Quality of Life in Children With Diabetes Treated With Insulin Pump Compared With Multiple Daily Injections in Tertiary Care Center

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ABSTRACT

BACKGROUND: Continuous Subcutaneous Insulin Infusion (CSII) and Multiple Daily Injections (MDI) have been widely used as options in treating diabetes in childhood. Glycemic control is important to reduce diabetes complications; however, more focus needs to be on patients' Quality of Life (QoL). Diabetes and QoL have strong associations in terms of patients' overall health including their psychology, physical well-being, compliance with medication. A previous systematic review stressed that strong evidence to deny or prove the benefits of insulin pump therapy on health-related quality of life is deficient. The aim of this study is to assess the health-related quality of life and the psychological impacts of children with diabetes who use CSII and MDI treatment.

METHODS: A cross-sectional study included 68 pediatric patients with type 1 Diabetes (T1DM) who were treated in a tertiary center in Jeddah, Saudi Arabia. We used the Pediatric Quality of Life Inventory 3.0 Diabetes Module and this module assesses the health-related quality of life of children with diabetes.

RESULTS: Thirty-four (50%) participants found to be on MDI, of which 21 (61.8%) are males, compared to 34 (50%) patients using CSII, of which 12 (35.2%) are females. Participants using CSII had statistically significant better symptom control, less treatment difficulties but were more worrisome than MDI participants.

CONCLUSION: CSII group had better quality of life in almost all aspects even though they were more worrisome. Further studies with a larger sample size are needed to give comprehensive generalizations.

KEYWORDS: Health related Quality Of Life, diabetes mellitus, children, insulin pump, multiple daily injections

Introduction/Background

Type 1 diabetes mellitus (T1DM) is a chronic autoimmune illness that is characterized by an inability to produce insulin due to an autoimmune destruction of beta cells in the pancreas.[1] Although onset frequently occurs in childhood, the disease can also develop in adults. According to the eighth Edition of the International Diabetes Federation (IDF) Diabetes Atlas, the number of patients below 20 years of age with T1DM globally is estimated to be 1 110 100.[2] That is approximately double the number cited in the previous edition of Diabetes Atlas considering the expansion of the age group by 5 years.[2,3] The prevalence and incidence of T1DM are both increasing with great variation worldwide.[4] In Saudi Arabia, the incidence of T1DM has increased over the last 3 decades.[5] A study that was conducted by the IDF in 2015 showed that Saudi Arabia has 16 100 children (0-14 years) with T1DM, accounting for nearly one-quarter of the 60 700 total affected individuals in the Middle East and North Africa region (MENA).[4] However, the most recent report from the IDF in 2017 showed that Saudi Arabia has the highest number of people in the MENA region with T1DM with more than 35 000 (0-19 years) and has the highest number of newly diagnosed cases with 3900.[2]

An insulin pump, also known as continuous subcutaneous insulin infusion (CSII) is one of the most effective methods capable of delivering precise doses of rapid-acting insulin which can achieve near normal blood glucose levels to match the body's needs.[6] Continuous Subcutaneous Insulin Infusion (CSII) has been widely used in conjunction with Multiple Daily injections (MDI) in diabetes management; it emerged in 1970s as a method to achieve and maintain strict control of blood glucose in patients with T1DM.[6,7] Both insulin pump (CSII) and MDI have been used as options in treating diabetes in pediatric and adult population.[7,8] Several studies showed that CSII provides better glycemic control than MDI treatment.[9-11] Glycemic control is essential to reduce long-term diabetes complications.

Treating physicians need to have more focus on the patients' Quality of Life (QoL) since QoL and diabetes have strong associations in terms of patients' overall health including their psychology, physical well-being, compliance with medication.[12]

A previous systematic review by Nuboer et al stated that strong evidence to deny or prove the benefits of insulin pump therapy on quality of life is deficient.[13] The aim of that study was to compare the quality of life of diabetic children on CSII and MDI by determining which group has better symptom control, less treatment difficulties, and psychological impacts.

