Contents available at ScienceDirect

Diabetes Research and Clinical Practice

journal homepage: www.elsevier.com/locate/diabres

Effect of Ramadan fasting on renal function in patients with type 2 diabetes

M.M. Abushady [a,*], M. Samy [a], M. Bekhet [a], A. Abdullah [b]

[a] Internal Medicine & Endocrinology Department, Faculty of Medicine, Ain Shams University, Cairo, Egypt
[b] Internal Medicine Department in Specialized Damietta Hospital, Damietta, Egypt

ARTICLE INFO

Article history:
Received 20 February 2019
Accepted 30 May 2019
Available online 10 June 2019

Keywords:
Type 2 diabetes
Fasting Ramadan
Albuminuria
Kidney functions

ABSTRACT

Aim: To evaluate the effect of Ramadan fasting on kidney functions in patients with type 2 DM.

Methods: We recruited 90 subjects with type 2 DM intending to fast Ramadan; classified into 30 with albuminuria and renal impairment (group I), 30 with albuminuria and normal kidney functions (group II) and 30 without albuminuria and normal kidney functions (group III). Two weeks before and after Ramadan, fasting plasma glucose, 2 h plasma glucose, hemoglobin A1c, fructosamine, serum creatinine, BUN, eGFR and albumin/ creatinine ratio were measured.

Results: On comparing data before and after Ramadan, significant reduction in HbA1c was found in all groups. As regards kidney function parameters, no significant difference was found in group I but a significant decline in these parameters was found in groups II and III; serum creatinine, eGFR, urinary albumin/ creatinine ratio ($p < 0.001$). Only Group I showed significant hypoglycemic events and need for dose reduction.

Conclusion: Ramadan fasting improved glycemic control in patients with type 2 DM with no decline in kidney functions in renally impaired group, only a decline in albuminuric and healthy groups within the normal range. Patients should be adviced regarding adequate hydration and dietary modification during Pre-Ramadan health care education.

1. Introduction

Ramadan fasting is a religious pillar carried out by Muslims all over the world. During Ramadan, Muslims abstain from eating, drinking and smoking during daylight hours with Iftar being the main meal taken at sunset and sohoor is a small meal taken before sunrise [1].

Despite taking fewer meals, the overall caloric consumption of individuals with diabetes has been reported to increase during Ramadan [2]. People with diabetes who fast usually are more prone to fluctuations in their blood glucose values depending upon the type, composition, and quantity of food consumed, regularity in medicine taking, alterations in daily physical activities or occasional binge eating after breaking the fast [3].

Abbreviations: 2hPPG, 2 h plasma glucose; ADA, American Diabetic Association; Alb, Albumin; ANOVA, Analysis Of Variance; BMI, Body Mass Index; BUN, Blood Urea Nitrogen; CKD, Chronic Kidney Disease; DBP, Diastolic Blood Pressure; DM, Diabetes Mellitus; eGFR, Estimated Glomerular Filtration Rate; ESRD, End Stage Renal Disease; FPG, Fasting Plasma Glucose; Fra, Fructosamine; HbA1C, Glycated Hemoglobin A1C; LSD, Least Significant Difference; MDRD, Modification of Diet in Renal Disease Study; SBP, Systolic Blood Pressure; SD, Standard Deviation; T1DM, Type 1 Diabetes Mellitus; T2DM, Type 2 Diabetes Mellitus; UACR, Urinary Albumin to Creatinine Ratio

* Corresponding author.
E-mail address: manalabushady@med.asu.edu.eg (M.M. Abushady).

https://doi.org/10.1016/j.diabres.2019.05.036
0168-8227/

Diabetic nephropathy is the major cause of end stage renal disease (ESRD) throughout the world. It is defined clinically as the presence of microalbuminuria or overt nephropathy in patients with diabetes who lack indicators of other renal diseases [4].

Individualization of the advice given to the patients about Ramadan fasting is an important thing and caution is advised for people with diabetes with moderate to severe CKD and the physicians should monitor their patients carefully during Ramadan in order to avoid any deleterious effects [5].

Some studies demonstrated good tolerance, safety and favorable outcome of fasting Ramadan in nephropathy patients [6], while other studies, fasting was shown to adversely affect the kidney particularly in tropical climate with heat and humidity. The custom of depriving food and water sets in events leading to pre-renal azotemia and renal dysfunction [7].

Randomized clinical trials are particularly encouraged since there is a lack of evidence-based guidelines and protocols which correctly address the issue of the impact of the fasting on CKD patients and proper counsel and advise them [8].

2. Aim of the work

We aimed to evaluate the effect of Ramadan fasting on kidney functions in type 2 diabetes mellitus patients.

