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Original Article

Culprit Lesion Characteristics and Outcomes of Myocardial Infarction during The Month of Ramadan among Fasting Muslims Population

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Abstract

Objectives: This study aims to investigate the characteristics of culprit lesions and outcomes of myocardial infarction (MI) in fasting Muslims during Ramadan, compared to those in non-Ramadan periods.

Methodology: This study included 138 patients diagnosed with myocardial infarction (both ST elevation and non-ST elevation) who were referred for primary percutaneous coronary intervention (PPCI) or an early invasive strategy during Ramadan (Group I: the fasting group). For comparison, 131 patients with myocardial infarction, referred for PPCI or an early invasive strategy in non-Ramadan months, were included in Group II (the non-fasting group). We compared the culprit lesion characteristics and clinical outcomes of MI between these two groups.

Results: The incidence of myocardial infarction was similar during Ramadan and outside of it. However, significant differences were observed in the culprit lesion characteristics and outcomes between the two groups. During Ramadan, culprit lesions exhibited non-atheromatous characteristics with a heavier thrombus burden in Group I. The use of aspiration catheters during PCI was more frequent, and the decision to defer stenting was significantly higher in this group. Favorable metabolic changes, such as lower blood glucose, serum CRP, total cholesterol, and LDL, were noted in the fasting group; however, these changes did not significantly impact the overall clinical outcomes between the groups.

Conclusion: Myocardial infarction during Ramadan is characterized by non-atheromatous coronary lesions and a higher thrombus burden. Despite these differences, the incidence of myocardial infarction and major adverse cardiac events did not significantly differ between Ramadan and other months of the year.

Keywords: Criteria; myocardial infarction; Ramadan; fasting Muslims; coronary lesions; clinical outcomes

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INTRODUCTION

Acute myocardial infarction (AMI) can be influenced by a range of environmental and behavioral factors, including work conditions, socioeconomic status, changes in daylight savings time, smoking, and variations in eating and sleeping patterns [1]. Among these, the observance of Ramadan—a significant Islamic rite involving fasting from sunrise to sunset—provides a unique context to study the impact of altered eating and sleeping schedules on cardiovascular health [2]. The duration of fasting can extend up to 20 hours daily, depending on geographical location and the time of year.

During Ramadan, Muslims not only adjust their eating and drinking patterns but also experience changes in sleep habits, medication regimens, and overall calorie intake [3]. These changes, combined with behavioral and social adjustments, have been the focus of various studies examining cardiovascular morbidity during this period. Some studies report no significant change in cardiovascular outcomes, while others suggest a potential increase in health risks, including elevated cardiovascular events, impaired renal function, and disturbed glucose homeostasis [4].

A key factor contributing to these potential adverse outcomes is dehydration—a common issue associated with fasting. Dehydration can lead to increased hematocrit, elevated hemoglobin concentration, higher plasma osmolality, and increased blood viscosity, all of which elevate the risk of thrombosis [5]. Additionally, dehydration reduces fibrinolysis (the breakdown of clots) and increases the levels of coagulation factors, potentially leading to a higher incidence of myocardial infarction [6].

Despite these concerns, there is a lack of research focusing specifically on how the characteristics of culprit lesions, treatment approaches, and outcomes of myocardial infarction during Ramadan compare to those in other months of the year. Therefore, this study aims to investigate the characteristics of coronary lesions, treatment strategies, and clinical outcomes for myocardial infarction during Ramadan in fasting Muslims, in comparison to other periods of the year.

METHODOLOGY

Study Design: This study is a cross-sectional, observational study designed to investigate the impact of fasting during Ramadan on patients presenting with acute myocardial infarction (AMI). The study compares clinical outcomes and culprit lesion characteristics between patients admitted during Ramadan and those admitted during a non-Ramadan period. Data collection occurred at Tanta University Hospital in Egypt, between March 22, 2023, and April 20, 2023, for the Ramadan group, and January 2023 for the non-Ramadan group.

