



Contents available at ScienceDirect

Diabetes Research
and Clinical Practicejournal homepage: www.elsevier.com/locate/diabresInternational
Diabetes
Federation

The role of optimum diabetes care in form of Ramadan focused diabetes education, flash glucose monitoring system and pre-Ramadan dose adjustments in the safety of Ramadan fasting in high risk patients with diabetes

Mohamed Hassanein^a, Elamin Abdelgadir^{a,*}, Alaaeldin Bashier^a, Fauzia Rashid^a, Maryam Al Saeed^a, Azza Khalifa^a, Fawzi Eltayb^a, Sona Abuelkheir^a, Mohammed Abdellatif^a, Fatima Sayyah^a, Suad Khalifa^b, Fatheya Alawadi^a

^a Endocrine Department, Dubai Hospital, United Arab Emirates

^b Diabetes Educator, Dubai Hospital, United Arab Emirates

ARTICLE INFO

Article history:

Received 3 November 2018

Accepted 28 December 2018

Available online 11 January 2019

Keywords:

Diabetes and Ramadan
High risk diabetes patients
Safety of fasting
Ramadan

ABSTRACT

Background: Physiology of intermittent and prolonged fasting is known from healthy subjects. Evidence on high and very high-risk groups is lacking. The anticipated risks include hypoglycemia, hyperglycemia, dehydration and thrombosis. Education, pre-Ramadan doses adjustment, and glucose monitoring devices (Optimum diabetes care in Ramadan) is expected to lower this risk.

Aims: We aimed to assess the value of optimum care in diabetes management during Ramadan on the metabolic parameters of high risk patients with diabetes. Moreover, we wanted to assess and understand the safety of fasting in this group.

Methods: This is a prospective interventional study. Patient with high-risk diabetes who insisted on fasting. High risk patients defined as any one with type 1 or type 2 diabetes on insulin, Gestational diabetes, stage 3 kidney disease, and having history of ischemic heart disease. All patients received a Freestyle Libre continuous glucose monitoring device, and was offered to attend the clinic at any time during the study, this collectively defined as optimum diabetes care during Ramadan. Biometric (Weight, height, Blood pressure) and biochemical (Glycosylated hemoglobin A, Lipids profile, creatinine, and estimated glomeru-

Abbreviations: eGFR, estimated glomerular filtration rate; FGMS, continuous flash glucose monitoring system; CKD, chronic kidney disease; Cr, creatinine; CSII, continuous subcutaneous insulin infusion; CV, cardio vascular; DAR, diabetes and Ramadan; HbA1c, glycosylated hemoglobin A; HDL, high density lipoproteins; Kg, kilograms; LDL, low density lipoproteins; MDI, multiple daily injections; TG, triglycerides; T2DM, type 2 diabetes mellitus; T1DM, type 1 diabetes mellitus

* Corresponding author at: Dubai Health Authority, Alkhaleej Road, P.O. Box 7272, Dubai, United Arab Emirates.

E-mail addresses: MMHassanein@dha.gov.ae (M. Hassanein), EElaminAbdelgader@dha.gov.ae (E. Abdelgadir), aeKhidir@dha.gov.ae (A. Bashier), FRashid@dha.gov.ae (F. Rashid), AAlSaeed@dha.gov.ae (M.A. Saeed), AABinHussain@dha.gov.ae (A. Khalifa), FBachet@dha.gov.ae (F. Eltayb), SMAbuelkheir@dha.gov.ae (S. Abuelkheir), MAElsayed@dha.gov.ae (M. Abdellatif), FASayyah@dha.gov.ae (F. Sayyah), skali@dha.gov.ae (S. Khalifa), ffAlawadi@dha.gov.ae (F. Alawadi).

<https://doi.org/10.1016/j.diabres.2018.12.013>

0168-8227/© 2019 Elsevier B.V. All rights reserved.

lar filtration rate) were reported within 4–6 weeks before and after Ramadan.

Results: Total of 169 patients were. Majority were females 54.4% (n = 92). There was a remarkable improvement in glycemic control from 7.6 + 1.2 to 7.3 + 1.2 percent (p = 0.00). Serum creatinine showed a negligible change at the end of the study from 0.81 + 0.3 to 0.82 + 0.2 mg/dl). Only total cholesterol worsened significantly (p = 0.02).

© 2019 Elsevier B.V. All rights reserved.

1. Background

Fasting the holy month of Ramadan is a religious obligation to all Muslim individuals. The fasting hours varies between 14 and 20 h a day, for this reason, those with chronic illnesses or acutely unwell and those who do not tolerate long fasting hours are exempted from doing so.

Physiology of intermittent and prolonged fasting in healthy subjects is well understood. However, there are few studies that assessed the impact of fasting on diabetes, especially the high-risk patients. Such studies will consolidate the evidence on risk stratification on whom to fast and whom not to. Risk stratification of fasting is essential in diabetes management as well as other chronic diseases. International diabetes federation/diabetes and Ramadan guidelines (IDF/DAR) have risk-stratified fasting in patients with diabetes into Moderate/low, high and very high risk to fast [1]. Evidence on high and very high-risk groups is still scarce and needs a special focus in the future researches.

