Periodontal status and serum biomarkers levels in haemodialysis patients


Abstract
Aim: To investigate the association between periodontal status and serum biomarkers levels in haemodialysis patients.

Methods: This cross-sectional study included 96 haemodialysis patients. The periodontal evaluation was realized using clinical attachment level (CAL), probing depth (PD), gingival bleeding index (GBI), visible plaque index (VPI) and gingival index (GI). Biochemical and haematological data – serum albumin, phosphorus, creatinine, transferrin, ferritin, iron, alkaline phosphatase, calcium, potassium and haemoglobin – were collected from the medical records. The subject was diagnosed with periodontitis if he/she had at least two inter-proximal sites in different teeth with CAL ≥ 4 mm and/or at least two inter-proximal sites in separate teeth with PD ≥ 5 mm.

Results: The study population consisted of 45 men and 51 women, with mean time under haemodialysis of 45.6 ± 33.1 months. Periodontitis was observed in 59.4% of the subjects. The periodontitis group had albumin (p = 0.021) and phosphorus (p = 0.024) serum levels lower than the no periodontitis group. Thus, there was a positive association of periodontitis with hypoalbuminaemia (OR = 9.10, p = 0.006) and a negative association with hyperphosphataemia (OR = 0.21, p = 0.010).

Conclusions: These findings suggest that periodontitis is associated with albumin and phosphorus serum levels in haemodialysis patients.

Chronic kidney disease (CKD) is an important public health problem worldwide. Its incidence and prevalence present an upward trend, and most subjects affected with this disease are undergoing haemodialysis therapy (Coresh et al. 2007). Although technological and therapeutic advances have brought a better life quality and longer life expectancy for these individuals, cardiovascular complications, such as atherosclerosis, are still the major cause of morbidity and mortality in CKD patients (Sarnak et al. 2003, Muntner et al. 2005).

Epidemiological studies have shown that CKD patients have poor oral hygiene and high prevalence of periodontal inflammation (Duran & Erdemir 2004, Davidovich et al. 2005, Castillo et al. 2007, Dias et al. 2007, Craig 2008, Cengiz et al. 2009, Chen et al. 2011). This fact is of great importance since non-traditional risk factors such as chronic inflammation, infection, hypoalbuminaemia, hyperphosphataemia, calcium–phosphate metabolism, also
appear to play a prominent role in the development of accelerated atherosclerosis process in these individuals (Tripepi et al. 2005, Recio-Mayoral et al. 2011, He et al. 2012). Among the chronic inflammatory processes, evidence suggests that periodontal disease (PD) may contribute to the high frequency of atherosclerotic complications in patients undergoing haemodialysis (Chambere et al. 2013).

The biological plausibility underlying the assertion above is supported by the knowledge that PD is characterized as an immuno-inflammatory process triggered by the accumulation of bacterial biofilm on the outer surface of the tooth, that may affect the gingival tissues, periodontal ligament, cementum and alveolar bone in susceptible individuals (Darveau 2010). This imbalance induces the production of pro-inflammatory cytokines and subsequent formation of periodontal pockets and the destruction of supportive connective tissue, i.e. PD (Ebersole & Cappelli 2000, Lu et al. 2006). The production of these cytokines triggers a local and systemic inflammatory response that, hypothetically, can damage the vascular endothelium and promote atherosclerosis (Oliveira et al. 2010), as well as could generate an imbalance in levels of serum biomarkers. Therefore, it is important to reinforce the incorporation of dental care in the therapeutic management of these patients, as it can contribute to improving the prognosis of CKD.

Considering the high prevalence of PD in individuals with CKD and the limited number of studies (Rahmati et al. 2002, Chen et al. 2006, Kshirsagar et al. 2005, 2007) that have analysed the relationship between the periodontal inflammation process and albumin, phosphorus, creatinine, transferrin, ferritin, iron, alkaline phosphatase, calcium, potassium and haemoglobin serum concentrations, the objective of this study was to investigate the influence of periodontal status in the serum biomarker above in haemodialysis patients. The study hypothesis is that periodontal-pathogenic bacteria, potentially inducing inflammatory response with release of cytokines (Ebersole & Cappelli 2000, Kshirsagar et al. 2007) are associated with an imbalance in the concentrations of serum biomarkers of nutritional status and bone metabolism in haemodialysis patients. Besides, there are evidences that the uremic state promotes periodontitis initiation and progression (Borawski et al. 2007), making CKD patients particularly in risk. In this sense, this study also seeks information that may help identify individuals at risk, which may contribute to the improvement of the therapeutic management and the quality of life of this group.

