Influencing factors and predictors of short-term normal parathyroid function after thyroidectomy: a case control study

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Research article

Keywords: Hypoparathyroidism, Hypocalcemia, Thyroidectomy

Posted Date: August 28th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-60114/v1>

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Version of Record: A version of this preprint was published at BMC Surgery on April 21st, 2021. See the published version at <https://doi.org/10.1186/s12893-021-01173-8>.

Abstract

Background

Postoperative hypoparathyroidism is the main reason for outpatient follow-up and long-term oral calcium and calcitriol treatment. Our study investigated the influencing factors and powerful predictors of postoperative normal parathyroid function.

Methods

Logistic regression was used to compare the clinicopathological characteristics, surgical details, and serum calcium, magnesium, and phosphorus concentrations of patients. A receiver operating characteristic (ROC) curve was used to analyze the predictors of normal parathyroid hormone (PTH).

Results

Among the 111 patients with $PTH < 10$ pg/mL on the first postoperative day, most patients experienced a return to normal PTH ($PTH > 15$ pg/mL) within 30 days postoperatively. Univariate analysis showed that Pod (postoperative day) 1PTH, Pod3 PTH, Pod7 Ca, Pod7 Mg, and Pod7 P ($P < 0.05$) were associated with normal parathyroid function on the seventh postoperative day. Multivariate logistic regression analysis revealed the following independent risk factors for normal PTH levels at Pod7 after thyroidectomy: Pod3 PTH ($P = 0.038$), Pod1 PTH ($P = 0.056$), Pod7 Mg ($P = 0.001$), Pod7 P ($P = 0.020$), and the number of parathyroid glands in situ intraoperatively. The combined sensitivity of serum magnesium concentration and phosphorus concentration to predict normal parathyroid function on the seventh postoperative day was 82.76%, with a sensitivity of 76.83%.

Conclusion

Serum magnesium concentration, phosphorus concentration and PTH concentrations are important influencing factors and effective predictors of short-term postoperative normal parathyroid function. The surgeon should treat each parathyroid gland as the only one during the operation.

Background:

Thyroid cancer is one of the most prevalent endocrine tumors, and hypoparathyroidism is one of the most common complications after total thyroidectomy[1-3]. Accidental resection, thermal injury, or devascularization of the parathyroid glands is generally considered to be the common cause of hypoparathyroidism after thyroid surgery[4]. The need for frequent postoperative monitoring of serum ions and parathyroid function concentration, as well as regular adjustment of the dosage of calcium and calcitriol, increase the financial burden of these patients[5]. A PTH concentration of <10 pg/mL on the

first day after thyroid surgery has good sensitivity and specificity for predicting postoperative hypocalcemia. Calcium supplementation and calcitriol can effectively prevent the occurrence of hypocalcemia and promote the recovery of parathyroid function[6-9]. However, these treatments can cause gastrointestinal discomforts such as constipation in the short term and increase the risk of kidney stones, gout, hypercalcemia, hypercalciuria, and hyperphosphatemia[10]. Thus, high-frequency follow-up of patients treated with calcitriol and calcium is necessary. However, there are few studies on the short-term parathyroid function return to normal after surgery in patients with hypoparathyroidism. Moreover, there is currently no consensus regarding the appropriate follow-up frequency and biochemical measures. Therefore, the purpose of this study was to investigate influencing factors and effective ionized predictors of short-term normal parathyroid function after thyroidectomy under the condition of prophylactic calcium supplementation and calcitriol.

Methods:

This was a retrospective study of patients undergoing thyroid surgery from January 2018 to May 2019 at the Department of Thyroid Surgery, Xiangya Hospital, Central South University. This study was approved and agreed upon by the Ethics Committee of Xiangya Hospital of Central South University, and all patients participating in the study provided written informed consent. All operations were performed by the same experienced surgical team. The inclusion criteria were patients with PTH levels <10 pg/mL on the first day after thyroidectomy who could complete follow-up after surgery. The exclusion criteria were patients with a previous history of thyroid or parathyroid surgery, parathyroid disease, MEN I or II, abnormal albumin levels before or after surgery, and chronic or acute renal insufficiency. In total, 111 patients were ultimately included in the study.

