Original Article

Establishing a predictive model of hypoparathyroidism after total thyroidectomy and central lymph node dissection for postoperative calcium supplementation selectively

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Background: The core goal of this article is to find some meaningful risk factors that can affect the postoperative hypoparathyroidism of thyroid cancer, create an effective prediction model on this basis, and use it to selectively implement routine prophylactic calcium supplementation for patients after thyroid carcinoma surgery.

Methods: The clinicopathological characteristics of patients with papillary thyroid carcinoma (PTC) who underwent conventional bilateral total thyroidectomy (TT) + bilateral central lymph node dissection from January 2020 to August 2021 in the Affiliated Hospital of Nantong University were retrospectively analyzed. Firstly, this study analyzed the relationship between postoperative hypocalcemia and hypoparathyroidism. Then, we included many potential risk factors such as gender, age, body mass index (BMI), lateral lymph node dissection (LLND) and so on and also performed univariate and multivariate analysis of the independent risk factors for postoperative hypoparathyroidism in patients, and established a predictive scoring model.

Results: Among the 401 patients with PTC, 50.1% developed postoperative hypoparathyroidism. There was significant difference in serum calcium concentration between normal parathyroid group and hypoparathyroidism group after thyroid carcinoma surgery. BMI <24 kg/m^2, lateral lymph node dissection, multifocality, and extrathyroidal extension (ETE) were all identified as independent risk factors for postoperative hypoparathyroidism. Based on these independent risk factors, a nine-point risk scoring model was created to firstly assess the postoperative parathyroid function status of patients and then to determine whether routine prophylactic calcium supplementation is needed. Importantly, the area under the curve (AUC) of the risk scoring model is equal to 0.979.

Conclusions: At present, prophylactic calcium supplementation after thyroid carcinoma surgery is a controversial postoperative treatment. It should be selectively implemented for high-risk patients with hypoparathyroidism after surgery. Routine prophylactic calcium supplementation is recommended for PTC patients with a score greater than or equal to 5, although there are no clinical symptoms of postoperative hypocalcemia caused by hypoparathyroidism. However, prophylactic calcium supplementation is not recommended for patients with PTC with a score of less than 5; if the patient develops hypocalcemia at the later stage, therapeutic calcium supplementation can then be implemented.

Keywords: Papillary thyroid carcinoma (PTC); total thyroidectomy (TT); hypoparathyroidism

Submitted Mar 10, 2022. Accepted for publication Jun 08, 2022.

doi: 10.21037/atm-22-1779

View this article at: https://dx.doi.org/10.21037/atm-22-1779

Introduction

In recent years, the incidence rate of thyroid cancer has increased dramatically, and has become the most common endocrine malignancy (1,2). This phenomenon is mainly determined by the incidence rate of papillary thyroid carcinoma (PTC) (3). PTC is the most common pathological type of thyroid carcinoma, accounting for about 80% of all thyroid carcinomas (4). At present, PTC is treated with open surgery, remote access thyroidectomy, percutaneous ablation, and regular review (5), with open surgery being the predominant treatment. Surgical methods include total thyroidectomy (TT)/subtotal thyroidectomy (ST) and central lymph node dissection (CLND) (6). However, complications such as breathing difficulties or suffocation caused by major hemorrhage after surgery, superior laryngeal nerve or recurrent laryngeal nerve injury, hypocalcemia, hypoparathyroidism are more likely after thyroidectomy (7).

Hypocalcemia is a common complication after thyroid surgery, with an incidence rate of 1.2–40% (8). The main cause of hypocalcemia is postoperative hypoparathyroidism, and patients with PTC who have undergone TT + central lymph node dissection are at greater risk of hypoparathyroidism and hypocalcemia after surgery (9). According to the duration of hypoparathyroidism after thyroid carcinoma surgery, the normal return of parathyroid function within 6 months after surgery is generally defined as temporary hypoparathyroidism. Meanwhile, a failure to return to normal levels of parathyroid function that lasts for more than 6 months is defined as permanent hypoparathyroidism, although there is a study that apply 12 months as the time cut-off point for the diagnosis of permanent hypoparathyroidism (10). The incidence of temporary hypoparathyroidism is 1.6–53.6% (11), while that of permanent hypoparathyroidism is as high as approximately 3% (12), and its clinical manifestations are mainly numbness and convulsions, decreasing the quality of life in patients and, in some cases, leading to death (13,14).

