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Articulos Originales

Cadmium kidney damage assessment in farmers previously exposed to it, in Quila-Quila, Potosí.

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Abstract: Cadmium is a heavy metal found in mining and other wastes, and has deleterious effects on human health, especially in the kidney where it destroys tubular cells. In an investigation of the quality of river beds receiving wastewater in northern Potosi, Bolivia, cadmium was reported in potatoes irrigated with wastewater in Quila-quila, a rural town in the area. Objective: The aim of this study was to identify possible damage caused by cadmium to the health of the inhabitants of Quila-quila. Methods: clinical review and clinical and chemical laboratory analysis of blood and urine of the inhabitants of Quila-quila was carried out, and the glomerular filtration rate (TFG) was calculated and correlated with indicators of glomerular damage. Results: elevated blood cadmium levels were found in some people, and a correlation of TFG with blood cadmium concentration and with indicators of glomerular membrane damage. Conclusions: In conclusion, the inhabitants of Quila-quila were contaminated by cadmium, which produced mild kidney damage.

Keywords: cadmium, environmental pollution, glomerular filtration rate.

Resumen: El cadmio es un metal pesado presente en desechos mineros y otros, y tiene efectos deletéreos en la salud humana especialmente en el riñón en el que destruye células tubulares. En una investigación de la calidad del lecho de los ríos que reciben aguas residuales en el norte de Potosí, Bolivia, se reportó presencia de cadmio en papas regadas con esas agua en Quila-quila, una población rural de la zona. Objetivo: de este trabajo fue el de identificar posibles daños del cadmio en la salud de los pobladores de Quila-quila. Métodos: para ello se realizó revisión clínica y análisis laboratorial clínico y químico de sangre y orina de los pobladores de Quila-quila, y se calculó la tasa de filtración glomerular (TFG) y se correlacionó ésta con indicadores de lesión glomerular. Resultados: se encontraron niveles elevados de cadmio en sangre en algunas personas, y una correlación de la TFG con la concentración de cadmio en sangre y con indicadores de lesión de membrana glomerular. Conclusiones: en conclusión, los pobladores de Quila-quila estuvieron contaminados por cadmio, el cual produjo lesión renal leve.

Palabras clave: cadmio, contaminación ambiental, tasa de filtración glomerular.

Cadmium is a heavy metal common in mining and industrial areas with no known biological function. It is considered a pollutant because its

accumulation causes biological damage by inhibiting the sulphydryl (SH) groups involved in most enzymatic processes in our body.

Cadmium can enter the body through the lungs, the digestive system or the skin. Most of it is deposited in the liver and mainly in the kidneys where it causes the most damage by damaging the proximal tubular cells through chronic accumulation1. Its excess can cause death. It is essentially eliminated via the kidneys, intestines and faeces.

Acute cadmium poisoning can be detected by direct measurement of cadmium in blood and urine. Chronic accumulation is associated with renal dysfunction, and it is now accepted that the most sensitive and specific indicator for the detection of cadmium renal failure is decreased tubular reabsorption of low molecular weight proteins [1] . The most common markers of renal impairment are serum creatinine beta2-microblobulin, retinol-binding protein and alpha1-microglobulin [2,3] . On the other hand, glomerular filtration rate (GFR) is an important parameter as it indicates the filtration capacity of the kidneys and thus the state of the glomerular membrane.

GFR can be accurately determined from serum creatinine using equations [4,5]. Recently, the association of high cadmium levels with serum creatinine levels has been reported6, so that the possible effects of cadmium on the kidney can be estimated by obtaining creatinine values. Minimal urinary Cd levels are estimated to range from 2 to 10 micrograms/gram of creatinine.

Quila-quila is a village in the Bolivian altiplano located in a mining area where rivers are polluted with water from the waste and washings of mines and metallurgical mills. The inhabitants of Quila-quila grow their food, mainly potatoes and beans, with this contaminated water. In a study carried out by Oporto, high levels of cadmium were found in the potatoes and beans grown in the region, and the calculated intake of Cd exceeded the maximum recommended by the WHO7 , so it was thought that the inhabitants of Quila-quila were contaminated with cadmium and had a high prevalence of kidney damage, since they themselves consume the potatoes and beans. The aim of the study was to determine the incidence of renal pathology caused by chronic cadmium contamination in the population of Quila-quila exposed to cadmium.

Material and methods

Observational, cross-sectional, cross-sectional study carried out in the population of Quila Quila-Potosi, with non-probabilistic, accidental sampling.