Setting: The study was conducted in the cardiology department of Tanta University Hospital, a tertiary care facility, where patients were admitted for primary percutaneous coronary intervention (PPCI) and early invasive strategies in the setting of acute myocardial infarction (AMI), either with ST-segment elevation (STEMI) or non-ST-segment elevation (NSTEMI).

Participants: A total of 269 patients diagnosed with acute myocardial infarction were enrolled. The participants were divided into two groups:

- **Group I (Ramadan Group):** 138 patients admitted during Ramadan. Of these, 85 patients (61.6%) presented with STEMI, while 53 patients (38.4%) had NSTEMI.
- **Group II (Non-Ramadan Group):** 131 patients admitted during January 2023. Of these, 78 patients (59.5%) presented with STEMI, and 53 patients (40.5%) had NSTEMI.

Inclusion Criteria: Inclusion criteria for the study required participants to be adult patients aged 18 years or older with a diagnosis of ST-elevation myocardial infarction (STEMI) or non-ST elevation myocardial infarction (NSTEMI) necessitating primary percutaneous coronary intervention (PPCI) or early invasive intervention. For Group I, participants were required to be fasting during Ramadan.

Exclusion Criteria: Exclusion criteria included patients younger than 18 years, those who were non-fasting during Ramadan, and individuals with impaired left ventricular function, defined as an ejection fraction less than 40% prior to myocardial infarction.

Variables: The primary variables of interest in this study were the characteristics of culprit lesions, including thrombus burden, infarct-related artery (IRA), and lesion grading. Clinical outcomes such as recurrence of chest pain, re-infarction, arrhythmias, hospitalization for cardiogenic shock or heart failure, target vessel revascularization, stroke, and cardiovascular mortality were also key focuses.

Secondary variables included baseline demographic data (age, sex), and risk factors for coronary artery disease, such as diabetes, hypertension, smoking, dyslipidemia, and family history of coronary disease. Additionally, body mass index (BMI), blood pressure, and laboratory parameters—including serum troponin, blood urea, serum creatinine, lipid profile, fasting blood glucose, and high-sensitivity C-reactive protein (hs-CRP)—were collected and analyzed.

Data Sources/Measurements: All patients underwent a thorough clinical examination, which included the measurement of blood pressure using a calibrated digital sphygmomanometer, with at least two readings taken five minutes apart and the average recorded. Body mass index (BMI) was calculated based on each patient's height and weight, while a standard 12-lead electrocardiography (ECG) was performed to assess myocardial infarction (MI) type and cardiac rhythm. Additionally, echocardiography was conducted using the Vivid E9 ultrasound system (GE Vingmed Ultrasound, Horten, Norway), utilizing an M5S phased array transducer. This examination measured left atrial diameter, left ventricular volumes, valvular status, and ejection fraction (EF) via the Simpson method [7].

For coronary angiography, all patients underwent diagnostic coronary imaging followed by primary percutaneous coronary intervention (PPCI) according to European Society of Cardiology (ESC) guidelines for STEMI and NSTEMI [8]. Preloading with 180 mg of ticagrelor was administered unless contraindicated. Thrombus burden was classified on a scale from 0 (no thrombus) to 5 (vessel occlusion) [9]. Drug-eluting stents (DES) were used when feasible, while cases with heavy thrombus burden required deferral of stenting for 24-48 hours after administering glycoprotein IIB/IIIA inhibitors [10-12].

Bias: Efforts to minimize bias included strict inclusion/exclusion criteria and standardized procedures for diagnostic tests and interventions. The study's observational nature inherently limits its control over potential confounders, but baseline characteristics were compared between groups to account for these. Patients were consecutively enrolled to prevent selection bias, and a random sampling method was not employed due to the convenience-based approach.

Study Size: The study included a total of 269 patients, with 138 in Group I (Ramadan) and 131 in Group II (non-Ramadan). The sample size was deemed sufficient for the analysis based on power calculations performed prior to the study initiation to detect differences in clinical outcomes between groups.