Since the treatment of postoperative hypocalcemia is personalized and relatively difficult, the prevention of postoperative hypocalcemia is more significant (15). A previous study has shown that prophylactic calcium supplementation after surgery can reduce the risk of hypoparathyroidism and hypocalcemia, thus reducing the incidence of postoperative complications related to thyroid carcinoma (16). However, some scholars object to this because most patients have no parathyroid function damage after surgery. For these patients, routine prophylactic calcium supplementation after surgery will result in a waste of medical resources and increase the incidence of hypercalcemia in patients. Also, the incidence of calciuria, kidney stones, nephroncalcinosis, and renal failure may inhibit the compensatory function of the parathyroid glands (17). There are relatively few reports regarding the decreased incidence of hypocalcemia and hypoparathyroidism through prophylactic calcium supplementation, and it is still controversial whether to routinely perform prophylactic calcium supplementation for patients with thyroid carcinoma after surgery. Therefore, it is particularly important to clarify the risk factors of hypoparathyroidism after thyroid carcinoma surgery.

In this article, we collected the clinicopathological data of 401 patients with thyroid cancer from the Affiliated Hospital of Nantong University, and then analyzed them retrospectively. We summarized the independent risk factors for postoperative hypoparathyroidism, and constructed a related risk scoring model. Based on this predictive model, we can evaluate high-risk groups of patients with PTC who may have postoperative hypoparathyroidism. Routine prophylactic calcium supplementation can then be given to these patients after surgery to achieve precise treatment effects and improve their quality of life. We present the following article in accordance with the STARD reporting checklist (available at https://atm.amegroups.com/article/view/10.21037/atm-22-1779/rc).

Methods

Patients

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This retrospective study was approved by the Ethics Committee of Affiliated Hospital of Nantong University (No. 2022-LW196), and all patients were exempted from providing informed consent. We collected patients who first underwent total thyroidectomy at the General Surgery Department of the Affiliated Hospital of Nantong University from January 2020 to August 2021 and were pathologically confirmed with PTC. The exclusion criteria were as follows: (I) patients who were pathologically diagnosed with benign thyroid disease; (II) those with preoperative intact parathyroid hormone (iPTH) and serum calcium concentrations below the lower limit of

normal; (III) patients who had previously received thyroid surgery or insufficient resection of the bilateral lobes; (IV) patients who did not undergo iPTH and serum calcium concentration testing on the first postoperative day; (V) those with secondary hyperparathyroidism caused by parathyroid tumors or chronic renal insufficiency; and (VI) patients with incomplete data. In this study, a total of 401 eligible patients with PTC were collected for analysis.

Surgical procedures and postoperative management

All enrolled patients underwent conventional bilateral TT + bilateral central area lymph node dissection. During the operation, the carbon nanoparticles suspension was injected into the fully exposed bilateral thyroid glands to facilitate identification of the parathyroid glands by the surgeon. For suspicious parathyroid tissue, if insufficient blood supply or dissociation was found intraoperatively, autologous parathyroid transplantation was performed. All patients underwent iPTH, serum calcium concentration, and serum phosphorus concentration testing on the first morning postoperatively. Patients with lower iPTH than normal or with symptoms of hypocalcemia were given an intravenous infusion of calcium gluconate using a micropump. The iPTH and serum calcium concentrations were used to adjust the calcium supplementation for patients with hypoparathyroidism after surgery. IPTH and serum calcium concentrations were reviewed in the first postoperative month, and follow-up treatment should be guided according to the changes in their levels.