The use of insulin pumps for pediatric patients with T1DM has increased markedly from 1.3% in 1995 to 47% in 2016.[14] This study was a Population-based cohort study included 30 579 participants with a mean age of 14.1 years. It was conducted in more than 400 diabetes centers involved in the Diabetes Prospective Follow-up Initiative in Europe. The mean glycated hemoglobin (HbA1c) was 0.2% lower in the insulin pump users compared with the MDI users ($P < .001$), This difference was significantly different from the non-pump patients.[14] Some studies indicate other benefits of CSII, including a reduction of total insulin dose, lower incidence of severe hypoglycemia, and decreased glycemic variability.[11,15-19] CSII has shown a reduction in "dawn phenomenon" which is an increase in the level of blood glucose before breakfast.[16] Moreover, glycemic control is improved by absorbing insulin in a more stable method.[16] No significant difference was found between the 2 treatment groups in regard to gender, diabetes duration, BMI, and micro- and macrovascular complications, except for a lower prevalence of microalbuminuria in patients on CSII.[17]

Health-related quality of life (HRQOL) is a measurement of individuals' well-being considering the impact of health on their daily life. Several aspects are embraced by this definition.[20] For instance, satisfaction with individuals' health condition and the provided care concerning their illness. Additionally, how daily functioning is affected by their illness, and the stress that may accompany that.[20] Quality of life and type 1 diabetes has a strong association in terms of patients' overall health including their psychology, physical well-being, and compliance with medication.[20] Further, HRQOL influences glycemic control reflected by HbA1C level and the disease's complications.[20]

A systematic review has reported that benefits of using insulin pump therapy are contradictory.[21] Many of the included studies lack the presence of clear results, and many others had some serious methodological issues.[21] Thus, making the association between usage of insulin pump therapy and improving persons' quality of life difficult to established.[21] Furthermore, none of the available researches defined their inclusion and exclusion criteria clearly.[21] Quality of life is used restrictedly as a primary outcome on a limited number of studies, and many had no validated measures or utilized questionnaires that are not tailored to measure the participants' quality of life.[21] Several other questionnaires were not exclusive designed for insulin pump therapy.[21] Moreover, most of the research involved a low number of participants, which significantly impacted the studies' power and sensitivity in terms of study design.[21] These

shortcomings in turn prevented the possibility of generalizing any of these studies.[21] A randomized, controlled trial study reported a small sample size in each group and a narrow period of randomization phase as well.[17] Finally, the previously mentioned systematic review stressed that strong evidence to deny or prove the benefits of insulin pump therapy on quality of life is deficient.[17]

This study measures and compares the quality of life in a pediatric population with type 1 diabetes on insulin pumps, with those on multiple daily injections. This study also aimed to contribute to the literature of patients with type 1 diabetes in Saudi Arabia and to increase awareness regarding the QOL in this chronic disease. Finally, based on our knowledge, there are no studies in Saudi Arabia that focus on measuring the quality of life in this group of patients.

Methods

The study included pediatric patients who were treated in the National Guard Hospital, Jeddah, Saudi Arabia, as it is currently one of the few centers to offer CSII for their patients. The included age group ranged from 0 to 18 years with a clinical diagnosis of type 1 diabetes, who are using MDI or CSII as a treatment, based on the criteria of the American diabetes association. The sample was collected through a non-probability consecutive sampling method. The enrolled patients had to be registered via the electronic health record system (Bestcare) from its start in May 2016. On the other hand, the study excluded patients of 18 years old and above, as well as patients of the same age group who had not yet been clinically diagnosed, and patients who were not eligible for being treated at the National Guard Hospital. The included patients and their parents provided informed consent to be part of the study.

