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Islamic Fasting and Health

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Key Words
Fasting · Glucose homeostasis · Glycogen · Serum lipids

Abstract
Background: Muslims fast from sunrise to sunset during the month of Ramadan, the 9th lunar month. The duration of fasting varies from 13 to 18 h/day. Fasting includes avoidance of drinking liquids and eating foods. The aim of this article is to review health-related aspects of Ramadan fasting. ***Methods:*** Related abstracts from 1960 to 2009 were obtained from Medline and local journals in Islamic countries. One hundred and thirteen articles meeting the criteria for paper selection were reviewed in depth to identify details of related materials. ***Results:*** During the fasting days of Ramadan glucose homeostasis is maintained by meals taken before dawn and by liver glycogen stores. Changes in serum lipids are variable and depend on the quality and quantity of food consumption and changes in weight. Compliant, well-controlled type 2 diabetics may observe Ramadan fasting, but fasting is not recommended for type 1, noncompliant, poorly controlled and pregnant diabetics. There are no adverse effects of Ramadan fasting on the heart, lung, liver, kidney, eyes, hematologic profile, endocrine and neuropsychiatric functions. ***Conclusions:*** Although Ramadan fasting is safe for all healthy individuals, those with various diseases should consult their physicians and follow scientific recommendations.

Introduction

Many of the world's great religions recommend periods of fasting and, of these, the Islamic fast during the month of Ramadan is strictly observed worldwide by millions of Muslims. Ramadan is the 9th month of the Islamic lunar calendar and fasting during Ramadan is the religious duty of all healthy adult Muslims. A whole month of intermittent fasting, from dawn to dusk, every year is particular only to Islam and considering that Islam has over one billion followers worldwide, it can be assumed that a few hundreds of million people observe Ramadan fasting each year. The experience of fasting teaches Muslims self-discipline and self-restraint and enables them to empathize with those less well off, the suffering and the impoverished. Fasting is not obligatory for children, menstruating women, or the sick and travelers; pregnant and lactating women are also exempt and permitted to postpone their fasting to an appropriate time when it can be observed without it affecting their maternal obligations [1].

During Ramadan, the majority of Muslims have two good-sized meals, one immediately after sunset and the other just before dawn. They are allowed to eat and drink only between sunset and dawn, when they begin their day of fasting until sunset. Since the Islamic calendar is based on a lunar cycle, the Islamic year contains 354 days, and therefore Ramadan moves back 11 days every year and

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may fall during any of the four seasons, making the duration of daily fasting vary between 11 and 18 h in the north and in tropical countries. The month of Ramadan is either 29 or 30 days.

From a physiological standpoint, Islamic fasting provides a unique model of intermittent fasting daily for 1 month. It is also distinct from regular voluntary or experimental fasting in that the faster does not drink during fasting hours. Not only does Ramadan fasting discipline the body to restrain from eating food and drinking water, it also requires restraining every part of one's physical body, the mouth and ears from gossip and profanity; all sexual thoughts and activities during fasting hours are also forbidden. Thereby, a Muslim engages his or her entire body in the physical observance of the Ramadan fast. The eyes, the ears, the tongue, and even the private parts are equally obligated to be restrained. Therefore, one may assume that physiological changes occurring during Islamic fasting would differ from those observed during an experimental fast [2].

This review discusses various health-related aspects of Ramadan fasting in health and its impact on some disease processes.

Methods

Data Source

The terms 'Islamic fasting', 'Ramadan', 'Ramadan fasting', and 'fasting in Ramadan' were used to search Medline for articles published between 1960 and July 2009. All abstracts were reviewed and, if appropriately designed, studies in English, French and German were included. Articles of abstracts meeting the criteria were then reviewed to identify details of materials related to fasting in the month of Ramadan. Some local journals in Islamic countries and research findings of two international congresses on health and Ramadan [3, 4] were also reviewed. The strategy used to search for articles was developed with the assistance of a research librarian at the Research Institute for Endocrine Sciences of Shaheed Beheshti University of Medical Sciences.

Study Selection

The following criteria were considered essential to qualify an article for inclusion in this review: (1) proper study design of survey, case control, cohort studies and clinical trials, and (2) review articles by prominent scholars.