Clinicopathological properties

We collected the clinicopathological characteristics of the patients based on medical records and supplementary examination, including gender, age, body mass index (BMI), hypertension, diabetes, lateral lymph node dissection, tumor number, extrathyroidal extension, Hashimoto's disease, and pre/postoperative serum calcium and iPTH concentrations. After the operation, two experienced pathologists cross examined the pathological specimens of the patients. There is more than one lesion in the thyroid tissue, which is the evaluation standard of multifocality. The normal range of serum iPTH is 12–88 pg/mL, and hypoparathyroidism was diagnosed when iPTH (intact parathyroid hormone) was less than 12 pg/mL. The patients were compared according to the pre/postoperative serum calcium concentrations of the two groups based on the iPTH after thyroid carcinoma surgery. Extrathyroidal extension (ETE) is defined as the tumor invading sternothyroedeus muscle and surrounding soft tissue, or invading surrounding organs, blood vessels, nerves and other tissues. Patients with Hashimoto's thyroiditis were required to meet any of the following criteria: (I) Serum anti-hyroglobulin antibody (TGAb) and/or thyroid peroxidase antibody (TPOAb) were positive; (II) Fine needle aspiration cytology (FNAC) or postoperative pathological specimens if thyroid suggest Hashimoto's thyroiditis.

Research design

According to the postoperative parathyroid function, patients with thyroid papillary carcinoma who met the inclusion conditions were divided into normal parathyroid function group and hypoparathyroidism group. In addition, we analyzed whether there were differences in preoperative/postoperative serum calcium concentration between the two groups. The clinicopathological data of patients were collected, and the univariate and multivariate analysis of postoperative hypoparathyroidism was carried out for each variable. Then, a risk scoring model was constructed to calculate the probability of postoperative hypoparathyroidism on the basis of the multivariate analysis results. We selected the independent risk factors for postoperative hypoparathyroidism as scoring indicators, and the scores of each risk factor were weighted according to the beta coefficient obtained by the logistic regression model. In order to optimize the risk score model, we have expressed the coefficients of independent risk factors are the nearest integer. Adding the coefficients of the risk factors of patients with PTC equals their total score. In this study, the receiver operating characteristic (ROC) curve was used to test the effect of this model on predicting the occurrence of postoperative hypoparathyroidsim, and a great cut-off point was found.

Statistical analysis

All statistical analyses were carried out using SPSS software (IBM Corp., Chicago, IL, USA). Continuous variables were expressed as mean ± standard deviation. The Clinicopathological data of patients was analyzed by the Fisher's exact test and chi-square test. In this article, $P<0.05$ is two-sided and means that the difference is statistically

Table 1 Pre/postoperative serum calcium concentration in the two groups

Groups	Preoperative serum calcium concentration (mmol/L)	Postoperative serum calcium concentration (mmol/L)	T value	P value
Normal postoperative PTH group	2.28±0.09	2.18±0.10	0.62	0.53
Reduced postoperative PTH group	2.32±0.93	2.02±0.12	14.49	<0.05

PTH, parathyroid hormone.

significant.

Results

Comparison of the serum calcium concentrations between the normal and reduced iPTH groups after thyroid carcinoma surgery

There were significant differences in the blood calcium concentrations after thyroid carcinoma surgery between the two groups (*Table 1*). The serum calcium concentration of the postoperative reduced iPTH group was significantly lower than that of the normal iPTH group postoperatively (P<0.05).

The basic clinicopathological data of the patients was used to create the risk scoring model

This study summarized the baseline clinicopathological characteristics of patients with PTC to establish a postoperative hypoparathyroidism risk scoring model (*Table 2*). Among the 401 patients with PTC, 84 were males and 317 were females, with an average age of 47 years (range, 18–79 years), of which 250 cases (62.3%) were ≥45 years old. The BMI of the included patients ranged from 17.72–42.45 kg/m^2, with an average value of 24.25 kg/m^2, of which 210 cases (52.4%) were BMI <24 kg/m^2. There were 94 cases of hypertension, 39 cases of diabetes, and 180 cases of lateral lymph node dissection. Furthermore, there were 198 patients with multifocality, and 71 patients (17.7 %) had extrathyroidal extension. Among the included patients, there were 97 patients (24.2%) with Hashimoto's thyroiditis. All patients with PTC underwent conventional bilateral TT + bilateral central lymph node dissection. In total, 201 cases (50.1%) had postoperative hypoparathyroidism.

