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Diabetes and Ramadan: A multicenter study in Algerian population

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ABSTRACT

Objective: The aims of this study are to describe the behaviour of an Algerian population with diabetes and the consequences of fasting.

Methods: In 2017, a prospective multicenter study was conducted in 26 counties before and after fasting. The study concerned 901 patients with 836 type 2 diabetes mellitus (T2DM) and 65 with type 1 diabetes mellitus (T1DM).

Results: The average age for T2DM and T1DM was 57.86 ± 10.44 and 45.8 ± 17.69 years respectively. The duration of diabetes was 9.09 ± 8.19 for T1DM and 7.87 ± 5.97 years for T2DM. 89.1% of T2DM and 69.2% of T1DM fasted during Ramadan. 51.4% of T2DM were classified among the high and very high risk. The average glycemia increased (162 ± 49 mg/dL vs. 197 ± 65 mg/dl) (p 0.035×10^{-6})]. About 30% of patients had hypoglycemic episodes. Self-monitoring blood glucose (SMBG) during Ramadan was not conform to the physicians' advice and thus significantly lowered than suggested (2.6 vs. 3.4 per day). The therapeutic adjustment was mainly a reduction in insulin dose and glucose-lowering agents.

Conclusion: Diabetic patients insist on fasting regardless of their doctors' warnings. The main consequences were hyperglycemia and hypoglycemia. SMBG was less checked during Ramadan. Therapeutic education remains unsufficient and needs much more emphasis.

Contents

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1. Introduction

Globally, the number of patients with diabetes increases up to 451 million among the population aged between 18 and 99 years. If these trends continue by 2045, 693 million people will have diabetes [1].

A recent survey in 39 countries involving over 38,000 Muslims reported that a median of 93% fasted during Ramadan [2].

Diabetes is a serious problem in Algeria, both in terms of its high prevalence with a gradual increase [3,4] and its socio-economic consequences [5]. Ramadan remains an essential concern for diabetic patients as in the rest of the Muslim world. Algeria's population is 99% Muslim, and as in all majority-Muslim countries. Although Ramadan allows exemptions from fasting for high-risk patients, including people with diabetes, most of them still insist on fasting [2]. Both, in EPIDIAR study [6] and CREED study [7] a high proportion of patients with diabetes did fast.

The impact of Ramadan on biochemical parameters is different in several studies and depends on diet and drug intake [8].

Since the first ADA working group report and the update on 2010, therapeutic education coupled with new oral and injectable medication may be useful for diabetes management during Ramadan [9].

The IDAR IDF 2016 guidelines have given practitioners new approaches to the management of diabetes during Ramadan, particularly in terms of risk classification, self-monitoring and treatment adjustments [2].

Fasting during Ramadan is much more difficult during summer as temperatures are very high, with an increased risk of dehydration because of the long period of fasting which lasts up to 16 h.

Furthermore, Ramadan fasting is a dilemma for Muslim diabetics. They believe that it is a religious obligation and also a socio-cultural value [10].

The aims of our study are to describe the behaviour of an Algerian population with diabetes and the consequences of Ramadan fasting. We also want to find out the proportion of patients who fast during Ramadan, their risk regarding DAR/IDF guidelines 2016, the adjustment of treatment and SMBG.

2. Materials and methods

2.1. *Study design, participants and data collection*

It is a multicentre study conducted in 26 counties out of 48 in Algeria in 2017.

In this prospective study, data was recorded by retrieving information from the patients' files, as well as by conducting individual interviews and physical exam.

The period of our study covered 1–3 months before Ramadan and 1 to 2 months after Ramadan.

The parameters of study are demographic characteristics of population, average glucose (before and during Ramadan), HbA1c (before and after Ramadan), items of therapeutic education, risk status of fasting, adjustment of SMBG and medications (oral drugs and insulin). The study involved 88 health care professionals. Each practitioner had to randomly recruit 10 patients or more in his consultation.