Quantitative Variables: The key quantitative variables collected included blood pressure, BMI, left ventricular ejection fraction, blood glucose levels, lipid profiles, hs-CRP, and troponin levels. Continuous variables were expressed as means and standard deviations, while categorical variables were reported as percentages.

Statistical Methods: Statistical analysis was conducted using IBM SPSS Statistics version 23. Quantitative data were presented as mean ± standard deviation (SD), while categorical data were expressed as absolute values and percentages. The significance of differences between the two groups for numeric data was assessed using the Student’s t-test. For categorical variables, the chi-square test was used. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Participants: The study involved 269 patients divided into two groups: Group I (n=138) and Group II (n=131). Group I comprised patients diagnosed with acute myocardial infarction (MI) who were fasting during Ramadan. Among these, 85 patients (61.6%) had ST-elevation myocardial infarction (STEMI) and 53 patients (38.4%) had non-ST-elevation myocardial infarction (NSTEMI). Group II included patients who were not fasting during Ramadan, with 78 (59.5%) diagnosed with STEMI and 53 (40.5%) with NSTEMI.

Descriptive Data: The baseline characteristics of the participants were similar across both groups regarding age, sex, and prevalence of diabetes mellitus, hypertension, and body mass index (BMI). Specifically, the average age was 58.47 ± 13.39 years in Group I and 57.56 ± 11.67 years in Group II

(p=0.555). The proportion of males, smokers, and patients with other risk factors like dyslipidemia and chronic kidney disease did not differ significantly between the groups (Table 1).

Table 1: Basal characteristics, risk factors of all patients in both groups

	Group I (n=138)	Group II (n=131)	P value
	Ramadan fasting group	Non fasting group	-
Age (Years)	58.47 ± 13.39	57.56 ± 11.67	0.555
Male	78 (56.5%)	69 (52.7%)	0.526
Smoking	36 (26.1%)	28 (21.4%)	0.364
DM	43 (31.2%)	41 (31.3%)	0.98
Hypertension	46 (33.3%)	39 (29.8%)	0.53
Dyslipidemia	52 (37.7%)	57 (43.5)	0.33
CKD	7 (5.1%)	4 (3.1%)	0.403
Peripheral vascular disease	6 (4.3%)	3 (2.3%)	0.348
Prior myocardial infarction	9 (6.5%)	7 (5.3%)	0.683
Prior cerebral stroke	7 (5%)	6 (4.6%)	0.851
Cardiovascular disease	13 (9.4%)	5 (3.8%)	0.066
Family history of cardiovascular disease	10 (7.2%)	9 (6.9%)	0.904

Outcome Data

Clinical and Laboratory Findings: Significant differences were observed in hemoglobin levels, hematocrit values, and serum high-sensitivity C-reactive protein (Hs-CRP) levels between the two groups. Group I exhibited higher hemoglobin levels (12.98 ± 1.39 mg/dl vs. 12.45 ± 1.33 mg/dl, p=0.001) and hematocrit values (46.93 ± 5.66% vs. 42.17 ± 4.87%, p=0.001) compared to Group II. Conversely, serum Hs-CRP levels were significantly lower in Group I (12.99 ± 9.27 mg/dl vs. 19.53 ± 17.66 mg/dl, p=0.001) (Table 2).

Metabolic Profile: Group I had lower blood glucose levels during catheterization (123.49 ± 37.51 mg/dl vs. 137.70 ± 45.45 mg/dl, p=0.005) and lower serum cholesterol, LDL, and triglycerides compared to Group II. Specifically, serum cholesterol was lower in Group I (186.49 ± 29.62 mg/dl vs. 198.63 ± 45.04 mg/dl, p=0.009), LDL (101.70 ± 28.12 mg/dl vs. 113.13 ± 34.49 mg/dl, p=0.003), and triglycerides (163.20 ± 36.39 mg/dl vs. 193.05 ± 74.39 mg/dl, p=0.001) (Table 2).