Materials and Methods

Design and population study

An observational analytic cross-sectional study was carried out. First, this study was approved by the Research Ethics Committee of the University Hospital of the Federal University of Maranhão, São Luís, Brazil (No. 388/10). The individuals were informed about the study objectives and signed the “Informed and Free Consent Form”, after fully understanding its contents, which briefly described the study. All participants were instructed, after collecting the data, on the prevention, and treatment of PD and on oral hygiene procedures.

The study participants were patients undergoing haemodialysis at the Nephrology Center of Maranhão in São Luís, Maranhão, Brazil. Inclusion criteria consisted of individuals of both sexes, aged over 18 years, who had at least 16 teeth and that were undergoing haemodialysis for at least 6 months, with the same dialysis units. Individuals with decompensated diabetes mellitus, edentulous and who had undergone periodontal treatment within the last 6 months were excluded from the study. The individuals were recruited by the staff at the haemodialysis centre between June and November 2010.

Interview and collection of serum biomarkers

The initial interview consisted of questions, asked orally, based on a semi-structured questionnaire with the following sections: identification, socioeconomic status, smoking and medical history.

Time undergoing haemodialysis (months), haematological and biochemical data (albumin, phosphorus, creatinine, transferrin, ferritin, iron, alkaline phosphatase, calcium, potassium and haemoglobin serum levels) were collected by consulting the electronic medical record, taking into consideration data collected 15 days prior to or after the periodontal evaluation. The serum biomarkers that were used to monitor individuals undergoing haemodialysis were the same employed to investigate the hypothesis of the present study. All serum markers measurements were performed in the same laboratory.

Periodontal status evaluation

The clinical periodontal assessment was performed by a single examiner (VPR) using a Williams periodontal probe (Trinity, São Paulo, Brazil). The following parameters were evaluated: probing depth (PD), distance in millimetres (mm) between the gingival margin and the bottom of periodontal pocket; and clinical attachment level (CAL), distance in millimetres (mm) between the cemento-enamel junction and the bottom of periodontal pocket. The highest values obtained in each of the following sites were recorded: distobuccal, med-buccal, mesiobuccal, distolingual, med-lingual and mesiolingual, from all present teeth, except third molars. Furthermore, the gingival condition was diagnosed using the gingival bleeding index (GBI) (Ainamo & Bay 1975), gingival index (GI) (Löe 1967) and visible plaque index (VPI) (Silness & Löe 1964).

Prior to the beginning of clinical data collection, the examiner underwent a training program with an experienced periodontist. Calibration process was conducted at the Department of Dentistry of the Federal University of Maranhão, involving 10 randomly selected patients; the volunteers were examined twice at an interval of 1 week. The intra-examiner correlation coefficient was calculated for the PD (0.87) and CAL (0.83) measurements, considering the sites examined precisely or to an accuracy of 1 mm to each site; the quality of the benchmarking was considered very good.
Variables and statistical analysis

The participant was considered to have periodontitis when he/she presented at least two inter-proximal sites in different teeth with CAL ≥ 4 mm and/or at least two inter-proximal sites in different teeth with PD ≥ 5 mm (Page & Eke 2007). The independent variables consisted of socioeconomic characteristics, habits, comorbidities and serum biomarkers for renal disease.

The data were analysed by software program (SPSS 17.0, IBM, Chicago, IL, USA). First, descriptive statistical analysis was performed using frequencies, means and standard deviations. For numeric variables, the normality of distribution was checked by the Shapiro–Wilk test. To analyse the association between the presence of periodontitis and the level of serum biomarkers, the Student’s t test was used for parametric data and the Mann–Whitney test for non-parametric data, whereas the Chi-squared test was used for analysis of categorical variables. The level of significance adopted was 5% (p < 0.05).

Furthermore, a linear model was used to estimate the regression coefficients (RC) and determination coefficients (R²). In this procedure, the serum biomarker concentration was considered as a dependent variable, while the independent variable was considered periodontitis in the sum of all surveyed.