The time to complete the questionnaire takes between 10 and 15 min. Then, the patient undergoes a complete clinical examination. The total duration per patient lasts more than 1 h. After Ramadan practitioners had to collect some parameters such as HbA1c, average glycemic control, SMBG, hypoglycemia events, hyperglycemia, and find out if the patients broke out the fasting.

The exclusion criteria were gestational diabetes and limitations like acute illnesses.

Once our study got the approval of the ethics committee, all patients included in the study (T1DM and T2DM) signed an informed consent.

2.2. *Statistical analyses*

The analyses were performed on all patients enrolled in the study. Continuous variables were presented as mean (standard deviation) and categorical variables as number (percentage). Percentages were calculated from the total number of patients with evaluable data (ignoring missing values).

The link is statistically significant if $p < 0.05$.

The analysis was performed using Excel and EPI info V6.

Table 1 – Baseline characteristics of participants.

	Overall	T2DM	T1DM
Type of diabetes	n = 901	836 (92.78%)	65 (7.2%)
Age, mean (year)	56.99 ± 11.54 (17–88)	57.86 ± 10.44	45.8 ± 17.69
Sex (Male/Female)	377/524	346/490	31/34
Level education	n = 787		
No formal or primary education	410 (52.09%)		
Average level	140 (17.78%)		
Secondary or university level	237 (30.11%)		
Smoking, n, (%)	n = 900 Current smokers: 84 (9.33%) Non smokers: 816 (90.66%)		
Duration of diabetes , years, mean (SD)		7.87 ± 5.97	9.09 ± 8.19
Doctor	Endocrinologist 252 (28%) Internal Medical 191 (21.2%) General practitioners 458 (50.8%)		
Height (cm), mean (SD)	164 ± 14	164 ± 09	168 ± 10
Weight (kg), mean (SD)	77.56 ± 13.71	77.72 ± 13.93	75.63 ± 13.92
BMI (kg/m^2), mean (SD)		29.04 ± 5.77 F: 29.9 ± 6.48 M: 27.8 ± 4.30 $p < 0.005$	27.14 ± 5.76 (H) F 28.8 ± 5.43 M:25.3 ± 5.65 $p < 0.005$
Waist circumference (cm), mean (SD)		99.44 ± 13.56 cm	94.58 ± 16.22 cm
SBP (mmHg), mean (SD)	n = 868; 128.85 ± 17.55	T2DM: n = 807 129.36 ± 17.46	T1DM n = 61 122.04 ± 17.42
DBP mm Hg (mmHg), mean (SD)	n = 868; 75.7 ± 11.07	n = 807 76.03 ± 11.06	n = 61 71.32 ± 11.04
HbA1c before Ramadan (%),mean (SD)	7.77 ± 1.44	7.73 ± 1.39 OADs n = 477: 7.48 ± 1.32. OADs+Insulin n = 264: 8.20 ± 1.38 Insulin n = 73 8.26 ± 1.31 $p < 10^{-5}$	8.31 ± 1.86
eGFR (MDRD) ml/mn/1.73 m^2 mean (SD)	n = 710: 101.26 ± 28.6		
>90	534 (75.2%)		
60 et 90	140(19.7%)		
30–60	31(4.4%)		
15–30	2 (0.3%)		
<15	3 (0.4%)		

Lipids mg/dL(mmol) mean (SD)		
TC	N = 636	
LDL c	163 ± 41 (4.21 ± 1.06)	
HDL c	92 ± 36 (2.37 ± 0.93)	
	45 ± 0.16 (1.24 ± 0.46)	
	– F: 47 ± 18 (1.21 ± 0.46)	
	– M: 44 ± 18 (1.13 ± 0.46)	
TG	170 ± 79 (1.92 ± 0.89)	
Medical assessments in the last 12 months		
HbA1c	98%	
Creatinine	79%	
Fundoscopy	74%	
Blood pressure	96%	
Lipids	75%	
Foot exam	73%	
ECG	76%	
Visit every 3 months	89%	
Treatment		OAD: n 478 (61.04) OAD + insuline : n = 264 (33.71%) Insulin: n = 41 (5.23%)

n: calculated based on the following number of participants.
SD: standard deviation.
SBP: systolic blood pressure; DBP: diastolic blood pressure.
eGFR: Estimated Glomerular Filtration Rate (GFR).
MDRD equation (MDRD = Modification of Diet in Renal Disease Study).
HbA1c: glycated hemoglobin.
TC: total cholesterol, LDLc: low-density lipoprotein, HDLc: low-density lipoprotein; TG: triglyceride.
OADs: oral anti-diabetic drugs.