3. Subjects and methods

The study was conducted on 90 patients with type 2 diabetes on oral antidiabetic medications intending to fast Ramadan (2016) with average fasting time 16 h from 3:10 am to 7:30 pm with an atmospheric temperature between 37°c and 40°c. Patients were recruited from internal medicine and diabetes clinics of Mansoura central hospitals. This study was approved by the internal review board of Ain Shams University. Before inclusion, an informed written consent was obtained from each patient after full explanation of the study protocol. Subjects were divided into three groups: 30 patients with type 2 diabetes (24 males and 6 females) with albuminuria and renal impairment (Group I), 30 patients with type 2 diabetes (10 males and 20 females) with albuminuria and normal kidney functions (Group II) and 30 patients with type 2 diabetes (20 males and 10 females) with no albuminuria and normal kidney functions (Group III).

Exclusion criteria included patients with eGFR <60 ml/min/1.73 m^2, history of heart failure, liver cell failure or autoimmune kidney disease. All patients were subjected to full medical history, thorough clinical examination including measurement of blood pressure, weight, height and BMI (kg/m^2).

3.1. *Laboratory measurements*

Laboratory tests; including fasting plasma glucose (FPG), 2 h post prandial plasma glucose (2hPPG), hemoglobin A1c (HbA1c), fructosamine, serum creatinine, blood urea nitrogen, urinary albumin/creatinine ratio (UACR) and estimated glomerular filtration rate (eGFR), were measured two weeks before and after Ramadan.

FPG and 2HPG were measured using an automated glucose oxidase method using Behring Diagnostics Reagents (SVR Glucose Test; Behring, La Jolla, CA, USA). HbA1c was measured by Stanbio Procedure No.0350 "Quantitative colorimetric determination of Glycohemoglobin in blood". Fructosamine was measured using quantitative colorimetric assay method. Normal range is 200–285 μmol/L and varies in relation to the serum albumin concentration. Reduction in serum albumin lowers the serum fructosamine value [9]. A correction equation for fructosamine: FRAc = FRA × 4 (Alb) [10]. Quantitative determination of albumin in urine was done using Enzyme Immunoassay. According to the ADA, 2014, the patients are either albuminuric with increased urinary albumin excretion > 30 mg/g or non-albuminuric with urinary albumin excretion <30 mg/g. [11].

Estimated GFR was calculated by MDRD equation eGFR = 186 × (Pcr)-1.154x (age)-0.203x (0.742 if female) × (1.210 if African) [12].

4. Statistical analysis

Data were analyzed using Statistical Package for Social Science (IBM SPSS) version 20. The quantitative data were presented as mean ± standard deviation (SD) and range when their distribution found parametric while qualitative data were presented as number and percentages. The comparison between two independent groups with qualitative data was done by using Chi-square test. The comparison between two independent groups with quantitative data and parametric distribution was done by using Independent *t*-test. Paired sample *t*-test of significance was used when comparing between related samples. The comparison between more than two independent groups with quantitative data and parametric distribution was done by using One Way Analysis of Variance (ANOVA). Post-hoc test (Tukey's) was used to identify the least significant difference (LSD) among the studied groups. Pearson's correlation coefficient (r) tests were used to assess the correlation between two quantitative parameters in the same group. Probability (P-value) >0.05 was considered Non-significant (NS), <0.05 was considered significant (S) and<0.01 was considered as highly significant (HS).

5. Results

The studied groups were sex matched (p = 0.07). The mean age was (48.67 ± 9.06) years and duration of diabetes (7.30 ± 4.60) years for group I, while group II had a mean age of (49.67 ± 6.35) years and duration of diabetes (7.53 ± 4.65). Finally, group III had a mean age of (49.03 ± 6.56) years and duration of diabetes of (8 ± 4.05) years. The cases were matched regarding age and duration of diabetes (p = 0.33, 0.82 respectively).

Before Ramadan, there was a highly statistical significant difference (p < 0.01) between groups regarding SBP, creatinine, UACR and eGFR, while there was no statistical significant difference regarding other parameters using ANOVA test.

Comparison of each two group using Tukey's test, group I had significantly higher SBP, and creatinine compared to groups II and III. A significantly lower eGFR was detected in

group I compared to groups II and III. UACR was significantly higher in groups I and II compared to group II (Table 1).

After Ramadan, DBP, SBP, FPG, 2hPPG, creatinine, UACR and eGFR showed a significant difference among all studied groups. However, we found no statistical significant difference regarding weight, BMI, HbA1c, fructosamine and BUN using ANOVA test.

Comparison of each two group using Tukey's test, group I had significantly higher SBP, DBP and creatinine compared to groups II and a significantly higher HbA1c, creatinine and UACR compared to group III. A significantly lower FBS, 2hPG and eGFR were detected in group I compared to groups II and III (Table 2).

Comparing the data before and after Ramadan in each group, group I showed a significant decrease in SBP, DBP and HbA1c, while group II and III showed significant decrease in HbA1c and eGFR and significant increase in creatinine (Table 3).

Group II showed a significant negative correlation between eGFR and HbA1c ($r = -0.533$, $p = 0.002$) pre-fasting and a significant negative correlation between eGFR and duration of diabetes ($r = -0.381$, $p = 0.013$) post-fasting. Group III showed a significant negative correlation between eGFR and duration of diabetes ($r = -0.369$, $p = 0.045$) post-fasting.

