

# Nutritional evaluation in secondary hyperparathyroidism patients

*Avaliação nutricional de pacientes com hiperparatireoidismo secundário*

*Evaluación nutricional en pacientes con hiperparatiroidismo secundario*

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## Abstract

Secondary hyperparathyroidism is a common complication in hemodialysis patients. Dietary advice is a significant part of the management with a potentially favorable impact on calcium-phosphate retention. The purpose of this study was to monitor the nutritional status during the first year following nutritional advice. Forty one adult hemodialysis patients of Renal Osteodystrophy Outpatient Clinic at Sao Paulo University, with a mean age 43.4 (SD15.7) years were analyzed. During the follow-up, some patients were submitted to chemical and surgical PTX, and the analysis was performed based on three groups according to treatment during group diet (n = 21), group chemical PTX (n = 9) and group surgical PTX (n = 11). Energy, protein calcium and phosphorus intakes were assessed with 3-d dietary records. Weight, height, Body Mass Index and percentage of body fat were measured, and biochemical markers of bone metabolism were determined. Dietary, anthropometric and biochemical measurements were performed at the beginning of clinical intervention and after 1 year of follow-up. No significant improvement was observed in energy, protein and calcium intakes during the study, even after nutritional advice. Phosphorus intake was adequate considering the recommendations. No changes were observed in anthropometric parameters. There were significant decreases in serum total calcium, ionized calcium, phosphorus, Ca x P product and PTHi levels in patients submitted to surgical removal of parathyroid glands. Although the surgical PTX presented significant improvement in biochemical parameters of secondary hyperparathyroidism, dietary control can be effective not aggravate of the nutritional status and SHPT parameters with a low cost.

## Resumo

O hiperparatiroidismo secundário (HPTS) é uma complicação comum em pacientes que realizam hemodiálise. A orientação nutricional é parte integrante do tratamento, com potencial impacto favorável na retenção de cálcio e fósforo. O objetivo deste estudo foi monitorar o estado nutricional durante um ano de intervenção nutricional. Quarenta e um pacientes hemodializados, atendidos no Ambulatório de Osteodistrofia Renal do Hospital das Clínicas, em São Paulo, com média de idade de 43,4 (15,7) anos foram avaliados. Durante o período de avaliação, alguns pacientes foram submetidos à paratiroidectomia (PTX) química ou cirúrgica e a análise foi feita baseada em três grupos, de acordo com o tratamento: grupo dieta (n = 21), grupo PTX química (n = 9) e grupo PTX cirúrgica (n = 11). Poderam ser avaliadas as ingestões de energia, proteína, cálcio e fósforo por inquérito alimentar de três dias. Peso, altura, IMC e % gordura corporal foram mensurados, bem como marcadores bioquímicos do metabolismo ósseo. As medidas dietéticas, antropométricas e bioquímicas foram executadas no início da intervenção clínica e após um ano. Não houve alterações significativas nas ingestões de energia, proteína e cálcio durante o estudo, mesmo após a orientação nutricional. O fósforo dietético permaneceu dentro das recomendações. Não foram observadas alterações nos parâmetros antropométricos. Houve diminuição significativa no cálcio sérico total, cálcio iônico, fósforo, produto CaxP e níveis de PTHi nos pacientes submetidos à PTX cirúrgica. Embora esta prática tenha apresentado significativa melhora nos parâmetros bioquímicos do HPTS, o controle dietético pode ser efetivo para o não-agravo do estado nutricional e dos parâmetros do HPTS com baixo custo.

## Resumen

Hiperparatiroidismo secundario (HPTS) es una complicación común en pacientes en hemodiálisis. La orientación nutricional es parte integrante del tratamiento con impacto favorable en la retención del calcio y del fósforo. El objetivo de este estudio fue supervisar el estado nutricional durante un año de intervención nutricional. Cuarenta y uno pacientes adultos en hemodiálisis del Ambulatorio de Osteodistrofia Renal de la Universidad de São Paulo, con edad