The Pediatric Quality of Life Inventory (PedsQL™) 3.0 Diabetes Module is a questionnaire that is designated to assess the health related quality of life of pediatric patients with diabetes.[20,22] The questionnaire highlights different dimensions by way of a 28-items format and 5-point Likert scale ranked 0 = never, 1 = almost never, 2 = sometimes, 3 = often, and 4 = almost always. The scale values were recoded as 0 = 100, 1 = 75, 2 = 50, 3 = 25, and 4 = 0, with higher average scores mean better HRQoL. The scales were concerned with the symptoms of diabetes, obstacles to treatment, adherence to treatment, anxiety, and communication. An available, validated Arabic version was used, obtained via https://eprovide.mapi-trust.org/. We received written permission from Mapi-Trust authorizing us to use it within an academic research program, for individual clinical use or university degree. The parent proxy-reports were completed by the patients' caregivers through phone calls, and the phone numbers were acquired from the Bestcare system. The study protocol was approved by the Institutional Review Board (IRB) of the King Abdullah International Medical Research Center (KAIMRC) with IRB number SP19/529/J.

Simple descriptive statistics were produced for means ± SD using SPSS version 26 (IBM Corp., Armonk, NY, USA). The relationship among means of different domains' scores (Parent proxy-report MDI VS Parent proxy-report Pump) were challenged using Mann-Whitney test and independent *t*-test. A *P*-value was set to be significant at ≤.05.

Results

A total of 68 children with T1DM were enrolled in the study, 34 were treated on MDI compared to 34 other participants who were treated on CSII (pump). Male children accounted for 21 of the MDI group and 22 of the CSII group. In contrast, female children accounted for 12 patients of the MDI group and for only 11 patients in the CSII group.

The mean age of children treated with MDI was 12.9 years compared to 14.6 year for children treated with pump (Table 1). BMI *z* scores were calculated to compare the weights of patients treated with MDI and Pump methods. The total Insulin daily dose was higher in the MDI group, and the mean weight and BMI was higher in insulin pump patients. HbA1c control was found to be better in patients who were treated with insulin pump in this study.

Table 2 compares and tests the differences in the problems of the disease between the 2 groups of children who were included in this study. As demonstrated in the mean of the questions, and the *P*-values of the parametric *t* test of independent samples, the health related quality of life was found to be better in children treated with insulin pump for most aspects of the disease problems.

Regarding the statements of treatment problems and difficulties, 8 out of 11 statements showed significant differences between the 2 groups of children (Table 3). Primarily, children treated with insulin pump experienced a better health related quality of life compared to the children treated with MDI, as indicated by the means of the scale of problems and difficulties which were higher for Pump group.

The results in Table 4 compared the statements regarding the problems of children worried about the disease. A significant difference between the 2 groups of children was found in the area of "going low" and "medical treatment." Children treated with insulin pump experienced less problems compared to children treated with MDI as indicated by the means of the problems and the *P*-values of the test. Non-significant differences between the 2 groups of children regarding communications problems were identified.

The findings presented in Table 5 demonstrated an overall dimensions' comparison between children treated with MDI

Table 1. Patients characteristics and clinical data.

VARIABLE	MDI PATIENTS	PUMP PATIENTS
	N = 34	N = 34
Age (year)	12.9 ± 2.8	14.6 ± 2.5
Gender (female)	13 (38.2%)	12 (35.3%)
BMI Z-score	0.708 ± 0.837	0.802 ± 0.624
HbA1c (Median)	9.6% (IQR 2.3)	8.5% (IQR 2.4)
Insulin daily dose (unit/kg/day)	1.1 ± 0.23	0.89 ± 0.41
Type of insulin	Aspart/Glargin (37%)	Aspart (all)
	RI/Glargin (60%)	
	RI/Degludec (3%)	

Abbreviations: RI, regular insulin; IQR, interquartile range.

Table 2. Diabetes problems.

