Effects of fasting on patients with chronic kidney disease during Ramadan and practical guidance for healthcare professionals

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ABSTRACT

There are an estimated 1.8 billion Muslims worldwide, with the majority of them choosing to fast during the month of Ramadan. Fasting, which requires abstinence from food and drink from dawn to sunset can be up to 20 hours duration during the summer months in temperate regions. Fasting can especially be challenging in patients on haemodialysis and peritoneal dialysis, moreover, there is concern that those with Chronic Kidney Disease can experience electrolyte imbalance and worsening of renal function. In this paper, current literature is reviewed and a decision-making management tool has been developed to assist clinicians in discussing the risks of fasting in patients with CKD, with consideration also given to circumstances such as the COVID-19 pandemic.

Our review highlights that patients with CKD wishing to fast should undergo a thorough risk assessment ideally within a month before Ramadan, they may require medication changes and a plan for regular monitoring of renal function and electrolytes in order to fast safely. Recommendations have been based on risk tiers (very high risk, high risk and low/moderate risk) established by the International Diabetes Federation and the Diabetes and Ramadan International Alliance. Patients in the ‘Very high risk’ and ‘High Risk’ categories should be encouraged to explore alternative options to fasting, those in the low/moderate category may be able to fast safely with guidance from their clinician. Prior to the commencement of Ramadan, all patients must receive up-to-date education on sick day rules, instructions on when to terminate their fast or abstain from fasting.

Keywords: chronic kidney disease, COVID-19, dialysis, fasting, pandemic, Ramadan

INTRODUCTION

There are an estimated 1.8 billion Muslims worldwide (1). These include large minority populations in many Western countries - there are approximately 2.7 million Muslims in the UK, constituting 4.8% of the British population(1). With increasing prevalence of Chronic Kidney Disease (CKD) in UK and Europe
(2) combined with globalisation, nephrologists are more than likely to come across requests from patients asking for clinicians' opinion on suitability of fasting.

The fast of Ramadan is observed by abstaining from food and drink including water from sunrise to sunset (3). However, those who are ill or have underlying health conditions can be religiously exempt from it. The dates for Ramadan are based on a 12-month lunar calendar, thus Ramadan falls 11 days earlier annually and over a ~33-year period passes through all four seasons, leading to shorter fasts in winter and longer in the summer months of the northern hemisphere. Fasting during the summer months can stretch up to 20 hours in temperate regions(4).

Medical research on Ramadan is a nascent field and many studies are observational in nature and findings not generalisable. Given the lack of formal guidance and expert consensus, the aim of this review is to provide an up to date appraisal of current literature, and to subsequently provide health care professionals (HCPs) with an easy decision-making tool that can facilitate and guide discussions relating to the risks of fasting with their CKD patients. Though fasting is an obligation on Muslims, it remains a personal choice. Many Muslims, especially with chronic diseases tend to fast against medical advice (5, 6) and these guidelines would aid clinicians and patients alike in supporting them in the decision-making process.

MATERIALS AND METHODS

We undertook a narrative review of current literature on Ramadan fasting in patients with CKD. PubMed and Google Scholar databases were searched for studies using terms “Ramadan”, “fasting”, “kidney”,
“dialysis” and “chronic kidney disease” in various combinations. All retrieved articles were considered for inclusion, existing reviews of literature on these topics were also reviewed for references where appropriate. No language or study restrictions were applied but for practical considerations only English language articles were reviewed. Retrieved articles ranged from systematic reviews, observational studies and narrative reviews. Whilst the focus in this review relates to effect of fasting in CKD, fasting during the Covid-19 pandemic is briefly discussed.

Recommendations on risk stratification and management of patients were made through the consensus of authors based on their clinical experience of managing Muslim patients fasting in Ramadan. They are meant to be informative and do not form a directive; treating physicians need to take into consideration patient’s wishes and individual circumstances. We utilised a three-tiered risk assessment based on the widely used criteria established by the International Diabetes Federation and the Diabetes and Ramadan International Alliance (IDF-DAR) to form recommendations(2). Recommendations in table 5 can be used by healthcare HCP’s to assign a risk level and provide fasting advice accordingly (7).

RESULTS

No Randomized Controlled Trials (RCT) were identified, all studies were observational in nature. Majority of the studies were carried out in Middle Eastern countries during the winter season where fasting duration varied from 12-14 hours. In contrast, fasting duration in temperate regions during summer months can be up to 20 hours and therefore, findings are not generalisable (table 1). Although there is data on hospital attendance due to renal colic during Ramadan, no data is available on rate of
hospitalization due to Acute Kidney Injury (AKI) or hyperkalemia (8). Reported differences in studies refer to statistically significant differences. A review of the literature is presented below.