The anticipated risks during fasting include hypoglycemia, hyperglycemia, dehydration, hospitalization, diabetic ketoacidosis (DKA) and thrombosis [2–4]. Appropriate dedicated education, pre-Ramadan doses adjustment, and timely regular glucose monitoring lowers the risk of these complications [5–7]. These tools collectively will be described as optimum diabetes care during Ramadan in this article.

Monitoring of blood glucose is of paramount importance during fasting hours. Moreover, using continuous flash-glucose monitoring system (FGMS) showed remarkable glucose variability and hypoglycemia during fasting time [8,9]. FGMS is an expensive tool compared to self-monitoring of blood glucose, therefore, sparing it for the high-risk patients is advisable.

Minimal data are available regarding the impact of fasting on biochemical and biometric parameters in people with diabetes. This is of increased importance as Ramadan in most geographical regions occurs in summer months where the fasting hours range from 14 to 20 h as well as high temperature of the summer months. Indeed, fasting Ramadan results in a modest weight, lipids profile, and psychological changes in healthy individuals as well as patients with diabetes with or without complications [10–13].

Since Ramadan focused diabetes education has been shown to reduce the fasting related risks during Ramadan in low risk diabetes patients [5], this study is the first study that aims at understanding the biochemical and biometric changes in the high-risk group with diabetes while provided with optimum care.

2. Patients and methods

This is a prospective interventional single-centered trial conducted at Dubai Health authority (DHA), the main government sector in the emirate of Dubai, UAE. Recruitment and completion of data collection was in 2016. The study was approved by the local research ethics committee and was funded by a grant from Al-Jalila Foundation, UAE. We counselled all the patient with diabetes who were categorized as at high risk of fasting (as per the IDF/DAR risk stratification scale [1], who insisted on fasting despite the medical advice.

We included patients 18–75 years of age, with a known diagnosis of type 2 diabetes mellitus, who are using insulin, patients with concurrent renal disease, history of ischemic heart disease, and patients with gestational Diabetes, those patients were selected at convenience 1–2 months before Ramadan, counselled, and asked to sign an informed consent.

General aim of the study:

To assess the value of optimum care of diabetes during Ramadan, on the biometric and biochemical parameters of high risk patients with diabetes.

Primary objectives:

To assess changes in biometric parameters (blood pressure and weight) as well as biochemical changes (glycemic control, lipids profile and renal function) before and after Ramadan in people with diabetes considered as high risk of fasting.

Secondary Objectives:

- To know the risk of hospitalization due to fasting.
- To assess the frequency of breaking the fast (due to hypo or hyperglycemia).
- To evaluate the number of days fasted.

2.1. Procedure

The study was conducted 4–6 weeks before Ramadan to 2–4 weeks after Ramadan. The study flow through three phases, phase 1 (4–6 weeks before Ramadan) for counselling, education, and doses adjustment. Second phase (during Ramadan) for followup of adherence, trouble shooting, and the third phase (2–4 weeks after Ramadan) for completion of the study and any further medications alterations.

We screened all patients with diabetes 4–6 weeks before Ramadan. Those who decided to fast were provided with 90 min Ramadan focused education to empower them about

the diabetes management during Ramadan (Phase 1). Moreover, the session also covered the Freestyle Libre sensor installation techniques, functionalities of the flash glucose monitoring device and troubleshooting tips. Following the educational sessions, patients signed the informed consents. This was followed by collection of demographic data as well as the baseline biometrics parameters (blood pressure, weight, and BMI). Additionally, detailed data on treatment profile, medical history, history of hospital admission during the previous 3 months prior to study enrollment was recorded.

Patients were then asked to proceed to laboratory to give baseline blood tests that included HbA1c, Creatinine, Urea and electrolytes, eGFR, lipids profile, urinary albumin: creatinine ratio if not done the previous two weeks.

During the same visit, all patients received a freestyle libre device and sensors. A 24-hours hot line was established to help the patients applying the study protocol, and equally to aid them in having a safer fasting.

During Ramadan (Phase 2), patients were advised to attend at least one diabetes or diabetes educator clinic, in order to download the sensor data, and to supply them with the second and third libre sensor. During Ramadan, all patients received a telephone call to reinforce the education points on breaking fasting and dose adjustment if required (see Fig. 1).

Two to four weeks after Ramadan (phase 3), all participants were seen in the clinic and had their biometric and biochemical parameters rechecked. Additionally, all patients were asked to fill a post Ramadan structured questionnaire. The questionnaire contained the following questions: Did you have symptoms of hypoglycemia? If yes, did you check your blood sugar? If yes, did this confirm the hypoglycemia?

What time did you develop hypoglycemia? If it was during fasting, did you break your fast? Did you change your insulin or oral hypoglycemic agent dose during Ramadan? Did you have symptoms of severe dehydration (extreme and unusual thirst)? Have you ever been admitted due to high or low blood sugar level or extreme dehydration? How many days did you fast during Ramadan?

2.2. Ethical approvals

The study has been approved by the ethical committee of Dubai Health authority.