Concerning hypoglycemia related events and need for dose reduction, it was significant in group I ($p < 0.001$, 0.050 respectively) while groups II and III showed non-significant difference (Fig. 1).

6. Discussion

Regarding the effect of Ramadan fasting on kidney functions in the current study, serum creatinine showed statistically significant increase in group II and group III whereas the change was non-significant in group I ($p = 0.101$)

Table 1 – Comparison between data characteristics of all studied groups regarding demographic and laboratory data before Ramadan.

Laboratory Data	Group I	Group II	Group III	Tukey's test		
				I vs. II	I vs. III	II vs. III
Weight (kg)						
Mean ± SD	85.17 ± 10.57	86.70 ± 12.49	83.23 ± 8.67	0.580	0.486	0.213
Range	68–110	65–120	60–100			
BMI [wt/(ht)2]						
Mean ± SD	29.49 ± 3.59	31.08 ± 4.34	29.55 ± 2.63	0.089	0.946	0.103
Range	22.86–38.06	23.74–43.55	22.04–35.43			
SBP (mmHg)				<0.001	0.003	0.627
Mean ± SD	146.33 ± 18.33#	132 ± 16.06	134 ± 12.76			
Range	110–170	110–160	120–170			
DBP (mmHg)				0.055	0.203	0.232
Mean ± SD	88.50 ± 8.32	83.33 ± 9.59	85.83 ± 5.74			
Range	70–100	60–100	80–100			
FBS (mg/dL)				0.219	0.168	0.879
Mean ± SD	185.37 ± 57.20	204 ± 61.93	206.30 ± 55.58			
Range	95–390	100–360	120–346			
Post Prandial (mg/dL)				0.968	0.056	0.054
Mean ± SD	299.83 ± 56.68	299.57 ± 69.43	330.07 ± 54.53			
Range	200–420	150–450	230–469			
HbA1c (%)				0.821	0.063	0.076
Mean ± SD	11.23 ± 2.67	11.09 ± 2.40	9.28 ± 2.41			
Range	6–18	7–17.4	6–15			
Fructosamine(Umol/L)				0.350	0.679	0.601
Mean ± SD	275.23 ± 111.12	252.60 ± 84.99	265.23 ± 80.96			
Range	100–540	97–400	113–421			
S.creatinine (mg/dL)				<0.001	<0.001	0.194
Mean ± SD	1.33 ± 0.05#	0.66 ± 0.11	0.70 ± 0.12			
Range	1.3–1.5	0.5–0.9	0.5–0.9			
BUN (mg/dL)				0.016	0.316	0.153
Mean ± SD	14.37 ± 4.49#	12.06 ± 2.67	13.42 ± 3.56			
Range	9–26	7–18	7–20			
Urinary ACR(mcg/mg)				0.101	<0.001	<0.001
Mean ± SD	88.40 ± 64.86#	71.43 ± 21.17	16.18 ± 7.99			
Range	33–284	43–120	3–29			
eGFR(mL/min/1.73 m^2)				<0.001	<0.001	0.563
Mean ± SD	63.07 ± 3.27#	114.00 ± 18.74	112.70 ± 18.60			
Range	61–72	91–149	90–148			

**P-value < 0.01 is high statistical significant.
*P-value < 0.05 is significant.

Table 2 – Comparison between data characteristics of all studied groups regarding demographic and laboratory data after Ramadan.

Laboratory Data	Group I	Group II	Group III	Tukey's test		
				I vs. II	I vs. III	II vs. III
Weight (kg)				0.542	0.464	0.181
Mean ± SD	85.23 ± 10.47	86.90 ± 12.18	83.23 ± 8.66			
Range	69–107	66–120	60–99			
BMI [wt/(ht)2]						
Mean ± SD	29.50 ± 3.45	31.16 ± 4.28	29.55 ± 2.62	0.072	0.958	0.080
Range	22.86–37.02	23.74–43.55	22.04–35.08			
SBP (mmHg)						
Mean ± SD	135.50 ± 14.04#	125.50 ± 10.20	129 ± 9.14	0.002	0.029	0.235
Range	110–160	110–140	120–150			
DBP (mmHg)						
Mean ± SD	84.50 ± 6.61#	80.17 ± 7.01	82.33 ± 4.30	0.007	0.172	0.172
Range	65–90	60–90	80–90			
FBS (mg/dL)						
Mean ± SD	186.60 ± 38.36#	227.63 ± 35.49	225.97 ± 31.77	<0.001	<0.001	0.885
Range	102–278	154–286	169–298			
Post Prandial (mg/dL)						
Mean ± SD	288.50 ± 39.24#	316.37 ± 47.54	344.43 ± 42.84	0.015	<0.001	0.014
Range	218–398	206–401	257–396			
HbA1c (%)						
Mean ± SD	9.09 ± 1.95	8.80 ± 1.78	8.21 ± 1.45	0.525	0.005	0.195
Range	5.5–13	6.5–15	5.5–11			
Fructosamine(Umol/L)						
Mean ± SD	325.53 ± 125.56	332.70 ± 218.59	282.63 ± 96.88	0.859	0.290	0.217
Range	103–612	120–1103	168–620			
S.creatinine (mg/dL)						
Mean ± SD	1.41 ± 0.23#	0.93 ± 0.17	0.84 ± 0.16	<0.001	<0.001	0.053
Range	1–2	0.7–1.3	0.6–1.4			
BUN (mg/dL)						
Mean ± SD	16.72 ± 6.77	15.48 ± 4.27	14.50 ± 4.22	0.363	0.104	0.468
Range	8–34	9–27	9–28			
UrinaryACR(mcg/mg)						
Mean ± SD	86.03 ± 86.52	112.33 ± 72.40#	41.67 ± 22.00	0.128	0.011	<0.001
Range	11–434	27–330	15–114			
eGFR(mL/min/1.73 m^2)						
Mean ± SD	59.73 ± 13.25	77.83 ± 16.48#	97.50 ± 21.19	<0.001	<0.001	<0.001
Range	32–86	46–112	55–131			