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media 43.4 (SD15.7) años fueron evaluados. Se realizó un seguimiento clínico por un año, algunos pacientes fueron sometidos a paratiroidectomía (PTX) química o quirúrgica, las análisis se basaron en tres grupos según tratamiento: grupo dieta (n = 21), grupo PTX química (n = 9) e grupo PTX quirúrgica (n = 11). Abalearon las ingestiones de energía, proteína, grasa, calcio y fósforo por investigación alimenticia de tres días. Peso, altura, IMC, % grasa corporal fueron mensurados, así como marcadores bioquímicos del metabolismo óseo. Las medidas dietéticas, antropométricas y bioquímicas fueron ejecutadas en el inicio de la intervención clínica y después de 1 año. No hubo alteraciones significativas en las ingestiones de energía, proteína y calcio durante el estudio, mismo después de la orientación nutricional. El fósforo dietético estuvo dentro de las recomendaciones. No fueron observadas alteraciones en los parámetros antropométricos. Hubo disminución significativa del calcio sérico total, calcio iónico, fósforo, producto CaxP y niveles de PTHi en los pacientes de PTX quirúrgica. Aunque la PTX quirúrgica tenga presentado significativa mejoría en los parámetros bioquímicos del HPTS, el controle dietético puede ser efectivo en no agravar el estado nutricional y los parámetros del HPTS con bajo costo.

## Introduction

Secondary hyperparathyroidism (SHPT) is a common complication in hemodialysis patients, with high morbidity and mortality and difficult medical control. The condition may begin in the early stages of chronic renal insufficiency and is characterized by hyperplasia of parathyroid gland, extreme parathyroid hormone (PTH) secretion and abnormalities in calcium and phosphorus metabolism<sup>1-4</sup>. While at present there are no epidemiological studies concerning the prevalence of SHPT in the dialysis population, it has been shown that 50% of patients in dialysis had an intact PTH level more than three times the normal level<sup>5</sup>.

Physiopathologic alterations can lead to bone and muscular pains, itch, vascular calcification, calciphylaxis, bone fractures, decreased appetite, and abnormalities in palate and weight loss in varying intensities<sup>6-8</sup>. In addition, deficient nutrient intake, glucose intolerance, chronic inflammation and hormonal disturbances are frequently observed in hemodialysis patients<sup>9-11</sup>, and potentially could contribute to the development of malnutrition.

The treatment of SHPT consists of clinical management based on restriction of phosphorus intake (modification of the diet)<sup>12-14</sup>, administration of phosphate binders, as such as Al(OH)<sub>3</sub>, CaCO<sub>3</sub>, sevelamer, and the use of products derived from the vitamin D (calcitriol, calcipotriol) and calcium<sup>3,15-16</sup>.

Dietary advice is also a significant part of the management of SHPT patients. Nutritional counseling should be effective in reducing the phosphate load and limiting the phosphate burden related to an adequate protein intake, with a potentially favorable impact on calcium-phosphate retention<sup>14</sup>.

A more efficient form of treatment consists of surgical removal of parathyroid glands (PTX). The indication for surgery depends on the severity of the disease, the clinical symptoms<sup>17</sup> and also on co-morbidities. In the same circumstances, chemical PTX is also indicated. The chemical PTX consists of percutaneous absolute ethanol injection in parathyroid glands. This method also has limitations and could have additional consequences such as extensive fibrosis and recurrent palsy<sup>18</sup>. However, surgical or chemical PTX is so-

metimes unavailable and, as a consequence, most patients remain in clinical management for several months or years.

It has been demonstrated that high PTH levels can, directly or indirectly, exert a toxic action on energy and protein metabolism, inducing catabolism and negative nitrogen balance, as well as alterations in body composition<sup>19</sup>.

Furthermore, the correction of high PTH levels with parathyroidectomy (PTX), can improve nutritional status. Recent data collected by our group demonstrated a significance improvement in body composition parameters related to nutritional status six months after PTX<sup>20</sup>.

The purpose of this study was to monitor the nutritional status of patients, important in the clinical management of SHPT, for one year after the patients received nutritional advice.

## Methods

### Subjects

All patients visiting the Renal Osteodystrophy Outpatient Clinic at Sao Paulo University for the first time were invited to participate. Those patients under 18 years, or with recent infectious conditions, tuberculosis in treatment, gastrointestinal diseases, chronic alcoholism, malignant diseases, cardiac and pulmonary insufficiency, kidney transplantation, and use of mineralocorticoids were excluded; forty-one (41) patients agreed to participate and were evaluated. During the follow-up, some patients were submitted to chemical and surgical PTX, and the analysis was performed based on three groups according to treatment during follow-up: *group 1- Diet - D* (n = 21)- patients who received exclusive clinical treatment; *group 2- chemical PTX - C-PTX* (n = 9) – patients submitted to chemical PTX and *group 3 - surgical PTX - S-PTX* (n = 11) – patients submitted to surgical PTX. Nutritional and biochemical data were obtained at the beginning of clinical intervention and the nutritional evaluation performed after one year.

