Int J Clin Exp Med 2015;8(6):9830-9838
www.ijcem.com /ISSN:1940-5901/IJCEM0005425

Original Article

Impacts of parathyroidectomy on renal anemia and nutritional status of hemodialysis patients with secondary hyperparathyroidism

Chen Chen[1], Hua Wu[1], Lin Zhong[1], Xin Wang[1], Zhuang-Jie Xing[2], Bi-Hu Gao[1]

[1]*Department of Nephrology, The Affiliated Zhongshan Hospital of Dalian University, Dalian 116000, China;*
[2]*Department of Vascular Surger, The Affiliated Zhongshan Hospital of Dalian University, Dalian 116000, China*

Received January 1, 2015; Accepted February 28, 2015; Epub June 15, 2015; Published June 30, 2015

Abstract: The aim of this study was to investigate the impacts of parathyroidectomy (PTX) towards the renal anemia and nutritional status of hemodialysis patients with secondary hyperparathyroidism (SHPT). 32 patients, enrolled into the blood purification center of our hospital for the hemodialysis treatment, were collected and divided into the PTX group and the non-PTX group, with 16 patients in each group. The changes of relevant indicators such as immunoreactive parathyroid hormone (iPTH), anemia and nutrition were observed before, 1-, 3-, 6-month after the treatment. The contents of iPTH, Ca, P and Ca × P of the PTX group decreased rapidly 1 month after the surgery; while Hb and Hct increased significantly from the 1st postoperative month; the dosage of EPO was significantly reduced 3-month after the surgery; the content of Alb gradually increased from the 3rd postoperative month; the content of TG decreased significantly from the 6th postoperative month; while the contents of BMI and TSF increased significantly from the 6th postoperative month, which exhibited the statistically significant differences when compared with the preoperative and the non-PTX group ($P < 0.05$). PTX could quickly reduce the iPTH level and significantly improve the renal anemia and nutritional status; SHPT was the important factor that would affect the renal anemia and malnutrition; PTX could reduce the amount of EPO, and reduce the economic burden of patients.

Keywords: Parathyroidectomy, secondary hyperparathyroidism, renal anemia, nutrition

Introduction

The secondary hyperparathyroidism (SHPT) and renal anemia were the most common complications that would affect the life quality of chronic kidney disease (CKD) patients [1]. The incidence of anemia in Chinese adult CKD patients was 40%-60%, and about 98.91% patients that were ready for the dialysis had the anemia. Since the early 1990s, the application of recombinant human erythropoietin (EPO) was begun, and though the treatment rate in the dialysis patients was up to 97.42%, the standard-reaching rate was still low. The new version KDIGO guideline [2] pointed out that as for the adult chronic renal failure-induced dialysis patients, the EPO treatment should begin when Hb was within 90-100 g/l, while it was not recommended that the adult CKD patients used EPO for the maintenance when Hb was over 115 g/l. therefore, the anemia was still the problem that bothered the hemodialysis patients. After the EPO treatment, some patients did not obtain the improved symptoms of anemia, and there were about 5-10% patients existing the significant resistance towards the EPO treatment [3].

In addition, about 40% CKD patients might occur the malnutrition after the maintenance hemodialysis treatment. Some studies showed [4] that the clinical indicators of malnutrition, such as low body mass index (BMI) and low serum albumin (Alb) content, were associated with the high morbidity and mortality of hemodialysis patients. The reason that led to the malnutrition of dialysis patients was the direct effect of iPTH towards the protein metabolism, or other indirect causes such as lack of appetite, neuropsychiatric disorders, myopathy or bone disease was still unclear. The experimental work on the muscle tissues showed [5] that,

PTH could increase the protein catabolism; and there was also some other observation [6] that SHPT had no interference towards the patients' nutritional status.

The current clinical treatment strategies towards the SHPT of end-stage renal disease (ESRD) included: 1. limited the phosphorus intake; 2. applied the phosphate binder therapy; 3, performed the dialysis at least three times a week; 4, when the conventional medical treatment towards SHPT failed, it would usually require the performance of PTX. The previous studies had shown that, Coen et al [7] found that if the ESRD patients could obtain the improvements of anemia and nutritional status after PTX, their quality of life could be significantly improved. Therefore, the aim of this study was to observe the changes of iPTH, anemia, nutrition and other related factors in the uremic hemodialysis patients with SHPT after the PTX treatment, and explore the impacts of PTX towards anemia and nutritional status in the SHPT hemodialysis patients.