Because we wished to include all pertinent studies, reviewers were not blinded to the study authors' names. A deliberate strategy to limit bias was therefore employed; all articles were initially potential candidates for inclusion. Failure to provide appropriate study design resulted in exclusion of that article, leading to the exclusion of 98 papers. A review of the remaining 179 papers led to the identification of 133 papers with appropriate information and design.

Table 1. The effect of Ramadan fasting on metabolism and different organs in healthy individuals

Metabolism/ organ	Effects
Carbohydrate	Glycogenolysis of the liver, some degree of gluconeogenesis in longer fasting days
Lipids	Variable, depending on the quality and quantity of diet and weight change
Body weight	Variable, mostly decreased or unchanged
Liver	Slight increase in indirect bilirubin in the first half of Ramadan fasting
Kidney	Small, insignificant changes in serum urea, creatinine and uric acid
Hematological profile	Small decrease in both iron and total iron-binding capacity
Neuro-psychiatric	Change in chronotype and sleep patterns; increase in the prevalence of headaches; decrease in parasulcide
Endocrine glands	Slight changes in protein binding of T4 and T3 and in serum calcium concentration Small reversible shifts in cortisol, testosterone and prolactin secretions
Gastrointestinal tract, heart, lungs and eyes	None

Metabolic Effects of Ramadan Fasting

The metabolic effects of fasting during Ramadan, summarized in table 1, may be affected by genetic and environmental factors, such as nutrition habits and the length of fasting day. Therefore, differences in the effects of Ramadan fasting may occur between seasons and countries.

Carbohydrate Metabolism

Alterations in carbohydrate metabolism during experimental short-term fasting have been reviewed extensively [5]. The post-absorptive period is defined as 8–16 h after eating, a period of early adaption to starvation. The primary metabolic priority is the provision of adequate glucose for the brain and other vital tissues, such as red blood, peripheral nerves and renal medulla.

In the post-absorptive state, the rate of glucose turnover is 2 mg/kg/min. In normal adults, a slight decrease in serum glucose of between 3.3 and 3.9 mmol/l (60–70

mg/dl) occurs within a few hours after fasting; the fall in serum glucose however ceases due to breakdown of glycogen, and a decrease in both glycogen synthesis and glycolysis in the liver. These changes are a result of a fall in insulin and rises in glucagon and sympathetic activity [5]. In the early stage of the post-absorptive period, the fall in glucose is associated with a depletion in the already modest liver glycogen stores, approximately 5% of the net weight of the liver. Only 1,200 calories are stored as carbohydrate in the liver, providing the basal requirement for glucose for only 5–6 h. Skeletal muscle cells lack glucose-6-phosphatase and do not release glucose from stored glycogen directly into the circulation. Eventually, following about 16–24 h of starvation (8–16 h of the absorptive period plus 5–6 h of carbohydrate release from the liver), glycogen stores become depleted and gluconeogenesis is the only remaining source of glucose. Gluconeogenesis refers to the formation of glucose from three carbon precursors including lactate, pyruvate, amino acids and glycerol. Cortisol is the principal stimulus for the catabolism of muscle protein. These mechanisms provide the daily glucose needs of the brain (100–125 g) and red blood cells (45–50 g). Simultaneously the decrease in insulin and rise in catecholamine production results in lipolysis in the adipose tissue and a rise in the level of free fatty acids, which replaces glucose as the essential fuel for use by other tissues of the body [6].

Serum glucose may decrease slightly in the first few days of Ramadan fasting, normalizing by the 20th day and showing a slight rise by the 29th day [7]. The lowest serum glucose level in this study was 63 mg/dl. Other studies have shown a mild increase [8, 9] or variation in serum glucose concentration [10, 11].

Remarks and Recommendations

During longer fasting days of >16 h, which follow a rather heavy meal taken before dawn (Sahur), the stores of glycogen, along with some degree of gluconeogenesis, maintain serum glucose levels within normal limits. Since gluconeogenesis becomes the only source of glucose after 16–24 h of fasting, it is recommended that observers of fasts do not skip Sahur, their predawn meal, because of the possibility of extended gluconeogenesis.