**Chronic Kidney Disease**

A systematic review by Bragazzi (9) identified 26 studies, of which five concerned CKD non-dialysis (CKD-ND) and dialysis (CKD-D) patients. 11/26 were done in ‘cold’ seasons, and only 3/26 were in ‘hot’ seasons, there were incomplete data for the remainder. These studies reported fasting is overall well tolerated in patients with CKD with some caveats. Bragazzi (10) also conducted a meta-analysis from six studies with 350 patients with CKD during Ramadan and monitored changes in estimated Glomerular Filtration Rate (eGFR). Of these studies only two were done in CKD-D and CKD-ND patients, the rest were in transplant CKD recipients. Only one study included patients with CKD-ND stage 5 (total of five patients) (table 2) (11). Pooled results from all six studies did not show significant difference in change in GFR (standardized mean difference +/- SD of 0.00±0.098, 95% CI -0.19 to 0.19, P=0.99).

In a prospective cohort study from Saudi Arabia which enrolled CKD-ND and HD patients, metabolic profile and renal function change were studied before, during and three to four weeks after Ramadan (12). Of the 39 CKD patients, 10 were CKD-ND stage 5 and 19 CKD-ND stage 4. Only stable CKD patients were enrolled, those with unstable renal function, episodes of pulmonary oedema, poorly controlled diabetes were excluded. Patients were given low potassium diet advice and asked to restrict fluid intake to 1.5-2 L. Antihypertensives and diuretics were continued but modified to once daily preparations, those with a tendency for developing hyperkalaemia on angiotensin converting enzyme inhibitors (ACE-
I) or angiotensin receptor blocker (ARB) were switched to alternatives and advised calcium or sodium polystyrene sulphonate. No significant change in weight, blood pressure, creatinine clearance, MDRD eGFR or electrolyte measurements were seen. None reported symptoms of uraemia, eight had lower limb oedema no patients needed hospital admission. There was no comparator group (table 2).

In a UK observational study by Chowdhury et al. including stable patients with coexisting CKD-ND stage 3 and type 2 diabetes were enrolled during a 19-hour fast. 68 patients fasted and 71 did not, they found no significant differences in outcome measures or adverse events (13).

An interesting cohort study in CKD-ND stage 3-5 patients that looked at Major Adverse Cardiovascular Events (MACE) outcomes found that fasting patients with history of cardiovascular disease had a higher risk of MACE. The hypothesis being that dehydration causes hyperviscosity. In a total of 131 patients in two groups (fasting and non-fasting), baseline serum creatinine (SCr) in the fasting group was 247 +/- 123.8 umol/L, a SCr rise of >30% at Day 7 had a sensitivity of 66.6% and specificity of 89% in predicting cardiovascular events. A rise of SCr was noted in 60.4% of patients by Day 7 of fasting and was associated with intake of renin angiotensin aldosterone system antagonists [relative risk (RR) 2, P = 0.002]. Adverse cardiovascular events were observed in six patients in the fasting cohort and was associated with a rise of SCr after 1 week of fasting (P = 0.009) and the presence of pre-existing cardiovascular disease (RR 15, P = 0.001). In comparison, only one event was reported in the non-fasting group. The regression model adjusted for baseline characteristics including presence of pre-existing cardiovascular disease but did not adjust for antihypertensive medication use which was associated with a rise in SCr (14).
Long-term follow-up data of the effects of fasting during the month of Ramadan on renal function in patients with CKD-ND and CKD-D is lacking. However, two studies looked at the effects of repeated fasting in kidney transplant recipients (KTR), study by Ghalib et al. studied effect of fasting over 3 consecutive years and found no difference in GFR between fasters and non-fasters, eGFR before the first Ramadan was compared to eGFR after third Ramadan in 35 fasters and 33 non-fasters, in fasters eGFR was 56.4 ml/min versus 55.4 ml/min after fasting during Ramadan for three consecutive years (15).

Renal Replacement Therapy

Haemodialysis

A cross-sectional study of 635 Saudi patients on hemodialysis (HD) during the ‘hot’ season showed no difference in outcomes. Following parameters were collected in the month prior to and during Ramadan (following the longer, 2-day interdialytic periods) - weight gain, pre- and post-dialysis blood pressure, serum potassium, phosphorus, albumin, hypotensive episodes, and saline volume infused during the dialysis session. No statistically significant difference was found in the measured parameters. In the fasting group 22% of patients were working compared to 14.6% in the non-fasting group. There were only two dialysis shifts during the day and as performing dialysis during fasting in the daytime would invalidate the fast, it’s likely that patients observed fasting during non-dialysis days. Fasting patients were younger, working, missed dialysis sessions and had higher phosphate levels compared to the non-fasting group, no serious adverse events were reported in the fasting group (table 3)(16).