Materials and methods

Subjects

32 patients, treated with hemodialysis in the blood purification center of Zhongshan affiliated Hospital, Dalian University, from May 2012 to May 2013 were collected, among who 16 cases were performed the parathyroidectomy and divided into the PTX group, while the other 16 patients were not performed the parathyroidectomy, thus divided into the non-PTX group.

The PTX group had 9 males and 7 females. The mean age was (48.81±14.57) years old, with the mean duration of dialysis as (103.25±53.67) months. The primary diseases' situations: 6 cases were chronic glomerulonephritis, 5 cases were hypertensive renal damage, 3 cases were polycystic kidney disease, 1 case was diabetic nephropathy and 1 case was nephrotic syndrome. the non-PTX group had 8 males and 8 females. The mean age was (50.62±11.28) years old, with the mean duration of dialysis as (111.73±42.54) months. The primary diseases were: 6 cases were chronic glomerulonephritis, 5 cases were hypertensive renal damage, 4 cases were diabetic nephropathy, and 1 case was polycystic kidney disease. The average dialysis times of the two groups were (The hemodialysis patients of the 2 groups were treated with AK95S dialysis instrument (Gambro, Sweden), with the polysulfone membrane dialyzer (area as 1.4 m^2 - 1.6 m^2) and the standard bicarbonate dialysate.) three times per week, and 4 hours each time. The blood flow was 180-240 ml/min, the dialysate flow was 500 ml/min. and the patients in the two groups all exhibited various degrees of pruritus, bone pain, muscle weakness, muscle pain, multi-site metastatic calcification, while the situations in the PTX group were relatively heavy.

Inclusion criteria

1) Aged 35 to 75 years old; 2) the stable dialysis duration was > 6 months; 3) the iPTH levels were > 800 pg/ml, except for the primary and other secondary hyperparathyroidism, the patients were all performed the regular impact therapy of phosphorus-reduction and active vitamin D3, and the PTX group exhibited no effect towards the medication or had the contraindication, thus the patients were treated with the PTX treatment; 4) All patients were performed the regular EPO, iron and folic acid treatment for more than 3-6 months, the levels of Hb and Hct were stable; 5) the dialysis was adequate, with the urea clearance (Kt/V) ≥ 1.2.

Exclusion criteria

The patients exhibited no history of bleeding or blood transfusion, history of malignancy, serious infections, iron strengthening, lack of folic acid and vitamin B12, severe heart failure or active systemic disease 3 months prior to the observation and during the follow-up.

Surgical indications [8]

1) iPTH lasted greater than 800 pg/mL (the normal value 16-62 pg/mL); 2) imaging examination: at least one parathyroid gland dilated (d > 1.0 cm^3) and had the rich blood; 3) existed the following conditions simultaneously: hypercalcemia, uncontrollable hyperphosphatemia, histologic progressive bone disease, the efficacy of EPO towards the anemia was reduced.

Main observation indicators

The levels of P iPTH, Ca, P, Ca × P, Hb, Hct, Alb, TC, TG, SI, SF and CRP, etc. of the PTX group and the non-PTX group were detected before

the treatment, as well as 1, 3 and 6 months after the treatment, all the indicators were detected by the Monitoring and Inspection Center of our hospital. (the detection of the following elements used the corresponding methods: Ca: the Arsenazo method; P: phosphomolybdate method; Alb: bromocresol green method; TC: enzyme method; TG: phosphoric acid oxidase method, which were all detected by SIEMENS ADVIA2400 analyzer (Japan); SI: ferrous triazine colorimetry; SF and CRP: scattering turbidimetric method, and detected by SIEMENS BN II analyzer (Japan); All reagents were provided by SIEMENS medical diagnosis Co. Ltd (Japan); Hb and Hct: cell counting method, measured by Sysmex XE-2100 automated hematology analyzer (Japan), with the reagents provided by Shandong Lanqiao Medical Co., Ltd. (China); iPTH: electrochemiluminescence method, and detected by JYPYi2000 automatic analyzer (USA), with the reagents provided by the Abbott Trade Co. Ltd (USA). The dialysis adequacy (Kt/V, URR%) was calculated, meanwhile, the EPO amount of the same period was recorded, and the anthropometric indicators were measured: TSF, MAC, height, weight, MAMC and BMI were calculated.

Assessment of dialysis adequacy

Based on the formula of Daugirdas urea single room model Kt/V = -ln (R-0.008t) + (4-3.5R) × (UF/W), in which ln was the natural logarithm, t was the dialysis Time (h); R was the concentration ratio of urea nitrogen (BUN) after and before the dialysis; UF was the ultrafiltration volume (L); W was the post-dialysis weight (kg). Urea reduction rate (URR) = (1-R) × 100%.