Lipid Metabolism

Serum cholesterol may decrease in the earlier days of fasting [12] and subsequently rise to pre-fasting values during the following days of Ramadan [12, 13]. Raised concentrations of cholesterol and LDL, reported by some investigators [14–17], may be related to weight loss during Ramadan fasting; others, however, have found either no change [17, 18] or decreased levels of cholesterol during Ramadan fasting [2, 9, 18–21]. A marked increase in plasma HDL cholesterol occurring after Ramadan fasting has been observed and might be a promising finding [19–22]. In trained athletes, sub-maximal exercise during Ramadan fasting increases lipid oxidation [23]. The Apo A-1 concentration increases and Apo B levels fall in both normal and diabetic individuals [24, 25]. Alterations in serum lipid may be related to consuming a large meal, as has been shown in individuals taking one large meal every day [26]. In fasting subjects, who did not show any weight change during the month of Ramadan, it has been seen that serum leptin and insulin concentrations increased and neuropeptide Y levels decreased [27]; another study, however, did not find any significant change in amplitude or 24-hour mean concentration of leptin during Ramadan fasting [28]. The significant reduction in energy intake during Ramadan is accompanied by a decrease in plasma total cholesterol, LDL-C, and triglyceride concentrations [29], and cardiovascular risk profiles [30].

Remarks and Recommendations

Changes in blood lipids seem to be variable and probably depend on the quality and quantity of food consumption and the degree of weight changes. Avoiding weight gain and reducing the consumption of total calories and saturated fatty acids are the main recommendations for those fasting during Ramadan.

Diabetes

Approximately half of the patients with type 1 and two thirds of the patients with type 2 diabetes observe Islamic fasting in Muslim countries [31]. The majority of studies on Islamic fasting indicate that no major problems are encountered by patients with type 2 and even well-controlled type 1 diabetes during Ramadan fasting [32–35]. The amount of energy intake is unchanged or decreased in most patients during fasting and weight loss may be observed [36]. There are no significant changes in fasting plasma glucose (FPG), HbA1c [37–39], fructosamine, insulin and C-peptide [32, 37, 38] levels during fasting, although some studies do show a trend towards better glycemic control [40] while others indicate an increase in FPG and poor control of diabetes during this month of fasting [41]. Changes in FPG may occur due to the changes in body weight and exercise habits, amount and type of foods consumed, gorging after breaking of the fast, or irregularity of medication compliance [2]. Although in-

creases in total cholesterol levels have been reported [36, 40], most patients with either type 1 or type 2 diabetes do not show significant changes in lipid profiles during Islamic fasting [35, 39, 42].

In diabetic patients, serum concentrations of blood urea nitrogen, creatine, uric acid, alanine aminotransferase, aspartate aminotransferase, protein and albumin values show no significant changes during Ramadan fasting [37, 43].

Although some reports do not show any increase in the rate of hypoglycemia, a study of 13 Muslim countries reported an increased frequency in the occurrence of severe hypoglycemic episodes in both type 1 and 2 diabetes patients during this month of fasting, in particular in those who had changed their dose of oral hypoglycemic agents or insulin or had modified their levels of physical activity [31].

Remarks and Recommendations

Diabetic patients who should not fast are those known to be noncompliant, poorly controlled, and all brittle type 1 diabetics; pregnant diabetics, those with a history of diabetic ketoacidosis or hyperosmolar coma, and patients with serious complications such as coronary artery disease, cirrhosis and chronic renal failure; elderly patients with any degree of alertness problems, and diabetics with frequent episodes of hyper- or hypoglycemia before and/or during Ramadan fasting [44–46].

Diabetics who are motivated to observe fasting in Ramadan must visit a physician and a dietician before Ramadan. Dietary and glycemic control should be achieved and advice relating diet adherence, appropriate exercise, self-monitoring of blood glucose and compliance with medical therapy should be emphasized [47, 48].

During Ramadan fasting, patients are advised against excessive gorging. If taking single-dose short-acting sulfonylurea or metformin, or both, the patient should take these with the sunset meal. If 2 or 3 doses of oral hypoglycemic drugs are taken each day, the morning and midday doses should be taken after sunset and half the normal evening dose before dawn, with Sahur. If a patient with insulin-controlled diabetes insists in fasting, he/she should take the normal morning dose after sunset and half of the evening dose before dawn. If basal insulin is taken, long-acting insulin should be reduced to two thirds [47–49]. Glycemic control may improve and the rate of hypoglycemia reduced by using short-acting insulin analogs [50] or continuous subcutaneous insulin infusion [51].

Metabolic Syndrome

Small decreases in daily energy intake, accompanied by around 2 kg weight loss, induce a decrease in FPG and increase insulin sensitivity in subjects with metabolic syndrome [52]. Assessment of abdominal fat distribution using computed sonography showed no change in males but a reduction was seen in the visceral fat component in females and younger individuals, probably due to fat redistribution, related to more physical activity [53].