A 12-week multicentre observational study in Malaysia of 87 patients where patients formed their own controls, nutritional and functional parameters compared two weeks before and four weeks after
Ramadan did not show significant changes, interestingly, handgrip strength improved post Ramadan along with phosphate control and Interdialytic Weight Gain (IDWG) (17). The time point of biochemical parameters measurement in relation to a patient’s weekly dialysis schedule is not known, data on whether participants were working or whether they observed fasting on dialysis days was not provided.

In a recent study from Palestine conducted during the summer, 269 HD patients were divided into 3 groups, those who fasted daily, those who partially fasted (observed fast on non-dialysis) and those who did not. Biochemical parameters were measured one month prior, in the second week of and two weeks after Ramadan. The mean age was 57.5 years, average fasting duration was 16 hours, reference non-fasting group IDWG mean was 3.2 kg whereas the fasting groups were noted to have additional IDWG of 0.62 Kg (P = 0.001) and 0.23 (P = 0.005) kg respectively. Potassium levels in all groups were <6.0 mmol/L (18), although the fasting group had higher mean potassium than those who did not fast (P < 0.001). Adverse events or hospitalization were not recorded. There were no significant differences between the fasting groups in age (P = 0.064), gender (P = 0.202), dialysis vintage (P = 0.202) or hypertension status (P = 0.765), however, the non-fasting group had higher proportion of diabetic patients (58.1%) than the fasting (38.7%) and partial fasting groups (31.6%), P <0.001. Biochemical parameters were tested before a dialysis session, it isn’t clear if any were done after a weekend off period.

With respect to mortality, retrospective data of 1,841 patients from 1989-2012 in a single centre in Karachi, Pakistan showed a higher mortality during Ramadan for patients on HD but fasting status was not determined and other than a percentage no other statistical analysis were performed to justify the observation (19). In contrast, a recent observational study from Egypt compared 965 patients who
fasted at least partially to 1090 of those who did not, found mortality to be higher in the non-fasting group. This could be explained by the fact that patients in the fasting group were younger and had less co-morbidities, no regression analysis was done to adjust for confounders(20).

Peritoneal Dialysis

Only one study was identified that reported outcomes of fasting in Peritoneal Dialysis (PD) patients, stable patients were included, patient with uncontrolled diabetes, hypertension, angina, postural hypotension, or a history of noncompliance with therapy were excluded (table 4). Dialysis prescriptions were modified, Continuous Ambulatory Peritoneal Dialysis patients (CAPD) performed three exchanges at night with either a 1.36% or 2.27% strength PD fluid (after dusk) and icodextrin daytime fill. Similarly, Continuous Cycling Peritoneal Dialysis (CCPD) patients performed a rapid 6-hour cycle starting at 2100 and ending at 0300 with icodextrin daytime fill. Of the 31 patients in the study, less than a quarter (22.5%) developed complications but did not experience serious morbidity. Two patients developed peritonitis which required admission and discontinuation of modified therapy, one developed pleural effusion, three experienced hypotension, two in the CAPD group and one in the CCPD group. In the CCPD group, one patient developed lower limb oedema which was managed by adjusting dialysate concentration and fluid restriction. Urine output, Kt/V urea and creatinine clearance were not statistically different when compared pre and post Ramadan according to the authors although no p values were reported (21).
Discussion on existing data

All identified studies were observational studies which are prone to selection bias among other drawbacks including small sample size. It is likely that patients in the studies are motivated and willing to adhere to dietary advice and fluid restriction than others. Other than in one study where patients with pre-existing cardiovascular disease were included, all other studies excluded unstable patients or patients with significant co-morbidities. Treatment changes had to be made to both medications and in some studies to dialysis therapy. It is also important to note that majority of literature in this area are from the Middle East and North Africa where the duration of fasting is around 12 to 14 hours with reduced working hours in comparison to European countries where fast duration can be as high as 20 hours with normal work hours and hence findings are not generalisable (table 1).