1. Patient's clinical data

The demographic information collected from the patients included sex and age. The data collected related to the operation included the scope of the operation, the number of parathyroid glands retained in situ (PGRIS) during the operation, and the postoperative pathological results of the thyroid nodules. Biochemical indicators including preoperative serum calcium, magnesium, phosphorus, and 25-hydroxyvitamin D3 levels and PTH levels, serum calcium, magnesium, and phosphorus levels were measured on days 1, 3, 7, and 30 after surgery

2. Preoperative preparation and parathyroid gland characterization

Examinations included laryngoscopy and ultrasonography of the thyroid and neck lymph nodes before surgery. Thyroid function, PTH, albumin, and serum ions were measured within one week before surgery. The scope of surgery was determined by preoperative diagnosis. All patients defaulted to having 4 parathyroid glands in the normal position of the parathyroid gland. During the operation, the surgeon did not intentionally search for ectopic parathyroid glands and recorded the number of parathyroid glands remaining in situ (PGRIS). Intraoperative parathyroid glands are based on visual recognition, and any suspicious parathyroid tissues were sent to intraoperative frozen section pathological biopsy. The

number of PGRIS during the operation was divided into 5 groups: group 1, no PGRIS; group 2, 1 PGRIS; group 3, 2 PGRIS; group 4, 3 PGRIS; and group 5, 4 PGRIS. The parathyroid glands that were accidentally removed or had obvious color changes during the operation were excised and preserved in 0.9% saline. A thorough examination was performed to inadvertently identify parathyroid glands in the specimen after total thyroidectomy. Parathyroid autoimplantation was performed by cutting the parathyroid glands into 1-mm-sized pieces and placing them into the ipsilateral sternocleidomastoid muscle.

3. Postoperative management and follow-up

The patients prophylactic received intravenous infusion of calcium gluconate (0-2 g/day) from the first postoperative day, as well as oral calcium (1.2-3.6 g/day) and calcitriol (0.25-0.75 µg/day). Once the patient develops symptomatic hypocalcemia, we will increase the dose of continuous calcium supplementation. The dose at which the patient did not develop symptomatic hypocalcemia was considered adequate. All patients were discharged on the third day after surgery. Our hospital informed these patients to follow-up on the seventh day and one month after surgery so that the parathyroid function return to normal and serum ion concentrations could be measured, and the doses of calcium and calcitriol could be adjusted. Thereafter, the same surgical team followed these patients for at least one year at 3-month intervals.

4. Definitions

The symptoms and signs of symptomatic hypocalcemia include numbness or tingling around the mouth and fingers, muscle spasms, or cramps in the limbs. Other signs include the Chvostek sign, Trousseau sign. Normal parathyroid function was defined as PTH > 15 pg/mL without oral calcium or calcitriol replacement therapy, hypoparathyroidism was defined as PTH < 15 pg/mL, and permanent hypoparathyroidism was defined as postoperative PTH < 15 pg/mL lasting for more than 1 year and requiring oral calcium or calcitriol replacement therapy. PTH levels were determined using an electrochemiluminescence immunoassay (normal reference value range is 15-65 pg/mL), with a serum calcium concentration reference value range of 2.0-2.6 mmol/L, serum magnesium concentration reference value range of 0.66-1.07 mmol/L, and serum phosphorus concentration value reference range of 0.86-1.78 mmol/L.

5. Statistical analysis

According to the recovery trend of serum ions and PTH, linear interpolation and the linear trend of neighboring points are used for variables with missing values. These variables included the Pod3 PTH (2.7%), Pod3 Mg (1.8%), Pod3 Ca (1.8%), and Pod3 P (1.8%); Pod7 PTH (1.8%), Pod7 Mg (5.4%), Pod7 Ca (4.5%), and Pod7 P (5.4%); and Pod30 PTH (4.5%). The optimal cut-off values for serum phosphorus concentration, serum calcium concentration, and serum magnesium concentration on the seventh postoperative day and for PTH on the first and third postoperative days were determined by receiver operating characteristic (ROC) curve analysis. This analysis method uses the maximum value of the Youden index as the cut-off value[11]. The area under the ROC curve represents the predictive power of

laboratory parameters. Categorical variables are represented by frequency, and the data of continuous variables conforming to a normal distribution are expressed as the mean $\pm$ standard deviation. If the data do not conform to a normal distribution, then they are expressed by the median and IQR. Continuous variables were compared using the Kruskal-Wallis test to examine the differences between groups, and categorical variables were compared using the chi-square test. If there were theoretical numbers <10 in the categorical variables, then Fisher's exact probability test was used to obtain the p-value. Logistic regression analysis was performed to determine the effects of these factors on normal parathyroid function on the seventh day after thyroid surgery. Statistical analysis was performed using SPSS 25.0, Medcalc 15.8, and Excel 2019. All tests were two-tailed tests, and $P < 0.05$ was considered statistically significant.

