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Original article

Insulin Pump Therapy in Libya: A Comparative Study on Glycemic Control and Patient Outcomes in Type 1 Diabetes

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Keywords.
Type 1 diabetes mellitus, Insulin pump therapy, CSII, HbA1C, Hypoglycemia, Diabetic ketoacidosis, Libya

A B S T R A C T

This study evaluated the clinical effectiveness of continuous subcutaneous insulin infusion (CSII) versus multiple daily injections (MDI) in managing type 1 diabetes mellitus (T1DM) among Libyan patients. Conducted in June 2022, the comparative cross-sectional study compared 32 CSII users (≥6 months of therapy) with 30 MDI controls through structured questionnaires. The CSII group demonstrated significantly better outcomes, including superior glycemic control (mean HbA1c 6.97±0.61 vs 9.8±1.99), reduced acute complications (hypoglycemia: 31.3% vs 50%; DKA: 3.1% vs 20%), and higher treatment adherence (81.3% vs 43.3%). Glycemic improvement correlated strongly with pump duration, showing progressive HbA1c reduction from 7.2±0.2 at 6-12 months to 6.89±0.16 after >2 years of use. The CSII cohort also exhibited more favorable BMI distributions (78.1% healthy weight vs 33.3%) and reported enhanced quality of life. Despite these benefits, challenges in maintenance supply availability were reported. These findings provide compelling evidence for CSII's clinical superiority in Libya's context and support its wider implementation through national programs that address current supply chain limitations while ensuring proper patient training and follow-up support. The results highlight CSII as a valuable therapeutic advancement for T1DM management in resource-constrained settings

Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from impaired insulin secretion, insulin resistance, or both, leading to long-term complications affecting multiple organ systems (1). The global prevalence of DM is increasing rapidly, with the World Health Organization (WHO) estimating that approximately 3% of the world's population is affected, a figure projected to rise to 6.3% by 2025 (2). This surge is attributed to urbanization, sedentary lifestyles, unhealthy dietary patterns, and the growing prevalence of obesity, particularly in developing regions (3).

In Libya, DM poses a significant public health challenge, with the International Diabetes Federation (IDF) reporting that 11.2% of the population (around 399,200 individuals) had diabetes in 2022 (4). However, due to underdiagnosis, the actual prevalence is likely higher, with local studies suggesting that 50% of type 2 diabetes (T2DM) cases remain undetected (5). The Middle East and North Africa (MENA) region, including Libya, is experiencing a sharp rise in diabetes cases, driven by rapid socioeconomic changes and shifting lifestyle habits (6).

While type 1 diabetes (T1DM) accounts for a smaller proportion of cases, it necessitates lifelong insulin therapy. Conventional treatment relies on multiple daily injections (MDI), but continuous subcutaneous insulin infusion (CSII or insulin pump therapy) has emerged as an advanced alternative, offering improved glycemic control and quality of life (7). CSII mimics physiological insulin delivery by providing a continuous basal rate with adjustable meal-time boluses, reducing glycemic variability (8). Despite its benefits, CSII adoption in Libya remains limited, with only a few studies examining its efficacy and patient satisfaction (9). This study aimed to compares glycemic control (HbA1c), complication rates, treatment adherence, follow-up compliance, and quality of life between T1DM patients using insulin pumps (≥6 months) and those on MDI.

Methods

Study Design

comparative cross-sectional study employed an interviewer-administered questionnaire to compare type 1 diabetes mellitus patients using insulin pump therapy (for ≥6 months) with those on multiple daily injections (MDI). We collected data from 62 participants between June 12 and June 23, 2022.

The study employed a dual sampling approach, utilizing purposive sampling for insulin pump users and simple random sampling for participants on multiple daily injection therapy. Eligible participants met the

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following criteria: confirmed diagnosis of type 1 diabetes mellitus, Libyan nationality with residence in Tripoli, and capacity to provide informed consent. Additionally, insulin pump users were required to demonstrate a minimum of six months' continuous therapy experience to ensure adequate exposure to the treatment modality.