Chronic Kidney Disease

Majority of the studies included stable CKD-ND stage 3 patients and only a small number of CKD-ND stage 4 and an even smaller number of CKD-ND stage 5 patients. In the reported literature, despite study design flaws it appears that stable CKD-ND stage 3 patients would be able to observe fast without any ill consequences as long as they are closely monitored and adhere to medical advice. The same cannot be said about CKD-ND stage 4 and 5 patients who are at higher risk of renal function deterioration due to dehydration and life-threatening electrolyte abnormalities. The studies that included CKD-ND stage 4-5 patients did not have a comparator group therefore it is difficult to make an evidence-based conclusion in this group; patients would have to be motivated and compliant with advice in order to fast safely. Additionally, patients with CKD and known cardiovascular disease should be discouraged from fasting given concerns raised from one study of higher adverse cardiovascular outcomes(14).
Whether repeated fasting in subsequent years has long term effects is also unknown, although, studies on transplant recipients showed no long-term consequences. Some CKD patients may be prone to stone formation and urinary tract infections, meeting their hydration requirement after breaking their fast is key if they were to fast (8, 22).

Hemodialysis

In the reported literature HD patients were younger. In contrast, the mean age of HD patients in the UK is 67 (18, 23), with frailty as a common comorbidity (24). Dialysis is a catabolic state and dialysis patients normally have to follow a restricted diet of low potassium and phosphate. While fasting the difficulty imposed with dietary restrictions in such patients can make it difficult to meet their nutritional requirements further increasing their frailty and adding to morbidity. Although published studies showed no significant adverse effects, electrolyte imbalances and higher IDWG have been observed as has increased mortality during Ramadan in a retrospective analysis (12, 18, 19).

Peritoneal Dialysis

In the single reported study of patients on PD, patients had to undergo modification of their treatment regime in order to fast, patients were able to carry out PD with modifications (21).
Religious considerations on fasting and recommendations pertaining to Chronic Kidney Disease (non-dialysis) and dialysis patients

As a general rule, any form of nutrition and medication that involves administration via a mucosal route i.e. oral, nasal or rectal is not permitted, for a person observing fast, this includes any form of fluid including water. Use of topical, intramuscular, subcutaneous medications such as insulin is permitted and do not invalidate the fast (2). In relation to HD and PD, whilst there are religious edicts (fatawaa) that state that fasting would NOT be invalidated by HD(25), there is contemporary scholarly view, that such treatments whilst fasting are impermissible and would invalidate the fast, however, patients may choose to fast on non-dialysis days or with modifications to PD prescription and this is the position adopted by the authors of this review (26, 27).

It is traditional practise to have two meals over the 24-hour period – Suhoor (also known as Sehri), the pre-dawn meal, and Iftaar the sunset meal. It is also worth noting that fasting (21)has been associated with beneficial changes to general wellbeing (3). Ultimately the decision to fast or otherwise rests with the individual concerned. Islam permits, and indeed supports, those with appropriate ailments to terminate the fast or be exempted from fasting, the two main options being:

- Making up the missed fast when health permits them to do so—either when the illness is no longer present, such as in acute illness; or when health is not worsened by fasting at another point in time (e.g. in the winter) in relation to chronic illness (3).
• An exemption from fasting in those whose illness will not permit them to keeping fasts indefinitely, this being replaced by a requirement to feed the poor, known as fidyah.

Appropriate ailments that enable the above exemptions can also include old age/frailty, or a condition which is stable, but through fasting, the condition can adversely affect health or increase the risk of doing so (1,4). This also includes abstaining from the use of medication which increase the risk of decompensation of chronic, but stable health conditions. Arriving at such decisions is based on the premise that the ailment will worsen, or recovery delayed or impaired by fasting, or a substantial fear that either may occur. This can be determined by prior experience of fasting with the ailment, or common knowledge that this can happen, or on the advice/opinion of an appropriate HCP (5). Muslims are encouraged, if they have any uncertainty regarding the various dispensations, to seek counsel from a trusted religious authority.

Despite valid exemptions, there is an intense desire to fast during this month even among those who are considered high risk e.g. the elderly and multimorbid, such as individuals with diabetes mellitus and patients with CKD (6, 14). A more detailed exposition pertaining to the religious obligation of fasting and practical considerations in relation to health and illness with particular consideration to diabetes has been published elsewhere (3).