Measurement of anthropometric indicators

Used a soft tape to measure the perimeter from the right arm shoulder peak to the center of ulnar olecranon process (MAC); 2 cm above this center, the skin and fat were separated, then used the vernier caliper to measure 3 times for the average (TSF), MAMC (cm) = MAC (cm) -3.14 × TSF (cm). BMI = post-dialysis dry weight (kg) / height 2 (m^2).

Treatment of anemia

According to the latest KDIGO guidelines [9], the EPO dosage: 1) initial subcutaneous dosage: 100-120 IU/(Kg • w), 2-3 times a week; intravenous dosage 120-150 IU/(Kg • w), three times a week. As for the patients with such basic diseases as high blood pressure, severe cardiovascular disease and diabetes, EPO should be applied from the dose as small as possible. 2) during the EPO treatment period, the Hb level should be detected once every 1-2 months; then the EPO dosage was adjusted according to the patient's Hb growth rate; the initial treatment Hb growth rate should be controlled within 10-20 g/l per month, while with the steady improvement, and reached the Hb target value in the 4^{th} month; if the monthly Hb concentration changes were ≥ 10 g/l during the maintenance treatment period, the EPO dose should be increased or decreased by 25% appropriately towards the original basis, and the medication frequency was once-twice a week.

During the EPO treatment, the enough iron should be supplemented to maintain the iron status. As for the dialysis patients: serum ferritin (SF) > 200 ug/l and the transferrin saturation (TSAT) > 20%. If the patient's SF was < 100 ug/l, 100-125 mg iron should be intravenously administrated weekly, for continuous 8-10 weeks; if SF ≥ 00 ug/l, 25-125 mg iron should be intravenously administrated once per week; if SF > 500 ug/l, the intravenous iron would not be recommended the routine use. Meanwhile, 10mg folic acid should also be orally administrated, 3 times/d.

Nutrition guidance

The patients' water and sodium intake should be controlled, the high-quality protein diet was chosen and supplemented the essential amino acids, carbohydrates, vitamins and fats, limited the diet with high potassium and phosphorus, controlled the blood glucose, and supplemented the calcium and so on. According to the latest KDIGO guidelines [9], it was suggested that the adults diabetes or non-diabetes, and GFR < 30 ml/min/1.73 m^2, should reduce the protein intake to 0.8 g/kg/d, together with the suitable announcement.

Surgical treatment

There were three main kinds of surgical procedures: subtotal parathyroidectomy (sPTX); parathyroidectomy + autologous transplantation (PTX + AT); total parathyroidectomy (TPTX).

Table 1. Changes of serum iPTH, Ca, P, Ca × P of the two groups before and after the surgery

	Group	Before	1-month after	3-month after	6-month after
iPTH (pg/ml)	PTX	2273.97±273.96	390.96±693.72[2,4)]	464.17±752.05[2,4)]	380.19±683.77[2,4)]
	Non-PTX	1335.94±556.92[2)]	1335.27±532.19	1292.90±543.64	1330.62±520.19
Ca (mmol/l)	PTX	2.49±0.25	1.88±0.32[2,4)]	1.90±0.28[2,3,4)]	1.95±0.25[2,4)]
	Non-PTX	2.13±0.42[2)]	2.23±0.32	2.34±0.43	2.32±0.27
P (mmol/l)	PTX	2.55±0.73	1.30±0.48[2,3)]	1.42±0.51[2,3)]	1.41±0.57[2,3)]
	Non-PTX	2.05±0.54[1)]	1.93±0.63	1.87±0.61	2.18±0.43
Ca × P	PTX	6.37±1.98	2.45±1.01[2,4)]	2.48±0.99[2,4)]	2.65±1.21[2,4)]
	Non-PTX	4.51±2.09[1)]	4.42±2.02	4.39±1.69	5.11±1.36

[1)]$P < 0.05$; [2)]$P < 0.01$ vs before the surgery; [3)]$P < 0.05$; [4)]$P < 0.01$ vs the non-PTX group.

After the surgery, 10% calcium gluconate was continuously intravenous infused and the serum calcium should be strictly monitored, meanwhile, 2.0 mmol/L high-calcium dialysate was sued for the dialysis, then according to serum calcium levels, the amount of calcium should be gradually reduced, which was maintained by the oral administration of calcium carbonate or calcium acetate and active vitamin D3.