The association measurement obtained by Odds Ratio (OR) with its respective confidence intervals was created using two models to test the hypothesis of an association between periodontitis and the presence of two outcomes: hypoalbuminemia and hyperphosphataemia. A logistic regression analysis was applied taking into consideration the confounding covariables to obtain the adjusted association measurement. In model 1, hyperphosphataemia was considered when the phosphorus serum level was >5.5 mg/dL (National Kidney Foundation 2003), adjusted for gender, age, smoking habit, hypertension and hyperphosphataemia. It was estimated that a minimum sample of 33 people per group would have power of 80%, at least, to estimate statistically significant differences in serum concentrations of different biomarkers of kidney disease (albumin, transferrin, ferritin, phosphorus, potassium, and haemoglobin) among haemodialysis patients with and without periodontitis. For the calculation of the sample size, estimates of mean and standard deviation of serum ferritin (which maximized the sample size) in patients with periodontitis (227.7 ± 76.7) and without periodontitis (306.3 ± 142.3) were employed, considering a significance level of 5% in bilateral t-test.

Results

From a total of 103 subjects recruited, there were seven dropouts (one due to refusal to participate, one edentulous patient, five patients with decompensated diabetes mellitus), giving a final sample of 96 individuals (45 men and 51 women) with a mean age of 39.8 ± 13.2 years and mean duration of haemodialysis treatment of 45.6 (±33.1) months. A high frequency of patients with hypertension (84.4%) was observed. As regards to smoking habit, 34.4% reported being former smokers. In relation to schooling level, 56.3% of the sample had completed elementary school. There were no statistically significant differences in general characteristics between the comparison groups (Table 1).

The prevalence of periodontitis was 59.4%. In accordance with periodontal clinical parameters, individuals diagnosed with periodontitis, as expected, showed the worst values for PD, CAL, as well as for bleeding on probing, visible plaque and GI, with statistically significant differences (p < 0.001) when compared to the non-periodontitis group (Table 2).

Table 3 shows the mean distribution, standard deviation and linear regression of the variables related to serum biomarkers, indicators of monthly routine laboratory tests during haemodialysis which are grouped in accordance with the presence or absence of periodontitis. Statistically significant differences were observed in serum albumin concentration (p = 0.021) between the comparison groups, and the lowest value was observed in the group with periodontitis. Moreover, a statistically significant difference in the phosphorus serum level (p = 0.024) was also verified between the groups, and the highest average value was observed in the group without periodontitis. The serum biomarker levels that demonstrated greater variation due to the presence of periodontitis were albumin ($R^2 = 0.16$), phosphorus ($R^2 = 0.16$), ferritin ($R^2 = 0.11$) and haemoglobin ($R^2 = 0.10$).

Table 4 shows the association measurement between periodontitis and two outcomes: hypoalbuminaemia and hyperphosphataemia, obtained by logistic regression analysis. The OR adjusted was equal to 0.21 (95% CI = 0.07–0.64). As for the decrease in albumin serum concentration, the OR adjusted was 7.33 (95% CI = 2.01–26.63) showed that in the group of subjects with periodontitis the chance of hyperphosphataemia was 74% lower than those without periodontitis. After the necessary adjustments for confounding covariables gender, age, smoking habit, hypertension and hypoalbuminaemia, this measurement showed a slight increase, OR adjusted equal to 9.10 (95% CI = 1.48–55.83). Both results were statistically significant.

Discussion

In accordance with the main findings of this study that investigated the serum biomarkers monitored during haemodialysis, an association between periodontitis and albumin and phosphorus serum levels was observed, demonstrating a association of periodontitis in both serum...
biomarkers. These findings suggest that periodontitis has a positive association with hypoalbuminemia, even after adjustment for confounding covariables. Moreover, periodontitis was inversely associated with an elevated concentration of serum phosphorus, also after adjustment for confounders.