### Nutritional assessment

Dietary intake was evaluated by means of 3-day dietary records that included one dialysis day, one off-dialysis day

and one weekend day. The mean energy, protein, calcium, and phosphorus intakes were measured. NutWin software (Unifesp, São Paulo, BR, 2002) was used to calculate mean nutrient intakes.

Anthropometric measurements as such as weight, height, tricipital, subscapular and suprailiac skinfold thickness and midarm muscle circumference (MAMC) were also taken at the beginning of treatment. Body mass index (BMI) was calculated as body weight divided by squared height<sup>21</sup>. Skinfold thickness was measured using Harpenden calipers (British Indicators Ltd, Luton, UK). These measurements were performed by the same observer on the side of the body opposite to that of the vascular access for hemodialysis. MAMC was calculated using the formula  $MAMC = \text{arm circumference} - (0.314 \times \text{TSF})^{22}$ . Body Fat (BF) was calculated using the equation offered by Durnin & Wormersley<sup>23</sup>.

Data was collected by a nutritionist trained for uniformity and accuracy in the techniques in obtaining anthropometric and food intake data.

### **Dietary advice**

All patients received dietary counseling based on the National Kidney Foundation- Disease Outcome Quality (K/DOQI 2003)<sup>24</sup> (30 - 35 Kcal/Kg/day and 1.0 - 1.2 g protein/Kg/day, respectively) at the beginning of the study and this was reviewed every time that patients visited the outpatient clinic. In addition, the use of phosphate binders (CaCO<sub>3</sub>, sevelamer) were also managed by a trained nutritionist according to the levels of serum phosphorus each time a patient visited the clinic.

### **Biochemical assessment**

Blood samples were drawn from the patients before and after one year. Serum intact PTH (normal range, 8 - 76 pg/ml) was measured by a radioimmunoassay (Cis-Bio International, ELISA PTH, Gif-sur-Yvette, France). Serum total calcium (normal range, 8.5 - 10.5 mg/dl), serum-ionized calcium (normal range, 4.8 - 5.4 mg/dl), and serum phosphorus (normal range, 2.3 - 4.6 mg/dl) were determined with an automated analyzer (Auto analyzer Cobas-Integra, Roche). The analyses were made at the Central Laboratory in the Hospital das Clinicas at Sao Paulo University.

### **Statistical analysis**

The results were expressed as mean (SD) and median. The Fisher exact test was used to compare age and

sex between groups. The ONEWAY ANOVA with Tuckey post-hoc was performed to compare differences between the three groups at baseline. The ANOVA for repeated measures was used to analyze parameters at beginning and the end of treatment between subjects at each group. The Profile test was performed for variable comparisons between time of PTX within groups. For these analysis variables were adjusted for PTX time. Variables without normal distribution were transformed in logarithm (log 10). Statistical significance was defined as  $p < 0.05$ . The analysis was performed using the SAS System for Windows (Statistical Analysis System), version 8.02 SAS Institute Inc, 1999 - 2001, Cary, NC, USA.

## **Results**

The characteristics of the 41 hemodialysis patients with secondary hyperparathyroidism divided in three groups in baseline and after 1 year are reported in Table 1. Patients included 23 females and 18 males. All the patients were adults, with  $6.8 \pm 3.1$  years in dialysis therapy. No significant difference in age and sex between groups was observed (Table 1).

The overall analysis of dietary composition in baseline and after 1 year of the three groups showed a trend toward lower energy protein and calcium intake when compared with K/DOQI<sup>24</sup> recommendations. However, mean phosphorus intake was adequate considering the recommendation ( $< 17$  mg/kg/day). When evaluating individual phosphorus intake, only 5 (12%) of patients presented phosphorus intakes higher than 17 mg/kg/day at the beginning of follow-up. The energy intake at baseline was found to be significantly higher in patients submitted to surgical PTX.

There are no significant differences in anthropometric parameters between groups at baseline and after one year, nor when analysis was performed within group.

In biochemical parameters the mean PTH levels at baseline were significantly different between groups. The mean serum total calcium and ionized calcium were in the normal range during the follow-up. Serum phosphorus was above in all groups at baseline and after one year (Table 2).