Other Effects of Ramadan Fasting on Health Parameters

The Heart

Bradycardia and hypotension may occur and changes in the electrocardiogram, including decreased altitude of the QRS complex and T wave and right axis deviation have been reported in prolonged fasting. During the first few days of fasting, however, the heart rate and blood pressure remain normal and, in short fasts, changes in electrocardiogram are not seen [54]. Studies report no increase in the incidence of acute myocardial infarction, unstable angina [55] or stroke [56] during Ramadan fasting, indicating that the effects of Ramadan fasting on stable patients with cardiac disease are minimal [57, 58]. It is not known if mild dehydration and hemoconcentration may harm those with moderate to severe coronary artery disease. However, one study has speculated that Ramadan fasting does not increase acute coronary artery disease events [59].

Remarks and Recommendations

There seems to be no contraindications to fasting for patients with valvular problems or subjects with mild coronary artery disease.

The Lung

It has been shown that fasting in Ramadan does not exert any significant effect on pulmonary volume functions and spirometry values in healthy individuals [60–62]. Dehydration and dryness of the respiratory tract mucosa may, however, worsen bronchoconstriction in asthmatic patients.

Remarks and Recommendations

Some healthcare personnel permit asthmatic patients whose disease is stable to fast, while using inhalers, slow release drugs, and suppositories [63]. However, the majority of patients with clinically symptomatic chronic

lung disease or asthma should be advised against fasting in Ramadan.

Gastrointestinal Tract

There is a fall in gastric secretion during prolonged fasting and gastrointestinal tract movements occur every 2 h [64]. The gallbladder empties one to three times every 4 h, less frequently than in the fed state [65]; the onset of acute cholecystitis is not precipitated by Ramadan fasting [66]. Gastrointestinal function during Ramadan remains to be investigated.

Complications of ulcers in fasting patients have been reported [67]; it has been shown that treatment with a proton pump inhibitor is equally effective for patients with duodenal ulcer, both for those who fast and those who do not [68].

Remarks and Recommendations

Patients with complicated peptic ulcer may be advised against fasting. However, asymptomatic patients may try fasting, and take cimetidine or ranitidine or small dose proton pump inhibitors at Iftar (fast breaking after sunset) and Sahur, if hyperacidity continues to be a problem. Fasting may benefit patients with spastic colitis and other intestinal motility disorders.

The Liver

In experimental fasting, an increase in indirect bilirubin occurs 15 h after fasting [69, 70]. Refeeding the patient with a normal meal or carbohydrates only, but not protein or fat diets, returns bilirubin concentrations to normal values. Serum bilirubin may rise [7] or remain unchanged [12] after 10 days of Ramadan fasting, the peak increase being on the 10th day when blood glucose levels are the lowest; falls in bilirubin are seen in the last 10 days of fasting, when blood glucose concentrations rise [7]. No significant changes in serum SGOT, SGPT, protein and albumin concentrations are reported during Ramadan [7, 12].

Remarks and Recommendations

Ramadan fasting is harmless to the liver in normal subjects. Those with clinically apparent hepatitis and cirrhosis should not fast.

The Kidney

Urinary volume, osmolality, pH, nitrogen, solute and electrolyte excretion remain normal [71] with maybe small, insignificant changes in serum urea and creatinine during Ramadan fasting [12, 72]. In prolonged fasting, serum levels of uric acid increase to abnormal values [73]. Because of decreases in GFR and uric acid clearance, a slight increase in uric acid may be seen [12, 74], due to the nature of fasting which is short-lasting and intermittent. No detrimental effects on health have been attributed to negative water balance at the levels that may be produced during Ramadan [75]. In experimental prolonged fasting, whereas continued urinary excretion of potassium has been reported, serum potassium remains normal [76]. Ramadan fasting does not cause significant alterations in serum sodium and potassium [12].

Ramadan fasting may have adverse/injurious effects on the renal tubules in chronic kidney disease patients [77]; due to increased food consumption when they break their fast at Iftar, subjects on hemodialysis may experience rises in serum potassium, body weight and fluid overload between dialysis sessions [78, 79]. Studies report that renal transplant recipients on immunosuppressive therapy, who have normal allograft function, experience no harmful effects from fasting [80, 81]; glomerular filtration rate, mean arterial pressure, urinary protein excretion and renal concentrating ability remain unchanged [82, 83], as is the case with kidney transplant recipients with mild to moderate renal dysfunctions that were stable prior to fasting [84]. Studies on the frequency of urinary stones throughout the year in Saudi Arabia [85] and Iran [86] found no significant increase in stones during Ramadan fasting.

