Medical Journal of the
Islamic Republic of Iran

Special Issue
Supplement of
Volume 6, Number 3
Fall 1992
Payiz 1371

SERUM GLUCOSE, BILIRUBIN, CALCIUM, PHOSPHORUS, PROTEIN AND ALBUMIN CONCENTRATIONS DURING RAMADAN

F. AZIZI AND H. A. RASOULI

From the Department of Medicine, Taleghani Medical Center, Shahid Beheshti University of Medical Sciences, Tehran, Islamic Republic of Iran.

ABSTRACT

Serum levels of glucose, bilirubin, calcium, phosphorus, protein and albumin were measured in a group of nine healthy men before, and on the first, 10th, 20th and 29th day of Ramadan, and four weeks after Islamic fasting was terminated. There was a significant reduction in body weight, a significant increase in serum bilirubin and a slight decrease in calcium during Ramadan. Serum glucose decreased on the first and 10th days of Ramadan, but increased thereafter and reached pre-Ramadan values on the 29th day. The lowest serum glucose recorded was 63 mg/dl. All changes returned to basal values four weeks after Ramadan. There was no significant change in the levels of serum phosphorus, protein or albumin. Physicians caring for Muslims during this month should be aware of these changes.

INTRODUCTION

Fasting during Ramadan is a religious duty for all adult and healthy Muslims. Ramadan is the ninth month of the Islamic lunar calendar. Since the lunar year contains 354 days, Ramadan begins 11 or occasionally 12 days earlier each solar year and is situated in all of the four seasons, changing seasons every eight to nine years. During Ramadan the majority of Muslims have two main meals, one immediately after sunset and the other just before dawn. They are allowed to eat and drink between sunset and dawn but they do not consume any food or drink after dawn.[1]

Although millions of muslims fast in Ramadan, physiological changes occurring during Islamic fasting (dawn to sunset) have only recently received attention.[2-4] As we were unable to find any data regarding changes in serum glucose, bilirubin, calcium, phosphorus, protein and albumin during Ramadan, the present study was undertaken to evaluate the effect of Islamic fasting on these serum constituents.

MATERIALS AND METHODS

Nine healthy male volunteers, ages 23 to 54 years (mean age 35), were selected and studied in Ramadan, 1403 (June 13 to July 11, 1983) at the Taleghani Medical Center in Tehran. They fasted each day from dawn to sunset for 29 days. The length of each day of fasting was approximately 17 hours (3 a. m. to 8 p. m.). The subjects of the study had two main meals, one after sunset (*Iftar*) and the other just before dawn (*Sahur or Sahar*), and they were allowed to eat and drink in the interim. Like the majority of Muslims in Iran, their *Sahar* meal was an ordinary meal consisting of meat, vegetables, and rice or bread, and their *Iftar* meal was variable, but was usually composed of the same substances as *Sahar*. There is however a tendency to consume more sweet food and drinks, particularly dates, at and following *Iftar*.

Blood samples were taken immediately after sunset for one week before Ramadan and on the first, 10th, 20th and 29th day of Ramadan, and four weeks after the month of fasting was terminated. Pre-Ramadan samples were taken after an eight hour fast, from 12 noon to 8 p. m. The following blood tests were performed by routine laboratory methods: hematocrit, white blood count, urinalysis, and serum concentrations of glucose, bilirubin, calcium, phosphorus, protein and albumin. The results were evaluated with Student's t and paired t tests.

RESULTS

Body weight decreased in each subject during Ramadan. The mean ± SD body weight was 65.4 ± 9.1 kg before Ramadan, and decreased to 63.3 ± 9.2, 62.9 ± 8.9 and 61.6 ± 9.0 kg on the 10th, 20th and 29th day of Ramadan respectively. Four weeks after Ramadan, body weight had increased to pre-Ramadan values (64.8 ± 8.5 kg). On the days of the blood tests, the subjects had no complaints and review of systems was normal. Results of hematocrit and white blood cell counts were normal throughout Ramadan. Urinalysis was normal except for occasional trace ketonuria.

There were no significant changes in serum concentrations of protein, albumin and phosphorus throughout Ramadan. There occurred a slight decrease in serum calcium, a moderate fall in serum glucose and moderate increase in serum bilirubin levels. Four weeks after Ramadan, concentrations of all aforementioned serum constituents were almost equal to those of basal levels.

Serum Calcium Levels

By the 10th day of Ramadan, there was a slight but significant decrease in serum calcium concentration, such that the basal mean ± SD of 9.6 ± 0.5 dropped to 8.7 ± 0.6 mg/dl (p 0.05). In five of the nine subjects, there was a decrease of more than 0.5 mg/dl in the serum calcium level. On the 20th and 29th days of Ramadan, mean serum calcium levels were 9.3 ± 0.6 and 9.1 ± 0.3 mg/dl (NS when compared to basal values). Compared to values taken on day 10, there was a significant increase in serum calcium on the 20th (p 0.025) and 29th (p 0.025) days.