Statistical processing

All data were processed with spss19.0 statistical software. The measurement data were expressed as mean ± standard deviation (x±s), the intergroup data were compared with independent sample t test, the intragroup pair comparison used the t-test, with $P < 0.05$ considered as the statistically significant difference.

Results

Improvements of clinical symptoms and signs

The patients of the PTX group exhibited the postoperative conscious skin-itching and bone pain symptoms, while the diet, sleep and blood pressure were significantly improved. 2 patients exhibited the dramatic improvement on the postoperative 2nd day, and be able to move on their own.

Changes of serum iPTH, Ca, P, Ca × P

The serum iPTH, Ca, P and Ca × P levels of the 2 groups were high in the early stage of follow up, and those of the PTX group were higher than the non-PTX group, with the statistically significant difference (**Table 1**, $P < 0.05$). from the postoperative 1st month, the levels of serum iPTH, Ca, P and Ca × P of the PTX group were significantly decreased, and maintained at the relatively stable levels in the postoperative 1st, 3rd and 6th month, which were significantly lower than the preoperative, and the differences were significant statistically significant (**Table 1**, $P < 0.01$), when compared with the non-PTX group, the differences were statistically significant (**Table 1**, $P < 0.05$). While the levels of serum iPTH, Ca, P and Ca × P of the non-PTX group had no significant changes before and after the treatment, remaining at the high levels, and the differences were not statistically significant (**Table 1**, $P > 0.05$).

Comparisons of anemia indicators and EPO dosage

The situation of anemia of two groups were severe in the early follow-up, and the EPO usage was relatively large. While from the postoperative 1st month, the Hb and Hct levels of the PTX group were gradually increased, both with the statistical significance (**Table 2**, $P < 0.01$) when compared with those of the preoperative, and those of the postoperative 6th month exhibited the statistical difference than the non-PTX group (**Table 2**, $P < 0.05$). the amount of EPO usage gradually reduced after the surgery, and exhibited the statistical difference on the postoperative 3rd month than those of the preoperative (**Table 2**, $P < 0.05$), and those of the postoperative 6th month were statistically significant with the preoperative and the non-PTX group (**Table 2**, $P < 0.01$). While the levels of Hb and Hct, as well as the amount of EPO usage of the non-PTX group had no significant difference before and after the treatment (**Table 2**, $P > 0.05$).

Table 2. Comparisons of anemia indicators and EPO dosage of the 2 groups before and after the treatment

	Group	Before	1-month after	3-month after	6-month after
Hb (g/l)	PTX	88.43±9.16	96.06±12.26[2)]	100.81±14.65[2)]	114.18±14.06[2,3)]
	Non-PTX	96.75±15.47	98.37±20.59	97.00±19.54	94.93±13.33
Hct (%)	PTX	27.07±2.91	30.48±3.76[2)]	32.06±5.12[2)]	35.54±4.08[2,3)]
	Non-PTX	29.91±4.75	30.37±6.44	29.49±5.75	28.69±3.95
EPO dosage (U/kg.W)	PTX	160.81±13.53	159.09±16.99	150.85±24.30[1)]	124.96±26.41[2,3)]
	Non-PTX	165.65±15.90	161.76±23.65	163.32±27.34	168.41±26.80

[1)]$P < 0.05$; [2)]$P < 0.01$ vs before the surgery; [3)]$P < 0.05$; [4)]$P < 0.01$ vs the non-PTX group.

Table 3. Changes of nutrition indicators, lipid metabolism and anthropometric indicators of the 2 groups before and after the treatment

	Group	Before	1-month after	3-month after	6-month after
Alb (g/l)	PTX	40.32±4.03	40.00±4.06	41.13±3.52[1)]	43.50±2.79[2,3)]
	Non-PTX	40.08±4.62	40.78±4.67	40.41±5.42	40.09±5.20
TC (mmol/l)	PTX	4.43±0.90	4.31±1.06	4.36±1.08	4.41±0.95
	Non-PTX	4.79±1.38	4.59±1.09	4.22±0.78	4.46±1.22
TG (mmol/l)	PTX	2.20±1.06	2.18±1.08	2.09±0.89	1.89±0.78[2)]
	Non-PTX	2.42±1.42	2.34±1.21	2.34±1.31	2.42±1.37
BMI (kg/m^2)	PTX	21.63±2.69	21.62±2.69	21.63±2.68	21.67±2.67[2)]
	Non-PTX	21.85±3.60	21.86±3.61	21.85±3.61	21.84±3.60
TSF (mm)	PTX	12.56±3.45	12.56±3.45	12.59±3.47	12.62±3.47[2)]
	Non-PTX	12.98±3.53	12.99±3.54	12.98±3.54	12.97±3.54
MAMC (cm)	PTX	17.36±1.21	17.36±1.21	17.35±1.20	17.36±1.21
	Non-PTX	17.55±1.12	17.54±1.12	17.55±1.12	17.56±1.12

[1)]$P < 0.05$; [2)]$P < 0.01$ vs the preoperative; [3)]$P < 0.05$ vs non-PTX group.