Table 2 presents the biochemical parameters during follow-up. As expected, a significant decrease in serum total and ionized calcium, PTH and Ca<sub>2+</sub>P, was observed after surgical PTX.

Significant difference was observed in ionized calcium in dietary advice. Chemical PTX did not decrease biochemical parameters during the follow-up. However, no increments were observed in these groups.

**Table 1** - The nutritional and anthropometric characteristics of the 41 hemodialysis patients with secondary hyperparathyroidism divided in three groups, in baseline and after one year.

	Group D (N = 21)			Group C-PTX (N = 9)			Group S-PTX (N = 11)		
	Mean	S.D.	Median	Mean	S.D.	Median	Mean	S.D.	Median
Age (years)	44.9	17.8	44.0	44.8	14.9	46.0	39.6	12.4	42.0
Time in HD (years)	6.8	3.2	6.0	6.4	2.7	7.0	7.3	3.3	7.0
PTX Time (months)	-	-	-	5.8	4.8	6.0	5.6	4.2	5.0
Energy (kcal/day) – baseline	1337.7	334.9	1251.7	1438.1	595.0	1416.5	1848.9*	658.6	1647.4
Energy (kcal/day) – after 1y	1379.8	394.7	1394.1	1395.8	574.0	1462.9	1534.4	283.1	1589.2
Energy (kcal/kg/day) – baseline	24.5	10.6	20.8	24.1	8.5	25.4	27.8	7.2	28.7
Energy (kcal/kg/day) – after 1y	24.7	8.1	24.0	24.8	10.4	20.6	24.7	8.9	21.4
Protein (g/kg/day) – baseline	1.0	0.5	1.0	1.0	0.3	1.1	1.1	0.3	1.2
Protein (g/kg/day) – after 1y	1.0	0.4	1.0	1.0	0.4	0.9	0.9	0.3	0.8
Calcium (mg/day) – baseline	367.8	146.7	331.8	345.4	181.3	290.6	391.9	175.5	340.6
Calcium (mg/day) – after 1y	316.8	111.8	309.2	271	95.1	261.6	444.4	143.9	471
Phosphorus (mg/kg/day) – baseline	11.9	5.3	11.6	11.5	4.5	11.6	13.7	4.1	13.7
Phosphorus (mg/kg/day) – after 1y	11.1	3.4	11.3	11.8	4.4	10.9	12.3	3.8	11.5
BMI (kg/m <sup>2</sup> ) – baseline	24.4	6.3	23.2	22.9	2.7	23.7	24.2	4.7	23.6
BMI (kg/m <sup>2</sup> ) – after 1y	24.1	6.4	22.6	23.5	3.0	23.5	23.9	4.3	21.4
BF (%) – baseline	27.2	11.2	28.1	26.9	7.9	28.1	25.5	11.9	22.8
BF (%) – after 1y	27.2	8.9	29.5	25.5	8.5	28.1	26.1	12.6	25.4
MAMC (mm) – baseline	23.1	4.5	22.5	22.9	2.7	22.0	24.7	3.6	23.7
MAMC (mm) – after 1y	23.2	4.7	23.1	24.0	2.1	23.8	24.1	3.1	24.5
TST (mm) – baseline	16.8	10.5	14.4	15.1	6.9	19.0	16.5	9.9	14.2
TST (mm) – after 1y	15.1	8.2	14.0	13.0	5.7	13.0	15.9	10.4	14.5
SeST (mm) – baseline	16.0	10.6	14.4	12.8	5.7	12.6	18.0	9.0	19.0
SeST (mm) – after 1y	15.7	10.4	13.0	11.9	4.6	11.0	18.9	10.3	20.0
SiST (mm) – baseline	15.3	10.7	14.0	13.7	5.8	13.0	17.2	11.6	12.0
SiST (mm) – after 1y	13.1	8.5	13.0	12.1	5.9	11.0	16.7	10.3	16.5

BMI = body Mass Index; BF = body fat; MAMC = midarm muscle circumference; TST: tricipital skinfold thickness; SeST: subscapular skinfold thickness; SiST: suprailiac skinfold thickness; Kcal = Kilocalories.

\*p < 0.05. Oneway ANOVA test.

**Table 2** - The biochemical characteristics of the 41 hemodialysis patients with secondary hyperparathyroidism divided in three groups, in baseline and after one year.