2.3. Funding

This study was funded by a grant from Al-Jalila foundation of Dubai – UAE.

2.4. Definitions

A patient was considered to have diabetes as per the American Diabetes Association criteria for the diagnosis of diabetes mellitus (FBG \geq 126 mg/dL, RBG \geq 200 mg/dL, or HbA1c \geq 6.5%). Hypoglycemia was recognized when blood glucose was less than 70 mg/dL, and if the person required third-party assistance or admission to emergency room, it was considered to be severe hypoglycemia.

2.5. Data collection and analysis

All data was then entered in an excel sheet and was prepared for analysis. Paired Student's t-tests were used to test the

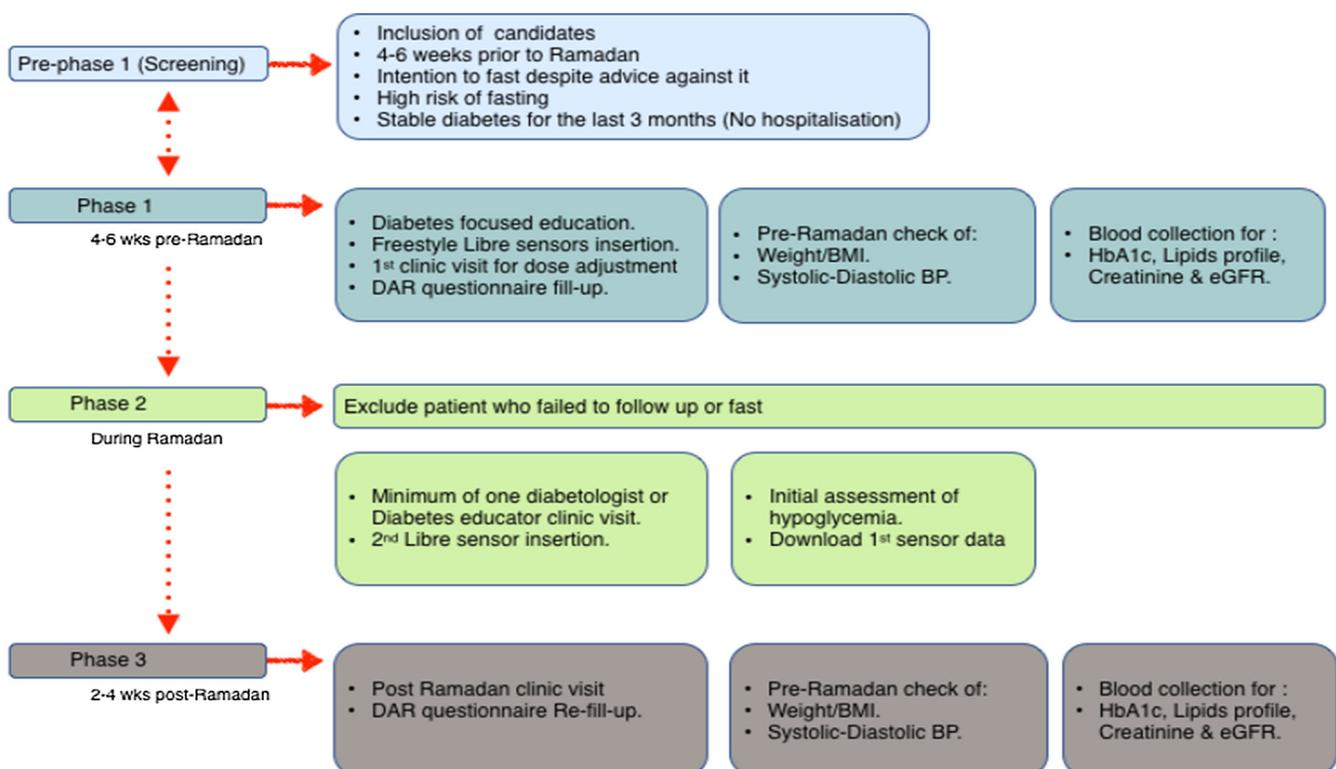


Fig. 1 – Summary of the study methodology.

significance of differences between values for continuous variables measured at baseline and at various time points. Independent t test, one-way analysis of variance (ANOVA) and Chi square (χ^2) test were used to assess the significance of differences between the groups. Continuous data are presented as the mean \pm standard deviation (SD), and categorical data are presented as frequencies and percentages. Differences with P-values ≤ 0.05 were considered to be statistically significant. Analyses were performed using Statistical Package for the Social Sciences (SPSS) version 23 (IBM Corp, New York, USA).

3. Results

Total of 195 patients recruited to the study, out of them only 169 completed the study and had their biochemical markers checked. All of them were patients with diabetes at high risk of complications if fasted Ramadan, all patients received FGMS with three sensors, and all received dedicated Ramadan education and minimum of 2 diabetes clinic visits during the study period.

Majority of participants were females 54.4% ($n = 92$). Mean age was 47.7 ± 16.5 years (minimum 18, maximum 75). Sixty five percent of the population were Emiratis nationals. Number of patients per risk – category is shown in (Table 1).