Remarks and Recommendations

Patients with chronic kidney disease should be advised against fasting. They must be advised about the potential risk of hyperkalemia and if they still insist on fasting, their renal function and electrolytes should be monitored, and should any deterioration occur, they must break their fast [78]. Stable renal transplant patients may be allowed to fast under observation of a specialist.

The Eyes

There is no significant change in intraocular pressure during Islamic fasting. Although it has been suggested that Ramadan fasting may be allowed in selected glaucomatous patients without any modifications in therapy [87], a general recommendation awaits further studies.

Hematological Profile

No significant changes in hemoglobin, red blood cell indices, white blood cell count or the sedimentation rate have been seen [7, 12]. Decreased serum iron levels and total iron-binding capacity have been reported [12], indicating that iron stores are not significantly disturbed.

Neuropsychiatric Function

No alteration in EEG has been reported, even in prolonged starvation [88]. In experimental fasting, the appetite decreases after 1–4 days of fast [89, 90], probably due to ketosis; β-endorphin may also play a role in diminishing the appetite during fasting [91]. A significant decrease in meal frequency occurs during Ramadan as compared to before and after Ramadan. Chronotype as evaluated by the Horn and Ostberg scale was changed significantly during Ramadan with an increase in the evening type and a decrease in the morning type of subjects. Some studies showed that daytime sleepiness as evaluated by the Epworth Sleepiness Scale [92] and walking EEG [93] increased significantly, a finding not supported by other data [94]. Oral temperature, subjective alertness and mood are decreased during daytime and increased at 23.00 h during Ramadan intermittent fasting [95]. Determination of platelet aggregation responses shows that stress encountered during the Ramadan fasting is less than that encountered on an ordinary non-fasting day [96]. One report has found that significantly fewer parasuicides occur during Ramadan in Jordan [97], a finding that needs to be confirmed by further research.

Headaches were reported by 41% in fasting as compared to 8% of non-fasting subjects, with the tension type reported in 78% of the cases. Any increase in the hours of daily fasting, especially in those prone to headaches, increased headache frequency. The most important exogenous-associated factor was caffeine withdrawal [98].

Remarks and Recommendations

Patients with apparent neuropsychiatric disease and frequently occurring headaches should consult their physician before deciding to fast in Ramadan.

Changes in Body Weight

Weight losses of 1.7 [7], 1.8 [99], 2.0 [100], 3.8 kg [101] and more after fasting the month of Ramadan have been reported in normal weight individuals. In one study, over-represented by females, no change in body weight was seen [15]. It has also been reported that overweight persons lose more weight than normal or underweight subjects [100]; another study, however, reported an increase in body weight due to more consumption of sweets and total calories [12].

Endocrine Glands

No significant alterations in serum concentrations of T_4, T_3, TSH, and TSH response to intravenous injection of thyrotropin-releasing hormone (TRH) were found to occur in fasting males [74]. In women, serum T_4 and T_3 concentrations may decrease in the last days of Ramadan, the fall, however, being mainly due to alterations in protein binding as free thyroid indices remain unchanged [101, 102]. A small increase in serum T_4 in the last days of Ramadan has been reported by some studies [14], but not substantiated by others [74, 99, 101–103]. Experimental fasting for over 48 h causes a fall in serum T_3 along with a rise in serum rT_3 [104–106]; TSH response to TRH may decrease or remain unaltered. Refeeding with carbohydrates but not protein or fat causes an increase in serum T_3 [104]. The length of fasting in Ramadan is not enough to cause any alteration in the pituitary-thyroid axis or peripheral conversion of T_4. In prolonged experimental fasting, serum testosterone and FSH may be unchanged [107], decreased [108] or testosterone decreased and FSH increased [109]. The serum luteinizing hormone (LH) concentration and its response to gonadotropin-releasing hormone (GnRH) injection remains unchanged, but the FSH response to GnRH may be attenuated [108]. Serum prolactin is normal and its response to TRH injection may remain normal or diminished [110]. In short periods of fasting, no alterations in serum concentrations of testosterone, FSH, LH and prolactin, and prolactin response to TRH were detected in normal males during Ramadan fasting [108]. There is a shift in the onset of cortisol and testosterone secretion; the nocturnal peak of melatonin is diminished, while the evening peak of prolactin is enhanced [111, 112]. The increase in diurnal values and the decrease in nocturnal concentrations of cortisol may be related to disturbances in sleep schedule and a reduction in physical activity [111–113].