Correlation between clinicopathological factors and postoperative hypoparathyroidism

We then analyzed the risk factors of postoperative hypoparathyroidism among the 401 patients with PTC who underwent conventional bilateral TT + bilateral central lymph node dissection. The univariate analysis showed (*Table 3*) that BMI <24 kg/m^2, lateral lymph node dissection, multifocality, and extrathyroidal extension were significantly correlated with postoperative hypoparathyroidism (P<0.05). However, there was no significant correlation with age, gender, hypertension, diabetes, or Hashimoto's thyroiditis. Subsequently, multivariate analysis (*Table 4*) showed that BMI <24 kg/m^2 [odds ratio (OR): 126.531, 95% confidence interval (CI): 40.041–399.844, P<0.001], lateral lymph node dissection (OR: 24.511, 95% CI: 9.439–63.651, P<0.001), multifocality (OR: 19.300, 95% CI: 6.774–54.990, P<0.001), and extrathyroidal extension (OR: 3.655, 95% CI: 1.091–12.237, P=0.036) are independent risk factors for postoperative hypoparathyroidism (P<0.05).

Establishment of a risk scoring model for predicting postoperative hypoparathyroidism

We constructed a nine-point risk scoring model based on the beta coefficients of the above four risk factors (BMI <24 kg/m^2, lateral lymph node dissection, multifocality, and extrathyroidal extension) from the logistic multivariate analysis of postoperative hypoparathyroidism in patients with PTC (*Table 5*). According to the scoring model, the probability of postoperative hypoparathyroidism in patients with PTC ranged from 0.0% to 100% (*Table 6*).

The ROC curve of the risk assessment model for postoperative hypoparathyroidism in patients with PTC was drawn, and the area under the curve (AUC) for predicting postoperative hypoparathyroidism was 0.977 (95% CI: 0.963–0.990, P<0.001), indicating that the model has an excellent forecasting effect (*Figure 1*). In addition, a total score =5 was selected as the appropriate cut-off point for the model, and patients with a total score between 0 and 4 were classified as having a low risk of postoperative hypoparathyroidism (average incidence: 16.82%). However, patients with a score between 5 and 9 were classified as

Table 2 Demographics and clinical characteristics of the 401 included PTC patients

Clinicopathological properties	Total, n	Hypoparathyroidism, n (%)	
		Yes	No
Subject	401	201 (50.1)	200 (49.9)
Gender			
Male	84	44 (52.4)	40 (47.6)
Female	317	157 (49.5)	160 (50.5)
Age (years)			
≥45	250	123 (49.2)	127 (50.8)
<45	151	78 (51.7)	73 (48.3)
BMI (kg/m^2)			
≥24	191	18 (9.4)	173 (90.6)
<24	210	183 (95.8)	27 (4.2)
Hypertension			
Presence	94	51 (54.3)	43 (45.7)
Absence	307	150 (48.9)	157 (51.1)
Diabetes			
Presence	39	24 (61.5)	15 (38.5)
Absence	362	177 (48.9)	185 (51.1)
LLND			
Presence	180	158 (87.8)	22 (12.2)
Absence	221	43 (19.5)	178 (80.5)
Multifocality			
Presence	198	154 (77.8)	44 (22.2)
Absence	203	47 (23.2)	156 (76.8)
Extrathyroidal extension			
Presence	71	48 (67.6)	23 (32.4)
Absence	330	163 (49.4)	177 (50.6)
Hashimoto's thyroiditis			
Presence	97	48 (49.5)	49 (50.5)
Absence	304	153 (50.3)	151 (49.7)

PTC, papillary thyroid carcinoma; PTH, parathyroid hormone; BMI, body mass index; LLND, lateral lymph node dissection.

having a high risk of postoperative hypoparathyroidism (average incidence: 96.26%).