IDF-DAR convened recognized experts to develop joint practical guidelines on the management of diabetes during Ramadan, guidelines were developed following literature review and on expert consensus where evidence did not exist. Guidance is based on three risk categories – “Very High Risk” where patients must not fast, “High Risk” patients should not fast and those in the Low/Moderate category should take guidance from their clinician, the guidance was approved by religious scholars (2).
We have developed a decision-making tool based on the principles of the IDF-DAR risk tiers that HCP’s can use while counselling patients regarding the risk of complications if they were to fast, consensus was sought from renal physicians involved in the care of Muslim patients and a religious scholar while developing our guidance. Patients in the ‘Very High Risk’ and ‘High Risk’ tiers should receive medical advice that they ‘must not fast’ and ‘should not fast’ respectively. Those in the ‘Low/Moderate Risk’ category may be able to fast on the discretion of the physician, considered along with the ability of the individual to tolerate the fast (table 5). During counselling, patients and HCPs are best to consider the alternatives discussed below which for some patients may be safer options (see figure 1).

Trial fasting:
Following any necessary medication or dialysis treatment changes, patients could consider a trial of fasting for a few days prior to start of Ramadan (we suggest within the month prior) with close monitoring to establish safety and tolerability.

Winter fasting:
In temperate regions, time period between dawn and dusk can be as short as 8-10 hours in the winter, for many patients this may be tolerable and safely achievable without changes in medication or dialysis regimes (4).

It is also important to reinforce sick day rules on which medications to stop during an acute illness, examples include ACE-I, ARB, tolvaptan, SGLT2 inhibitors, mineralocorticoid receptor antagonists and diuretics.
Options for Peritoneal Dialysis patients:

The decision making tool below (figure 2) has been developed specifically for PD patients wishing to fast.

CAPD – complete 3-4 CAPD exchanges between dusk and dawn with last icodextrin fill to be infused at or before suhoor, daytime dry may be an option for some patients, no exchanges until completion of fast.

CCPD – treatment between dusk to dawn with last icodextrin fill to be infused at or before suhoor, no exchanges until completion of fast.

For both modalities, volume, strength of fluid and treatment duration as per treating clinician’s prescription. If required, patients may be able to drain out icodextrin before completion of fast. Daytime dry may be an option for some patients. We would advise patients to fast when the total duration of fast does not exceed 16 hours, this is in order for exchanges to be carried out adequately over a minimum 8-hour period.

Hemodialysis patients

Options for hemodialysis patients wishing to fast are limited, some may be able to fast on non-dialysis days after individual risk stratification, others should consider alternatives discussed above.
Specific considerations in context of COVID-19 pandemic

Although the world is in a different phase of the pandemic, it is far from over. Therefore, patients and clinicians may want to consider local factors when counselling patients about the risks and feasibility of fasting during the pandemic.

Chronic Kidney Disease (non-dialysis)

Logistical challenges of having blood tests during the pandemic may mean monitoring is not readily available. Patients who in normal circumstances may be able to observe fast must consider alternatives to fasting.

Hemodialysis and Peritoneal Dialysis

Some dialysis units in the UK moved to twice weekly sessions during the peak of the pandemic. Potassium levels were managed with binders along with dietary restrictions. Fasting when dialysis treatments may have to be reduced to twice a week poses very significant risk of complications and death. Similarly, PD patients may also not have access to monitoring or be able to modify their regime and hence must consider not fasting and explore alternatives.

CONCLUSION

Data around the safety and feasibility of patients with CKD observing the Ramadan fast is scarce, stable CKD-ND (up to stage 3) patients may be able to fast with close monitoring, whereas, HD and PD patients would be considered very high risk, we suggest risk stratifying patients wishing to fast. Patients whose
illnesses does not permit them to fast should explore alternatives. Well-designed observational studies with large sample sizes or randomized controlled trials are needed to address the gap in knowledge (table 6). We propose a method of risk stratifying and managing patients which can be used to facilitate patient-centric conversations, aid decision making, improve patient and clinician satisfaction, and provide a safer Ramadan experience.

AUTHORS’ CONTRIBUTIONS
All other authors have provided intellectual content of critical importance to the work described.

CONFLICT OF INTEREST STATEMENT
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DATA AVAILABILITY STATEMENT
The data that support the findings of this review are openly available at PubMed Central
Table 1. Approximate start dates for Ramadan and duration of fasts for 2021 - 2051

| Year | Approximate start date of Ramadan* | Duration of first fast in London† | Mean day-time temperature London | Duration of first fast in Riyadh | Mean day-time temperature in Riyadh |
|------|-----------------------------------|----------------------------------|----------------------------------|---------------------------------|-----------------------------------|
| 2021 | 13 April                          | ~15.5 – 16.5                    | 13 C                             | ~13-14                          | 33 C                              |
| 2031 | 16 December                       | ~9.5 - 10                       | 6 C                              | ~11.5-12.5                      | 22 C                              |
| 2041 | 28 August                         | ~15.5 -16.5                    | 19 C                             | ~13-14                          | 43 C                              |
| 2051 | 12 May                            | ~17.5 - 18.5                    | 16 C                             | ~14-15                          | 39 C                              |

*Dates may differ by a day either side depending on methodology used to determine the new moon
†scholarly difference of opinion exists in relation to the onset of dawn in temporal regions in the summer.