Mean serum concentrations of calcium may decrease slightly 10 days after fasting in Ramadan, but no subnormal values can be seen [7]. In the last half of Ramadan, serum calcium remains normal, although it may be slightly increased, as compared to pre-Ramadan values [7, 12]. Serum phosphorus and parathormone (PTH) concentrations do not change in Ramadan [7, 8].

Remarks and Recommendations

There are no important alterations in endocrine function during Ramadan fasting. Also advised against fasting during Ramadan are those with severe untreated hypothyroidism, hyperthyroidism, Cushing's and Addison diseases, and other apparent endocrinopathies.

Pregnancy and Lactation

Although starvation in pregnant women may result in decreased blood glucose, after 20 h of fasting, blood glu-

cose remains within the normal range, i.e. above 2.8 mmol/l (50 mg/dl) [114]. Even in long-term starvation, fetal energy is provided via compensatory mechanisms [115]. A significant fall in glucose, insulin, lactate and carnitine and a rise in triglycerides and hydroxybutyrate was reported at the end of the fasting day in pregnant women [116]. In another reports the LDL/HDL ratio was decreased and the outcome of pregnancy was comparable to those who did not fast [117, 118]. The outcome of pregnancy in Gambian women who fasted during Ramadan was unsatisfactory; however, no control group was evaluated [119]. However, in areas without malnutrition Ramadan fasting did not affect the intrauterine growth [120] and birth weights of over 13,300 babies at delivery were reported to be normal [121]. Fasting during Ramadan has no effect on the decrease in amniotic fluid index, deepest vertical pocket and amniotic fluid volume [122] and does not lead to maternal ketonemia or ketonuria [123]. There is no significant difference in physical and intellectual development in 4- to 13-year-old children born to mothers who fasted in Ramadan during pregnancy, as compared to those children whose mothers did not fast [124]. Lactating mothers who fast may lose body water and show changes in plasma osmolality, and uric acid, lactose, sodium, and potassium content of breast milk. In addition, although the quantity of macronutrients remain unaltered in breast milk, the amount of zinc, magnesium, and potassium content may decrease in the nursing mother fasting during Ramadan [125].

Remarks and Recommendations

Pregnant women should be advised against fasting except for those who are well nourished, do not have emesis, and have an appropriate diet. Lactating mothers should not fast.

Use of Medications during Ramadan

Adherence to and frequencies of drug taking appear to be uncompromised in various patients during Ramadan fasting [126], although there have been some reports to the contrary [127]. Parenteral administration (intravenous or intramuscular) of certain necessary medications or the use of suppositories and inhalers are allowed by some scholars during fasting. However, taking of oral medications is not allowed [128] and, if there is no other alternative route for medications, the patient is exempt from fasting.

Remarks and Recommendations

Physicians should make every attempt to prescribe long-acting or slow-release drugs once or twice at night, and allow the patient to observe fasting. Patients who must take their medications more than twice in 24 h should avoid fasting. Others may take their drugs at Iftar or Sahur (or both). A daily dose of 100 mg phenytoin at night may not be enough to control epilepsy [129]; however, the condition could be controlled with a single dose of 300 mg phenytoin daily [130], and still allow the patient to fast [131]. A single night time dose of long-acting oral anticoagulant medications could be prescribed without affecting the incidence of thromboembolic events or hemorrhagic complications [132]. Since fasting may increase serum urea and sodium levels in elderly patients, those with underlying renal disease, taking non-steroidal anti-inflammatory drugs should be frequently monitored for renal function [133].

In conclusion, since over 400 million people fast each year during the month of Ramadan, further scientific research on the medical and health-related aspects of Ramadan fasting is needed. Health personnel practicing in Muslim countries, as well as those caring for Muslims in various parts of the world need to be fully aware of the physiological alterations occurring during Ramadan, the effects of Islamic fasting on various diseases and the pharmacodynamics of different medications during the month of Ramadan.

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