	Group D (N = 21)			Group C-PTX (N = 9)			Group S-PTX (N = 11)		
	Mean	S.D.	Median	Mean	S.D.	Median	Mean	S.D.	Median
Serum Ca (mg/dL) – baseline	10.1 <sup>a</sup>	0.7	10.0	10.0 <sup>e</sup>	0.7	9.8	10.8 <sup>fa</sup>	1.3	10.6
Serum Ca (mg/dL) – after 1y	10.0	0.6	10.0	10.0	0.3	10.0	8.8 <sup>f</sup>	1.5	8.6
Serum Cai (mg/dL) – baseline	5.2 <sup>f</sup>	0.2	5.2	5.1	0.4	5.1	5.2	0.5	5.0
Serum Cai (mg/dL) – after 1y	5.1 <sup>fd</sup>	0.3	5.0	5.0 <sup>d</sup>	0.2	5.0	4.5 <sup>d</sup>	0.7	4.4
Serum P (mg/dL) – baseline	6.2	1.8	6.5	5.5	1.1	5.0	6.3	1.4	6.7
Serum P (mg/dL) – after 1y	6.0	2.0	5.6	5.8	0.8	5.8	4.9	2.3	4.7
Ca x P (mg/dL <sup>2</sup> ) – baseline	63.2	18.6	63.0	55.5	13.4	50.5	69.3 <sup>f</sup>	20.7	71.0
Ca x P (mg/dL <sup>2</sup> ) – after 1y	60.6	19.6	56.8	58.4	8.6	58.0	44.0 <sup>f</sup>	27.4	40.4
PTH (pg/dL) – baseline	373.8 <sup>b</sup>	436.9	271.5	777.8 <sup>b</sup>	238.7	762.0	883.7 <sup>fb</sup>	215.6	875
PTH (pg/dL) – after 1y	470.7	390.1	415.5	618.4 <sup>c</sup>	384.4	435.0	246.2 <sup>fc</sup>	180.1	297.0

\*p < 0.05. Oneway ANOVA test. – † Profile test, a p < 0.01. ANOVA for repeated measures; Group S-PTX ≠ Group D and Group C-PTX; b p < 0.05 ANOVA for repeated measures; Group D ≠ Group S-PTX and Group C-PTX; c p < 0.05 ANOVA for repeated measures; Group S-PTX ≠ Group C-PTX; d p < 0.05 ANOVA for repeated measures; Group S-PTX ≠ Group D and Group C-PTX.

## Discussion

The present study is unique in presenting nutritional data in severe hyperparathyroidism patients at beginning of clinical intervention and after one year of follow-up. No significant differences were observed between the three forms of treatment. The group without surgical removal of parathyroid glands did not present significant increases in biochemical markers of SHPT as such as PTH, phosphorus and Ca x P product. In part, this can be attributed to dietary advice, at least with regards to phosphorus control and the use of phosphorus binders.

Significant dietary inadequacy in terms of energy and protein was observed in the evaluated patients. Low protein and energy intake has been frequently observed in patients in hemodialysis<sup>25-27</sup>. However an adequate protein intake is necessary to ensure neutral or positive nitrogen balance and an adequate energy intake is important for the maintenance of nitrogen balance, even when sufficient amounts of protein are provided, further assisting in maintaining nutritional status<sup>27</sup>.

The low energy intake in our patients could be explained, in part, by reduced appetite, intercurrent illness, physical illnesses affecting gastrointestinal function, and also by the low socioeconomic levels of the patients. By the other hand, low protein intake could be related to the phosphorus content of protein rich foods, since the patients were instructed to decrease the phosphorus content of the diet.

Ruffino et al.<sup>28</sup> observed that dietary phosphorus control can only be achieved if there is a severe protein restriction of diet which can induce malnutrition. Indeed, it was argued that, if the offering of energy is to be satisfactorily maintained, the restriction of proteic foods must not compromise the nutritional status of the patient<sup>14</sup>. However, after a detailed dietary counseling, none of the evaluated patients reached the proposed values for energy and protein intakes, indicating that the use of dietary supplements should be considered for these patients in order to ensure an adequate energy/protein balance.

On the other hand, after one year of nutritional advice, serum phosphorus and iPTH levels and CaxP did not significantly increase, but the serum ionized calcium did significantly decrease suggesting that the clinical management which includes nutritional advice contributed, at least in part, to the not aggravate of the SHPT parameters.