Table 2 – Percentage of patients who fasted and those who did not fast (T1DM and T2DM) according to the level of risk of fasting (IDF-DAR 2016).

Risk status (IDF-DAR)[2]	N of patients who don't fasted		N (%) of patients who fasted		Overall	
	T1DM	T2DM	T1DM	T2DM	T1DM	T2DM
Very high	11	42	19 (63.3%)	173 (80.5%)	30	215
High	7	29	18 (72.0%)	239 (89.2%)	25	268
Moderate/low	2	20	8 (80.0%)	333 (94.3%)	10	353
Total	20	91	45 (69.2%)	745 (89.1%)	65	836

(IDF-DAR)[2]: International diabetes Federation- Diabetes and Ramadan International Alliance.
T1DM: $KHI^2(\chi^2) = 1,12$ ($p = 0,570$).
T2DM: $KHI^2(\chi^2) = 26,50$ ($p < 10^{-5}$).
T1DM + T2DM: KHI^2 (χ^2) = 32,84 ($p < 10^{-7}$).

Table 3 – Difference between HbA1c before and post Ramadan. (%) and mean glycemia before and during Ramadan in patients who fasted.

HbA1c, n, (%)			
	T1DM	T2DM	Global
Number	n = 36/45	n = 566/745	n = 602/790
Extreme values	−0,90% to +1,50%	−2,70% to +4,90%	−2,70% to +4,90%
Mean	−0,008%	−0,084%	−0,079%
SD	0,573%	0,541%	0,542%
P value	0,93095	0,00026	0,00038
Mean glycemia (mg/dL)			
Number	n = 25/45	n = 423 /745	448/790
Extreme values	−280 to +135	−270 to +250	−280 to +250
Mean	−51.3	−38.0	−38.7
SD	82.7	56.5	58.2
P value	0.00487	0.00000	0.00000

SD: standard deviation

3. Results

3.1. *Baseline demographic and clinical characteristics (Table 1)*

A total of 901 patients with diabetes (377 men and 524 women) was enrolled with 836 T2DM (92.7%) and 65 T1DM (7.2%). The overall mean age is 56.99 ± 11.54 (17–88 years), 57.86 ± 10.44 years for T2DM and 45.8 ± 17.69 years for T1DM. The duration of T2DM is 7.87 ± 5.97 years and for T1DM 9.09 ± 8.19 years.

50% of investigators are general practitioners and 50% specialists in the field.

The mean (SD) of weight and height are 77.66 ± 13.71 and 164 ± 14 cm respectively.

The BMI differs statistically ($p < 1\,0^{-6}$) according to sex with an average of 28.89 ± 6.3 among women and 27.6 ± 4.47 among men. It also differs significantly according to the type of diabetes (p = 0.011). It averages 27.14 ± 5.76 in T1DM and 29.04 ± 5.77 in T2DM.

The waist circumference mean (SD) in 809 patients is 99.07 ± 13.83 cm. It is a significantly different according to sex (p = 0.019) with 97.70 ± 13.40 cm for men and 100.02 ± 14.06 cm for women. The abdominal obesity diagnosis was selected according to ATPIII criteria [11].

The mean (SD) of SBP recorded in 868 subjects (96.33% of cases) was 128.85 ± 17.55) and 75.7 ± 11.07) for DBP. Among 400 patients who received antihypertensive treatment and 187 (46.75% of cases) exceed the blood pressure goal (PA ≥ 140/85).

The T2DM HbA1c mean is 7.73 ± 1.39%. However, patients treated with only OADs had better HbA1c than patients treated with insulin or OAD + insulin (OAD n = 477: 7.48 ± 1.32%; OADs + Insulin (n = 264): 8.20 ± 1.38%, Insulin (n = 73): 8.26 ± 1.31%) ($p < 1\,0^{-5}$).