Data Collection

Data collection was conducted through face-to-face interviews using a structured 24-item questionnaire, supplemented by an online version administered via Google Forms (Appendix). The comprehensive assessment tool evaluated multiple domains including glycemic control (measured by HbA1c levels), frequency of acute complications, treatment adherence patterns, follow-up attendance rates, and quality of life indicators encompassing psychological impact, physical functioning, and social well-being. For pump users specifically, the questionnaire also examined device-related challenges such as maintenance protocols, usability factors, and troubleshooting experiences.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics 20 and Microsoft Excel. Continuous variables were presented as mean±SD, while categorical data were expressed as frequencies/percentages. Chi-square tests compared categorical outcomes (e.g., complications, adherence), and Spearman's correlation assessed nonparametric associations. Independent measures evaluated HbA1c differences, with $p<0.05$ considered significant.

Ethical Considerations

All participants provided verbal informed consent prior to enrollment. Researchers conducted interviews in private settings to ensure confidentiality, with no personal identifiers recorded in study documents. Electronic data were stored in password-protected files, while paper records were maintained in locked cabinets. Participation was strictly voluntary without financial compensation.

Results

This comparative study analyzed 62 participants (32 insulin pump users, 30 MDI patients) with type 1 diabetes. The pump cohort (43.8% male, 56.3% female) was predominantly adolescent (78.1%), with preparatory-level education (68.8%), low smoking rates (3.1%), and mostly single status (90.6%). This group demonstrated superior glycemic control (mean HbA1c 6.97±0.61) and healthier weight profiles (78.1% normal BMI, 0% obese). In contrast, the MDI group showed higher female representation (73.3%), older age distribution (83.3% adults), and greater educational attainment (66.7% higher education). MDI patients exhibited significantly poorer metabolic outcomes, including elevated HbA1c (9.80±1.99, $p<0.001$) and higher obesity prevalence (26.7% vs 0%, $p=0.003$).

Age distribution differed markedly between groups ($p<0.001$), while gender showed no significant variation ($p=0.18$). These findings highlight distinct demographic and clinical profiles between treatment modalities, with pump users demonstrating better glycemic control and healthier metabolic parameters, as mentioned in table 1.

Table 1. Demographic and Clinical Characteristics by Treatment Group

Characteristic	Pump Therapy (n=32)	MDI Therapy (n=30)	p-value
Gender			
Male	43.8 %	26.7 %	0.18
Female	26.7%	73.3%	
Age distribution			
Childhood	9.4%	0%	<0.001
Adolescents	78.1%	16.7%	
Adults	12.5%	83.3%	
Mean HbA1c (SD)	6.97 (0.61)	9.80 (1.99)	<0.001
BMI categories			
Underweight	0%	3.3%	0.003
Healthy weight	78.1%	33.3%	
Overweight	21.9%	36.7%	
Obese	0%	26.7%	

** p-value is significant when it is less than 0.05.*

A significant difference in HbA1c levels was observed between groups (pump: 6.97±0.6142 vs. MDI: 9.8±1.9895). Pump users demonstrated progressive improvement, with mean HbA1c decreasing from 7.2±0.2 (6-12 months use) to 6.89±0.159 (>2 years use). This contrasted sharply with MDI users, whose

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HbA1c remained above therapeutic targets. As showed in figure 1.