There was no significant change in weight from 84.0 ± 16.5 to 84.1 ± 16.2 kg ($p = 0.315$), while there was an improvement in glycemic control from 7.6 ± 1.2 to 7.3 ± 1.2 percent ($p = 0.000$). Both systolic and diastolic blood pressure means showed statistically non-significant reduction after Ramadan ($p = 0.336, 0.181$, respectively) Fig. 1a. Creatinine showed no significant change during the study from 0.82 ± 0.3 to 0.83 ± 0.3 mg/dl ($p = 0.311$). Total cholesterol rose from 158.4 ± 38.1 to 164.9 ± 47.4 mg/dl ($p = 0.072$), while other lipids parameters modestly changed, and likewise, did not show statistical significance (Table 2) and (Fig. 1b). There was no diabetic ketoacidosis (DKA) reported during the whole study period.

Continuous glucose assessment before and during Ramadan there was a drop of number of patient with on-target glucose reading from 61.8 ± 24.6 to 56.9 ± 27.3 ($p = 0.014$). The number of hypoglycemic episodes significantly increased during Ramadan from 3.9 ± 4.9 to 5.5 ± 5.3 ($p = 0.001$). The hypoglycemia was predominantly reported during Ramadan

between 00:00 to 06:00 and from 12:00 to 18:00 h compared to pre-Ramadan readings ($p = 0.024$ and 0.000 , respectively), Table 3.

4. Discussion

Several studies showed favorable effect of intermittent fasting on the metabolic profile of healthy individuals [10–12]. Similarly, there are few studies conducted on safety of fasting on patients with diabetes, who were on low risk of fasting [8,14]. Since the high risk and very high-risk groups used to be encouraged not to fast [1], there was not much of research work in this area [15–19]. In this study, we recruited different subgroups of patients with diabetes who were categorized as high risk of fasting. The outcome of different study objective can be classified into hypoglycemia and glycemic control, Lipid profile, weight and BP changes, as well as DKA and hospitalization during the study period.

4.1. Weight and blood pressure

In our study, the weight has not change from the before and after Ramadan fasting (83.8 ± 17 to 83.9 ± 16.8 kg, $p = 0.59$). This was noted in different studies in both healthy [10,20,21] and diabetic individuals. However, some studies have demonstrated a weight reduction in diabetic patients after Ramadan. Hassoun et al. [22] and Khattab et al. [23] have shown a weight reduction after Ramadan by around 0.68 Kg and 0.8 kg, respectively. Salahuddin et al. reported a statistically significant reduction in both weight and BP after Ramadan fasting in a group of hypertensive patients [24]. A metaanalysis by Gray et al. summarized 16 studies, showed a trend of weight reduction after Ramadan upon using the incretin-based therapy, while the opposite was observed in Sulphonyureas and pioglitazone treated patients [25]. Overall, the weight does not seem to change remarkably in both healthy and diabetic individuals.

The data on blood pressure changes after fasting Ramadan in people with diabetes classified as high-risk group is consistent with what was seen in previous studies. In a study of hypertensive group who did fast full month of Ramadan, the systolic BP decreased from 148 ± 19.6 to 132.5 ± 17.9 mm of Hg ($p = 0.0009$), while the diastolic BP decreased from

Table 1 – This table shows the demographic distribution of the study population and the number of patients in each risk subgroup.

Gender	Males	Females	Total number		
	77	92	169		
Age	Lowest	Highest	Mean		
	18	70	49.1 ± 16.4		
Nationality	Emiratis	Other Arabs	Asians		
	111	47	11		
Risk category	Type 1 DM	Type 2 DM on Insulin	Gestational Diabetes	CKD (stage 3)	Previous CV disease
Number of patients	29	68	26	20	26

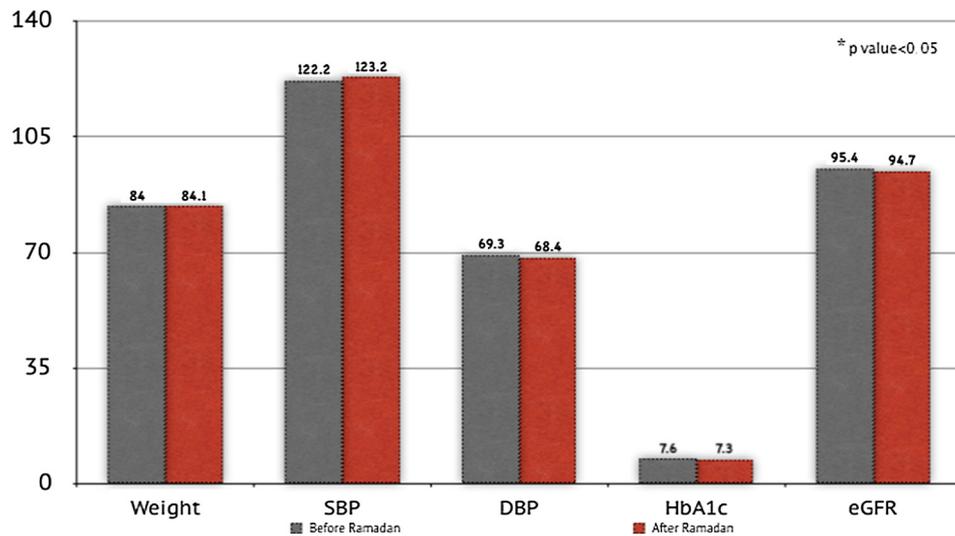


Fig. 1a – Summary of Biometric and biochemical changes before and after Ramadan.