Calcium intake can be considered adequate, since there were extra sources of the nutrient in form of supplements and calcium content in dialysis procedure.

It is important to consider that using 3-day records to measure nutrient intake is a complex task that must take into consideration human behavior, changes in the patient's usual diet, underreporting of foods perceived as unhealthy, as well as limitations in nutrient composition Tables and databases. These errors can be minimized by motivating the patient to provide accurate information, and by increasing the number of days for dietary evaluation. Furthermore, nutrient intake data is valuable in assessing nutritional status when used in conjunction with anthropometric and biochemical data, as performed in the present study.

There are no differences in anthropometric parameters. Similar to Rezende et al.<sup>19</sup> when compared hemodialysis patients with and without SHPT. Maybe the anthropometric measurements have not been sensitive enough. Nutritional status evaluation in dialysis patients should be analysed with caution, since several conditions, as such as hydration, dialysis adequacy and the presence of comorbidities, interfere with the body compartments. Therefore the body composition evaluation in SHPT patients requires more sensitive methods.

The use of more sensitive and reliable methods for the evaluation of body compartments in chronic renal failure patients, such as bioelectrical impedance and Dual Energy X-ray Absorptiometry (DXA), have been proposed, Woodrow et al.<sup>29</sup> found that body fat measures obtained by skinfold thickness were similar to DXA. A study by Peters et al.<sup>20</sup> which evaluated changes in body composition in SHPT patients after PTX, did not find significant improvement when data were analyzed by conventional Bioelectrical Impedance Analysis (BIA). However, the same data analyzed by Bioimpedance Vector Analysis (BIVA) identify subtle changes in body composition six months after surgery.

As expected, surgical PTX was effective in normalizing biochemical parameters of secondary hyperparathyroidism. Chemical PTX, however, did not significantly decrease these parameters. According to Tanaka et al.<sup>30</sup>, the PTHi reached recommended levels after one year of utilization of ethanol. In the present study, the biochemical evaluation was performed at mean of five months after Chemical PTX, indicating that a longer period of evaluation is necessary to better evaluate these treatment effects.

In conclusion, our findings indicates that, although surgical PTX presented significant improvement in biochemical parameters of secondary hyperparathyroidism, besides not worsening in nutritional parameters were observed during the follow-up, the present study indicates that dietary advice is important in the management of these patients with a low cost.