Angiographic Results and Management Strategies: Group I showed a higher thrombus burden with significant differences in thrombus grading compared to Group II (44.2% vs. 30.5%, p=0.025). The frequency of glycoprotein IIb/IIIa inhibitors usage (12.3% vs. 2.3%, p=0.002) and aspiration catheter use during PCI (13.0% vs. 3.1%, p=0.003) were notably higher in Group I. Deferred stenting was more common in Group I (9.4% vs. 3.1%, p=0.032). The prevalence of non-atheromatous culprit lesions was also significantly higher in Group I (6.5% vs. 1.5%, p=0.031) (Table 3).

Table 2: Clinical and laboratory findings of all patients in both groups

	Group I (n=138)	Group II (n=131)	P value
	Ramadan fasting group	Non fasting group	
BMI (kg/m2)	27.22 ± 4.33	27.19 ± 4.42	0.96
Blood Glucose during catheterization (mg/dl)	123.49 ± 37.51	137.70 ± 45.45	0.005
Cholesterol (mg/dl)	186.49 ± 29.62	198.63 ± 45.04	0.009
LDL (mg/dl)	101.70 ± 28.12	113.13 ± 34.49	0.003
HDL (mg/dl)	52.88 ± 5.68	52.03 ± 7.60	0.296
TG (mg/dl)	163.20 ± 36.39	193.05 ± 74.39	0.001
Hematocrit value (%)	46.93 ± 5.66	42.17 ± 4.87	0.001
Hemoglobin level (mg/dl)	12.98 ± 1.39	12.45 ± 1.33	0.001
CRP (mg /dl)	12.99 ± 9.27	19.53 ± 17.66	0.001
Platelet count (x109/L)	270.8 ± 79.40	270.3 ± 77.95	0.959
Creatinine (mg /dl)	1.07 ± 0.57	1.05 ± 0.60	0.611
HR (bpm)	76.32 ± 14.98	76.79 ± 15.92	0.801
Systolic BP (mmHg)	126.91 ± 21.07	125.35 ± 19.96	0.753
Diastolic BP (mmHg)	80.58 ± 12.47	79.88 ± 11.75	0.553

Abbreviations:-LDL:-Low density lipoprotein, HDL:-high density lipoprotein, TG:-triglycerides, CRP:-C -reactive protein

Major Cardiovascular Events: No significant differences were observed between the groups in the incidence of major cardiovascular events after one year. Mortality rates were similar (1.4% in Group I vs. 1.5% in Group II, p=0.958), as were rates of cerebral stroke (1.4% vs. 0.8%, p=0.592), heart failure (6.5% vs. 4.6%, p=0.488), cardiogenic shock (5.1% vs. 6.1%, p=0.712), arrhythmias (2.9% vs. 1.5%, p=0.446), and target vessel revascularization (0% in both groups) (Table 4).

DISCUSSION

The study aimed to evaluate the impact of Ramadan fasting on the incidence and characteristics of myocardial infarction (MI), along with related clinical outcomes. The findings indicated that Ramadan fasting does not significantly alter the incidence of acute coronary syndrome (ACS) compared to non-fasting periods. This aligns with previous research by Raffee et al., who reported no significant change in acute cardiovascular illness during Ramadan, and Amen et al., who found no notable difference in acute MI rates or cardiovascular risk factors between Ramadan and non-Ramadan months in the Iraqi population [13, 14].