The biological plausibility of the relationship between periodontitis and hypoalbuminemia is grounded in the knowledge that albumin is the most abundant plasma protein and its serum level is commonly used as a marker of nutritional status in haemodialysis patients. The reduction of its plasma level is an important predictor of morbidity and mortality in the population with CKD (Friedman & Fadem 2010). In this study, the group of subjects with periodontitis was associated with low albumin serum levels. Similar findings were observed by Rahmati et al. (2002) Chen et al. (2006) and Kshirsagar et al. (2007). This relationship can be explained due to the possible influence of unfavourable nutritional factors during the progression of PD in haemodialysis patients (Ogawa et al. 2006). Malnutrition causes a suppression of defence mechanisms against infectious agents, mainly by reducing the number of immune cells, resulting in decreased host resistance to periodontal pathogens (Iwasaki et al. 2002). Furthermore, the inflammatory process, as a result of mediators, such as cytokines, may reduce protein synthesis in the liver resulting in reduction of plasma albumin (Kshirsagar et al. 2005).

Another important finding of this study was the negative association between periodontal status and elevated phosphorus serum level - hyperphosphataemia. To comprehend this relationship, it is necessary to understand that the regulation of plasma phosphorus is performed by the kidneys, and that the elevation of phosphorus serum level is common in patients with CKD, being considered a range of 2.4–4.1 mg/dL as a reference value for a systemically healthy patient (Isakova et al. 2009), and 3.5–5.5 mg/dL in end-stage renal disease (National Kidney Foundation 2003). Hyperphosphataemia contributes to abnormal bone metabolism and cardiovascular calcification; components of the syndrome of CKD-Mineral and Bone Disorder (Moe et al. 2006). The high phosphorus levels can stimulate vascular smooth muscle cells to undergo osteoblast differentiation, which may lead to atheromatous plaque formation (Mathew et al. 2008). This vascular calcification is a predictor of cardiovascular mortality in haemodialysis patients (Kestenbaum et al. 2005). In an attempt to control this event, the clinical management of these patients includes the use of chelating drugs, together with a low phosphorus diet (Coladonato 2005). In periodontal tissues, it may contribute to reduction of alveolar bone resorption rates.

In the studied groups, those with periodontitis had a negative association with hyperphosphataemia: the individuals with periodontitis showed more frequency of serum phosphorus level in the normal limits - 3.5 to 5.5 mg/dL. Lee et al. (2010) in animal model study noted that CKD in mice, especially under

Table 1. General characteristics of haemodialysis patients in accordance with presence or not of periodontitis (N = 96)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Total n (%)</th>
<th>Presence of Periodontitis</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Yes n (%)</td>
<td>No n (%)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>45 (46.9)</td>
<td>23 (40.4)</td>
<td>22 (56.4)</td>
</tr>
<tr>
<td>Female</td>
<td>51 (53.1)</td>
<td>34 (56.6)</td>
<td>17 (43.6)</td>
</tr>
<tr>
<td>Smoking habit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-smoker</td>
<td>63 (65.6)</td>
<td>37 (64.9)</td>
<td>26 (66.7)</td>
</tr>
<tr>
<td>Current or former smoker</td>
<td>33 (34.4)</td>
<td>20 (35.1)</td>
<td>13 (33.3)</td>
</tr>
<tr>
<td>Hypertension</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>81 (84.4)</td>
<td>48 (84.2)</td>
<td>33 (84.6)</td>
</tr>
<tr>
<td>No</td>
<td>15 (15.6)</td>
<td>9 (15.8)</td>
<td>6 (15.4)</td>
</tr>
<tr>
<td>Schooling level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illiterate</td>
<td>9 (9.4)</td>
<td>8 (14.0)</td>
<td>1 (2.6)</td>
</tr>
<tr>
<td>Elementary school uncompleted</td>
<td>21 (21.9)</td>
<td>14 (24.6)</td>
<td>7 (17.9)</td>
</tr>
<tr>
<td>Elementary school completed</td>
<td>24 (25.0)</td>
<td>14 (24.6)</td>
<td>10 (25.6)</td>
</tr>
<tr>
<td>High school</td>
<td>33 (34.4)</td>
<td>18 (31.6)</td>
<td>15 (35.5)</td>
</tr>
<tr>
<td>Graduation</td>
<td>9 (9.4)</td>
<td>3 (5.3)</td>
<td>6 (15.4)</td>
</tr>
</tbody>
</table>

Table 2. Distribution of periodontal clinical parameters in accordance with presence or not of periodontitis (N = 96)