Results:

Of the 111 patients with PTH <10 pg/mL on the first day after total thyroidectomy, 92 (82.88%) were female, with an average age of 42 years. Only 3 (2.70%) patients had permanent hypoparathyroidism. Among them, 106 (95.50%) patients had papillary thyroid cancer, 65 (58.56%) patients underwent bilateral total thyroidectomy +CND, and 43 (38.74%) patients underwent LND. On average, each patient had 3.0 parathyroid glands retained; 5 (4.50%) patients did not have any parathyroid glands retained during surgery, and 43 (38.74%) patients had all 4 parathyroid glands retained in situ. The specific study population characteristics are listed in Table. 1

1. The parathyroid function return to normal and the changing trend of serum ions within 1 month after thyroidectomy.

In this study, parathyroid function returned to normal on the third postoperative day in only one patient (0.90%), while it returned to normal on the seventh postoperative day in a total of 29 patients (26.13%) and on the thirtieth postoperative day in a total of 97 patients (87.39%). The recovery of patients with hypoparathyroidism after surgery is shown in Figure 1 (Fig 1). The change trends in serum Ca, Mg, and P concentrations before and after surgery are shown in Figure 2 (Fig 2).

2. The predictive effect of serum Mg concentration and serum P concentration on normal parathyroid function on the seventh postoperative day

The predictive effect of Pod7 Mg and Pod7 P on normal parathyroid function on the seventh postoperative day was determined using ROC curve analysis, and the results are shown in Fig 3. The optimal cut-off values for serum ions on the seventh postoperative day and blood PTH levels on the first and third postoperative days were Pod7 Mg > 0.8 mmol/L, Pod7 P ≤ 1.51 mmol/L, Pod7 Ca > 2.05 mmol/L, Pod1 PTH > 5.18 pg/mL, and Pod7 PTH > 5.6 pg/mL. The combined sensitivity and specificity of serum Mg and P concentrations to predict normal PTH on the seventh day after total thyroidectomy were 82.76% and 76.83%, respectively. This is superior to the diagnostic performance of Pod7 Mg, Pod7 P, Pod1 PTH, or Pod3 PTH alone (Table 2).

3. Influencing factors of normal parathyroid function on the seventh postoperative day

Univariate analysis showed that Pod1 PTH ($P < 0.05$), Pod3 PTH ($P < 0.05$), Pod7 Mg ($P < 0.05$), Pod7 Ca ($P < 0.05$), and Pod7 P ($P < 0.05$) were the influencing factors of normal parathyroid function on the seventh day after surgery (Table 3). However, the scope of surgery was not a factor influencing the return of PTH to normal after surgery. Intraoperative PGRIS (OR 0.025 $P = 0.025$), Pod3 PTH > 5.6 pg/mL (OR 3.745 $P = 0.038$), Pod1 PTH > 5.18 pg/mL (OR 3.439 $P = 0.056$), Pod7 Mg ≥ 0.8 mmol/L (OR 19.221 $P = 0.001$) and Pod7 P ≤ 1.51 mmol/L (OR 4.475 $P = 0.02$) were included in the final multifactor analysis equation, and the results are shown in Table 4.

Discussion:

Hypoparathyroidism is one of the most common complications after total thyroidectomy. Some studies have found that calcium and calcitriol supplementation can aid the recovery of parathyroid function in patients with hypoparathyroidism[7, 12-14]. In agreement with previous findings[13, 15], in the present study, parathyroid function in most patients returned to normal within 1 month (87.39%) after the operation, and intraoperative PGRIS scores was an independent influencing factor for the return of normal PTH after surgery. In addition, we found that serum ion concentrations were predictors of parathyroid function return to normal on the seventh postoperative day. Some scholars believe that intraoperative PGRIS, intraoperative accidental resection, and the number of parathyroid glands that are autotransplanted are not influencing factors for postoperative hypocalcemia[16, 17]. However, the surgical methods in these studies are relatively conservative, and the sample sizes are relatively small and less representative of the population of patients undergoing total thyroidectomy. Surgeons should treat each parathyroid gland as the only parathyroid gland during the operation.