Table 2 – This table shows the biometric and biochemical changes before and after Ramadan.

Variables	Mean ± SD before Ramadan	Mean ± SD after Ramadan	P value
Weight (Kg)	84.0 ± 16.5	84.1 ± 16.4	0.315
Systolic BP (mmHg)	122.2 ± 18.6	123.2 ± 17.5	0.336
Diastolic BP (mmHg)	69.3 ± 8.9	68.4 ± 10.6	0.181
HbA1c (%)	7.6 ± 1.2	7.3 ± 1.2	0.000
Total cholesterol (mg/dl)	158.4 ± 38.1	164.9 ± 47.4	0.072
Triglycerides (mg/dl)	145.5 ± 72.3	159.3 ± 102.6	0.065
HDL (mg/dl)	49.2 ± 15.7	49.8 ± 14.3	0.239
LDL (mg/dl)	93.3 ± 42.1	97.2 ± 53.9	0.037
Creatinine (mg/dl)	0.82 ± 0.36	0.83 ± 0.36	0.311
Estimated GFR (ml/min/m ²)	95.4 ± 29.2	94.7 ± 28.2	0.084

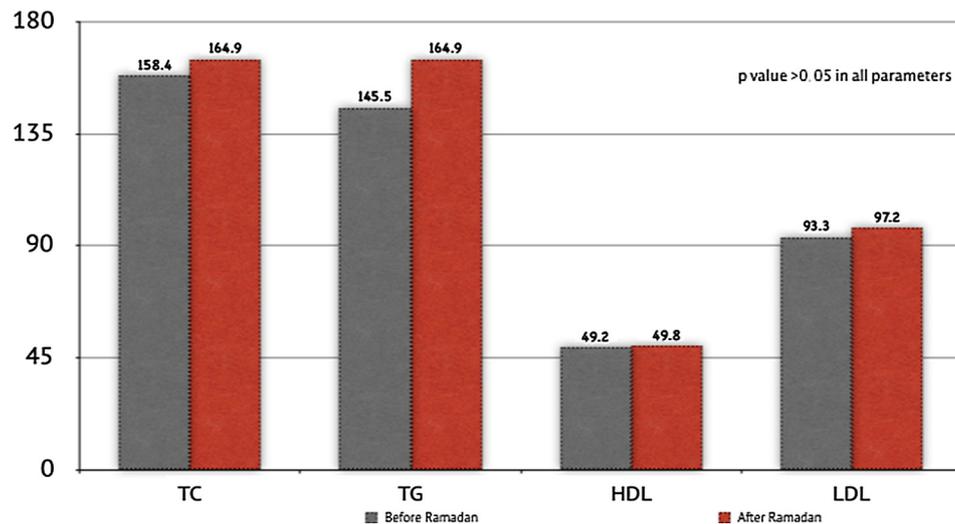


Fig. 1b – Summary of lipids panel changes before and after Ramadan.

90.4 ± 7.8 to 81.1 ± 6.3 mm of Hg ($p < 0.0001$) [26]. More recently, Norouzy A. and his groups recruited a group of hypertensive and normotensive individuals, and attached an ambulatory BP monitoring device before, during and after

Ramadan. The BP did not significantly differ before and after Ramadan in both groups. However, it is worth mentioning that there was a trend of weight gain in the hypertensive group after Ramadan [27]. Similar to many studies, our cohort

Table 3 – This table shows the FGMS readings before and during Ramadan.

	Before Ramadan Mean \pm SD	During Ramadan Mean \pm SD	P-value
Average glucose	170.8 \pm 55.0	161.3 \pm 52.3	0.081
% Above target	61.8 \pm 24.6	56.9 \pm 27.3	0.014
% In target	34.7 \pm 23.6	38.1 \pm 24.5	0.043
% Below target	3.5 \pm 5.0	5.0 \pm 7.8	0.203
Peak glucose	306.4 \pm 97.8	293.6 \pm 101.1	0.497
Number of hypo events	3.9 \pm 4.9	5.5 \pm 5.3	0.001
Average hypo duration	79.5 \pm 73.8	95.2 \pm 80.8	0.096
Lowest glucose value	70.6 \pm 39.6	61.3 \pm 24.7	0.007
Number of hypos between 00:00–06:00 h	1.2 \pm 1.7	1.4 \pm 1.7	0.024
Number of hypos between 06:00–12:00 h	0.9 \pm 1.5	0.9 \pm 1.5	0.451
Number of hypos between 12:00–18:00 h	1.0 \pm 1.6	2.0 \pm 2.2	0.000
Number of hypos between 18:00–00:00 h	0.8 \pm 1.5	1.2 \pm 1.7	0.057

The bold values denotes $P < 0.05$ is statistically significant.

had a signal of reduction in both diastolic BP and increment of systolic BP before and after Ramadan, but both did not meet statistical significance.