Temperature units are in Celsius (C)

Dates for Ramadan are based on a 12-month lunar calendar; thus, Ramadan falls 11 days earlier annually and over a ~33-year period passes through all four seasons

Data taken from [www.islamicfinder.org](http://www.islamicfinder.org)
| Author          | Year   | CKD stages (non-dialysis)                      | No. of patients | Outcome measure                  | Result                                                                 |
|-----------------|--------|-----------------------------------------------|-----------------|-----------------------------------|-------------------------------------------------------------------------|
| Al Muhanna      | 1998   | ‘Moderate to severe CKD’, Creatinine Clearance (CrCl)<35 ml/min | 36 – 18 males and 18 females | Change in renal function (CrCl)   | CrCl Pre-Ramadan 17.2+/−3.5 ml/min, end of Ramadan 13.2+/−2.2 ml/min and 2 weeks later 13.7+/−3.2 ml/min |
| El-Wakil        | 2007   | Mean GFR for study group 33.3 +/- 21.1 ml/min; for controls 111.6 +/- 21.3 ml/min | 12 (40% males) and 6 controls (100% males) | Change in GFR measured by Technetium99m DTPA and NAG- | Change in GFR not statistically significant with -6.56+/−31.1% change in CKD patients compared to 9.58+/−30.1% in controls (p 0.43), although NAG was different between CKD and control group, there was no statistically significant difference in NAG within CKD group pre and post Ramadan |
| Bernieh         | 2010   | CKD 3,4 and 5                                 | 31 (61.3% males) | CrCl (Cockcroft Gault), albumin, lipids, weight | CrCl increased post Ramadan compared to pre Ramadan, this could however be explained by observed decease in body weight |
| Al-Wakeel       | 2014   | CKD 3 and 4 (dialysis cohort excluded in this table) | 39 (23.1% males) | Change in renal function (CrCl)   | No significant change noted. Potassium pre Ramadan 4.8 ± 0.6 mmol/L, post-Ramadan 4.7 ± 0.5 mmol/L, CrCl pre Ramadan 40.8 ± 25.4 ml/min and post Ramadan 44 ± 29.3 ml/min. |
| NasrAllah       | 2014   | CKD 3,4 and 5                                 | 106 – 52 fasting (32% males); 54 non-fasting (27% males) | Cardiovascular outcomes         | In the fasting group, 6 adverse cardiovascular events occurred compared to 1 in the control group. All of those affected in the fasting group had associated drop in eGFR. Mean deviation in eGFR in fasting group was -3% (SD 17.8) compared to -1.3% (SD 24.5) in the non-fasting group |
| Mbarki          | 2015   | Mean CrCl 72.85+/−40 ml/min                   | 60 (41.6% males) | Development of AKI (as defined by KDIGO criteria) | Seven patients met the criteria for AKI. In five there was full recovery and in two there was partial. Follow up was one week post Ramadan, findings were not statistically significant |
| Author     | Year | Stage/Conditions                        | Participants | Change in Renal Function/Parameters | Results                                                                 |
|------------|------|-----------------------------------------|--------------|-------------------------------------|---------------------------------------------------------------------------|
| AA Bakhit (31) | 2017 | CKD 3, 4 and 5 (36 CKD 3, 24 CKD 4 & 5 CKD 5) | 65 (61.5% males) | Change in renal function (eGFR by CKD EPI) Pre and 3 months post-Ramadan | Mean eGFR 31.1+/−13.3 ml/min and Serum Creatinine of 206+/−88 umol/L, mean rise during Ramadan to 214 umol/L and a drop to 209 umol/L Relative risk of worsening of renal function: CKD 3B - 1.6, 95% CI (0.5-5.4), CKD 4 - 3.6 (1-13.9), CKD 5 - 2.2 (0.7-6.5) |
| Kara (32) | 2017 | CKD 3-4 | 45 who fasted (31% male) and 49 non-fasting (25% male) | Change in renal function (eGFR) | No difference within group or between groups |
| Ekinci (33) | 2018 | CKD 1-2 with ADPKD | 23 in fasting group (17.4% males) and 31 non-fasting (41.9% males) | Change in eGFR, electrolytes, KIM-1 and NGAL | No statistically significant difference in any of the observed measures. |
| Hassan (34) | 2018 | CKD 2-4 | 31 in fasting group (54.8% males) and 26 in non-fasting (53.8% males) | Change in eGFR | No significant difference found |
| Alawadi (35) | 2019 | CKD 3 | 19 (57.8% males) | Glucose level, change in BP, HBA1c, renal function (eGFR) and BMI | No significant change found |
| Chowdhury (13) | 2019 | CKD 3 | 68 fasting (51.4% males) and 71 non-fasting (48.6% males) | Change in renal function (eGFR) | No significant differences in biochemical parameters |
| Study | Year | CKD Stage | Sample Size | Gender Distribution | Renal Function (eGFR by CKD EPI) | Findings |
|-------|------|-----------|-------------|---------------------|-----------------------------------|----------|
| Mahmoud (36) | 2019 | CKD 3-4 | 20 (60% females) | Renal function fatigue, mood and cognition were worse when measured after Ramadan. |
| Baloglu (37) | 2020 | CKD 2-3 | 117 (69.2% males) | Development of AKI (as defined by KDIGO criteria) 27 developed AKI, history of hypertension was associated with AKI, unclear if AKI resolved and whether patients were on RAAS inhibitors or diuretics. |
| Eldeeb (38) | 2020 | 3-4 | 34 (58.8% females) and 37 controls (59.5% females) | Improved central and brachial blood pressure, weight and creatinine were lower post Ramadan. |