Discussion

At present, ST can be performed for low-risk papillary thyroid microcarcinoma. However, TT should be favored for intermediate/high-risk PTCs, despite the higher frequency of postoperative complications (18). After surgical treatment, patients with PTC are prone to hypoparathyroidism, especially after TT. The factors related to postoperative hypoparathyroidism and the mechanism of early

Table 3 Univariate analysis of the risk factors of postoperative hypoparathyroidism

Factors	OR	95% CI		P value
		Lower	Upper	
Gender				
Male	1.121	0.693	1.814	0.713
Female	1			
Age (years)				
<45	1.103	0.736	1.653	0.68
≥45	1			
BMI (kg/m^2)				
<24	65.142	34.639	122.504	<0.001
≥24	1			
Hypertension				
Presence	1.241	0.781	1.973	0.41
Absence	1			
Diabetes				
Presence	1.672	0.85	3.292	0.177
Absence	1			
LLND				
Presence	29.729	17.039	51.872	<0.001
Absence	1			
Multifocality				
Presence	11.678	7.278	18.542	<0.001
Absence	1			
Extrathyroidal extension				
Presence	2.414	1.404	4.152	0.02
Absence	1			
Hashimoto's thyroiditis				
Presence	1			
Absence	1.034	0.655	1.634	0.908

BMI, body mass index; LLND, lateral lymph node dissection; OR, odds ratio; CI, confidence interval.

Table 4 Multivariate analysis of the risk factors of postoperative hypoparathyroidism

Factors	OR	95% CI		P value
		Lower	Upper	
BMI (kg/m^2)				
<24	126.531	40.041	399.844	<0.001
≥24	1			
LLND				
Presence	24.511	9.439	63.651	<0.001
Absence	1			
Multifocality				
Presence	19.300	6.774	54.990	<0.001
Absence	1			
Extrathyroidal extension				
Presence	3.655	1.091	12.237	0.036
Absence	1			

BMI, body mass index; LLND, lateral lymph node dissection; OR, odds ratio; CI, confidence interval.

Table 5 Development of a nine-point risk-scoring model to predict postoperative hypoparathyroidism

Variables	P value	Beta coefficient	Points
BMI (kg/m^2)			
<24	<0.001	4.840	4
≥24			
LLND			
Presence	<0.001	3.199	2
Absence			
Multifocality			
Presence	<0.001	2.960	2
Absence			
Extrathyroidal extension			
Presence	0.036	1.296	1
Absence			

BMI, body mass index; LLND, lateral lymph node dissection.

postoperative hypoparathyroidism to recovery or permanent hypoparathyroidism are still not fully understood (19). The sensitivity of serum iPTH <12 pg/mL to monitor hypoparathyroidism is 100%, and the specificity is 92% (20). In this study, patients with iPTH <12 pg/mL after thyroid carcinoma surgery were used as the diagnostic criteria. There were 201 cases of postoperative hypoparathyroidism, with an incidence rate of 50.1%. Reports on the incidence

Table 6 Risk scores and percentage of postoperative hypoparathyroidism in PTC patients

Risk score	Hypoparathyroidism (+)	Hypoparathyroidism (–)	Total	Positive rate, %
0	1	104	105	0.95
1	0	15	15	0.00
2	3	42	45	6.67
3	0	7	7	0.00
4	17	25	42	40.48
5	8	1	9	88.89
6	51	5	56	91.07
7	12	0	12	100.00
8	81	1	82	98.78
9	28	0	28	100.00

"+", positive; "–", negative. PTC, papillary thyroid carcinoma.

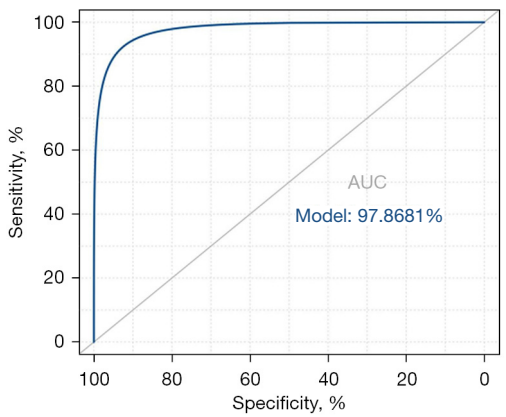

Figure 1 Receiver operating characteristic curve of the ability of the risk scoring model to predict the risk of postoperative hypoparathyroidism for the creation of a model group. AUC, area under the curve.