**P-value <0.01 is high statistical significant.
*P-value <0.05 is significant.

This was in agreement with NasrAllah and Osman (2014), who showed worsening kidney functions in fasting patients, defined as ≥30% rise of serum creatinine (baseline 1.4–2.8 mg/dl), at Day 7. By the end of the month, serum creatinine showed marked elevations exceeding 30%, in only seven instances (13.2%). Three months after the end of Ramadan, serum creatinine remained elevated in 12 of 52 (23%) patients, the remaining portion showed returning of serum creatinine mostly to baseline levels by the end of the month. The initial rise in serum creatinine may be explained by dehydration and its effect on renal perfusion. This effect was reversed by the end of the month, possibly by adaptations in renal hemodynamics and homeostasis of fluid preservation [13].

Bakhit et al. (2017) in a prospective observational study performed on 65 patients with stage 3 or higher chronic kidney disease (CKD) showed that 33% of patients developed worsening of renal functions, being defined as serum creatinine levels increase by 0.3 mg/dl from baseline during or within 3 months after Ramadan. Of the 22 patients who developed worsening of renal functions, 8 later improved, while 14 continued to have elevated serum creatinine [14].

However, El-Wakil et al. (2007) and Bernieh et al. (2010) showed non-significant change in serum creatinine after Ramadan but these studies were performed on smaller sample size (15 and 31 patients respectively) [6,15].

As regards eGFR, patients in our study revealed significant decrease in eGFR after Ramadan in groups II and III respectively and non-significant decrease in group I. This is in agreement with NasrAllah and Osman (2014) who observed significant reduction (corresponding to ≥25% drop of eGFR) occurring in nine of fifty two subjects (17%) at Day 7 of fasting. By the end of the month reduction of eGFR persisted but the magnitude of deviation of eGFR from baseline was insignificant, (p = 0.5) [13].

On the contrary, El-Wakil et al. (2007) showed that GFR did not change significantly in CKD patients (baseline eGFR 33.3 ± 21.1 ml/min/1.73 m2) during Ramadan. However, the

Table 3 – Comparison between pre and post fasting laboratory data of all studied groups:

Laboratory Data	Group I				Group II				Group III			
	Pre	Post	t	p	Pre	Post	t	p	**Pre**	**Post**	**T**	**p**
FBG (mg/dL)												
Mean ± SD	185.37 ± 57.20	186.60 ± 38.36	0.043	0.922	204 ± 61.93	227.63 ± 35.49	1.342	0.075	206.30 ± 55.58	225.97 ± 31.77	2.117	0.098
Range	95–390	102–278			100–360	154–286			120–346	169–298		
PostPrandial(mg/dL)												
Mean ± SD	299.83 ± 56.68	288.50 ± 39.24	0.264	0.372	299.57 ± 69.43	316.37 ± 47.54	0.693	0.279	330.07 ± 54.53	344.43 ± 42.84	1.534	0.261
Range	200–420	218–398			150–450	206–401			230–469	257–396		
HbA1c (%)												
Mean ± SD	11.23 ± 2.67	9.09 ± 1.95	7.455	<0.001	11.09 ± 2.40	8.80 ± 1.78	5.492	<0.001	9.28 ± 2.41	8.21 ± 1.45	3.518	0.042
Range	6–18	5.5–13			7–17.4	6.5–15			6–15	5.5–11		
Fructosamine (Umol/L)												
Mean ± SD	275.23 ± 111.12	325.53 ± 125.56	0.857	0.106	252.60 ± 84.99	332.70 ± 218.59	2.342	0.066	265.23 ± 80.96	282.63 ± 96.88	0.871	0.453
Range	100–540	103–612			97–400	120–1103			113–421	168–620		
S.creatinine(mg/dL)												
Mean ± SD	1.33 ± 0.05	1.41 ± 0.23	1.122	0.101	0.66 ± 0.11	0.93 ± 0.17	4.967	<0.001	0.70 ± 0.12	0.84 ± 0.16	5.687	<0.001
Range	1.3–1.5	1–2			0.5–0.9	0.7–1.3			0.5–0.9	0.6–1.4		
BUN(mg/dL)												
Mean ± SD	14.37 ± 4.49	16.82 ± 7.20	0.857	0.119	12.06 ± 2.67	15.48 ± 4.27	5.791	<0.001	13.42 ± 3.56	14.50 ± 4.22	0.166	0.287
Range	9–26	8–35			7–18	9–27			7–20	9–28		
UrinaryACR(mcg/mg												
Mean ± SD	88.40 ± 64.86	90.03 ± 86.52	0.194	0.905	71.43 ± 21.17	112.33 ± 72.40	4.716	0.004	16.18 ± 7.99	41.67 ± 22.00	6.748	<0.001
Range	33–284	11–434			43–120	27–330			3–29	15–114		
eGFR(mL/min/1.73 m^2)												
Mean ± SD	63.07 ± 3.27	59.73 ± 13.25	0.88	0.186	114.00 ± 18.74	77.83 ± 16.48	7.176	<0.001	112.70 ± 18.60	97.50 ± 21.19	4.114	0.008
Range	61–72	32–86			91–149	46–112			88–148	55–131		