For the evaluation of renal pathology and possible association with cadmium levels in the inhabitants of Quila Quila, a medical examination and blood and urine analysis were carried out. The clinical examination was carried out in the clinic of the health centre in the village of Quila-quila. Demographic data, anthropometric measurements, an anamnesis of the diet, measurement of clinical parameters such as PA, FC,

temperature, physical examination for general and specific pathological signs of the genitourinary and neurological systems were taken.

The blood sample was taken from venous blood and preserved at 4ºC during transport to the laboratory, where a complete blood count, lipid profile, liver profile and renal profile, determination of beta-2-microglobulin, albumin and ferritin were performed. Plasma levels of total cholesterol, triglycerides, HDL, LDL, creatinine, urea, uric acid and alkaline phosphatase, GOT transaminase, GPT transaminase were determined by analysis with Stat fax 3300.

Urine tests were partial urine and chemical microscopic examination, determination of Beta-2-microglobulin, microalbumin and creatinine.

The concentration of cadmium in blood and urine was determined by atomic absorption spectrophotometry, after digestion of the organic matter in the samples, in a Milestone-Ethos 900 microwave oven. The readings were performed on a Perkin Elmer AAnalyst 700 Atomic Absorption Spectrometer with PU 9095 electrothermal atomisation system and Argon as purge gas.

All laboratory techniques were previously standardised with control sera and standards or calibrators from commercial kits. Quality control of blood chemistry tests (enzymatic and kinetic) was performed with level 1 and level 2 controls.

Renal function analysis was performed based on direct parameters measured in blood and urine, and glomerular filtration rate was calculated using the Levey equation based on serum creatinine, age, and other parameters [4, 5], the equation for which is shown below. GFR= 170*SCr-0,999*age-0,176*BUN-170*album0,318

Where GFR is the glomerular filtration rate; SCr, the serum creatinine level; and BUN the blood urea nitrogen concentration.

Results

The population of Quila-quila is generally composed of elderly people and children. Most of the young adult population has migrated mainly in search of work and lives in larger cities such as Llallagua and Oruro (Figure 1).

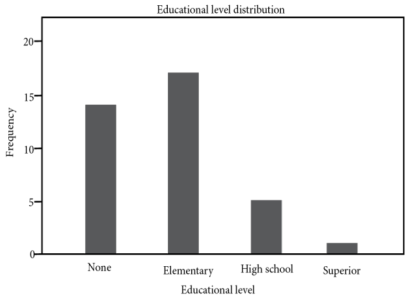

Figure 1.
Figure 1. Graph of the educational level of the inhabitants of Quila-quila

Of the population studied, the level of education of the majority is low (primary or none), which corresponds to the age of the population, as very few previously attended school. The majority (67%) are originally from Quila-quila; the average number of children per person is 5.6; the main occupation is farmer, followed by housewife.

The average results of the measurement of the different anthropometric and clinical parameters are shown in Table 1 below

Table 1. Clinical characteristics of the study population

	Media	SD
Age (yearss)	58,06	18,235
Height (cm)	152,42	11,497
Weight (kg)	53,58	8,911
Head circumference. (cm)	54,14	1,536
Brachial Perimeter(cm)	24,09	2,930
Tricipital fold(cm)	8,55	4,928
BMI	23,4431	5,45984
Systolic Blood Presure (mmHg)	107,361	8,55278
Diastolic Blood Presure (mmHg)	61,4722	17,5355

Table 1.
Clinical characteristics of the study population

These measurements (Table 1) show a general picture of the health status of the population studied, which can be described as middle-aged, short, underweight, but with increased BMI, 6 people are obese and have hyperlipidaemia. In other words, from a nutritional point of view, it is a chronically malnourished population with overweight. In the anamnesis we found BP within normal ranges, but lower than the average of the general population. Examination of the cardiovascular system shows that there are no problems at this level. The analysis of the nervous and osteo-muscular system shows that 7 people had symptoms of rheumatoid arthritis. The most frequently observed pathology from the clinical point of view among the inhabitants of Quila-quila is urinary tract infection (N=11) and one possibly with nephropathy.

Effect of cadmium

The levels of cadmium found in the inhabitants of Quila-quila were: 6.32 (±4.33 SEM) in plasma and 12.14 (±10.6 SEM), in urine, the permitted levels of Cd in blood are up to 10 ug/L. Cadmium levels were correlated with different population parameters to determine if any of the factors were altered by possible cadmium accumulation. No correlation was found between age and cadmium concentration in blood or urine, nor was there a correlation between cadmium levels in blood and urine (Figure 2).