The average of eDGR (MDRD) in our patients (n = 710) is 26 ± 28.6 ml/min/1.73 m^2.

The monitoring of lipids was performed in 636 patients (70.6%). The mean in mg/dL (SD) was for total cholesterol 1.63 ± 0.41, LDL-c 0.92 ± 0.36, HDL-c 0.45 ± 0.16 and triglycerides 137 ± 79.

The rate of exam analysis achieved (HbA1c, creatinine, fundoscopy, blood pressure, Lipids, Foot exam, ECG) during the last 12 months is satisfactory in our patients. The periodical check up every 3 months is compulsory.

89% of the 901 patients benefit from a social medical insurance.

Table 4 – Adjustment of treatment (before and during Ramadan): Mean daily Insulin U/day/ Mean (SD) dosing OADs treatment (mg/day) (insulin analogs: 88% of insulin prescriptions).

	Before Ramadan	During Ramadan			
		At Iftar	Suhoor	Overall	p*
Basal insulin	25.7 ± 13.6 (post diner)	23.8 ± 12.3**			0.087547
Premixed insulin	41.6 ± 19.8	23.6 ± 11.1	15.5 ± 8.0	35.4 ± 18.1	0.033963
Rapid insulin	27.5 ± 15.5	15.3 ± 7.1	8 ± 3.9	21.2 ± 10.2	0.0324
Biguanide	1872.8 ± 555.8	878.4 ± 221	831.9 ± 157.4	856 ± 194.3	0.0006
Glimeperide	3 ± 1.8	2.4 ± 1.5	1.2 ± 0.5	2.4 1.6	0.001151
Glibenclamide	14.5 ± 1.6	6.7 ± 2.6	0	6.7 ± 2.6	0.000521
Gliclazide	72.2 ± 45.6	56.2 ± 29.0	30	61 ± 28	0.1520
Repaglinide	2.5 ± 1.9	1.1 ± 1.06	1.1 ± 1.06	1.7 ± 1.1	0.000543
Acarbose	113.5 ± 34.7	50 ± 0	50 ± 0	88.5 ± 21.5	0.00079

Iftar: Pre-sunset meal.
Suhoor: Pre-dawn meal.
p*: correlation between dosing before and during Ramadan.
SD = Standard Deviation.
** : Basal injection schedule: 2 h after Iftar.

88% of patients received insulin analogs and only 12% insulin human.

3.2. Risk status of fasting

The majority of diabetic patients practice fasting and this represents 87.6%. In fact, and among 901 patients, 111 of them did not fast during Ramadan and 790 fasted with 745 T2DM (89, 1%) and 45 T1DM (69, 2%) and according to the risk classification [2], only 43.16% were allowed to fast (Table2). 56, 8% of patients fasted in spite of a high and very high risk while 80% of the patients with a high and a very high risk who did not fast (Table 2).

Does the percentage of fasting patients differ significantly according to the level of risk?

Concerning T1DM, there is no significant difference ($\chi^2 = 1.12$ $p = 0.570$).

Concerning T2DM, there is no significant difference ($\chi^2 = 26.50$ $p < 1\,0^{-5}$).

For both T1DM and T2DM, there is no significant difference ($\chi^2 = 32.84$ $p < 10^{-7}$).

The number of fasted days ranges from 1 to 30 days, averaging 27.1 ± 5.6.

It varies significantly according to the type of diabetes ($p = 0.049$). The number of fasted days was on an average of 24.5 ± 8.0 in the T1DM, 27.2 ± 5.5 in the T2DM. This number also varies according to the risk involved ($p < 10^{-6}$); it is on an average of 26.2 ± 5.5 of high-risk patients, 25.9 ± 6.7 in patients of a very high risk, and 28.4 ± 4.5 in patients with a medium/low risk. It has also been noticed that 44% of the patients practice fasting outside Ramadan.