**P-value <0.01 is high statistical significant.

*P-value <0.05 is significant.

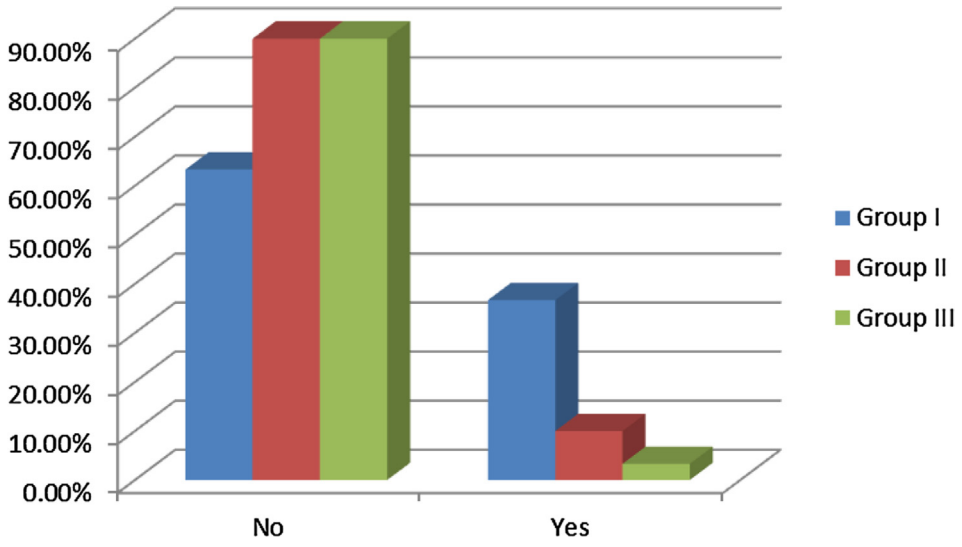

Fig. 1 – Bar chart of groups regarding hypoglycemia related events.

study was conducted on small sample size (15 subjects) and it recommended that CKD patients should be meticulously followed during Ramadan [15].

Bragazzi 2015, in a mini meta-analysis that included six studies investigated the effects and impact of Ramadan fasting with emphasis on GFR [16]. All the selected studies were prospective observational. Five studies were neutral, finding only in-significant differences between before and after Ramadan fasting while the study by Bernieh et al. (2010) found improvements during the fasting and the month after but that study was performed on 31 patients [6]. However, most studies were conducted in cold seasons, while only two were conducted in hot seasons. For this reason, the findings may be not generalizable to hot seasons and therefore caution should be taken when fasting during those periods.

In the current study, urinary albumin-creatinine ratio (UACR) was significantly increased in group II and III with non-significant increase in group I. This is consistent with Kamar et al. (2014) who showed significant increase of ACR concluding that fasting had adverse effect on albuminuria in Type 2 diabetes patients [17].

On the other hand, El-Gendy et al. (2012) in a study performed on 20 patients with diabetes showed non-significant change of ACR after Ramadan and it remained lower than baseline values six weeks after the end of Ramadan concluding that, fasting during the month of Ramadan is relatively safe and devoid of serious complications among patients, provided they are well hydrated and properly educated about drug regimen adjustment and compliance as well as diet regimen [18]. Sahin et al. (2013) even showed that microalbuminuria significantly decreased during Ramadan but that study was conducted on 122 patients with type 2 diabetes; 32 of whom were on insulin regimens either alone or in combination with oral antidiabetics [19].

As regards levels of blood urea nitrogen (BUN), the current study showed significant increase in group II and non-significant increase in group I and III. Similarly, Emami-Naini et al. (2013) in their mini review showed an overall non-significant increase in BUN after Ramadan emphasizing importance of adequate hydration in patients with diabetes intending to fast [20].

Looking at kidney functions in this study, we noticed there had been deterioration in group II and III but within normal values; where as in group I there had been non-significant impact of fasting on kidney functions despite being the renal impairment group. However this can be attributed to the compliance of these patients to the proper diet, hydration and medication regimen with a regular scheduled follow up and close monitoring.