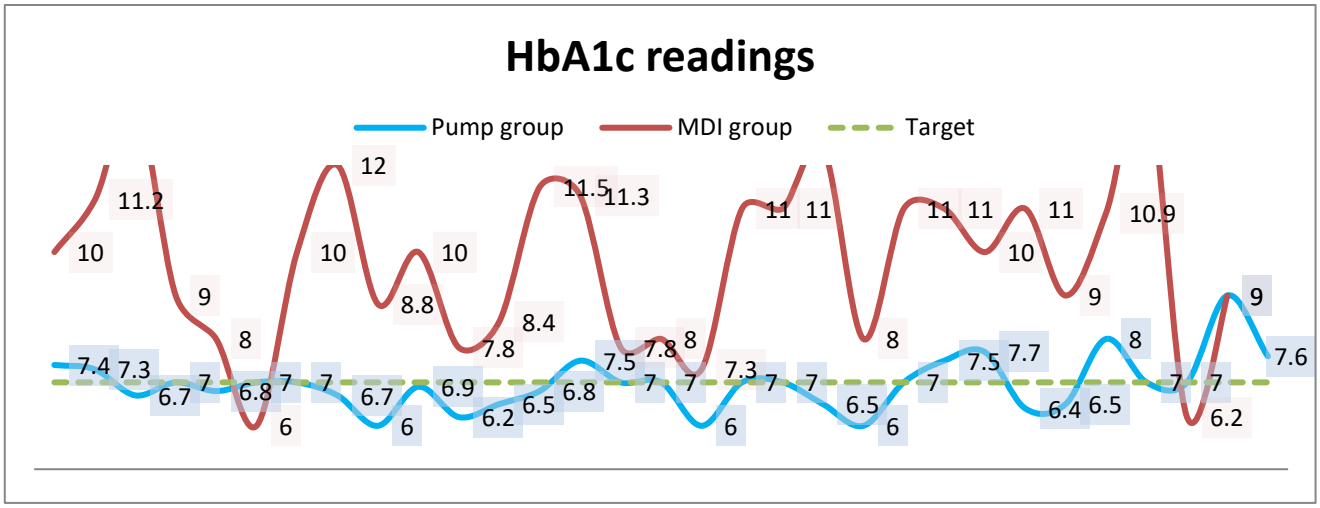

Figure 1. A histogram demonstrates HbA1c readings between both groups.

Pump therapy was associated with fewer acute events. Hypoglycemia episodes (≥4/month) occurred in 31.3% of pump users versus 50% of MDI users. Similarly, DKA incidence (≥2 episodes/6 months) was significantly lower in the pump group (3.1% vs. 20%; p=0.002, r=0.394).

Adherence rates differed substantially between groups (81.3% pump users vs. 43.3% MDI users; p=0.013, r=0.385). The pump group's higher compliance was attributed to device convenience and structured education programs, while MDI users reported difficulties with regimen complexity.

Psychological and functional outcomes favored pump therapy: 81.3% reported no psychological impact versus 66.7% of MDI users experiencing distress. Similarly, 71.9% of pump users maintained unrestricted daily activities compared to only 30% of MDI patients. Access to replacement components proved problematic, with 43.8% reporting complete unavailability and 46.9% noting intermittent supply. All pump users reported adequate training, with 68.8% describing device operation as "very easy." Most (90.6%) were knowledgeable about troubleshooting common technical issues.

The study identified several operational challenges associated with insulin pump use, with skin irritation being the most prevalent issue (reported by 56.3% of users). Additionally, 34.4% of participants experienced tubing disconnections, while 28.1% reported alarm malfunctions. All aspects of comparative were summarized in Table 2.

Table 2. Comparative Outcomes Between Insulin Pump and MDI Therapy

Parameter	Pump Therapy (n=32)	MDI Therapy (n=30)	Statistical Significance
Glycemic Control			
Mean HbA1c (SD)	6.97 (0.61)	9.80 (1.99)	P < 0.001
Acute Complications			
Hypoglycemia (≥4/month)	31.3%	50.0%	P = 0.032
DKA episodes (≥2/6mo)	3.1%	20.0%	P = 0.002
Treatment Adherence			
Daily adherence rate	81.3%	43.3%	P = 0.013
Quality of Life			
Psychological distress	18.7%	66.7%	P < 0.001
Activity limitations	28.1%	70.0%	P < 0.001

*p < 0.001 is more stringent and significant than the typical *p* < 0.05.*

Discussion

The findings of this comparative study demonstrate significant advantages of insulin pump therapy over multiple daily injections (MDI) in managing type 1 diabetes mellitus (T1DM), particularly in glycemic control, acute complication reduction, treatment adherence, and quality of life (QoL). The results align with existing literature supporting the efficacy of continuous subcutaneous insulin infusion (CSII) in improving metabolic outcomes and patient satisfaction (10, 11).

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The study revealed markedly lower HbA1c levels in pump users (6.97 ± 0.61) compared to MDI patients (9.80 ± 1.99), consistent with the American Diabetes Association's standards emphasizing tighter glycemic targets for T1DM (1) and previous research indicating superior glycemic stability with CSII (12, 13). The progressive HbA1c reduction observed with prolonged pump use (6.89 ± 0.159 after >2 years) underscores the sustained benefits of this therapy, likely due to its ability to mimic physiological insulin secretion (14). These findings corroborate international studies where CSII significantly reduced HbA1c by 0.5–1.0% compared to MDI (15), as well as the Cochrane review by Misso et al. (8) demonstrating CSII's superiority in long-term glycemic control. Additionally, pump users experienced fewer acute complications, including hypoglycemia (31.3% vs. 50%) and diabetic ketoacidosis (DKA) (3.1% vs. 20%). This aligns with evidence that CSII reduces glycemic variability (16) and supports WHO's global report highlighting complication reduction as a key benefit of advanced diabetes technologies (2). The lower DKA incidence may be attributed to improved basal insulin delivery and reduced missed doses (17), particularly relevant in Libya where *Elmehdawi et al.* (5) reported high rates of undiagnosed complications.