Among fasting motives invoked by patients, the markers of cultural and religious identification dominate responses. There is also the feeling of belonging to a group (comfort zone) and thus there is no need to skip fasting.

The decision to fast or not to fast strongly depends on the educational level. It should be noted that 46% of patients who fasted had no formal or primary education level.

3.3. Impact of Ramadan on the glycemic balance

Fasting in Ramadan leads to an increase in blood glucose. Both, in T1DM and T2DM, the mean glycemia before and during Ramadan was (162 ± 49 mg/dL versus 197 ± 65 mg/dl) ($p = 0.035 \times 10^{-6}$). The HbA1c before and after Ramadan is respectively (7.77% ± 1, 44 versus 7.82 ± 1.27%) ($p < 10^{-6}$). For patients who fasted, the HbA1c was available for 35/45 T1DM and 566/745 T2DM and for glycemic average information was available for 25/45 T1DM and 423/745 T2DM (Table 3).

For HbA1c, the difference is significant only for T2DM. This is partly due to the small number of T1DM patients. For blood glucose, the difference is significant in the two types of diabetes, more marked in T2DM (Table 3).

3.4. Adjustment of treatment

The adjustment of treatment was part of the therapeutic education program provided before Ramadan. It was performed by practitioners and was done to 718 patients (79.7%). It dealt with adjustment on OADs or insulin. A reduction in OADs was decided in 257 patients (32.6%) out of the 788 patients receiving at least one OAD. A decision to stop OAD (Glibenclamide) was done on 42 patients (5.3%).

The reduction in the number of insulin injections was decided on 111 patients (29.0%).The reduction of insulin doses was decided on 271 patients (70.7% of cases). Both the reduction in the number of injections and insulin doses was decided on 103 patients (26.9% of cases).

When we compared the period of treatment before and during Ramadan on all the patients, we found out that there was a significant reduction in the dose of OADs and insulin's (except for basal insulin) (Table 4).

3.5. Education; Self-monitoring blood glucose; hypoglycemia

Patients followed an education program on the following items: fasting, hyperglycemia, hypoglycemia, and practice of

SMBG during Ramadan, when to stop fasting, dietetics and treatment adjustment.

The education program was only provided to 77% out of patients, according to individual or group patients. Most of the diabetics' patients (80%) were educated one month before Ramadan and 20% two months before Ramadan.

Among the 790 patients who fasted, the 3 quarters of the patients affirmed that they have respected the dietetic measures and orientations during Ramadan.

The SMBG was done by 686 patients (76.1% of cases). The practice of SMBG decreased during Ramadan and was from the recommendations provided during the pre-Ramadan education. The frequency average of SMBG before Ramadan was 3.5 ± 1.4 per day and during Ramadan 2.6 ± 1.1 per day. However, we noticed that the post Iftar (main meal) glycemia was less controlled by the patients to avoid knowing the rate of glycemia.

It goes without saying that the main meal consists of various dishes which are most of the time fat and very calorific. This results in the increase of glycemia.

Among the patients who stopped fasting, 31.1% represented T1DM and 18.5% represented T2DM. The reasons are multiple and mainly dominated by hyperglycemia and hypoglycemia.

In 106 cases (13.4%), patients had to stop fasting because of hyperglycemia. Hyperglycemia was more frequent in 10 T1DM patients (15.4%) versus 96 T2DM patients (11.5% of cases) ($p < 10^{-3}$).

Hypoglycemia was observed in 182 cases (20.2%) and was more frequent in T2DM: 12 T1DM patients (18.5% of cases) had hypoglycemia versus 170 T2DM patients (20.3% of cases) ($p < 10^{-3}$).

The number of hypoglycemia reported in 135 patients, ranged at an average of 2.87 ± 2.33. In 112 cases (61.5%) of hypoglycemia was documented with an average of 59 ± 10 mg/dl. In 23 cases (12.6%), the severe hypoglycemia led to the immediate break of the fasting.

Hypoglycemia occurs in patients with a high and a very high risk versus patients with a moderate/low risk ($p = 0.0026$).