of hypoparathyroidism after thyroid carcinoma surgery are inconsistent, ranging from 1.7% to 68%, since the positions of the superior parathyroid glands are generally fixed, and are easy to identify and preserve. Meanwhile, the positions of the lower parathyroid glands are variable, such as the dorsal side of the lower pole of the thyroid gland, the thymus or thymic ligament, and the tracheoesophageal space, which are difficult to locate and preserve (21). Bilateral central lymph node dissection will significantly increase the incidence of postoperative hypoparathyroidism. Therefore, the incidence of hypoparathyroidism after thyroid carcinoma surgery in this study was higher than that generally reported.

For patients undergoing TT for PTC, whether to perform routine prophylactic calcium supplementation after surgery is still controversial. Many experienced surgeons support routine prophylactic calcium supplementation after TT (22,23). They believe that it can reduce the incidence of postoperative complications (hypoparathyroidism and hypocalcemia) to a certain extent. However, some experts believe that it is not necessary to perform prophylactic routine calcium supplementation after TT. Lee *et al.* showed that routine low-dose calcium supplementation after TT does not reduce the risk of postoperative hypocalcemia (24). At present, selective calcium supplementation based on postoperative parathyroid function is a commonly accepted treatment in the medical field (25,26).

In this study, based on the clinicopathological characteristics of patients undergoing TT for PTC in our hospital, a risk scoring model for predicting postoperative hypoparathyroidism was established to better guide surgeons in selectively treat patients with calcium supplementation. However, the samples of this retrospective study came from a single clinical center and the sample size was small. Therefore, it is necessary to further expand the sample size to identify more related risks of hypoparathyroidism after TT and central lymph node dissection in patients with PTC.

In summary, BMI <24 kg/m^2, lateral lymph node dissection, multifocality, and extrathyroidal extension may increase the incidence of hypoparathyroidism after TT and central lymph node dissection for PTC. Based on these four independent risk factors, we established a nine-point risk scoring model to better guide postoperative prophylactic

calcium supplementation. Surgeons should pay attention to evaluating the clinicopathological characteristics of patients before surgery. For patients with PTC with a score of ≥5, routine prophylactic calcium supplementation is recommended even if no hypoparathyroidism is found after surgery. However, prophylactic calcium supplementation is not recommended for patients with PTC with a score of less than 5; if the patient develops hypocalcemia at the later stage, therapeutic calcium supplementation can then be implemented to improve their prognosis.

Acknowledgments

Funding: This work was supported by grants from the Research Project of Maternal and Child Health of Jiangsu Province (No. F201953), and the Science and Technology Project of Nantong (No. JC2020067 to Z He).

Footnote

Reporting Checklist: The authors have completed the STARD reporting checklist. Available at https://atm.amegroups.com/article/view/10.21037/atm-22-1779/rc

Data Sharing Statement: Available at https://atm.amegroups.com/article/view/10.21037/atm-22-1779/dss

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://atm.amegroups.com/article/view/10.21037/atm-22-1779/coif). ZH reports that the study was supported by the Science and Technology Project of Nantong (No. JC2020067). The other authors have no conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). This retrospective study was approved by the Ethics Committee of Affiliated Hospital of Nantong University (No. 2022-LW196), and all patients were exempted from providing informed consent.