<table>
<thead>
<tr>
<th>Periodontal Clinical Parameters</th>
<th>Total (N = 96, 100%)</th>
<th>Presence of Periodontitis</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Yes (n = 57, 59.4%)</td>
<td>No (n = 39, 40.6%)</td>
</tr>
<tr>
<td>PD</td>
<td>4.79 ± 2.04</td>
<td>5.54 ± 1.81</td>
<td>2.92 ± 1.08</td>
</tr>
<tr>
<td>CAL</td>
<td>4.97 ± 2.68</td>
<td>5.91 ± 2.15</td>
<td>3.02 ± 1.11</td>
</tr>
<tr>
<td>GBI (%)</td>
<td>14 ± 17</td>
<td>21 ± 18</td>
<td>2 ± 3</td>
</tr>
<tr>
<td>VPI</td>
<td>1.06 ± 0.84</td>
<td>1.46 ± 0.80</td>
<td>0.37 ± 0.26</td>
</tr>
<tr>
<td>GI</td>
<td>0.69 ± 0.56</td>
<td>0.94 ± 0.53</td>
<td>0.27 ± 0.34</td>
</tr>
</tbody>
</table>

CAL, clinical attachment level; GBI, gingival bleeding index; GI, gingival index; PD, probing depth; SD, Standard deviation; VPI, visible plaque index.

*p-Value: statistically significant (p < 0.05).
conditions of high-phosphate diet, affects alveolar bone homeostasis by deregulation of phosphate metabolism, the histological evaluation demonstrated thinning in cortical bone and increase in trabeculation in mandible. A plausible biological explanation is that kidney disease results in elevated phosphate serum levels, which could contribute to higher osteoblastic activity (Grossi et al. 1995). Therefore, the higher level of phosphorus in the group without periodontitis can result in a decrease in the rate of alveolar bone loss. However, systemically, high levels of phosphorus can lead to extra-osseous calcification in renal patients, including the formation of atheromatous plaques, worsening the prognosis of the disease and increasing the risk of cardiovascular complications (Block et al. 2004).

In this context, it is worth pointing out that in the assessed group of the present study, the prevalence of periodontitis was 59.4%. This high occurrence of an infection and inflammation process, in patients undergoing haemodialysis and with elevated phosphorus serum levels, contributes to undesirable systemic complications.

Chronic inflammation is associated with an increased risk of cardiovascular complications in patients with CKD (Stenvinkel et al. 2008). One possible explanation for this interaction is the fact that the inflammatory process involved in PD induces the production of inflammatory mediators such as IL-1β, IL-6, TNF-α and C-reactive protein (CRP), and they play an important role in the pathogenesis of atherosclerosis, increasing the risk of cardiovascular mortality and morbidity in patients with chronic renal failure (Blaziot et al. 2009).

Chen et al. (2011) found that the association between the prevalence of PD and mortality in haemodialysis patients is proportional to the severity of periodontitis. Fisher et al. (2007), in a study with multivariate analysis of risk factors including traditional and non-traditional ones, with samples coming from the Third National Health and Nutrition Examination Survey, have reinforced the interaction of PD with severe renal damage, and suggested the incorporation of periodontal therapy as a preventive instrument.

Furthermore, individuals with CKD have two alterations that may also play an important role in the onset and progression of PD: metabolic and functional alterations of polymorphonuclear neutrophils (PMN) and bone disorders (Lee et al. 2010). In PD as in any infection, PMN cells are the first line of cellular defence against infections caused by bacterial biofilms (Mandalunis et al. 2003). This deficiency can increase bacterial invasion in periodontal tissues, enhancing the risk of these pathogens reaching the systemic circulation. It is noteworthy that periodontal pathogens have been identified in atherosclerotic plaques (Haraszyth et al. 2000, Van Dyke & Serhan 2003). This aspect can further enhance the likelihood of atheroma formation in renal patients.