In the current study, there was a non-significant change in BMI in the three groups before and after Ramadan. Jaleel et al. (2011) demonstrated that patients with diabetes who fasted during Ramadan have shown non-significant change in body weight, while in normal individuals with no diabetes; an average weight loss of 1.7–3.8 kg has been reported in different studies [1].This was consistent with Yeoh et al. (2015), as it also showed non-significant change in BMI after than before Ramadan [21]. Sadiya et al. (2011) on the other hand showed significant body weight reduction after Ramadan fasting which could be attributed to the small sample size of the study group as it was done on 19 subjects [22].

There was a significant decrease in systolic and diastolic blood pressure in group I post Ramadan. Bener and Yousafzai (2014) agreed with us in their observational study conducted on 1301 patients with diabetes aged above 18 years systolic and diastolic blood pressures were significantly lower after as compared with before Ramadan [23]. Similarly, Samad et al. (2015) observed significant improvement of systemic blood pressure after Ramadan [24].

Regarding the effect of fasting on fasting blood glucose (FBG), this study showed non-significant change in all groups. This was consistent with Lessan et al. (2012) who performed a study on 63 subjects with continuous glucose monitoring before, during and after Ramadan and reported non-significant changes in FBG after Ramadan among patients with good baseline glycemic control [25]. Kamar et al. (2014),

also concluded in a study conducted on 44 type 2 diabetes mellitus patients showed non-significant decrease in mean fasting blood glucose after Ramadan [26]. As for post-prandial blood glucose level (2hPPG), our study showed non-significant change in 2hPPG in all groups which was consistent with Sahin et al. (2013) who also showed non-significant increase in 2hPPG after Ramadan fasting [19].

Concerning HbA1c, our study showed statistically significant decrease in the three groups after Ramadan fasting. It was more prominent in the group I and II with renal impairment and albuminuria than control group. This was consistent with Bener and Yousafzai (2014) [23] and Siaw et al. (2014) [27]. Both studies showed significant reduction in HbA1c after Ramadan.

On the other side Ahmadani et al. (2007) conducted a study on 453 subjects 72.5% of whom fasted, the majority of them (96.3%) with type 2 diabetes while only 3.7% with type I diabetes. That study showed non-significant change of HbA1c after Ramadan [28].

As for fructosamine, our study proved non-significant change after Ramadan fasting in all group. Similarly, Bouguerra et al. (2006) showed non-significant change in fructosamine level after Ramadan in patients with initial level of <340miromol/L but a significant increase was observed in patients whose initial fructosamine before Ramadan was >340 micromol/L consequently concluding that Ramadan fasting in type 2 diabetes mellitus patients seems to cause slight effects on glycaemia when previous control is quite good; but fasting induces more deterioration when previous control is poor [29]. Also Gustaviani et al. (2004) and M'guil et al. (2008) showed non-significant reduction in fructosamine after Ramadan in previously well-controlled type 2 diabetes mellitus patients [30,31].

This study also revealed a significant negative correlation between HbA1c level and eGFR in pre-fasting group II. This goes in line with Joly et al. (2015), who showed HbA1c was significantly higher in patients with lower eGFR in 986 patients adjusted to age, body mass index, hemoglobin level and erythropoietin use [32].

We found a significant negative correlation between duration of DM and eGFR in post-fasting group II and III. This is in line with the study done by Al-Rubeaan et al. (2014) that showed that duration of DM is an important risk factors having a strong impact on the prevalence of diabetic nephropathy, ranging from 3.7% in patients with a duration of >5 years, to 21.8% in patients with a diabetes duration of ≥15 years [33]. Also AlWakeel et al. (2011) in a retrospective study on 621 patients showed that the mean duration of diabetes was significantly longer among the progressors to nephropathy compared to non-progressors [34].

One of the principal risks for people with diabetes who participate in Ramadan is hypoglycemia. The study reported hypoglycemia related events and need for dose reduction. This agreed with The EPIDIAR study that recorded higher rates of severe hypoglycemia in people with T1DM or T2DM during Ramadan compared with before Ramadan (4.7-fold and 7.5-fold increases, respectively) [35]. Also a study in Pakistan, carried out by Ahmedani et al., found that of the 388 patients with diabetes who chose to fast, symptomatic hypoglycemia was reported by 35.3% and 23.2% of patients with T1DM and T2DM, respectively [36]. The occurrence of hypoglycemia and need for dose reduction was significantly higher in group I as compared with the other two groups. This goes with Miller et al. (2010) who showed that comparing patients with normal kidney function with those having baseline serum creatinine of 1.3–1.5 mg/dl, there was a 66% increased risk of hypoglycemia in impaired patients [37]. Taking all these risks into account, it is easy to see why religious regulations, as well as medical recommendations, allow exemption from fasting for some people with diabetes.