Changes of nutrition indicators, lipid metabolism and anthropometric indicators

The nutrition and fat metabolism of the two groups were poor in the early follow-up, but there was no statistically significant difference between the groups (**Table 3**, P > 0.05). the indicators of the PTX group gradually increased from the postoperative 3rd month, and exhibited the statistical significance than the preoperative (**Table 3**, P < 0.05); the Alb level increased significantly since the postoperative 6th month, and exhibited the statistical significance than the preoperative (P < 0.01), and the nutritional status of the PTX group was relatively improved than the non-PTX group, with the statistically significant difference (**Table 3**, P < 0.05).

The indicators of the PTX group were significantly decreased since the postoperative 6th month, and the differences were statistically significant than the preoperative (**Table 3**, P < 0.05).

The anthropometric indexes of the two groups were close in the early follow up, and there was not statistically significant difference between the two groups (**Table 3**, P > 0.05). The BMI and TSF levels were significantly increased since the postoperative 6th month, and exhibited the statistically significant difference than the preoperative (**Table 3**, P < 0.01). While the Alb, TC, BMI and TSF levels of the non-PTX group exhibited no statistically significant changes before and after the treatment (**Table 3**, P > 0.05).

Changes of anemia and nutritional indicators

The dialysis adequacy (Kt / V, URR%), iron metabolism (SI, SF) and inflammation (CRP), etc., had no statistically significant changes between the two groups (**Table 4**, P > 0.05).

Discussion

The hemodialysis patients with chronic kidney diseases existed a series of complications, and the most common ones were the renal anemia

Table 4. Changes of anemia and nutritional indicators of the two groups

	Group	Before	1-month after	3-month after	6-month after
SI (umol/l)	PTX	12.15±3.87	12.04±4.00	11.88±3.61	12.18±3.33
	Non-PTX	14.39±5.91	14.53±5.85	14.55±5.90	14.23±5.50
SF (ng/ml)	PTX	241.83±94.92	250.08±92.59	241.76±83.38	241.62±78.85
	Non-PTX	230.16±81.78	221.87±83.57	236.30±90.56	242.14±81.86
CRP (mg/l)	PTX	3.07±1.65	3.05±2.00	3.02±1.74	3.49±2.20
	Non-PTX	3.47±1.54	3.52±1.52	3.45±1.97	3.47±1.44
KT/V	PTX	1.35±0.07	1.36±0.09	1.37±0.11	1.39±0.08
	Non-PTX	1.39±0.12	1.37±0.13	1.35±0.09	1.37±0.09
URR	PTX	0.67±0.01	0.67±0.02	0.67±0.03	0.68±0.02
	Non-PTX	0.68±0.03	0.67±0.02	0.66±0.05	0.68±0.02

and SHPT, and they were also the problems that led to the significantly decreased life quality of hemodialysis patients. The animal and in vitro studies had shown that, SHPT interfered the generation and survival of red blood cells, and iPTH might be a potential factor.