42 patients (42/790) who required hospitalization have hyperglycemia (35.7%), infection (23.8%), hypoglycemia (21.4%), dehydration (7%), diabetic foot (7.1%), thrombosis (2.4%) and others reasons (15.3%) which one case of diabetic ketoacidosis.

4. Discussion

The aims of our study are to describe the behaviour of an Algerian population of patients with diabetes and complications of Ramadan fasting.

For T2DM treatment, 57.05% took OADs, 31.57% OADs + insulin and 8.72% insulin. Thiazolinidiones and SGLT2 - inhibitors are not marketed in Algeria. Two therapeutic classes are available (DPP4 inhibitors, GLP1 agonists) but unfortunately not reimbursed by medical insurance, which limits their prescriptions. These classes have demonstrated in many studies their safety during Ramadan, especially for their low risk of hypoglycemia [9]. Considering the follow up of the different exams (HbA1c, creatinine, fundoscopy, Blood pressure, Lipids, Foot exam, ECG, Visit every 3 months) conducted on patients during the last 12 months, we came to the conclusion that 75% of the required exam were made by our patients. This indicates a significant improvement in the management of diabetes in its different aspects.

The mean of HbA1c of T2DM was 7.73 ± 1.39%. However, patients treated only with OADs had a better HbA1c than patients treated with insulin or OADs + insulin.

For Ramadan, it is still a big problem for doctors because the majority of diabetic patients practice fasting. Indeed, 790 patients (87.6%) fast during Ramadan (89.1% of T2DM, 69.2% of T1DM). This percentage is higher than the results from EPIDIAR study where the percentage of patients who fasted was 43% for T1DM and 86% for T2DM [6]. According to the risk classification [2], only 43.16% of patients were allowed to fast. Since the first ADA working group report on the recommendations in 2005 [12] and the update in 2010 [13] and the new practical guidelines of IDAR IDF [2], patients' risk classification for fasting during Ramadan has greatly facilitated the task for practitioners. Nevertheless the patients insist on fasting despite all the dangers and consequences. The last recommendations insisted that a pre-Ramadan assessment is vital for any patient with diabetes who intends to fast in order to evaluate risks [14].

The total of day's fasted (mean ± SD) was 27.1 ± 5.6 versus 27 for EPIDIAR [6] and 27.3 ± 5.4 for CREED study [7].

Patients who fasted ≥ 15 days was 85.9% versus 78.7% in EPIDIAR and 94.2% in CREED studies [6,7].

Fasting outside Ramadan was 43.9% versus 29.9% in CREED Study.

The differences that appeared of these studies lies on the methodology based on the retrospective nature of EPIDIAR and CREED studies conducted in different seasons.

In our study the number of fasted days is of an average 24.5 ± 8.0 in the T1DM, 27.2 ± 5.5 in the T2DM with a statistical significantly difference ($p = 0.049$).

In our data the percentage of patients who fasted every day during Ramadan was 55.9% versus 63.6% in CREED study [7].

The number of fasted days varied according to the risk involved ($p < 10^{-6}$); it was of an average 26.2 ± 5.5 with a high-risk and 25.9 ± 6.7 in patients with a very high risk and 28.4 ± 4.5 in patients with a medium or low risk.

The IDAR IDF practical guidelines insisted on the role and position of religion, which is entirely patient-friendly. Religious fasting is not intended to create excessive hardship and ill individuals are exempt from fasting [2]. However, many Muslims with diabetes choose to fast during Ramadan for religious, cultural or social reasons. We also found that 46% of patients who fasted have no formal or primary education.

There was a significant increase in glycemic average in both types of diabetes before and during Ramadan and an increase in HbA1c (Table 3), mainly in T2DM. Several hypotheses can explain this imbalance among others, the non-compliance with dietetics (an increase in food and/or sugar intake), not acknowledged by patients, the systematic reduction of the doses of OADs and insulin (Table 4). According to our questioning with patients, we found out that the patients

and the practitioners are mostly afraid of hypoglycemia and consequently reduce the doses of insulin or OADs.

The EPIDIAR study has shown that the incidence of severe hyperglycemia has been shown to increase 3-fold in T1DM patients and 5-fold in T2DM patients who fasted during Ramadan [6].