Although this study has pointed to the association between periodontitis and hypoalbuminaemia, as well as hyperphosphataemia, these findings should be evaluated with caution given the limitations of the method employed. The cross-sectional study design does not allow for an assertion of causality between the factors investigated, on the other hand, it is a tool that can be used in epidemiological health studies because it has the advantages of execution speed and relatively minor cost compared to other existing study designs. Another limitation was the collection of serum markers through secondary data, giving that it is more susceptible to measurement bias. However, the tests were performed in one central laboratory, which minimized this further limitation. As the use of biomarkers in the therapeutic management of kidney

<table>
<thead>
<tr>
<th>Serum biomarkers</th>
<th>Presence of Periodontitis</th>
<th>p-Value</th>
<th>RC</th>
<th>R²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes Mean ± SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>No Mean ± SD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Albumin (g/dL)</td>
<td>3.44 ± 0.44</td>
<td>0.021*</td>
<td>-0.341</td>
<td>0.16</td>
</tr>
<tr>
<td>Creatinine (mg/dL)</td>
<td>10.05 ± 4.71</td>
<td>0.864</td>
<td>0.291</td>
<td>0.00</td>
</tr>
<tr>
<td>Transferrin (mg/dL)</td>
<td>227.7 ± 76.7</td>
<td>0.185</td>
<td>-78.63</td>
<td>0.06</td>
</tr>
<tr>
<td>Iron (µg/dL)</td>
<td>74.17 ± 62.15</td>
<td>0.409</td>
<td>-19.59</td>
<td>0.02</td>
</tr>
<tr>
<td>Alkaline phosphatase (U/L)</td>
<td>216.6 ± 186.1</td>
<td>0.985</td>
<td>1.049</td>
<td>0.00</td>
</tr>
<tr>
<td>Calcium (mg/dL)</td>
<td>8.67 ± 0.42</td>
<td>0.957</td>
<td>-0.008</td>
<td>0.00</td>
</tr>
<tr>
<td>Phosphorus (mg/dL)</td>
<td>5.02 ± 1.19</td>
<td>0.024*</td>
<td>-1.222</td>
<td>0.16</td>
</tr>
<tr>
<td>Potassium (mg/dL)</td>
<td>4.65 ± 0.61</td>
<td>0.220</td>
<td>-0.293</td>
<td>0.05</td>
</tr>
<tr>
<td>Haemoglobin (g/dL)</td>
<td>11.06 ± 1.63</td>
<td>0.073</td>
<td>1.281</td>
<td>0.10</td>
</tr>
</tbody>
</table>

RC. Regression coefficient. R² = Determination coefficient.

*p-Value: statistically significant (p < 0.05), (Student’s t-test or Mann–Whitney test).
disease is a common practice, the employment of secondary data was a factor in reducing the cost of the study and intervention in the research participants. The biomarkers provide information about the prognosis of the disease’s course, assessment of response to certain treatments and serve as predictors of morbidity and mortality (Zaremba et al. 2007).

Some advances achieved in this study can be highlighted. For example, the employment of a robust and very specific criterion for the diagnosis of periodontitis, utilizing, besides PD, CAL measurements. It is noteworthy that for association studies, it is important that the individuals diagnosed with periodontitis present no false-positive diagnoses of the disease, which can compromise the final association measurement. Also, it is worth mentioning that the comparability between studies on the theme is difficult since there is a diversity of diagnostic criteria of periodontitis in the literature. Another advance is the type of data analysis that sought to contemplate confounding covariables, such as the gender, age, smoking habit and hypertension, that may be associated both with the exposure and the outcome, making the final association measurement closer to the reality.

In conclusion, these findings suggest that periodontitis is associated with both albumin and phosphorus serum levels in patients undergoing haemodialysis. Other studies are suggested to better assess the theme in discussion, using designs most suitable to analyse the cause and effect, and contributing to consolidate knowledge in the area, for example an intervention study in patients undergoing haemodialysis. Furthermore, these findings reinforce the importance of the incorporation of dental care in the treatment planning of patients under haemodialysis, in the proportion that this management can contribute to improving the prognosis of this group of individuals.

Acknowledgement

The authors appreciate the clinical assistance of health workers in haemodialysis center.

References


**Clinical Relevance**

**Scientific rationale for the study:** Periodontal inflammation may be involved in the development of the atherogenic process in haemodialysis patients, increasing the risk of cardiovascular outcomes in this population. This study aims to investigate the association between periodontal status and the serum biomarker levels in haemodialysis patients.

**Principal findings:** Periodontitis was associated with albumin and phosphorus serum levels in haemodialysis patients. **Practical implications:** Periodontitis may be a factor that influences serum biomarkers levels in haemodialysis patients.