Pump therapy was associated with higher adherence rates (81.3% vs. 43.3%), likely due to its convenience and reduced regimen complexity (18). Structured education programs for pump users further enhanced compliance, as reported in other studies (19) and observed in Libya's pioneering pump therapy study by Badi et al. (9). Moreover, QoL assessments favored CSII, with fewer psychological distress reports (18.7% vs. 66.7%) and greater functional independence (71.9% vs. 30%). These findings support previous research indicating that pump therapy alleviates diabetes-related stress (20) and Hu's (3) observations about lifestyle impacts on diabetes management.

Despite its benefits, pump therapy faced logistical challenges in Libya, particularly regarding supply shortages (43.8% reported complete unavailability of components). Such barriers necessitate improved healthcare infrastructure, as highlighted in Al-Moosa's (6) systematic review of MENA diabetes care disparities. Skin irritation (56.3%) and tubing disconnections (34.4%) were common operational issues, consistent with global reports (22), though lower than MDI-related issues in Pickup's meta-analysis (7).

Conclusion

This study reinforces insulin pump therapy as a superior alternative to MDI for T1DM management in Libya, offering better glycemic control, fewer complications, and enhanced quality of life. However, addressing supply chain limitations and expanding patient education are crucial for optimizing CSII adoption. Future research should explore long-term outcomes and cost-effectiveness to inform policy decisions, particularly in resource-limited settings as identified in IDF reports. Given the current limitations in diabetes care infrastructure in Libya, urgent measures are needed to enhance treatment outcomes for T1DM patients. We strongly advocate for sustained government support and funding for the National Center of Diabetes and Endocrinology to optimize insulin pump therapy implementation.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this study.

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الملخص

قيّمت هذه الدراسة الفعالية السريرية للتسريب المستمر للأنسولين تحت الجلد (CSII) مقارنةً بالحقن اليومية المتعددة (MDI) في إدارة داء السكري من النوع الأول (T1DM) لدى المرضى الليبيين. في يونيو 2022، قارنت الدراسة المقارنة المقطعية 32 مستخدمًا للتسريب المستمر للأنسولين تحت الجلد (بعد 6 أشهر من العلاج) مع 30 مجموعة ضابطة من مجموعةMDI ، وذلك من خلال استبيانات منظمة. أظهرت مجموعة CSII نتائج أفضل بكثير، بما في ذلك تحكم أفضل في نسبة السكر في الدم) متوسط HbA1c 6.97±0.61 مقابل 9.8±1.99(، وانخفاض في المضاعفات الحادة (نقص سكر الدم: 31.3% مقابل 50%؛ الحماض الكيتوني السكري: 3.1% مقابل 20%)، والتزام أعلى بالعلاج (81.3% مقابل 43.3%). ارتبط تحسن نسبة السكر في الدم ارتباطًا وثيقًا بمدة الضخ، مما أظهر انخفاضًا تدريجيًا في الهيموغلوبين السكري (HbA1c) من 7.2±0.2 بعد 6-12 شهرًا إلى 6.89±0.16 بعد أكثر من عامين من الاستخدام. كما أظهرت مجموعة CSIIتوزيعًا أفضل لمؤشر كتلة الجسم (78.1% وزن صحي مقابل 33.3%)، وأفادت بتحسن في جودة الحياة. على الرغم من هذه المزايا، تم الإبلاغ عن تحديات في توافر إمدادات الصيانة. تقدم هذه النتائج دليلًا قاطعًا على التفوق السريري لـــ CSII في السياق الليبي، وتدعم تطبيقه على نطاق أوسع من خلال برامج وطنية تعالج قيود سلسلة التوريد الحالية مع ضمان التدريب المناسب للمرضى ودعم المتابعة. تُبرز النتائج CSII كتقدم علاجي قيّم لإدارة داء السكري من النوع الأول في البيئات محدودة الموارد.

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