Table 1. Serum glucose levels (mg/dl) before and during Ramadan.

Subject	Basal	Days of Ramadan			
		1	10	20	29
1	85	75	75	74	78
2	88	78	70	79	87
3	78	72	70	76	85
4	74	70	65	76	80
5	85	89	65	76	87
6	79	63	65	71	78
7	85	78	75	71	93
8	82	83	65	79	80
9	82	69	70	79	87
Mean	82	75	69	76	84
SD	4.4	7.9	4.2	3.2	5.2
P values (Paired t test):					
Basal v.		‹0.025	‹0.001	‹0.01	NS
Day 29 v.		‹0.01	‹0.001	‹0.005	
Day 20 v.		NS	‹0.01		
Day 1 v.			NS		

Serum Glucose Levels

After the 17-hour fast of the first day of Ramadan, serum glucose was significantly lower than the basal value. By day 10, it had further decreased and reached its lowest value. There was a significant increase in serum glucose on the 20th day as compared to the 10th day. By day 29, serum glucose had reached pre-Ramadan levels and remained unchanged four weeks after termination of the fasting month. The lowest serum glucose recorded during the study was 63 mg/dl, seen in subject No. 6 after 17 hours fasting on the first day. (Table 1).

Serum Bilirubin Levels

After 17 hours of fasting on the first day, serum bilirubin increased in every subject. The mean concentration of serum bilirubin on the first and 10th days was 2.5 times the basal value. By the 20th and 29th days of Ramadan, serum bilirubin had fallen significantly as compared to the value on the 10th day; however, it was still twice basal level. Four weeks after Ramadan, serum bilirubin decreased in all subjects, but in subjects nos. 5, 7, and 8, still remained above 0.97 mg/dl. These subjects had the highest basal level before and the largest increase is serum bilirubin during Ramadan. (Table 2).

DISCUSSION

One entire month of fasting every year is particular to Islam and is observed strictly by millions of Muslims. Children, menstruating women, and persons who are ill or travelling are exempted, and pregnant and lactating women are allowed to postpone fasting until such a

Table 2. serum bilirubin levels (mg/dl) before, during and after Ramadan.

Subject	Basal	Days of Ramadan				After*
		1	10	20	29	
1	.43	1.43	1.30	.90	.90	.42
2	.40	.90	1.70	.60	.62	.28
3	.40	1.00	.32	.58	.67	.49
4	.50	1.00	2.15	1.37	.60	.37
5	.83	2.10	1.10	1.17	1.47	1.30
6	.43	1.50	.75	1.10	.93	.42
7	.77	2.30	1.50	1.60	1.50	.98
8	.70	1.70	1.75	1.60	1.50	1.10
9	.58	.95	2.10	1.16	1.42	.58
Mean	.56	1.43	1.42	1.14	1.08	.66
SD	.17	.52	.60	.39	.40	.37
P Values (Paired t test):						
Basal v.		‹0.001	‹0.005	‹0.001	‹0.001	NS
Day 29 v.		‹0.025	NS	NS		‹0.001
Day 20 v.		NS	NS			
Day 10 v.		NS				

*Four weeks after Ramadan

time as they have no reason for exemption. The experience of Islamic fasting teaches Muslims self-restraint and self-discipline and enables them to appreciate the hunger of the impoverished.

Islamic fasting is distinct from regular voluntary experimental fasting by the fact that it is intermittent fasting from dawn to sunset every day for one month, and complete abstinence from both food and drink during fasting hours is observed. Therefore, it provides a unique model of fasting where physiological changes and homeostatic response require special and careful studies.

In the present study, slight decrease in serum calcium level occurred by the 10th day and serum phosphorus levels did not change significantly during Ramadan. In studies of prolonged continuous fasting, serum phosphorus is normal,[5] serum calcium may be normal[6,7] or deceased,[8] and there occur a significant increase in urinary excretion of both calcium and phosphorus.[5-9] However, there is a decline rather than a rise in calcium excretion on the first day of the fasting.[6,7,9] The cause of the slight decrease in serum calcium during Ramadan is not clear and requires studies of urinary excretion of calcium, and measurement of serum parathormone and vitamin D metabolites.

In the present study, intermittent 17-hour-a-day abstinence from food and drinks resulted in significant decline of serum glucose levels on the first and 10th day of Ramadan. In continuous starvation, serum glucose levels after one day of fasting may be normal[15] or slightly decreased.[11] After three to five days of continuous fasting, serum glucose declines to a minimum[8,10-13] and after seven days begins to rise slightly[13] or significantly[12] and may reach values higher than baseline by the third week.[12]

Elegant studies by Cahill and Felig and their co-workers summarized in two review articles[14,15] have established the homeostatic response to continuous starvation. The liver begins glycogenolysis four to five hours after a meal, and perhaps longer if it was a very large meal. This process may maintain blood glucose for 12 to 16 hours, along with gluconeogenesis which accounts for 25% of glucose released in the circulation.[15] With continuous fasting, gluconeogenesis becomes the most important pathway of producing glucose for two to ten days, and mobilization of fat stores plays a major role after this time. In the metabolic responses to fasting, insulin and glucagon play major roles. However, changes in serum concentrations of growth hormone, cortisol, thyroid hormones and catecholamines may have permissive roles. Of these, only the hypothalamic-pituitary-thyroid axis and peripheral metabolism of thyroid hormones were evaluated by us during Ramadan[16] and no significant changes were found.