The studies had shown that [5, 10], iPTH was closely associated with the Hb level. This study showed that the high levels of iPTH of the PTX group and the non-PTX group could aggravate the situations of renal anemia, while the symptoms of anemia were gradually improved after PTX, the Hb and Hct levels were increased gradually since the postoperative 1st month, and the average Hb level on the postoperative 6th month reached 114.18 g/l, making the Hb and Hct levels of these patients recover to the guideline-required levels, and fluctuate within the controllable ranges; correspondingly, the EPO dosage could be gradually reduced, which greatly reduced the financial burden of patients. the possible mechanism of action was analyzed: high iPTH inhibited the Na +-K +-ATP activity, interfered the energy metabolism, thus resulting in the significantly shortened lifespan of red blood cells [11]; higher iPTH enhanced the osteoclast activity, induced the bone marrow fibrosis, causing the severe fibrocystic osteitis, and undermining the bone marrow microenvironments [12]; higher iPTH suppressed the calcitriol receptor activity on the red cell surface, resulting in the deficiency of active vitamin D, leading to the reduced releasing of endogenous erythropoietin, reducing the sensitivity of peripheral tissue towards EPO, thus resulting in the EPO resistance [13] and erythropoiesis inhibition. But this was not consistent with Trunzo et al [14] study that observed the statistical significance of Hb and Hct only appeared on the postoperative 12th month than the preoperative, (which was no consistent with Trunzo et al [14], who reported that the results of Hb and Hct on the postoperative 12th month were significantly different from those before the surgery) and the reasons [15] might be: in this study, some patients of the PTX group and the non-PTX group had the diabetic nephropathy, which was much more commonly associated with the insulin resistance, after PTX, the insulin resistance might be reduced, thereby the renal anemia could be corrected; in this study, 16 patients of the PTX group were performed the different surgical procedures, and most patients were performed PTX, so that the postoperative resulting renal anemia correction exhibited the significant effects, this inference still required the further exploration. In this study, the iPTH levels of the non-PTX group remained at a high level consistently, and the drug treatment was difficult to correct that, the occurrence of renal anemia progressively increased, and the EPO demand was also correspondingly increased. Therefore, the present study confirmed the high iPTH might inhibit the process of erythropoiesis. The uremic hemodialysis patients with SHPT restored the hematocrit after PTX, which might because the elevated serum EPO concentration restored the bone marrow space.

Currently, there was still lack of specific study towards the impacts of iPTH on the nutritional status of hemodialysis patients domestically and internationally. The albumin was an important indicator of nutrition within the dialysis patients, and the level changes of Alb within the dialysis patients' bodies could reflect the

body's nutritional status in most cases. However, it was still controversial about the impacts of iPTH level on Alb, because a reported showed that [16] the iPTH and Alb levels in the dialysis patients were correlated, while another study [17] showed that after the injection of PTH into the muscle of normal rats, there was no relevance found in the levels of iPTH and Alb.

The results of this study showed that there existed various degrees of malnutrition of the 2 groups before the surgery, and it was considered to because of the uremic toxin accumulation-caused digestive gland atrophy within the patients, the secretion of digestive enzymes decreased, protein and calorie intake were lack, and the appearance of a variety of metabolic processes in vivo, SHPT and other disorders thus resulted in the digestive dysfunction and anorexia. The studies had shown that [18, 19] the severe hypoalbuminemia was related to the impaired erythropoiesis, the bone marrow mesenchymal stem cells tended to differentiate to the fat cells, which would directly result in the dysplasia of bone marrow microenvironment, as well as the negative effects towards the hematopoietic stem cells. After PTX, the protein synthesis was increased, the nutritional status was improved, and the anemia was also gradually corrected. In this study, the PTX group exhibited the gradually improved nutritional status since the postoperative 3rd month, which was especially significant in the postoperative 6th month. the possible mechanism of action might be: high iPTH could increase the breakdown rate of muscle proteins, increased the production and release of alanine, glutamic acid and urea nitrogen [6], which was basically consistent with Yasunaga et al [20]. While the Alb level of the non-PTX group exhibited no significant change before and after the treatment. Thus, it could be seen that after PTX, the uremic hemodialysis patients with SHPT exhibited the reduced proteolysis and increased protein synthesis, thus the nutritional status could be improved. But the Alb level generally decreased mildly in the postoperative 1st month, and he possible cause could be considered as the intraoperative loss of nutrients.

Another common complication of uremic hemodialysis patients with SHPT was lipid metabolism disorder. This study observed that the hypertriglyceridemia was also involved into the malnutrition, the results showed that the PTX group exhibited the significant TG decreasing since the postoperative 6th month, although not reached the normal range, it exhibited a significant statistical significance than the preoperative ($P < 0.01$), consistent with the domestic report [21]. (similar with Farahnak et al [21]). While the TG levels of the non-PTX group maintained at a high level continuously, suggesting that PTX could improve the lipid metabolism in the dialysis patients, and the possible mechanism [22] might be: accompanied with the decreasing of iPTH, the Ca^{2+} concentration inside the liver cells decreased, resulting in synthesis of triglycerides enzymes and lipid protease, thus improving the lipid metabolism and nutritional status.