AKI, Acute Kidney Injury; NGAL, neutrophil gelatinase-associated Lipocalin; RAAS, Renin Angiotensin Aldosterone System’ NAG, N-acetyld-Glucosaminidase; ADPKD, Autosomal Dominant Polycystic Kidney Disease; Cr Cl in ml/min
| Author          | Year | No of patients | Outcome measure                   | Result                                                                                                                                 |
|-----------------|------|----------------|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| A Al-Khader(39) | 1991 | 40             | IDWG and change in electrolytes   | Mean IDWG pre Ramadan 2.2 kg+/-0.3, during Ramadan 2.84 kg+/-0.35, none presented with pulmonary edema, patients fasted on non-dialysis days. Potassium mean pre Ramadan 5.05+/-.4, during Ramadan 5.76+/-.45 |
| Adnan(40)       | 2014 | 35             | Dialysis and biochemical parameters | Weight reduction was seen in all patients, no difference in IDWG, number of hypotensive episodes was lower at end of Ramadan compared to pre Ramadan. No difference in potassium or significant elevations. No difference in URR, albumin level was high and phosphate was lower at the end of Ramadan. |
| Study                | Year | Sample Size | Parameters                  | Findings                                                                 |
|---------------------|------|-------------|------------------------------|-------------------------------------------------------------------------|
| Alshamsi(16)        | 2016 | 635         | Biochemical and dialysis     | Other than phosphate level which was higher in fasting group, no other differences in dialysis or biochemical parameters were observed. |
| Imtiaz(41)          | 2016 | 252 did not fast and 34 fasted | Biochemical parameters      | Albumin was higher in fasting group, no other significant differences between groups. |
| Khazneh(18)         | 2019 | 269         | IDWG and biochemical        | Higher IDWG in fasting group, higher potassium by 0.48 mEq/L in fasting group compared to non-fasting. |
| Author         | Year | No of patients | Outcome studied                          | Result                                                                                                                                 |
|----------------|------|----------------|------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| Megahed(20)   | 2019 | 965 in fasting group and 1090 non-fasters | Dialysis parameters and mortality     | Potassium was <5 mmol/L in all groups, mortality was higher in non-fasting groups, patients in the fasting group were younger and had less co-morbidities. |
| Al Wakeel (12) | 2014 | 32             | Biochemical parameters                  | Significant increase in phosphate, hyperkalaemia in 15.6% and hyponatraemia in 28 %. No hospital admissions were observed.              |
| Adanan(17)    | 2020 | 87             | BMI, interdialytic, weight gain and dialysis parameters | Intermittent fasting during Ramadan led to reduced BMI, IDWG, and other nutritional parameters. Improvement seen in phosphate, albumin and urea levels. |

IDWG, intradialytic weight gain; BMI, body mass index

Table 4. published studies on peritoneal dialysis patients
No statistically Significant difference in urine output or Kt/V urea.