PROBLEM	MDI		PUMP		*P* VALUE
	MEAN	SD	MEAN	SD	
Feeling hungry	58.1	31.2	82.4	25.0	.001*
Feeling thirsty	48.5	26.8	66.9	32.4	.013*
Going to bathroom too often	47.8	33.9	69.1	26.9	.005*
Having stomach-aches	79.4	25.7	91.9	19.2	.026*
Having headaches	77.9	27.4	94.9	10.3	.001*
Going low	65.4	26.8	68.4	24.1	.636
Feeling tired or fatigued	69.9	27.4	85.3	20.5	.011*
Getting shaky	73.5	29.5	92.6	13.1	.001*
Getting sweaty	72.8	27.1	95.6	11.5	.000*
Trouble sleeping	74.3	23.4	92.6	13.1	.000*
Getting irritable	72.1	30.0	80.1	27.4	.250

*significant

Table 3. Treatments problems and difficulties.

PROBLEM	MDI		PUMP		*P* VALUE
	MEAN	SD	MEAN	SD	
Causing pain	69.1	26.9	95.6	15.7	.000*
Getting embarrassed	59.6	33.2	74.3	30.5	.061
Arguing about diabetes care	83.1	22.0	95.6	11.5	.004*
Sticking to care plan	52.2	32.2	84.6	22.2	.000*
Take blood test	64.0	30.9	77.2	27.8	.068
Take insulin shots	67.6	25.8	100.0	0.0	.000*
Having exercise	68.4	29.1	80.9	26.2	.067
Track carbohydrates	43.4	35.5	72.8	26.4	.000*
Wear id bracelet	36.0	37.5	11.0	30.9	.004*
Carry fast carbohydrates	53.7	40.4	81.6	20.7	.001*
Eat snacks	79.4	32.8	94.9	13.5	.014*

*significant

Table 4. Worry and communications problems.

PROBLEM	MDI		PUMP		*P* VALUE
	MEAN	SD	MEAN	SD	
Worry problems					
Going low	65.4	28.9	83.1	21.1	.005*
Medical treatment	68.4	25.6	83.8	23.7	.012*
Complications of diabetes	59.6	35.9	67.6	32.9	.336
Communications problems					
Telling doctor feelings	85.3	23.1	83.1	25.2	.708
Asking doctor questions	84.6	23.8	83.1	25.2	.805
Explaining illness	69.1	33.7	82.4	25.8	.074

*significant

Table 5. Overall problem dimensions.

DIMENSION	MDI		PUMP		*P* VALUE
	MEAN	SD	MEAN	SD	
Diabetes problems	67.2	18.4	83.6	10.3	.000*
Treatment problems	61.5	17.4	78.9	8.0	.000*
Worry problems	64.4	23.8	78.2	19.4	.011*
Communications problems	79.7	20.7	82.8	20.0	.523

*significant

and children treated with insulin pump. Utilizing the total score in each dimension, the results depict a significant difference in diabetes problems, treatment problems, and worry problems. No significant difference was identified regarding the communications problems. Finally, the health related quality of life was better for children treated with pump as indicated by the means of the problems which were higher compared to children treated with MDI.

The results of correlation analysis between HRQoL dimensions and the continuous variable glycemic control (HbA1c) summarized in Table 6 above. Diabetes problems were found to have positive and significant correlation with glycemic

Table 6. Correlational analysis between HRQoL dimensions and glycemic control.

DIMENSION	MDI		PUMP	
	R	P VALUE	R	P VALUE
Diabetes problems	0.385	.025*	−0.193	.274
Treatment problems	0.288	.098	0.176	.320
Worry problems	0.323	.062	0.286	.101
Communications problems	0.046	.797	0.146	.410

*significant

control among patients treated with MDI. No significant correlation was identified between HRQoL dimensions and glycemic control among children treated with insulin pump.