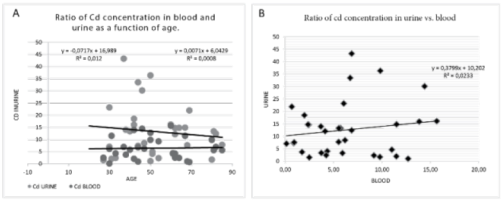

Figure 2.

Graph showing the correlation of age with cadmium concentration in urine and blood and between cadmium concentration in urine and blood. (A) Apparently cadmium levels are higher in urine of people between 30 and 50 years of age, although the data show great dispersion, while in blood the difference is minimal. (B) Those with high levels of cadmium in urine have medium levels in blood, and very few have high levels in both.

Glomerular membrane injury is expressed by the amount of protein in urine, specifically albumin or microglobulins, and the ratio between plasma and urine concentrations is an indicator of the extent of glomerular damage. In our study, none of the patients have a clinical state of renal failure, but 3 of 34 patients have increased albumin (> 20 ug/ml).

The presence of plasma proteins in urine, especially albumin, is an indicator of glomerular injury, as it indicates a breakdown of the glomerular barrier (endothelium and Bowman?s capsule). The value of the ratio of plasma albumin concentration to urine albumin concentration should always be greater than 1; a lower value indicates that the amount of albumin in urine is greater than plasma albumin, and therefore, albumin is being filtered and lost in the urine due to glomerular membrane damage. In our study, the ratio between these two parameters shows that in 12 out of 36 (33%) patients it was less than 1, i.e. one third of the patients have glomerular membrane injury. It is known that cadmium accumulation in the kidney causes membrane damage, thus affecting the glomerular filtration rate. In the patients studied, the glomerular filtration rate (GFR) was calculated using Levey?s formula5 and the correlation between GFR and albumin concentration was calculated, a correlation validated by the high correlation between GFR and creatinine concentration (figure 3), a correlation with R2 of 0.19 was found between the presence of albumin and GFR, also indicating that in patients with high albumin in urine, GFR is decreased, thus the glomerular membrane is damaged.

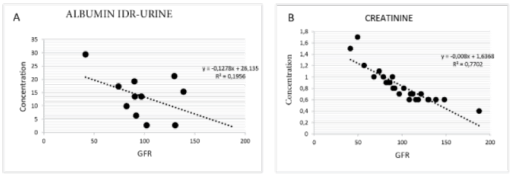

Figure 3.
Correlation between the glomerular filtration rate (GFR) calculated with the Levey equation and the concentration of albumin (A) and creatinine (B) in Quila-quila patients. The correlation for creatinine shown in B is evident with very low creatinine values for a high GFR, and less evident but positive correlation for albumin, indicating glomerular damage in patients with GFR less than 100 ml/min.

Moreover, microglobulin is an indicator of immune system cell activity, but also of tubular reabsorption [8,9]. In our study, 19 out of 34 patients (55.8%) had increased microglobulin in urine.

Discussion

Our data show that the population of Quila- quila has poor socio-economic conditions, mainly in terms of education. It was expected, based on the hypothesis that food products produced in the area, irrigated with cadmium-contaminated water from the river containing water from nearby mines, and consumed by the population of Quila- quila, would have accumulated cadmium [7] and possibly affect kidney function. This is confirmed in one third of the population studied, where high levels of cadmium were found in urine. However, due to the productive characteristics of the area, part of the year (in the dry season), the population resides in nearby cities, and therefore does not consume the food produced in the area and so the contamination process is stopped, which is why we did not find high levels that indicate acute exposure.

On the other hand, we know that cadmium accumulates in the kidney and alters glomerular filtration. In the study we did not perform a renal biopsy, but we were able to see that in the population studied there is a high percentage with decreased glomerular filtration rate (calculated with the Levey equation), even in young people. This leads us to believe that a certain percentage of the population has kidney damage. Our calculations based on the Levey equation [5] seem reliable, as they are validated by the good correlation between GFR and creatinine levels. Albumin levels also indicate glomerular membrane injury in a certain percentage of the population. The low correlation we found for albumin, and alpha and beta microglobulin, is real, and indicates that cadmium does indeed affect glomerular membrane rather than tubular function.

Conflict of interest: the authors declare that there is no conflict of interest.intereses.

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