| Risk level          | Moderate/low risk | High risk                      | Very high risk                                                                 |
|---------------------|-------------------|--------------------------------|-------------------------------------------------------------------------------|
| Advice              | Listen to medical advice | Should not fast | Must not fast                                                                |
| CKD stage           | 1-3 with stable kidney function | 1-3 with unstable kidney function* | 4-5 (non-dialysis) ** Patients on all forms of hemodialysis and peritoneal dialysis 3-5 patients with history of pre-existing cardiovascular disease |
| Other groups        | CKD patients prone to urinary tract infections or stone formation | CKD patients with known electrolyte abnormalities Patients at risk of dehydration due to fluid | Patients on tolvaptan Pregnant CKD patients |
CKD, Chronic Kidney Disease; ACE-I, Angiotensin Converting Enzyme inhibitor; ARB, Angiotensin Receptor Blocker; eGFR, estimated Glomerular Filtration Rate; SGLT2, sodium-glucose Cotransporter-2

*unstable patients would include those with rapidly declining GFR, history of fluid overload and frailty.

**although HD and PD patients would be considered very high risk, a select group may be able to fast following risk stratification and counselling, factors to consider would include – residual renal function, fluid balance, potassium >6.0 mmol/L, motivation, compliance with medical advice, consider alternatives to fasting and winter fasting.

**Table 6. Research needs**

| Category | Research gap |
|----------|--------------|
| All      | Capture fasting status on an annual basis prospectively including number of days |
| All | RCT to assess safety and tolerability of fasting |
|-----|------------------------------------------------|
| All | Well-designed observational studies in temperate regions in summer and winter months |
| All | Incidence of hyperkalemia in fasting individuals |
| All | Hospitalization due to AKI, fluid overload, electrolyte abnormalities |
| All | Capture information on lifestyle factors such as work conditions and working hours during Ramadan |
| CKD – non dialysis | High risk patients to be included in future studies – e.g patients with ADPKD on tolvaptan, patients with tendency for electrolyte imbalance Include patients with unknown causes of CKD Whether fasting can lead to progression of ADPKD |
| Hemodialysis | Include home hemodialysis patients Include patients wishing to fast on dialysis days with appropriate adjustment to dialysis treatment Include older patients |
| Peritoneal dialysis | Studies with larger sample size |
|--------------------|--------------------------------|
|                    | Include patients with diabetes and hypertension |
|                    | Intermittent fasting (fasting on non-dialysis days) |
|                    | vs. fasting on dialysis days |

Figure 1 shows decision making pathway when a patient wishes to fast during Ramadan.

Figure 2 shows decision making pathway for PD patients wishing to fast.
146x266mm (300 x 300 DPI)
Does the patient intend to fast?

Yes

Explore patient wishes for Ramadan including spiritual, lifestyle, work and social

Risk stratify patient

Very high risk

Explore alternative options:
  • Fasting on shorter days (e.g. winter)
  • Fidyah

Patient still chooses to fast

Yes

Education, optimisation and emergency plans:
  • Educate patient on risks and reinforce sick day rules
  • Counsel patients about risk of fluid overload, electrolyte abnormalities, nutritional requirements
  • Make necessary changes to medications, explore once-daily alternatives or temporary cessation of medications such as Tolvaptan
  • Discuss changes needed to dialysis regimes – shift changes, duration, move to APD/CCPD from CAPD
  • Advise to terminate fast if becomes unwell
  • Consider trial fasts (e.g. one month before Ramadan)

No

Continue current treatment

High risk

‘Low–moderate’ risk
Patient on PD wishing to fast

Does the patient have sufficient residual renal function to hold PD?

No

COPD

3–4 nighttime exchanges with last icodextrin fill or daytime dry

COPD

Nighttime exchanges with last icodextrin fill or daytime dry

Yes

Consider option of holding PD temporarily

• Patients with sufficient residual renal function holding PD will require frequent monitoring
• For patients on CAPD or CCPD wishing to fast, the suggested maximum fast is 16 hours
• Icodextrin fill to be completed before the fast begins
• CAPD and CCPD patients may drain out icodextrin prior to breaking fast

152x262mm (300 x 300 DPI)
Patient on PD wishing to fast

Does the patient have sufficient residual renal function to hold PD?

No

• CAPD
  • 3–4 nighttime exchanges with last icodextrin fill or daytime dry

Yes

• CCPD
  • Nighttime exchanges with last icodextrin fill or daytime dry

Consider option of holding PD temporarily

• Patients with sufficient residual renal function holding PD will require frequent monitoring
• For patients on CAPD or CCPD wishing to fast, the suggested maximum fast is 16 hours
• Icodextrin fill to be completed before the fast begins
• CAPD and CCPD patients may drain out icodextrin prior to breaking fast