 2000 CDC growth charts from the CDC website (www.cdc.gov/growthcharts). The annual mean BMI SDS before and after pump therapy were compared with BMI SDS at the start of treatment.

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Corresponding Author: Ooi Hooi Leng, Paediatric Endocrine Fellow, University Kebangsaan Malaysia Medical Centre, Paediatric Department, Jalan Yaacob Latif, Bandar Tun Razak, Cheras, 56000 Kuala Lumpur, Malaysia Email: ooihooileng@hotmail.com

Descriptive statistics were used to describe the cohort. Data were presented as mean ± standard deviations (SD) with 95% confidence interval. Statistical analyses were performed using SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). The differences between the observed annual mean HbA1c or BMI SDS before and after pump therapy were evaluated by using paired t - test. Statistical significance was defined as $p<0.05$.

Patients were also interviewed regarding their opinion on pump therapy using the following eight questions listed in Appendix. This was a face-to-face, structured interview with close-ended questions conducted either before or after their clinic visit. Three patients from outstation were interviewed via phone using the same questionnaire as their appointment date was rescheduled. The first author or the medical officer Dr Wong conducted the interview. Only patients were interviewed and their participation was totally voluntary. Parental consent was obtained before the interview and we managed to recruit 15 out of 18 patients (83%) for the purpose of this study.

RESULTS

18 patients with mean age of 14.6 ± 5.5 years old who were on insulin pump therapy from April 2004 to Dec 2009 were included in this study. 56% were male. The mean age of diagnosis of Type 1 Diabetes was 6.4 ± 3.1 years old with the mean duration of diabetes 8.3 ± 3.9 years. The mean age of starting insulin pump was 10.9 ± 4.5 years old. The mean duration of insulin pump treatment was 3.7 ± 2.0 years with six patients used insulin pump for at least six years at the time of data collection. The clinical characteristics of our study sample were shown in Table I below.

There was reduction in annual mean HbA1c throughout the six years after starting insulin pump when compared with HbA1c at the start of treatment. The annual mean HbA1c dropped 0.6 % in the first year of pump use (8.1 ± 1.2%) when compared with HbA1c at the start of treatment (8.7 ± 1.5%). The value then gradually increased from second year to fourth year of pump use before it dropped again in the fifth and sixth year of treatment. However when the differences between the annual mean HbA1c after using pump were compared with HbA1c at the start of treatment, only the differences in the first two years of treatment were statistical significant. The differences in mean annual HbA1c in the fifth and sixth year of treatment were not significant despite lower in actual HbA1c value.

On the other hand, the annual mean BMI SDS in the first year of insulin pump was the same as the BMI SDS at the start of treatment (-0.1 ± 1.2). Since then, the annual mean BMI SDS showed a small increasing trend from second year to sixth year of insulin pump treatment with the maximum value at the sixth year of treatment (0.7± 1.4). Nevertheless, when the differences between the annual mean BMI SDS after using pump were compared with BMI SDS at the start of treatment, there was no significant difference between them statistically. 15 out of 18 patients (83%) agreed to be interviewed. 80% of them were happy using the insulin pump (minimum score 4 out of 5). The main reasons cited by patients were there was no need for injection while on insulin pump (50%). Other reasons included flexibility in adjusting the basal rate, the pump was easy to use, flexible lifestyle and better glycemic control. Before using the pump, 40% of our patients (6/15) had occasionally eaten without injection (maximum score 3 out of 5) . After using the pump, 47% (7/15) of them had occasionally eaten without giving insulin bolus (maximum score 3 out of 5). 47% of patients (7/15) had more symptoms of hypoglycemia after using the pump (maximum score 3 out of 5). All of them said insulin pump was very easy to use (minimum score of 4 out of 5). Patients largely preferred insulin pump treatment over multiple daily injections of insulin as evidence by 73% of patients (11/15) did not want to switch back to insulin injection. Three patients were unsure and one patient would not mind switching back to injection. 73% of them (11/15) would also recommend insulin pump to another diabetic patient while the remaining were unsure.