Several studies have shown that Ramadan did not alter biochemical parameters in T2DM. However in others studies, there is either an increase or a decrease in biochemical parameters [8,15].

A significant reduction in hyperglycemic events was observed during Ramadan in diabetics, when continuous glucose monitoring system (CGMS) was used [16].

Adjustment of treatment was part of the therapeutic education program provided before Ramadan. It was performed in 79.7% of patients.

When we compared the period of treatment before and during Ramadan on all the patients, we found out that there was a significant reduction in the dose of OADs and insulin's (except for basal insulin) (Table 4).

For SMBG we have not been confronted, as in other studies, with the fact that the practice of SMBG means the break of fasting [17]. On the other hand, we found out that during Ramadan patients did not only perform less self-monitoring but also avoided controlling the main blood sugar post Iftar, which is the main meal and source of glycemic increases. Other behaviors were noticed in other studies such as the fact of avoiding going to doctor's checking before Ramadan [18,19].

In our study, we gave to most of patients a therapeutic education one month before the results went below our expectations as our therapeutic education lasted only one month (77% of cases) before Ramadan instead of two or three months as the international standards require it in such [20–24].

Patients continue to insist on fasting since more than 50% were classified with a high and a very high risk. These same patients were forced in 50% of cases to break up their fasting. The doctor and the religious agree on the recommendations but there is still a lot of preparation work with the patients, their families and the society because it is up to the patient to make the final decision to fast or not to fast.

For dietary aspects, the problem already exists before Ramadan with patients who do not respect lifestyles correctly.

The incidence of hypoglycemia was highest in T2DM ($p < 10^{-3}$) but only 61.5% was documented. Thus patients with severe hypoglycemia were required to stop fasting.

Hypoglycemia occurs in patients with a high and a very high risk versus moderate/low risk.

Many studies demonstrated that patients who fasted during Ramadan without attending a structured educational session had an increase in hypoglycemia, whereas those who attended an educational program focusing on Ramadan had a significant decrease in hypoglycemia [25].

The reasons of hospitalization were hyperglycemia (35.7%), infection (23.8%), hypoglycemia (21.4%), dehydration (7%), diabetic foot (7.1%), thrombosis (2.4%) and other reasons (15.3%) with one case of diabetic Ketoacidosis.

5. Conclusions

On a sample of 901 patients with diabetes and dominated by T2DM, our main concern was to find out about the behaviors of the population of diabetic patients during Ramadan. This study allowed us to have some results that are known at the international level with some specificity related to Algeria. More than 80% of the patients fasted during Ramadan despite the advice of their medical doctors. These patients are classified with a high and a very high risk and fasting caused an increase in blood glucose. We were also surprised by the behaviour of patients who reduced the frequency of SMBG and the avoidance of the main post-Iftar glucose measurement. The dietary habits were not respected. On the therapeutic side, there has been a reduction in doses of OADs and insulin by the patients and the practitioners who were afraid of hypoglycemia. In spite of our attempt at a pre-Ramadan education program carried out with the majority of patients one month before fasting the results were not satisfactory. It is essential that health professionals put more action, reinforce and improve the education of patients with diabetes to allow them to know their risks during Ramadan and accompany them to ensure good conditions and especially avoid acute complications.

The therapeutic education program should extend beyond the patient and take into account the socio-cultural, religious aspects. Moreover, an ideal health care should include the recent and appropriate drugs used a prescribed at the international level.

Author contributions

RM and SH: contributed in writing and editing the manuscript. All others authors contributed in writing the manuscript. All authors have approved the final article.

Conflict of interest

The authors state that they have no conflict of interest.

Strengths and weaknesses

Our study is the first study concerning diabetes and Ramadan and covered a large number of participants of a sample of Algerian diabetic population. We were able to come to the conclusion concerning the behaviour of patients and health professionals during Ramadan. This allowed us to improve some shortcomings especially on diabetes education. The lack of some drugs therapeutic classes has not allowed us to have a broad idea about their effects during Ramadan.

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