The anthropometric indicator BMI was an indicator that was internationally used to measure the body fat and health degrees, TSF was a reflector of body fat reservation amount, MAMC could reflect the amount of skeletal muscles, thus reflected the overall nutritional status of human body. Through the in vivo experiment, Smoqorzewski et al [23] found that after resected the parathyroid of renal failure rat, the oxidation of iPTH-inhibiting long-chain fatty acids could be corrected. One [24] study showed that iPTH was negatively correlated with BMI, TSF and MAMC, and the mechanism [25] might be that iPTH could impact the muscle energy synthesis by increasing the muscle proteolysis; inhibit the oxidation of fatty acids (vital energy of skeletal muscle), thus inducing the skeletal muscle metabolism disorder and causing the reduction of skeletal muscles.

The results of this study showed that after the PTX surgery, the appetite and general conditions of the PTX group were improved, the dry weight was also increased, BMI and TSF were increased significantly 6 months after the surgery, while the BMI and TSF levels of the non-PTX group showed the slight decreasing. Thus, it could be presumed that the clearance of excessive iPTH could increase the muscle protein synthesis, thus helped to improve the nutritional status.

In order to exclude the interference of iron deficiency, infection, inflammation and insufficient dialysis towards the results, the patients of the two groups were actively corrected the iron

deficiency and infection, and paid more attention towards the dialysis adequacy before and after the treatment. And it could be seen from the results of this study that there was no significant change in the iron metabolism, inflammation and dialysis adequacy between the two groups before and after the treatment, maintaining at a relatively stable state, and the difference was not statistically significant.

The results of this study suggested that towards the SHPT maintaining-hemodialysis patients, who exhibited no effects after the drug therapy, the early surgery would a good way to solve this problem, which could quickly reduce the iPTH level, significantly improve renal anemia and nutritional status, thus the corresponding dosages of active vitamin D and EPO could be significantly reduced, saving the expense of patients, reducing their financial burdens, and it also further suggested that SHPT was the important factor that would affect the renal anemia and malnutrition.

This experiment was a clinical observational study, aiming to perform a preliminary study towards the impacts of PTX towards the renal anemia and nutritional status of SHPT maintaining-hemodialysis patients, the follow-up work would increase the sample size, extende te follow-up period, and further explore the mutual relationships and mechanisms.

Conclusions

1. PTX treatment could rapidly reduce the iPTH levels and significantly improved renal anemia and nutritional status.

2. SHPT was an important factor that affected the renal anemia and malnutrition.

3. PTX could reduce the EPO dosage, and reduce the patients' financial burden.

Disclosure of conflict of interest

None.

Address correspondence to: Bi-Hu Gao, Department of Nephrology, The Affiliated Zhongshan Hospital of Dalian University, No. 6 Jiefang Street, Dalian 116000, China. Tel: +86 13840880309; Fax: +86 0411 628953555; E-mail: bihugao@163.com

References

[1] Cană-Ruiu D, Moța E, Istrate N, Văduva C and Trican E. Renal anemia-risk factor for chronic kidney disease. Curr Health Sci J 2013; 39: 214-217.

[2] Bennett L. Patient independence in chronic kidney disease and anaemia: implications of the 2012 KDIGO guideline. J Ren Care 2013; 39: 108-117.

[3] Morais C, Johnson DW, Vesey DA and Gobe GC. Functional significance of erythropoietin in renal cell carcinoma. BMC Cancer 2013; 13: 14.

[4] Chutia H, Ruram AA, Bhattacharyya H, Boruah P and Nath C. Association of secondary hyperparathyroidism with hemoglobin level in patients with chronic kidney disease. J Lab Physicians 2013; 5: 51-54.

[5] Campos SR, Gusmão MH, Almeida AF, Pereira LJ, Sampaio LR and Medeiros JM. Nutritional status and food intake of continuous peritoneal dialysis patients with and without secondary hyperparathyroidism. J Bras Nefrol 2012; 34: 170-177.

[6] Rezende LT, Cuppari L, Carvalho AB, Canziani ME, Manfredi SR, Cendoroglo M, Sigulem DM and Draibe SA. Nutritional status of hemodialysis patients with secondary hyperparathyroidism. Braz J Med Biol Res 2000; 33: 1305-1311.

[7] Coen G, Calabria S, Bellinghieri G, Pecchini F, Conte F, Chiappini MG, Ferrannini M, Lagona C, Mallamace A, Manni M, DiLuca M, Sardella D and Taggi F. Parathyroidectomy in Chronic Renal Failure: Short and Long-Term Results in Parathyroid Function, Blood pressure, and Anemia. Nephron 2001; 88: 149-155.