Table 3: Angiographic results and management strategies between both groups

	Group I (n=138) Ramadan fasting group	Group II (n=131) Non fasting group	P. value
STEM	85(61.6%)	78(59.5%)	0.731
Non STEMI	53(38.4%)	53(40.5%)	
Thrombus burden			
Low	33 (23.9%)	49 (37.4%)	
Intermediate	44 (31.9%)	42 (32.1%)	0.025
High	61 (44.2%)	40 (30.5%)	
Stent thrombosis	3 (2.2%)	1 (0.8%)	0.339
Non atheromatous coronary artery lesions	9 (6.5%)	2 (1.5%)	0.031
Ectasia with slow flow	2 (1.4%)	1 (0.8%)	0.592
Aspiration catheter use	18 (13.0%)	4 (3.1%)	0.003
Deferred stenting	13 (9.4%)	4 (3.1%)	0.032
Reperfusion type			
Balloon angioplasty	5 (4%)	4 (3%)	0.795
Direct stenting	63 (51.3%)	68 (53%)	0.305
Stenting after predilatation	55 (44.7)	56 (44%)	0.63
RCA coronary artery			
Left main coronary artery	6 (4.3%)	4 (3%)	0.575
Left anterior descending coronary artery	51 (37)%	47 (35.9%)	0.854
Circumflex coronary artery	39 (28.3%)	36 (27.5%)	0.887
Right coronary artery	42 (30.4)	44 (33.6%)	0.579
Number of diseased vessels			
One	62 (44.9%)	57 (43.8%)	0.815
Two	48 (34.8%)	48 (36.9%)	0.75
Three	28 (20.3%)	25 (19.2%)	0.804
Use of GPIIB/IIIA receptor inhibitors, n (%)	17 (12.3%)	3 (2.3%)	0.002

Abbreviations:-GPIIBIIIA:-Glycoprotein IIB/IIIA.

Culprit Lesion Characteristics: The study revealed significant differences in culprit lesion characteristics between the fasting and non-fasting groups. Notably, during Ramadan, lesions frequently exhibited a heavy thrombus burden, with some cases showing non-atheromatous lesions. This observation is particularly prominent in STEMI patients. The increased thrombus burden during Ramadan can be attributed to prolonged dehydration during daylight hours, which enhances thrombogenicity. This finding is consistent with the observed higher use of aspiration devices and intracoronary glycoprotein IIb/IIIa inhibitors in the fasting group, aimed at managing the heavy thrombotic load and preventing no-reflow phenomena. The tendency to defer stenting during Ramadan, especially in STEMI patients, may be explained by the prevalence of non-obstructive or non-significant lesions, coupled with concerns about potential no-reflow complications. Consequently, many patients, particularly younger individuals without significant atherosclerotic risk factors, were managed with intravenous glycoprotein IIb/IIIa inhibitors and delayed stenting.

Table 4:-Major cardiovascular events of both groups after one year follow up

	Group I (n=138) Ramadan fasting group	Group II (n=131) Non fasting group	P value
Mortality	2 (1.4%)	2 (1.5%)	0.958
Cerebral stroke	2 (1.4%)	1 (0.8%)	0.592
Heart failure	9 (6.5%)	6 (4.6%)	0.488
Cardiogenic shock	7 (5.1%)	8 (6.1 %)	0.712
Arrhythmia	4 (2.9%)	2 (1.5%)	0.446
Target vessel revascularization	0 (.0%)	0 (.0%)	-

Metabolic and Inflammatory Markers: The study found significantly lower blood glucose levels during admission in the fasting group, a result consistent with studies by Al-Hariri et al. and Al-Rawi et al. [15] These studies reported decreased fasting blood glucose levels and attributed this to alterations in the sleep-wake cycle and subsequent changes in insulin, neuropeptide-Y, and leptin levels during Ramadan [16].

Additionally, total serum cholesterol, LDL, and triglyceride levels were significantly lower in the fasting group. This is supported by findings from Farshidfar et al., Mansi et al., and Pathan et al., who noted improvements in lipid profiles during Ramadan. These improvements are likely due to

reduced caloric intake and altered metabolic states during fasting [17-19].

The study also observed a significant decrease in C-reactive protein (CRP) levels in the fasting group. This finding aligns with research by Aksungar et al., who demonstrated that intermittent fasting, such as that observed during Ramadan, positively affects inflammatory markers and cardiovascular risk factors [20]. A meta-analysis also suggested slight improvements in oxidative stress and inflammatory indicators during Ramadan fasting, potentially offering temporary protection against systemic inflammation and oxidative stress, which are linked to various chronic diseases [21].