Studies have shown that the scope of surgery is a risk factor for hypoparathyroidism after thyroid surgery[18-20]. The greater the scope of the operation is, the greater the chance of parathyroid gland parenchyma damage, blood vessel damage, and accidental resection. However, during the recovery of parathyroid function, scholars have found that intraoperative PGRIS is a more effective variable than the scope of surgery and found that the surgical scope is not an independent influencing factor for postoperative recovery of parathyroid function[13, 15]. Our research found similar results. Our results indicate that the effect of the scope of surgery on hypoparathyroidism is not statistically significant. There are two potential explanations for this finding. On the one hand, the scope of the operation may have little effect on parathyroid function return to normal after surgery; on the other hand, most of the patients in this study (108 96.34%) underwent bilateral total thyroidectomy + CND, and LND could not be performed independently of CND. Parathyroid function recovery is a dynamic process. Pod1 PTH and Pod3 PTH represent the baseline level of parathyroid function recovery. The higher Pod1 PTH and Pod3 PTH, the easier it is to recover parathyroid function after surgery. Although the p-value of Pod1 PTH > 5.18 pg/mL was greater than 0.05 ($P = 0.056$), it was retained in the stepwise forward logistic regression results output by SPSS. Because of its greater influence on the equation, combined with its clinical relevance and impact on the logistic regression model, this variable is still considered meaningful.

During the recovery of parathyroid function, multiple ions work in concert. From a physiological point of view, the decrease in the serum magnesium concentration after thyroid surgery inhibits PTH secretion and thus increases the resistance of terminal organs to PTH[21, 22]. PTH increases the reabsorption of magnesium by the renal tubules, and high phosphorus concentrations stimulate the secretion of PTH[23, 24]. Our study also found that normal parathyroid function after total thyroidectomy was associated with Pod7 Mg and Pod7 P levels. The multivariate analysis results showed that serum magnesium concentration and phosphorus concentration were independent factors influencing the return of Pod7 PTH to normal, and patients with Pod7 Mg > 0.8 mmol/l and Pod7 P ≤ 1.51 mmol/l (P < 0.05) experience a more rapid return to normal parathyroid function. Thus, it is necessary to detect ions other than calcium ions after thyroid surgery.

Parathyroid hormone is the main hormone regulating calcium ions. Hypocalcemia often occurs after hypoparathyroidism. Some scholars have reported that the magnesium concentration after thyroid surgery is closely related to hypoparathyroidism[25-28]. We also find that Pod7 Mg and Pod7 P are effective predictors of the return of PTH to normal levels on Pod7. The combined sensitivity of serum Mg and P concentrations to predict normal parathyroid function was 82.76%, and the specificity was 76.83%. The predictive effect of rapid biochemical indicators on parathyroid function will be helpful for clinicians to diagnose and better manage the dosage of calcium tablets and calcitriol in patients. In addition, many scholars have explored the predictive effect of short-term PTH after thyroid surgery [6-9]. However, many junior hospitals do not have the equipment to detect PTH, or the test is too time-consuming. From the perspective of medical expenses, ion prediction can reduce the cost of parathyroid function testing.

Serum PTH concentration and serum magnesium concentration showed a downward trend within 1-2 days after total thyroidectomy, whereas serum ionized phosphorus showed an upward trend, and a gradual return to the preoperative level. Some scholars have previously explored the changes in serum ionized calcium, magnesium, and phosphorus on day 1 and day 2 after total thyroidectomy[28, 29]. However, our study further explored the change trend in postoperative calcium, magnesium, and phosphorus ion concentrations within the first month after surgery. This study also has some limitations related to its retrospective nature. The study protocol required follow-up of patients' recovery of parathyroid function and serum ions within 1, 3, 7, 30 days, and 1 year after surgery. We conservatively estimate those patients' parathyroid function has returned to normal, which may lead to overestimation of parathyroid function recovery. Hypoparathyroidism, postoperative preventive calcium and calcitriol supplementation can affect the measurement of real postoperative serum calcium and calcitriol concentrations.

Conclusion:

We found that serum magnesium concentration, phosphorus concentration and PTH concentration are important influencing factors and effective predictors of short-term postoperative parathyroid function return to normal. In addition, we explored the trends of biochemical indicators after thyroid surgery. The surgeon should treat each parathyroid gland as the only parathyroid gland during the operation.

Abbreviations

PTH: parathyroid hormone; PGRIS: parathyroid glands remaining in situ; Pod: postoperative day; Pre: preoperative; TT: total thyroidectomy; CND: central lymph node dissection; LND: lateral lymph node dissection; ROC: receiver operating characteristic; AUC: Area under the ROC curve; SE: Standard error; CI: Confidence interval; PPV: positive predictive value; NPV: negative predictive value

Declarations

Acknowledgements

Not applicable.