4.2. Glycemic control

This is a unique trial since very few studies did focus on the high-risk patients in Ramadan, and even fewer have used a FGMS [16–18]. In a recent study by Afandi et al., they monitored 21 adolescents with T1DM who did fast Ramadan, patients were divided into two groups based on HbA1c ($7.5\% \pm 0.4$ and $9.1\% \pm 0.9$) and were monitored during and after Ramadan. In this study pre-Ramadan A1c was directly proportionated with during-Ramadan glycemic fluctuations. Since the frequency of hypoglycemia, and severe hyperglycemia were significantly higher in patients with uncontrolled HbA1c prior to Ramadan. Therefore, they concluded that pre-Ramadan optimal control reduces the risks with fasting [16]. Moreover, Al-Agha et al. recruited 51 adolescents who fasted Ramadan, and similar to our study, they used Freestyle Libre CGMS. In this study 15% of participants broke the fast due to hypoglycemia, although none of the patients developed severe hypoglycemia. Interestingly, the rate of hyperglycemic episodes during fasting hours was nearly two folds the hypoglycemic episodes (1.29–0.7 episodes per day, respectively). The conclusion of Al-Agha et al. study that the optimum DM care reduces fasting risks in patients with diabetes [17].

Unlike our cohort, Al-Agha et al. showed a modest increment in the HbA1c post Ramadan ($8.16 \pm 1.64\%$ to $8.2 \pm 1.63\%$) while in our study HbA1c improved from $7.6 + 1.2$ to $7.3 + 1.2$ pre- and post Ramadan. Despite the optimum care in our group of patient, there was significant higher incidences of hypoglycemia, specially during very early morning and the afternoon (pre-breaking the fast time). We are not certain whether this could have been worse without optimum care. This strongly call for replicating the study with a control group.

On a different scope of high risk patients; a study by Alamoudi et al. compared the use of continuous subcutaneous insulin infusion (CSII) compared with those who use multiple daily injections (MDI) insulin regimen during Ramadan. Similar the former studies [16,17] there was no difference in glycemic control before and after study period using fructosamine, which may be more suitable in assessing short

term changes in glycemic control (6 weeks). Interestingly, intra-fasting glucose variability was less with CSII in comparison to MDI [18].

4.3. Lipids panel control

Lipids changes in Ramadan is an interesting controversy. While fasting for 14–20 h can theoretically improve lipids profile, the dietary habits of many Muslims during Ramadan where they tend to eat more carbohydrates and fats in their recipes could lead to unfavorable change in lipids. Hence, some studies have shown beneficial effect of fasting on lipoproteins like raised HDL and decrease in LDL level, which persist even after 4 weeks post Ramadan [28–30] while other studies have shown a rise in LDL, Triglycerides (TG) and Total Cholesterols (TC) [20,21].

In high risk diabetes population, to date, only T1DM has been studied during Ramadan fasting [16–19], in which there was no clear comments on lipids metabolism changes during Ramadan. In our study, we noticed a non-significant rise of all lipids parameters, with the TC and TG showing the highest numerical rise after Ramadan, but that did not meet statistical significance.

4.4. Kidney function

Theoretically, fasting for 14–20 h, especially in hot weather, can lead to deterioration in kidney function. Part of our study population were people with type 2 diabetes and stage 3 chronic kidney disease (CKD). In them, as well as the whole group, the change in creatinine, eGFR and the micro-albumin/creatinine ratio was negligible after Ramadan. This finding is a replication of many studies that showed relatively stable kidney function in diabetics with normal kidney function who fasted Ramadan [10,30]. Moreover, Ghalib et. Al. recruited 68 patients post kidney transplant, 35 of them did fast and 33 did not. Interestingly, both groups had a stable eGFR after Ramadan [31]. However, former studies have been challenged by other studies that showed risk of renal deterioration with fasting. Mbarik et al. has assessed fasting effect on kidney function of 60 patients with stable CKD (stable creatinine clearance of <60 mL/min/1.73 m² for 6 months before Ramadan). Seven patients developed acute renal failure dur-

ing Ramadan [32]. However, they concluded that the sample size is small to extrapolate solid recommendation out of it [32].

4.5. Diabetic ketoacidosis

Abstinence from having regular meals interrupts the daily regular insulin regimens, this, in addition to stress of fasting, post-fast heavy meals, and dehydration. All of those may collectively lead to a sort of glycemic and metabolic derangements in patients at high risk of fasting. This has been observed in different studies, when the patient did not receive special pre-Ramadan management [3,4]. However, we have not observed any DKA during our study period. This has been also reported in many studies conducted on T1DM patients [17,18].

5. Limitations

Having control group could have strengthened the study results, this should be considered in case the same study protocol has been replicated. Also, our patients didn't do frequent SMBG as they relied of FGMS. The accuracy of FGMS during fasting has not been previously tested.