Clinical Outcomes: Despite these biochemical and angiographic differences, there was no significant disparity in clinical outcomes between the fasting and non-fasting groups. This contrasts with some studies, such as Rahman et al., who suggested that fasting might be associated with a shorter hospital stay and a potential cardio-protective effect in acute MI cases. Conversely, Betesh-Abay et al. [22] found that the post-Ramadan period could be a risk factor for adverse MI outcomes among Muslims. This discrepancy highlights the need for further research to understand the long-term implications of Ramadan fasting on cardiovascular health.

While Ramadan fasting does not appear to increase the incidence of MI or adversely affect clinical outcomes, it does influence thrombus characteristics, metabolic profiles, and inflammatory markers. These findings underscore the importance of individualized patient management strategies during Ramadan, especially for those with acute coronary conditions.

Limitations of the Study

This study has several limitations. The sample size was relatively small, and the study was conducted at a single center, which limits the generalizability of the results. Multicenter studies with larger sample sizes are needed to validate these findings. The follow-up period was also relatively short (6 months), and a longer follow-up may provide a more comprehensive understanding of outcomes between the fasting and non-fasting periods. Furthermore, the study did not utilize advanced imaging modalities, such as intravascular ultrasound (IVUS), during coronary angiography. Without these imaging techniques, it is challenging to fully confirm the presence or absence of atheromatous disease in the lesions.

CONCLUSION

During the month of Ramadan, myocardial infarctions were characterized angiographically by non-atheromatous coronary artery lesions and lesions with a heavy thrombus burden. This observation led to increased use of glycoprotein IIb/IIIa inhibitors, aspiration catheters, and a tendency to defer stenting, particularly in STEMI patients compared to non-STEMI patients. Despite these angiographic differences, the incidence of myocardial infarction and major adverse cardiovascular events (MACE) did not significantly differ between Ramadan and other months of the year. Additionally, favorable metabolic changes were noted during Ramadan fasting, including lower blood glucose levels, reduced serum CRP, and decreased total cholesterol and LDL levels.

AUTHORS' CONTRIBUTION

MK, MK, AM, ME, and AE: Concept and design, data acquisition, interpretation, drafting, final approval, and agree to be accountable for all aspects of the work. MK, MK, AM, ME, and AE: Data acquisition, interpretation, drafting, final approval and agree to be accountable for all aspects of the work.

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REFERENCES

1. Ohm J, Skoglund PH, Häbel H, Sundström J, Hambraeus K, Jernberg T, et al. Association of socioeconomic status with risk factor target achievements and use of secondary prevention after myocardial infarction. JAMA Network Open. 2021;4(3):e211129-e.
2. Rafie C, Sohail M. Fasting during Ramadan: nutrition and health impacts and food safety recommendations. Virginia Coop. Ext., pp. 1–10, 2016, [Online]. Available: www.ext.vt.edu. (Accessed. October 10, 2024).
3. Lessan N, Ali T. Energy metabolism and intermittent fasting: the Ramadan perspective. Nutrients. 2019;11(5):1192.
4. Betesh-Abay B, Shiyovich A, Davidian S, Gilutz H, Shalata W, Plakht Y. The association between acute myocardial infarction-related outcomes and the Ramadan period: a retrospective population-based study. J Clin Med. 2022;11(17):5145.
5. Hassan-Beck R, Hafidh K, Badi A, Dougman K, Karmo M, Mir R, et al. Ramadan Fasting in Health and Disease in 2021: A Narrative Review. Ibnosina J Med Biomed Sci. 2022;14(02):050-67.
6. Kami F, Kordi MR, Quchan ASK, Shahidi SH, Shabkhiz F. Effect of Ramadan Fasting on the Blood Coagulation System in a Session Soccer Match. J Nutr Fasting Health.2022;10(2):143-9..
7. Mitchell C, Rahko PS, Blauwet LA, Canaday B, Finstuen JA, Foster MC, et al. Guidelines for performing a comprehensive transthoracic echocardiographic examination in adults: recommendations from the American Society of Echocardiography. J Am Soc Echocardiogr. 2019;32(1):1-64.