DISCUSSION

As the importance of strict glycemic control in Type 1 diabetes becomes evident, use of insulin pump therapy in children and adolescents has become popular. However, there is controversy regarding long term usefulness of insulin pump therapy to lower HbA1c and improve glycemic control in Type 1 diabetes patients. Results of many studies vary with respect to the ability of insulin pump to sustain durable lower HbA1c levels after first 6 to 12 months [7,8,9]. Our study proved that annual mean HbA1c was lower compared to HbA1c at the start of treatment throughout the six years of insulin pump therapy even though only the reduction in the first two years of treatment were statistically significant. This change was likely not due to a transient placebo effect. However it would be better if there was a control group on multiple daily injections of insulin running parallel to the insulin pump patients. The finding also echoed well with many studies that insulin pump therapy improved glycemic control and resulted in sustainable reduction of HbA1c up to two to six years of treatment [6,10,11,12,13,14,15,16]. Nimri *et al*[11] and Kapellen *et al*[17] also showed that patients with history of poor glycemic control (HbA1c > 8%) would have greater reduction in HbA1c compared to those with good control especially in the first year of treatment.

The 0.4%-0.6% reduction of HbA1c level in the first two years of pump use in our patients was clinically significant as the Diabetes Control and Complications Trial (DCCT) reported a 21% to 49% decreased risk for microvascular complications with every 1% decrease in HbA1c [3]. However the slight increase in annual mean HbA1c in the third and fourth year of pump use though the values were still lower than HbA1c at the start of treatment might be due to lack of compliance in some of the patients, entering puberty or drop in motivation after several years of pump therapy. Some patients might not be checking their blood glucose regularly at home. This illustrated the importance of ongoing education and counseling to patients on insulin pump. Annual mean HbA1c in the fifth and sixth year of treatment were actually much lower when compared with HbA1c at the start of treatment but the values were not statistically significant most likely due to our small sample size.

Table I: Clinical characteristics of patients using insulin pump therapy in Hospital University Kebangsaan Malaysia.

Characteristics (n =18)			Mean ± SD (range)
Gender	Male : 10 (56%)	Female : 8 (44%)	
Current age (year)			14.6 ± 5.5 (7.1-23.1)
Age at diagnosis (year)			6.4 ± 3.1 (1.5-12.6)
Duration of diabetes (year)			8.3 ± 3.9 (2.6-15.1)
Age at starting insulin pump (year)			10.9 ± 4.5 (3.2-19.4)
Duration of pump therapy (year)			3.7 ± 2.0 (0.6-6.3)

Table II: Annual mean HbA1c and BMI SDS before and after insulin pump therapy

	No of patients	Mean HbA1c (%)	Mean BMI SDS
1 year before starting pump	18	8.6 ± 1.2	0.0 ± 1.3
At start of pump	18	8.7 ± 1.5	-0.1 ± 1.3
1st year of pump	18	*8.1 ± 1.2	-0.1 ± 1.2
2nd year of pump	14	*8.3 ± 1.4	0.0 ± 1.5
3rd year of pump	13	8.5 ± 1.5	0.1 ± 1.4
4th year of pump	11	8.6 ± 1.4	0.2 ± 1.5
5th year of pump	9	8.1 ± 1.0	0.6 ± 1.3
6th year of pump	6	7.9 ± 0.6	0.7 ± 1.4