## Referências bibliográficas

- Martinez I, Saracho R, Montenegro J, Llach F. The importance of dietary calcium and phosphorus in the secondary hyperparathyroidism of patients with early renal failure. *Am J Kidney Dis* 1997;29(4):496-502.
- Mendonça DU, Lobão RRL, Carvalho AB. Revisão hiperparatireoidismo secundário – visão atual de aspectos fisiopatológicos e clínicos *J Bras Nefrol* 2002;24 (1):48-55.
- Block GA. The impact of calcimimetics on mineral metabolism and secondary hyperparathyroidism in end-stage renal disease. *Kidney Inter* 2003;64(87):131-136 [suppl 1].
- Cozzolino M, Brancaccio D, Gallieni M, Galassi A, Slatopolsky E, Dusso A. Pathogenesis of parathyroid hyperplasia in renal failure. *J Nephrol* 2005;18(1):5-8.
- Salem MM. Hyperparathyroidism in the hemodialysis population: A survey of 612 patients. *Am J Kidney Dis* 1997;29:862-5.
- Brown EM, Wilson RE, Eastman RC, Pallotta J, Marynick SP. Abnormal regulation of parathyroid hormone release by calcium in secondary hyperparathyroidism due to chronic renal failure. *J Clin Endocrinol Metab* 1982;54:172-9.
- Llach F, Massry SG. On the mechanism of secondary hyperparathyroidism in moderate renal insufficiency. *J Clin Endocrinol Metab* 1985;61:601-6.
- Khajehdehi P, Ali M, Al-Gebory F, Henry G, Bastani B. The effects of parathyroidectomy on nutritional and biochemical status of hemodialysis patients with severe secondary hyperparathyroidism. *J Renal Nut* 1999;9(4):186-91.
- Ritz E, Stefanski A, Rombasek M. The role of the parathyroid glands in the uremic syndrome. *Am J Kidney Dis* 1995;26(5):808-13.
- Agudelo MA. Factores que inciden en el estado nutricional en los pacientes en tratamiento de hemodiálisis. *Lecturas Sobre Nutrición* 1999;6(2):55-7.
- Johansen LK, Kaysen GA, Young BS, Hung AM, Silva M, Chertow GM. Longitudinal study of nutritional status, body composition, on physical function in hemodialysis patients. *Am J Clin Nutr* 2003;77:842-6.
- Denda M, Finch J, Slatopolsky E. Phosphorus accelerates the development of parathyroid hyperplasia and secondary hyperparathyroidism in rats with renal failure. *Am J Kidney Diseases* 1996;28(4):596-602.
- Slatopolsky E, Finch J, Denda M, Ritter C, Zhong M, Dusso A, MacDonald PN, Brown J. Phosphorus restriction prevents parathyroid gland growth. High phosphorus directly stimulates PTH secretion in vitro. *J Clin Invest* 1996;97(11):2534-40.
- Cupisti A, D'Alessandro C, Baldi R, Barsotti G. Dietary habits and counseling focused on phosphate intake in hemodialysis patients with hyperphosphatemia *J Ren Nutr* 2004;14(4):220-5.
- Elder G. Pathophysiology and recent advances in the management of renal osteodystrophy. *J Bone Miner Res* 2002;17(12):2094-105.
- Ritz E. The clinical management of hyperphosphatemia. *J Nephrol* 2005;18:221-8.
- Ockert S, Willeke F, Richter A, Jonescheit J, Schunuelle P, van der Woude F, Post S. Total parathyroidectomy without autotransplantation as a standard procedure in the treatment of secondary hyperparathyroidism. *Langenbeck's Arch Surg* 2002;387:204-9.
- Fugakawa M, Kitaoka M, Kurokawa K. Ultrasonographic intervention of parathyroid hyperplasia in chronic dialysis patients: a theoretical approach. *Nephrol Dial Transplant* 1996;11:125-9 [suppl3].
- Rezende LTT, Cuppari L, Carvalho AB, Canziani MEF, Manfredi SR, Cendoroglo M, et al. Nutritional status of hemodialysis patients with secondary hyperparathyroidism. *Braz J Med Biol Res* 2000;33 (11):1305-11.
- Peters BSE, Jorgetti V, Martini LA. Influência do hiperparatireoidismo secundário grave no estado nutricional de pacientes com insuficiência renal. *Br J Nutr* 2006;19(1):111-118.
- Keys A, Fidanza F, Kcarvonen MJ. Indices of relative weight and obesity. *J Chronic Dis* 1972;25:329-43.
- Frisancho AR. New norms of upper limb fat and muscle areas for assessment of nutritional status. *Am J Clin Nutr* 1981;34:2540-5.
- Durnin JVGA, Womersley. Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women age from 16 to 72 years. *Br J Nutr* 1974;32:77-97.
- National Kidney Foundation. K/DOQI clinical practice guideline for bone metabolism and disease in chronic kidney disease. *Am J Kidney Dis* 2003;42:1-202 [suppl 3].
- Shoenfeld P, Henry RR, Laird NM, Roxe DM. Assessment of nutritional status of the national cooperative dialysis study population. *Kidney Int.* 1983;23(13):80-8.
- Toigo G, Situlin R, Tamaro G, Del Bianco A, Giuliani V, Vianello S, et al. Effects of intravenous supplementation of a new essential amino acid formulation in hemodialysis patients. *Kidney Int* 1989;36:278-281 [suppl.27].
- Duenhas MR, Draibe SA, Avesani CM, Sesso R, Cuppari L. Influence of renal function on spontaneous dietary intake and on nutritional status of chronic renal insufficiency patients. *Eur J Clin Nutr* 2005;57:1473-8.
- Rufino M, de Bonis E, Martin M, Rebollo S, Martin B, Miquel R, et al. Is it possible to control hyperphosphatemia with diet, without inducing malnutrition? *Nephrol Dial Transplant* 1998;13:65-7 [suppl 3].
- Woodrow G, Oldroyd B, Smith MA, Turney JH. Measurement of body composition in chronic renal failure: comparison of skinfold anthropometry and bioelectrical impedance with dual energy X-ray absorptiometry. *Eur J Clin Nutr* 1996;50:295-301.
- Tanaka M, Itoh K, Matsushita K, Fikagawa M. Efficacy of percutaneous ethanol injection therapy for secondary hyperparathyroidism in patients on hemodialysis as evaluated by parathyroid hormone levels according to K/DOQI guidelines *Ther Apher Dial* 2005;9(1):48-52