7. Conclusion

Ramadan fasting improved glycemic control in patients with type 2 DM with no decline in kidney functions in renal impaired group, only a decline in albuminuric and healthy groups within the normal range. Patients should be adviced regarding adequate hydration and dietary modification during Pre-Ramadan health care education.

8. Funding resources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

The authors declare no conflict of interests.
There was no financial funding from any institution.
We declare receiving no funds or grants for this study.

Acknowledgment

None.

REFERENCES

[1] Jaleel MA, Raza SA, Fathima FN, Jaleel BN. Ramadan and diabetes: As-Saum (The fasting). Indian J Endocrinol Metab 2011;15:268–73. https://doi.org/10.4103/2230-8210.85578.
[2] Vasan SK, Karol R, Vasan SK, Mahendri NV, Arulappan N, Jacob JJ, et al. A prospective assessment of dietary patterns in Muslim subjects with type 2 DM who undertake fasting during Ramadan. Indian J Endocrinol Metab 2012;16(4):552–7. https://doi.org/10.4103/2230-8210.98009.
[3] Azizi F, Siahkolah B. Ramadan fasting and diabetes mellitus. Arch Iranian Med 2003;6(4):237–42.
[4] Ritz E, Zeng XX, Rychlik I. Clinical manifestation and natural history of diabetic nephropathy. Contrib Nephrol. 2011;170:19–27. https://doi.org/10.1159/000324939.
[5] Hendawy A. Effect of fasting on renal physiology. J Fasting Health 2014;2(3):110–2.
[6] Bernieh B, Al Hakim MR, Boobes Y, Abu Zidan FM. Fasting Ramadan in chronic kidney disease patients: clinical and biochemical effects. Saudi J Kidney Dis Transpl 2010;21 (5):898–902.
[7] Gupta A, Lal C, Khaira A, Agarwal SK, Tiwari SC. R2 syndrome: religion and renal failure. J Assoc Physicians India 2010;58:201.