*p< 0.05 vs value at the start of insulin pump treatment

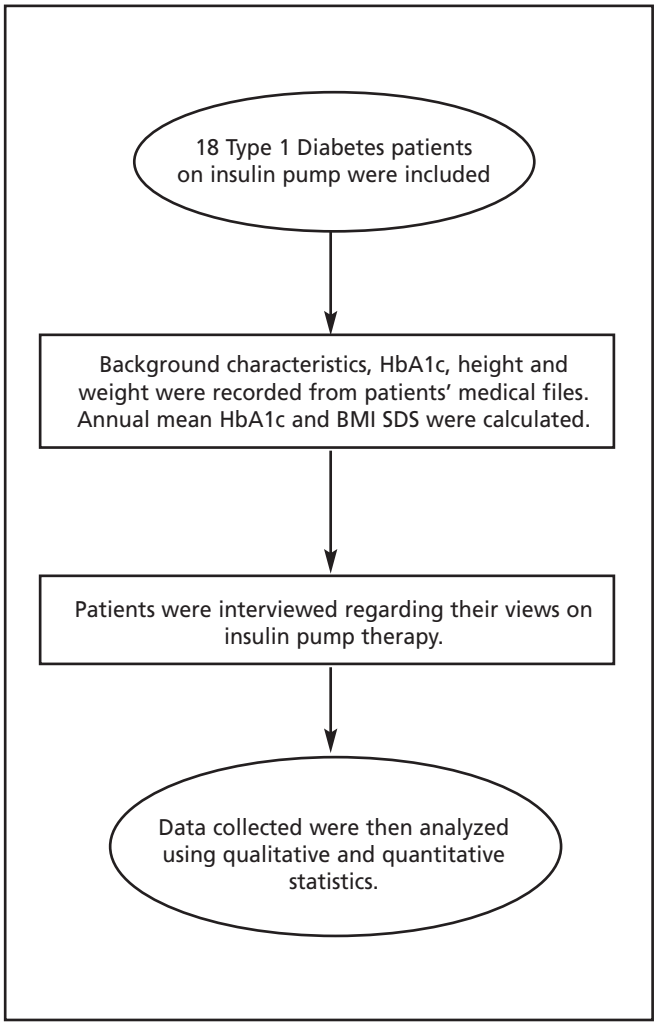

Fig. 1: Flow chart of study methodology.

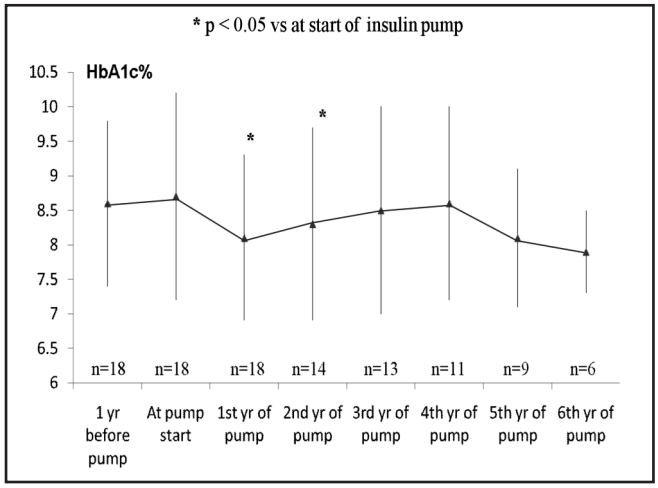

Fig. 2: Annual mean HbA1c levels before and after starting insulin pump.

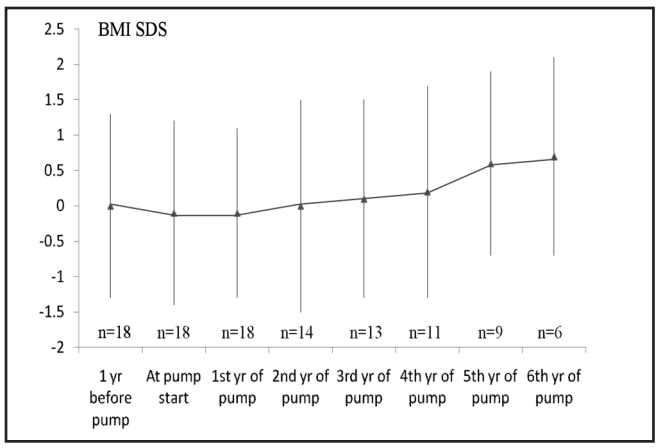

Fig. 3: Annual mean BMI SDS before and after starting insulin pump.