6. Conclusion

Patients with high-risk diabetes who fasted Ramadan did not show significant biometric changes during Ramadan. Similarly, there was no significant change in lipids profile nor in Renal function. While glycemic control improved, non-severe hypoglycemic episodes increased during fasting. Optimum diabetes care, including Ramadan focused diabetes education, FGMS and pre-Ramadan dose adjustments could be the key for reducing the complications of fasting in high risk diabetes patients. More studies are needed in this field before any change in recommendations of fasting for such high-risk group.

Availability of materials

Please contact author for data requests.

Authors' contribution

Mohamed Hassanein: Supervision of the study, Elamin Abdelgadir: Data analysis and manuscript writing, Alaaeldin Basheir: Proposal writing, Fauzia Rashid: Organization of the study and data collection, Maryam Al Saeed: Organization of the study and patients' education, Azza Khalifa: Organization of the study and patients' education, Fawzi Eltayb: Data collection, Sona Abuelkheir: Data collection, Mohammed Abdelatif: Data collection, Fatima Sayyah: Data collection, Suad Khalifa: CGMS installation and education, Fatheya Alawadi: Supervision of the study.

Competing interest

The authors declare that they have no competing interests.

Consent of publication

Does not apply.

Ethics approval and consent to participate

Ethical approval was obtained from the Dubai Health Authority Ethics committee. Approval document is available upon request.

REFERENCES

- [1] Hassanein Mohamed, Al-Arouj Monira, Hamdy Osama, et al. Diabetes and Ramadan: practical guidelines. *Diabetes Res Clin Pract* 2017;126:303–16. <https://doi.org/10.1016/j.diabres.2017.03.003>.
- [2] Salti I, Bénard E, Detournay B, Bianchi-Biscay M, Le Brigand C. The EPIDIAR Study Group A population-based study of diabetes and its characteristics during the fasting month of Ramadan in 13 countries: results of the Epidemiology of Diabetes and Ramadan 1422/2001 (EPIDIAR) study. *Diabetes Care* 2004;27:2306–11.
- [3] Abdelgadir EI, Hafidh K, Basheir AM, et al. Comparison of incidences, hospital stay and precipitating factors of diabetic ketoacidosis in Ramadan and the following month in three major hospitals in United Arab Emirates. A prospective observational study. *J DiabetesMetab* 2015;6:514.
- [4] Abdelgadir EIE, Hafidh K, Basheir AMK, Afandi BO, Alawadi F, et al. Comparison of incidences, hospital stay and precipitating factors of diabetic ketoacidosis in ramadan and the following month in three major hospitals in United Arab Emirates. A prospective observational study. *J DiabetesMetab* 2015;6:514.
- [5] Bravis V et al. Ramadan education and awareness in diabetes (READ) program for Muslims with T2DM who fast during Ramadan. *DiabetesObes Metab* 2014;16:527–36.
- [6] Lee SW, Lee JY, Tan CS, et al. Strategies to make Ramadan fasting safer in type 2 diabetics: a systematic review and network meta-analysis of randomized controlled trials and observational studies. *Medicine* 2016;95:e2457.
- [7] McEwen LN, Ibrahim M, Ali NM, et al. Impact of an individualized type 2 diabetes education program on clinical outcomes during Ramadan. *BMJ Open Diabetes Res Care* 2015;3:e000111.
- [8] Lessan N, Hannoun Z, Hasan H, et al. Glucose excursions and glycaemic control during Ramadan fasting in diabetic patients: insights from continuous glucose monitoring (CGM). *DiabetesMetab* 2015;41:28–36.
- [9] Lessan N, Hasan H, Barakat MT. Ramadan fasting: a study of changes in glucose profiles among patients with diabetes using continuous glucose monitoring. *Diabetes Care* 2012;35:e37.
- [10] Elamin Abdelgadir EI, Fauzia Rashid, Alaaeldin Bashier MK, Suada Makeen A. A prospective study comparing the effects of ramadan fasting on metabolic parameters in healthy muslims from three different nationalities in Dubai. *DiabetesMetab* 2015;6:1.
- [11] Mafauzy M, Mohammed WB, Anum MY, et al. A study of the fasting diabetic patients during the month of Ramadan. *Med J Malaysia* 1990;45:14–7.
- [12] Hajek P, Myers K, Dhanji AR, West O, McRobbie H. Weight change during and after Ramadan fasting. *J Public Health* 2012;34:377–81.
- [13] Mahjoub AO, Abdelgadir E. The association between health-related quality of life and Ramadan fasting in diabetic