Authors'contributions

All authors participated in the study. XL designed the study; DS and WH collected the data. DS drafted the manuscript and analyzed the data and reviewed the manuscript; FX, WD critically revised the manuscript for important

intellectual content; NB, ZZ and XL reviewed the manuscript and contributed for final approval. All authors have reviewed and approved the final version of the manuscript.

Funding

This work was funded by the National Natural Science Foundation of China (81672885).

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

This study was approved and agreed upon by the Ethics Committee of Xiangya Hospital of Central South University, and all patients participating in the study provided written informed consent.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1 Characteristics of the study population (N =111)

Characteristics	n	value
Age, years	111	41 (32-51)
Sex	111	
Male	19 (17.12%)	NA
Female	92 (82.88%)	NA
Vitamin D (ng/ml)	111	21.10 (16.52-27.41)
Hyperthyroidism		
Yes	1 (0.90%)	NA
No	110 (99.10%)	NA
Scope of surgery		
TT	3 (2.70%)	NA
TT+CND	65 (58.56%)	NA
TT+CND+LND	43 (38.74%)	NA
Thyroid pathology		
Goiter	5 (4.50%)	NA
Carcinoma	106 (95.50%)	NA
PGRIS		
0	5 (4.50%)	NA
1	5 (4.50%)	NA
2	19 (17.12%)	NA
3	39 (35.14%)	NA
4	43 (38.74%)	NA
Preoperative PTH (pg/mL)	111	39.27 (16.52-27.41)
Preoperative Ca (mmol/l)	111	2.35 (0.09)
Preoperative Mg (mmol/l)	111	0.89 (0.84-0.92)
Preoperative P (mmol/l)	111	1.17 (0.19)
Characteristics at postoperative day 1		
Pod1 PTH (pg/mL)	111	5.13 (3.70-6.97)
Pod1 Ca (mmol/l)	111	1.98 (0.12)

Pod1 Mg (mmol/l)	111	0.69 (0.06)
Pod1 P (mmol/l)	111	1.54 (1.40-1.72)
Characteristics at postoperative day 3		
Pod3 PTH (pg/mL)	111	4.91 (3.56-7.02)
Pod3 Ca (mmol/l)	111	1.89 (1.83-2.00)
Pod3 Mg (mmol/l)	111	0.67 (0.63-0.71)
Pod3 P (mmol/l)	111	1.67 (0.34)
Characteristics at postoperative day 7		
Pod7 PTH (pg/mL)	111	10.96 (6.42-15.38)
Pod7 Ca (mmol/l)		
All	111	2.12 (0.19)
Pod7 Ca $\geq$ 2.05 (mmol/l)	75 (67.57%)	2.23 (2.30-2.14)
Pod7 Ca<2.05 (mmol/l)	36 (32.43%)	1.94 (1.98-1.84)
Pod7 Mg (mmol/l)		
All	111	0.80 (0.09)
Pod7 Mg > 0.8 (mmol/l)	54 (48.65%)	0.85 (0.91-0.83)
Pod7 Mg $\leq$ 0.8 (mmol/l)	57 (51.35%)	0.75 (0.77-0.70)
Pod7 P (mmol/l)		
All	111	1.54 (0.29)
Pod7 P $\leq$ 1.51 (mmol/l)	57 (51.35%)	1.36 (1.45-1.20)
Pod7 P>1.51 (mmol/l)	54 (48.65%)	1.73 (1.87-1.63)
Characteristics at postoperative day 30		
Pod30 PTH (pg/mL)	111	30.44 (20.38-42.41)
Pod30 Ca (mmol/l)	111	2.25 (2.11-2.33)
Pod30 Mg (mmol/l)	111	0.86 (0.80-0.89)
Pod30 P (mmol/l)	111	1.26 (1.09-1.42)

Data are presented as n/N (%), mean (SD), and median (IQR). TT: total thyroidectomy; CND: central lymph node dissection; LND: lateral lymph node dissection; PGRIS: parathyroid glands remaining in situ; Pod: postoperative day