Appendix

Personal interview questions

1. Are you happy using insulin pump ?
   0 ----------→ 5
   Not happy Very happy
2. Give one reason why you are happy/not happy with the pump.
   _____
3. Before using the pump, I frequently eat without injecting insulin.
   0 ----------→ 5
   Never Frequent
4. After using the pump, I frequently forget to give insulin bolus when I eat.
   0 ----------→ 5
   Never Frequent
5. I experienced more symptoms of hypoglycemia after using the pump.
   0 ----------→ 5
   No hypoglycemia More hypoglycemia
6. The pump is easy to use.
   0 ----------→ 5
   Not easy Very easy
7. Do you want to switch back to multiple daily injection of insulin ?
   a.Yes
   b.Unsure
   c. No
8. Would you recommend another diabetic like you to use insulin pump?
   a. Yes
   b. Unsure
   c. No

Fig. 4

Intensive insulin treatment has been reported to cause weight gain [3], although data are conflicting. The annual mean BMI SDS in our patients showed a slight increasing trend throughout the six years of insulin pump treatment. When the differences between the annual mean BMI SDS after using pump were compared with BMI SDS at the start of treatment, there was no statistical difference between them. This showed that insulin pump therapy did not significantly increase BMI SDS in our patients as reported by other studies [6,11]. Nevertheless, we should be cautious about this potential side effect of intensive insulin treatment.

On the other hand, patients' satisfaction is difficult to assess objectively. According to Muller-Godeffroy *et al*,[7] insulin pump therapy may have substantial psychosocial benefits but randomized controlled studies are needed. In our cohort of patients, 80% of them were happy using insulin pump. Besides improving glycemic control, patients also enjoyed flexibility of lifestyle that come with insulin pump therapy. Before using insulin pump, 40% of them had occasionally eaten without injection, this was mainly true especially for snack in between the main meals. After using the pump, 47% of patients had occasionally eaten without giving insulin bolus for meals. Patients forgot to give the meal bolus and this is the major cause for suboptimal glycemic control in pump patients [18].

47% of our patients had more symptoms of hypoglycemia after using the pump though not frequent. This was not assessed objectively but just based on feedback during the interview and we did not enquire about the severity of hypoglycemia as well. However, studies had shown that insulin pump therapy improved glycemic control with a decrease in the rate of severe hypoglycemia [11,12,19]. Therefore the perceived increased symptoms of hypoglycemia in our pump patients need to be further assessed. With insulin pump, patients could eat at anytime by giving insulin bolus, insulin stacking in these patients would result in hypoglycemia. All of them said insulin pump was easy to use and not complicated. They largely preferred insulin pump treatment to multiple daily injections of insulin, as evidence by 73% of patients did not want to switch back to multiple insulin injections whereas 73% of them would also recommend insulin pump to another diabetic patient.

Results of the interview proved that our patients had high level of treatment satisfaction while on insulin pump therapy. Similar findings had been previously reported [19,20]. Low *et al* reported 89% of their adolescents and their parents had high satisfaction with insulin pump therapy. Those who had unrealistic expectations about the demands of pumping, outcomes were less positive [21]. The results of our study were limited by its retrospective design, small sample size and lack of a control group. It would be interesting to identify patients' characteristics which had positive influence on patients' response to pump therapy. However, the sample size of this study was small and unable to do a comparison.

Overall , insulin pump therapy achieve all current goals for the treatment of children and adolescents with Type 1 Diabetes i.e. near-normoglycemia, low rate of hypoglycemia, preventing or delaying long-term complications and increase quality of life [19]. Insulin pump mimics physiological insulin release better than multiple daily injections and allows greater flexibility in food intake and physical activity [15]. It also allows variable rates of insulin administration at different times of day or night and ability to administer insulin at will and in very small increments [22]. However, insulin pump is not reimbursed or funded in many countries, therefore, careful selection of patients will ensure success to achieve the target HbA1c of less than 7.5% for children and adolescents with Type 1 Diabetes [23]. Patients need to familiar with various aspects of self care and maintain close contact with members of diabetes team [24]. Persistent elevated HbA1c despite multiple daily injections, repeated hypoglycemia and high glycemic variability including dawn phenomena are the most validated indications for using insulin pump therapy in Type 1 diabetes patients [25].

CONCLUSION

Insulin pump therapy in our patients with Type 1 Diabetes resulted in sustainable improvement in glycemic control throughout the six years of treatment without significantly increasing the BMI SDS. The beneficial effects of reduction in HbA1c were statistically significant up to two years of pump therapy. There was high level of treatment satisfaction reported among our insulin pump patients. Due to the cost factors, careful selection of patients is of clinical importance and the decision remains to be individualized.

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