[8] Bragazzi NL. Ramadan fasting and chronic kidney disease: a systematic review. J Res Med Sci. 2014;19(7):665–76.
[9] Masharani U, German MS. Pancreatic Hormones and Diabetes Mellitus. In: Gardner DG, Shoback D, editors. Greenspan's Basic and Clinical Endocrinology. New York: McGraw Hill Medical; 2011. p. 573–655.
[10] Kunika K, Itakura M, Yamashita K. Correction of fructosamine value for serum albumin and globulin concentrations. Diabetes Res Clin Pract 1991;13(1–2):37–44.
[11] American Diabetes Association. Standards of medical care in diabetes. Diabetes Care 2014; 37 (1):S14-80.
[12] Woodhouse S, Batten W, Hendrick H, Malek PA. The glomerular filtration rate: an important test for diagnosis, staging and treatment of chronic kidney disease. Lab Med 2006;37(4):244–7. https://doi.org/10.1309/XQNL7L157DKQGMKA.
[13] NasrAllah MM, Osman NA. Fasting during the month of Ramadan among patients with chronic kidney disease: renal and cardiovascular outcomes. Clin Kidney J 2014;7(4):348–53.
[14] Bakhit AA, Kurdi AM, Wadera JJ, Alsuwaida AO. Effects of Ramadan fasting on moderate to severe chronic kidney disease. a prospective observational study. Saudi Med J 2017;38(1):48–52. https://doi.org/10.15537/smj.2017.1.17566.
[15] El-Wakil HS, Desoky I, Lotfy N, Adam AG. Fasting the month of Ramadan by muslims: could it be injurious to their kidneys? Saudi J Kidney Dis Transpl 2007;18(3):349–54.
[16] Bragazzi NL. Ramadan fasting and chronic kidney disease: does estimated glomerular filtration rate change after and before Ramadan? Insights from a mini meta-analysis. Int J Nephrol Renovasc Dis 2015;8:53–7. https://doi.org/10.2147/IJNRD.S61718.
[17] Kamar MEG, Orabi AA, Salem IM, EL- Shabrawy AM. Effect of Ramadan fasting on diabetic micro-vascular complications. Zagazig University Med J 2014;20(2):193–205.
[18] El-Gendy OA, Rokaya M, El-Batae HER, Tawfeek S. Ramadan fasting improves kidney functions and ameliorates oxidative stress in diabetic patients world. J. Med Sci 2012;7(1):38–48. https://doi.org/10.5829/idosi.wjms.2012.7.1.6256.
[19] Sahin SB, Ayaz T, Ozyurt N, Ilkkilic K, Kirvar A, Sezgin H. The impact of fasting during Ramadan on the glycemic control of patients with type 2 diabetes mellitus. Exp Clin Endocrinol Diabet 2013;121(9):531–4. https://doi.org/10.1055/s-0033-1347247.
[20] Emami-Naini A, Roomizadeh P, Baradaran A, Abedini A, Abtahi M. Ramadan fasting and patients with renal diseases: a mini review of the literature. J Res Med Sci 2013;18(8):711–6.
[21] Yeoh EC1, Zainudin SB, Loh WN, Chua CL, Fun S, Subramaniam T, et al. Fasting during Ramadan and associated changes in glycaemia, caloric intake and body composition with gender differences in Singapore. Ann Acad Med Singapore 2015 Jun;44(6):202–6.
[22] Sadiya A, Ahmed S, Siddieg HH, Babas IJ, Carlsson M. Effect of Ramadan fasting on metabolic markers, body composition and dietary intake in Emiratis of Ajman (UAE) with metabolic syndrome. DiabetesMetab Syndr Obes 2011;4:409–16. https://doi.org/10.2147/DMSO.S24221.
[23] Bener A, Yousafzai MT. Effect of Ramadan fasting on diabetes mellitus: a population-based study in Qatar. J Egypt Public Health Assoc. 2014 Aug;89(2):47–52. https://doi.org/10.1097/01.EPX.0000451852.92252.9b.
[24] Samad F, Qazi F, Pervaiz MB, Kella DK, Mansoor M, Osmani BZ, et al. Effects of Ramadan fasting on blood pressure in normotensive males. J Ayub Med Coll Abbottabad 2015;27(2):338–42.
[25] Lessan N, Hannou Z, Hasan H, Barakat MT. Glucose excursions and glycemic control during Ramadan fasting in diabetic patients: insights from continuous glucose monitoring (CGM). DiabetesMetab 2015;41(1):28–36. https://doi.org/10.1016/j.diabet.2014.11.004.
[26] Kamar MEG, Said NS, Salem IM, Abd-Elrahman AMN, Azab MMM. The effect of Ramadan fasting on beta cell secretory efficiency in a sample of egyptian diabetic patients. British J Sci 2014;10(2):2047–3745.
[27] Siaw MY, Chew DE, Dalan R, Abdul Shakoor SA, Othman N, Choo CH, et al. Evaluating the effect of Ramadan fasting on muslim patients with diabetes in relation to use of medication and lifestyle patterns: a prospective study. Int J Endocrinol 2014;2014:308546. https://doi.org/10.1155/2014/308546.
[28] Ahmadani MY, Riaz M, Gul A, Waheed MI, Hydrie MZ, Hakeem R, et al. Clinical profile of fasting diabetic subjects during Ramadan. J Coll Physicians Surg Pak 2007;17(7):446–7.
[29] Bouguerra R, Jabrane J, Maâtki C, Ben Salem L, Hamzaoui J, El Kadhi A, et al. Ramadan fasting in type 2 diabetes mellitus. Ann Endocrinol (Paris) 2006;67(1):54–9.
[30] Gustaviani R, Soewondo P, Semiardji G, Sudoyo AW. The influence of calorie restriction during the Ramadan fast on serum fructosamine and the formation of beta hydroxybutirate in type 2 diabetes mellitus patients. Acta Med Indones 2004;36(3):136–41.
[31] M'guil M, Ragala MA, El Guessabi L, Fellat S, Chraibi A, Chabraoui LIs, et al. Ramadan fasting safe in type 2 diabetic patients in view of the lack of significant effect of fasting on clinical and biochemical parameters, blood pressure, and glycemic control? Clin Exp Hypertens 2008;30(5):339–57. https://doi.org/10.1080/10641960802272442.
[32] Joly D, Choukroun G, Combe C, Dussol B, Fauvel JP, Halimi JM, et al. Glycemic control according to glomerular filtration rate in patients with type 2 diabetes and overt nephropathy: a prospective observational study. Diabetes Res Clin Pract 2015;108(1):120–7. https://doi.org/10.1016/j.diabres.2015.01.029.
[33] Al-Rubeaan K, Youssef AM, Subhani SN, Ahmad NA, Al-Sharqawi AH, Al-Mutlaq HM, et al. Diabetic nephropathy and its risk factors in a society with a type 2 diabetes epidemic: National Diabetes Registry-based study. PLoS One 2014;9(2):e88956. https://doi.org/10.1371/journal.pone.0088956. 21.
[34] Alwakeel JS, Isnani AC, Alsuwaida A, Alharbi A, Shaffi SA, Almohaya S, et al. Factors affecting the progression of diabetic nephropathy and its complications: a single-centerexperience in Saudi Arabia. Ann Saudi Med. 2011;31(3):236–42. https://doi.org/10.4103/0256-4947.81528.
[35] Salti I, Bénard E, Detournay B, Bianchi-Biscay M, Le Brigand C, Voinet C, et al., 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(10):2306–11.
[36] Ahmedani MY, Alvi SF, Haque MS, Fawwad A, Basit A. Implementation of Ramadan-specific diabetes management recommendations: a multi-centered prospective study from Pakistan. J Diabetes Metab Disord 2014;13(1):37. https://doi.org/10.1186/2251-6581-13-37.
[37] Miller ME1, Bonds DE, Gerstein HC, Seaquist ER, Bergenstal RM, Calles-Escandon J, et al. The effects of baseline characteristics, glycaemia treatment approach, and glycated haemoglobin concentration on the risk of severe hypoglycaemia: post hoc epidemiological analysis of the ACCORD study. BMJ 2010;340:b5444. https://doi.org/10.1136/bmj.b5444.