Discussion

This study represents the first study that measures the health related quality of life in a pediatric population with T1DM on insulin pump therapy compared with those on MDI in Saudi Arabia. It shows that the health related quality of life is better for 68 children with diabetes treated with insulin pump compared with MDI therapy. This was demonstrated clearly in the overall PedsQL dimensions' comparison between MDI and pump treated children. Similar findings were described in the literature in other countries.[12,13,21-24]

In our study population, the body mass index (BMI) was found to be higher among pump treated patients in comparison to the MDI group. Conversely, in Kuwait, a study consisting of 326 patients in the pump group and 326 other patients in the MDI group discovered no differences between them.[23] HbA1c was found to be lower in the pump group, and that complied with the conclusions of several other studies.[9-11,16-19] Maintaining metabolic control and long-term complication prevention are not merely achieved based on the biological efficacy of treatments, however, social and mental well-being play important roles in such patients as well. Therefore, authors insisted on determining whether patients on MDI or CSII have better QoL.[24,25] In terms of diabetes symptoms, patients on CSII had statistically significant better control over symptoms than the MDI group, as shown in Table 6 above. However, controlled trials have shown that CSII is similar to—or somewhat better than—MDI in achieving glycemic control and avoiding hypoglycemic episodes.[26,27] Data from the literature and the result of our first objective support the statements—made by the American Diabetes Association (ADA), European Society for Pediatric Endocrinology, and others—of considering CSII to be initiated in T1DM patients when recurrent severe hypoglycemic attacks occur or with suboptimal diabetes control.[28] Although the questionnaire is approved internationally, and used in multiple studies, results cannot be standardized since patients answering "always" to the prompt "having symptoms (in the past month)" is not reliable and is differs from one patient to another. To overcome this hurdle, authors

asked about the number of days a patient perceived having the symptoms and ranked them accordingly. Psychological symptoms, in addition to physical ones, were also addressed in our patients in hopes of making the conclusion more comprehensive.

There are many factors that are crucial in achieving metabolic control. One of the most important factors is patient's adherence to their treatment.[29] In our study, with regard to difficulties in receiving therapy for the included patients, the questionnaire was divided into 2 main domains. First, treatment barriers. We found that patients on CSII had statistically less treatment barriers when compared to those on MDI. Similarly, many studies have shown that patients on CSII have less treatment barriers compared to patients on MDI.[13] As mentioned previously, the questionnaire that was used in the study is validated internationally and used in many different studies; results cannot be standardized since some of the patients involved in the study may not fully comprehend the questions. Nevertheless, a 2013 Kuwait study measured Cronbach's alpha coefficient for total scores of the Parent proxy-report, Arabic versions of PedsQL 3.0 Diabetes Module was 0.85.[22] This value was stated in the aforementioned study as adequate.[23] The second domain is patient's adherence to their treatment. In our study, patients on insulin pump were more likely to adhere to their treatment plan than patients on MDI. Similarly, AbdulRasoul et al showed that patients on insulin pump are more adherent than those on MDI.[23]

Psychological well-being is a very subjective term. However, this term might be defined as patients' satisfaction with all elements of life, peace and happiness, and less worries about their medical condition. In terms of patients' psychological impact, we found that participants on MDI are more psychologically affected as a consequence of the disease compared to the CSII group. AbdulRasoul et al found that social and mental well-being is now considered an important factor for achieving metabolic control and in reducing the psychological effects of the disease.[23] Having clear and good communication with patients plays an essential role in establishing better rapport between patients and healthcare providers. However, there was no significant difference regarding communication with patients on both CSII group and MDI group in our study.

Conclusion

In conclusion, the outcome of our study suggests that the CSII group experienced a better health related quality of life in almost all aspects, the exception being communication which was better in the CSII group but statistically insignificant when compared to the MDI group. However, we cannot overlook the fact that our study had a small sample size with different ages that makes difficult to make precise comparisons. This can be attributed to the inclusion of only one center and the high cost of insulin pump which hinders the distribution of these devices for patients who are eligible to receive them.[30] Our study had fewer female participants for unknown reasons, and this may have affected our results as male patients report

better QoL.[23] To the best of our knowledge, current literature contains no published study that took place in all regions of Saudi Arabia comparing the health related quality of life between the MDI and insulin pump group. Therefore, we strongly suggest that future research further explore what has been established by this study. We also recommend the enrollment of several centers in Saudi Arabia to approach for more solid evidence regarding the influence of insulin pump on improving the QoL in type 1 diabetic patients. Finally, we encourage more equal gender distribution in future studies for more comprehensive findings.

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