8. Byrne RA, Rossello X, Coughlan JJ, Barbato E, Berry C, Chieffo A, et al. 2023 ESC guidelines for the management of acute coronary syndromes: developed by the task force on the management of acute coronary syndromes of the European Society of Cardiology (ESC). Eur Heart J Acute Cardiovasc Care. 2024;13(1):55-161.
9. Karagiannidis E, Papazoglou AS, Sofidis G, Chatzinikolaou E, Keklikoglou K, Panteris E, et al. Micro-CT-based quantification of extracted thrombus burden characteristics and association with angiographic outcomes in patients with ST-elevation myocardial infarction: the QUEST-STEMI study. Front Cardiovasc Med. 2021;8:646064.
10. Hurford R, Sekhar A, Hughes TAT, Muir KW. Diagnosis and management of acute ischaemic stroke. Pract Neurol. 2020;20(4):304-16.
11. McBeath K, Cowie MR. Heart failure: classification and pathophysiology. Medicine. 2022;50(8):471-8.
12. Kapur NK, Kanwar M, Sinha SS, Thayer KL, Garan AR, Hernandez-Montfort J, et al. Criteria for defining stages of cardiogenic shock severity. J Am Coll Cardiol. 2022;80(3):185-98.
13. Raffee LA, Alawneh KZ, Al Suleiman MK, Ibdah RK, Rawashdeh SI, Al-Mistarehi A-HW. An observational study of the occurrence of acute coronary syndrome (ACS) among jordanian patients: Identifying the influence of Ramadan Fasting. Ann Med Surg. 2020;59:171-5.
14. Amen SO, Baban ST, Yousif SH, Hawez AH, Baban ZT, Jalal DMF. The impact of ramadan fasting on acute coronary disease events among Iraqi population. Med J Babylon. 2020;17(2):181-4.
15. Al-Hariri M, Khan S, Albaker W, Al Malik W. Impact of knowledge and practice on fasting blood glucose levels among diabetics during ramadan fasting. J Epidemiol Glob Health. 2019;9(4):288-93
16. Al-Rawi N, Madkour M, Jahrami H, Salahat D, Alhasan F, BaHammam A, et al. Effect of diurnal intermittent fasting during Ramadan on ghrelin, leptin, melatonin, and cortisol levels among overweight and obese subjects: A prospective observational study. PloS One. 2020;15(8):e0237922.
17. Farshidfar GHR, Yousfi H, Vakili M, Noughabi FA. The effect of Ramadan fasting on hemoglobin, hematocrit and blood biochemical parameters. J Res Health Sci. 2023;6(2):21-7.
18. Mansi KMS. Study the effects of Ramadan fasting on the serum glucose and lipid profile among healthy Jordanian students. Am J Appl Sci. 2007;4(8):565-9.
19. Pathan M, Patil R. Effect of Ramadan fasting on body weight and lipid profile. Biomed Pharmacol J. 2015;3(1):167-70.
20. Aksungar FB, Topkaya AE, Akyildiz M. Interleukin-6, C-reactive protein and biochemical parameters during prolonged intermittent fasting. Ann Nutr Metab. 2007;51(1):88-95.
21. Mrad S, Rejeb H, Ben Abdallah J, Graiet H, Ben Khelifa M, Abed A, et al. The impacts of Ramadan intermittent fasting on oxidant/antioxidant stress biomarkers of stable chronic obstructive pulmonary disease male patients. Am J Mens Health. 2019;13(3):1557988319848281.
22. Rahman S. Ramadan Fasting and its Health Benefits: What's New? Open Access Maced J Med Sci. 2022;10(E):1329-42.