With consideration to the fact that in the present study, subjects had a large meal just before dawn and went to sleep thereafter, it is safe to assume that glycogen stores in the liver, along with some degree of gluconeogenesis, were the main factors in maintaining blood glucose until sunset. It is not clear if consumption of two meals within an interval of seven hours could restore glycogen stores completely. Of interest was the increase in serum glucose on the 20th day of Ramadan, similar to changes observed previously during continuous fasting for four weeks.[12] It has been shown during continuous fasting that decline in serum glucose is more marked in women than in men.[11] Therefore, the present results can not be applied to women during Ramadan.

In regard to increase in serum bilirubin during Ramadan, it is now well documented that continuous fasting in normal subjects results in a rise in the unconjugated fraction of serum bilirubin.[17,18] The rise becomes significant after 15 hours of fasting. Refeeding with carbohydrates or a mixed diet, but not by amino acids or fat, reverses fasting hyperbilirubinemia.[18] It is of interest that the degree of hyperbilirubinemia was significantly less on days 20 and 29 when compared with day 10 of Ramadan. The fall in serum bilirubin coincided with a rise in serum glucose levels during the latter days of Ramadan, suggesting carbohydrate dependency of amelioration of fasting hyperbilirubinemia.

We conclude that changes in serum concentrations of glucose, bilirubin and calcuim occur during Ramadan in men, and physicians working in Muslim countries and those caring for Muslims in other regions should be aware of these physiological alterations.

REFERENCES

1. Sakr AH. Fasting in Islam. J Am Dietet 67:17-21. 1975
2. Gumaa KA, Mustafa KY, Mahmood NA, Gader AMA. The effects of fasting in Ramadan. 1. Serum uric acid and lipid concentrations. Br J Nutr, 40:573-81. 1978.
3. Mustafa KY, Mahmood NA, Gumaa KA, Gader AMA. The effects of fasting in Ramadan. 2. Fluid and electrolyte balance. Br J Nutr, 40:583-90. 1978.
4. Fedail SS, Murphy D, Salih SY, Bolton CH, Harvey RF. Changes in certain blood constituents during Ramadan. Am J Clin Nutr, 36:350-53. 1982.
5. Kerndt PR, Naughton JL, Driscoll CE, Loxterkamp DA. Fasting: The history, pathophysiology and complications. West J Med, 137:379-399. 1982.
6. Consolazio CF, Matoush LO, Johnson HL, Nelson RA, Krzwicki HJ. Metabolic aspects of acute starvation in normal humans (10 days). Am J Clin Nutr, 20:672-83,1967.
7. Stein F, Kolanowski J, Bemelmans D, Desmecht P. Renal handling of calcium in fasting subjects: Relation to ketosis and plasma ionized calcium level. Scand J Clin Lab Invest,43: suppl.165, 99-100. 1983.
8. Spencer H, Lewin I, Samachson J. Changes in metabolism in obese persons during starvation. Am J Med, 40:27-37. 1966.
9. Fleming LW, Stewart WK. Effect of carbohydrate intake on the urinary excretion of magnesium, calcium and sodium in fasting obese patients. Nephron, 16:64-73. 1976.
10. Chill GF Jr, Herrera MG, Morgan JS et al. Hormone-fuel

interrelationships during fasting. J Clin Invest, 45:1751-1769, 1966.
11. Merimee TJ, Tyson JE. Stabilization of plasma glucose during fasting. Normal variations in two separate studies. N Engl J Med, 291:1275-78. 1974.
12. Rapaport A, From GLA, Husdan H.Metabolic studies in prolonged fasting. II. Organic metabolism. Metablism, 14:47-58. 1965.
13. Marliss EB,Aokj TT, Unger RH, Soeldner JS, Caghll GF Jr. Glucagon levels and metabolic effects in fasting man. J Clin. Invest, 49:2256-70. 1970.
14. Chill GF Jr. Starvation in man. Clin Endocrinol Metab, 5:397-415. 1976.
15. Felig P.Starvation. In Degroot LJ et al (eds). Endocrinology,vol 3. New York. Grune & Stratton, pp. 1927-1940. 1979
16. Azizi F.Male reproductive function, serum levels of prolactin, thyrotropin and thyroid hormones and TRH resposiveness in intermittent Islamic fasting (submitted for publication).
17. Owens D, Sherlock S.Diagnosis of Gilberts syndrome: Role of reduced caloric intake test. Br Med, J 3:559-563. 1973.
18. Barret PVD. Effects of caloric and noncaloric materials in fasting hyperbilirubinemia. Gastroenterology, 68:361-369. 1975.