Fig 3 ROC curves corresponding to serum ion concentrations

Viable	AUC	SE ^a	95% CI ^b
Pod7 Mg (mmol/l)	0.788	0.045	0.700 - 0.860
Pod7 P (mmol/l)	0.739	0.049	0.648 - 0.818
Pod7 Ca (mmol/l)	0.717	0.052	0.623 - 0.798
Pod1 PTH>5.18 pg/mL	0.720	0.052	0.627 - 0.801
Pod3 PTH>5.6 pg/mL	0.769	0.052	0.679 - 0.843
Pod7 Mg and Pod7 P Combined diagnosis	0.842	0.037	0.760 - 0.904

a DeLong et al., 1988

b Binomial exact

ROC: Receiver Operating Characteristic; AUC: Area under the ROC curve; SE: Standard error; CI: Confidence interval; Pod: Postoperative day

Table 2 The diagnostic sensitivity, specificity, positive predictive value and negative predictive value of the cut-off values of serum ionized calcium, magnesium and phosphorus for normal PTH levels at Pod7

	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Pod7 Mg >0.80 mmol/l	86.21	64.6	46.3	93
Pod7 P ≤1.51 mmol/l	82.76	59.76	42.1	90.7
Pod7 Ca >2.05 mmol/l	93.10	46.34	46.2	84.9
Pod1 PTH>5.18 pg/mL	79.31	62.20	42.6	89.5
Pod3 PTH>5.60pg/mL	75.86	71.95	48.9	89.4
Pod7 Mg and Pod7 P Combined diagnose	82.76	76.83	55.8	92.6

PPV: positive predictive value; NPV: negative predictive value; Pod: postoperative day

Table 3 Univariate analysis for Pos7 PTH

Covariate	OR	95%CI	P value
Age, years (mean $\pm$ SD)	1.01	(0.98, 1.05)	0.531
Continuous sex	1.01	(0.33, 3.11)	0.984
Female	Reference		
Male	1.01	(0.33, 3.11)	0.984
Vitamin D	0.98	(0.93, 1.04)	0.541
Continuous scope of surgery	0.93	(0.42, 2.06)	0.855
TT	Reference		
TT+CND	6464692.49	(0.00, Inf)	0.991
TT+CND+LND	4742836.60	(0.00, Inf)	0.991
Continuous PGRIS	0.71	(0.49, 1.05)	0.084
0	Reference		
1	6.00	(0.35, 101.57)	0.215
2	2.33	(0.22, 25.25)	0.486
3	1.57	(0.16, 15.67)	0.700
4	0.78	(0.08, 8.04)	0.833
Pre PTH	1.01	(0.99, 1.03)	0.369
Continuous Pod1 PTH	1.49	(1.18, 1.90)	0.001
Pod1 PTH>5.18 pg/mL	6.31	(2.31, 17.20)	<0.001
Continuous Pod3 PTH	1.39	(1.17, 1.64)	<0.001
Pod3 PTH>5.60 pg/mL	8.06	(3.03, 21.43)	<0.001
Pre Ca	0.14	(0.00, 14.01)	0.403
Pod1 Ca	3.68	(0.11, 126.12)	0.470
Thyroid pathology			
Carcinoma	Reference		
Goiter	1.95	(0.31, 12.30)	0.477
Continuous Pod7 Mg	5137891.30	(3242.36, inf.)	<0.001
Pod7 Mg > 0.80	11.42	(3.62, 36.02)	<0.001
Continuous Pod7 P	0.04	(0.01, 0.25)	<0.001

Pod7 P $\leq$ 1.51	7.13	(2.47, 20.57)	<0.001
Continuous Pod7 Ca	112.53	(6.38, 1984.65)	0.001
Pod7 Ca $\geq$ 2.05	9.77	(2.17, 43.88)	0.003

TT: total thyroidectomy; CND: central lymph node dissection; LND: lateral lymph node dissection; PGRIS: parathyroid glands remaining in situ; Pre: preoperative; Pod: postoperative day

Table 4 Multivariate analysis of factors affecting the Pod7 PTH return to normal

Variables	OR	(95%CI)	<i>P</i> value
PGRIS	0.517	(0.290, 0.921)	0.021
Pod1 PTH>5.18 pg/mL	3.439	(0.968, 12.222)	0.056
Pod3 PTH>5.60 pg/mL	3.745	(1.078, 13.008)	0.038
Pod7 Mg > 0.80	9.221	(2.374, 35.823)	0.001
Pod7 P $\leq$ 1.51	4.475	(1.262, 15.864)	0.020

Pre: preoperative; Pod: postoperative day

Figures

Figure 1

PTH returned to normal on days 1, 3, 7, and 30 after surgery. Pod: postoperative day

Figure 2

Change trend in serum ionized Ca, Mg and P before and after thyroidectomy . Pod: postoperative day

Figure 3

ROC curves corresponding to serum ion concentrations