[8] Goldenstein PT, Elias RM, Pires de Freitas do Carmo L, Coelho FO, Magalhães LP, Antunes GL, Custódio MR, Montenegro FL, Titan SM, Jorgetti V and Moysés RM. Parathyroidectomy improves survival in patients with severe hyperparathyroidism: a comparative study. PLoS One 2013; 8: e68870.

[9] Gianella P, Martin PY and Stucker F. Management of renal anemia in 2013. Rev Med Suisse 2013; 9: 462-464, 466-467.

[10] Sliem H, Tawfik G, Moustafa F and Zaki H. Relationship of associated secondary hyperparathyroidism to serum fibroblast growth factor-23 in end stage renal disease: A case-control study. Indian J Endocrinol Metab 2011; 15: 105-109.

[11] Romero JR, Youte R, Brown EM, Pollak MR, Goltzman D, Karaplis A, Pong LC, Chien L, Chattopadhyay N and Rivera A. Parathyroid hormone ablation alters erythrocyte parameters that are rescued by calcium-sensing re-

ceptor gene deletion. Eur J Haematol 2013; 91: 37-45.
[12] Khoury N, Chang J, Gru AA and Whyte MP. Resorptive hypercalcemia in post-essential thrombocythemia myelofibrosis: treatment with denosumab. J Clin Endocrinol Metab 2012; 97: 3051-3055.
[13] Battistella M, Richardson RM, Bargman JM and Chan CT. Improved parathyroid hormone control by cinacalcet is associated with reduction in darbepoetin requirement in patients with end-stage renal disease. Clin Nephrol 2011; 76: 99-103.
[14] Trunzo JA, McHenry CR, Schulak JA and Wilhelm SM. Effect of parathyroidectomy on anemia and erythropoietin dosing in end-stage renal disease patients with hyperparathyroidism. Surgery 2008; 144: 915-918.
[15] Bastürk T and Unsal A. Is insulin resistance a risk factor for the progression of chronic kidney disease? Kidney Blood Press Res 2011; 34: 111-115.
[16] Kaynar K, Songul Tat T, Ulusoy S, Cansiz M, Ozkan G, Gul S and Bektas O. Evaluation of nutritional parameters of hemodialysis patients. Hippokratia 2012; 16: 236-240.
[17] Patidar A, Singh DK, Winocour P, Farrington K and Baydoun AR. Human uraemic serum displays calcific potential in vitro that increases with advancing chronic kidney disease. Clin Sci (Lond) 2011; 125: 237-245.
[18] Cunha MC, Lima Fda S, Vinolo MA, Hastreiter A, Curi R, Borelli P and Fock RA. Protein malnutrition induces bone marrow mesenchymal stem cells commitment to adipogenic differentiation leading to hematopoietic failure. PLoS One 2013; 8: e58872.
[19] Gaweda AE, Goldsmith LJ, Brier ME and Aronoff GR. Iron, inflammation, dialysis adequacy, nutritional status, and hyperparathyroidism modify erythropoietic response. Clin J Am Soc Nephrol 2010; 5: 576-581.
[20] Yasunaga C, Nakamoto M, Matsuo K, Nishihara G, Yoshida T and Goya T. Effects of a parathyroidectomy on the immune system and nutritional condition in chronic dialysis patients with secondary hyperparathyroidism. Am J Surg 1999; 178: 332-336.
[21] Farahnak P, Lärfars G, Sten-Linder M and Nilsson IL. Mild primary hyperparathyroidism: vitamin D deficiency and cardiovascular risk markers. J Clin Endocrinol Metab 2011; 96: 2112-2118.
[22] Rhee CM, Brent GA, Kovesdy CP, Soldin OP, Nguyen D, Budoff MJ, Brunelli SM and Kalantar-Zadeh K. Thyroid functional disease: an under-recognized cardiovascular risk factor in kidney disease patients. Nephrol Dial Transplant 2014.
[23] Smogorzewski M, Piskorska G, Borum PR and Massry SG. Chronic renal fai lure Darathvtroidhomone and fattv acids oxida-tion inskeletal muscle. Kidney Int 1988; 33: 555-560.
[24] Sun ZH, An HX and Yang X. The relationship between serum level of PTH and nutritional status of maintenance hemodialysis patients with chronic renal failure. Journal of Harbin Medical Universit 2008; 42: 484-487.
[25] Pintos PM, Lezón CE, Bozzini C, Friedman SM and Boyer PM. Operational mechanism modification of bone mechanostat in an animal model of nutritional stress: effect of propranolol. Rev Invest Clin 2013; 65: 39-51.