- patients: a survey using a structured D-39 assessment tool. A Sudanese Cohort (DIAFARMA Study). *J Fasting Health* 2017;5(1):24–30. <https://doi.org/10.22038/jfh.2017.21682.1080>.
- [14] Brady EM, Davies MJ, Gray LJ, Saeed MA, Smith D, Hanif W, et al. A randomized controlled trial comparing the GLP-1 receptor agonist liraglutide to a sulphonylurea as add on to metformin in patients with established type 2 diabetes during Ramadan: the Treat 4 Ramadan Trial. *DiabetesObes Metab* 2014;16:527–36.
- [15] Pallayova M, Zaghoul HB, Arora T, Choudhury SM, Omar OM, Chagoury OL, et al. Investigating physiological glucose excursions before, during, and after Ramadan in adults without diabetes mellitus. *Physiol Behav* 2017;179:110–5.
- [16] Afandi B, Kaplan W, Al Hassani N, Hadi S, Mohamed A. Correlation between pre-ramadan glycemic control and subsequent glucose fluctuation during fasting in adolescents with Type 1 diabetes. *J Endocrinol Invest* 2017;40(7):741–4.
- [17] Al-Agha AE, Kafi SE, Zain Aldeen AM, Khadwardi RH. Flash glucose monitoring system may benefit children and adolescents with type 1 diabetes during fasting at Ramadan. *Saudi Med J* 2017;38(4):366–71.
- [18] Alamoudi R, Alsubaiee M, Alqarni A, Saleh Y, Aljaser S, Salam A, et al. Comparison of insulin pump therapy and multiple daily injections insulin regimen in patients with type 1 diabetes during Ramadan fasting. *Diabetes Technol Ther* 2017.
- [19] El-Hawary A, Salem N, Elsharkawy A, Metwali A, Wafa A, Chalaby N, et al. Safety and metabolic impact of Ramadan fasting in children and adolescents with type 1 diabetes. *J Pediatr Endocrinol Metab* 2016;29(5):533–41.
- [20] Lamine F, Bouguerra R, Jabrane J, Marrakchi Z, Rayana MCB, et al. Food intake and high density lipoprotein cholesterol levels changes during ramadan fasting in healthy young subjects. *Tunis Med* 2006;84:647–50.
- [21] Ziaee V, Razaee M, Ahmadijad Z, Shaikh H, Yousefi R, et al. The changes of metabolic profile and weight during Ramadan fasting. *Singapore Med J* 2006 May;47(5):409–14.
- [22] Hassoun AA, Al-Arouj M, Ibrahim M. The effect of vildagliptin relative to sulphonylurea as dual therapy with metformin (or as monotherapy) in Muslim patients with type 2 diabetes fasting during Ramadan in the Middle East: the VIRTUE study. *Curr Med Res Opin* 2017;33(1):161–7.
- [23] Khattab M, Mahmoud K, Shaltout I. Effect of vildagliptin versus sulphonylurea in Muslim patients with type 2 diabetes fasting during ramadan in Egypt: results from VIRTUE study. *DiabetesTher* 2016;7(3):551–60.
- [24] Salahuddin M, Sayed Ashfak AH, Syed SR, Badaam KM. Effect of Ramadan fasting on body weight, (BP) and biochemical parameters in middle aged hypertensive subjects: an observational trial. *J Clin Diagn Res* 2014;8:16–8.
- [25] Gray LJ, Dales J, Brady EM, Khunti K, Hanif W, Davies MJ. Safety and effectiveness of non-insulin glucose-lowering agents in the treatment of people with type 2 diabetes who observe Ramadan: a systematic review and meta-analysis. *DiabetesObes Metab* 2015;17(7):639–48.
- [26] Salahuddin M, Sayed Ashfak AH, Syed SR, Badaam KM. Effect of Ramadan fasting on body weight, (BP) and biochemical parameters in middle aged hypertensive subjects: an observational trial. *J Clin Diagn Res*. 2014;8(3):16–8.
- [27] Norouzy A, Hasanzade Dalooe M, Khoshnasab AH, et al. Trend of blood pressure in hypertensive and normotensive volunteers during Ramadan fasting. *Blood Press Monit* 2017;22(5):253–7.
- [28] Adlouni A, Ghalim N, Benslimane A, Lecerf JM, Saïle R. Fasting during Ramadan induces a marked increase in high-density lipoprotein cholesterol and decrease in low-density lipoprotein cholesterol. *Ann Nutr Metab* 1997;41:242–9.
- [29] Hashemian M, Akaberi A, Golshan A, Moojdekanloo M. Does fasting in Ramadan ameliorate Lipid profile? A prospective observational study. *Pak J Med Sci* 2014;30:708–11.
- [30] Tourkmani AM, Hassali MA, Alharbi TJ, Alkhashan HI, Alobikan AH, Bakhiet AH, et al. Impact of Ramadan focused education program on hypoglycemic risk and metabolic control for patients with type 2 diabetes. *Patient Prefer Adherence* 2016;10:1709–17.
- [31] Ghalib M, Qureshi J, Tamim H, Ghamdi G, Flaiw A, Hejaili F, et al. Does repeated Ramadan fasting adversely affect kidney function in renal transplant patients? *Transplantation* 2008;85(1):141–4. <https://doi.org/10.1097/01.tp.0000296841.99263.c2>.
- [32] Mbarki H, Tazi N, Najdi A, Tachfouti N, Arrayhani M, Sqalli T. Effects of fasting during Ramadan on renal function of patients with chronic kidney disease. *Saudi J Kidney Dis Transpl* 2015;26(2):320–4.