References

1. Seib CD, Sosa JA. Evolving Understanding of the Epidemiology of Thyroid Cancer. Endocrinol Metab Clin North Am 2019;48:23-35.
2. La Vecchia C, Malvezzi M, Bosetti C, et al. Thyroid cancer mortality and incidence: a global overview. Int J Cancer 2015;136:2187-95.
3. O'Neill RJ, Abd Elwahab S, Kerin MJ, et al. Association of BMI with Clinicopathological Features of Papillary Thyroid Cancer: A Systematic Review and Meta-Analysis. World J Surg 2021;45:2805-15.
4. Cabanillas ME, McFadden DG, Durante C. Thyroid cancer. Lancet 2016;388:2783-95.
5. Sanabria A, Pinillos P, Lira RB, et al. Current therapeutic options for low-risk papillary thyroid carcinoma: Scoping evidence review. Head Neck 2022;44:226-37.
6. Pacini F, Castagna MG, Brilli L, et al. Thyroid cancer: ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up. Ann Oncol 2012;23 Suppl 7:vii110-9. Erratum in: Ann Oncol 2018;29 Suppl 4:iv257-iv258.
7. American Thyroid Association (ATA) Guidelines Taskforce on Thyroid Nodules and Differentiated Thyroid Carcinoma, Cooper DS, Doherty GM, et al. Revised American Thyroid Association management guidelines for patients with thyroid nodules and differentiated thyroid carcinoma. Thyroid 2009;19:1167-214. Erratum in: Thyroid 2010;20:942. Erratum in: Thyroid 2010;20:674-5.
8. Păduraru DN, Ion D, Carsote M, et al. Post-thyroidectomy Hypocalcemia - Risk Factors and Management. Chirurgia (Bucur) 2019;114:564-70.
9. Caulley L, Johnson-Obaseki S, Luo L, et al. Risk factors for postoperative complications in total thyroidectomy: A retrospective, risk-adjusted analysis from the National Surgical Quality Improvement Program. Medicine (Baltimore) 2017;96:e5752.
10. Bergenfelz A, Nordenström E, Almquist M. Morbidity in patients with permanent hypoparathyroidism after total thyroidectomy. Surgery 2020;167:124-8.
11. Koimtzis GD, Stefanopoulos L, Giannoulis K, et al. What are the real rates of temporary hypoparathyroidism

following thyroidectomy? It is a matter of definition: a systematic review. Endocrine 2021;73:1-7.
12. Edafe O, Antakia R, Laskar N, et al. Systematic review and meta-analysis of predictors of post-thyroidectomy hypocalcaemia. Br J Surg 2014;101:307-20.
13. Almquist M, Hallgrimsson P, Nordenström E, et al. Prediction of permanent hypoparathyroidism after total thyroidectomy. World J Surg 2014;38:2613-20.
14. Melikyan AA, Menkov AV. Postoperative Hypoparathyroidism: Prognosis, Prevention, and Treatment (Review). Sovrem Tekhnologii Med 2020;12:101-8.
15. Lammert A, Nowak K, Weber R, et al. Postoperative hypocalcemia - the most common complication of endocrine head and neck surgery: acute management. Laryngorhinootologie 2021;100:610-7.
16. Dedivitis RA, Aires FT, Cernea CR. Hypoparathyroidism after thyroidectomy: prevention, assessment and management. Curr Opin Otolaryngol Head Neck Surg 2017;25:142-6.
17. Kala F, Sarici IS, Ulutas KT, et al. Intact parathormone measurement 1 hour after total thyroidectomy as a predictor of symptomatic hypocalcemia. Int J Clin Exp Med 2015;8:18813-8.
18. Colombo C, De Leo S, Di Stefano M, et al. Total Thyroidectomy Versus Lobectomy for Thyroid Cancer: Single-Center Data and Literature Review. Ann Surg Oncol 2021;28:4334-44.
19. Sitges-Serra A. Etiology and Diagnosis of Permanent Hypoparathyroidism after Total Thyroidectomy. J Clin Med 2021;10:543.
20. Orloff LA, Wiseman SM, Bernet VJ, et al. American Thyroid Association Statement on Postoperative Hypoparathyroidism: Diagnosis, Prevention, and Management in Adults. Thyroid 2018;28:830-41.
21. Hou D, Xu H, Yuan B, et al. Effects of active localization and vascular preservation of inferior parathyroid glands in central neck dissection for papillary thyroid carcinoma. World J Surg Oncol 2020;18:95.
22. Arer IM, Kus M, Akkapulu N, et al. Prophylactic oral calcium supplementation therapy to prevent early post thyroidectomy hypocalcemia and evaluation of postoperative parathyroid hormone levels to detect hypocalcemia: A prospective randomized study. Int J Surg 2017;38:9-14.
23. Xing T, Hu Y, Wang B, et al. Role of oral calcium supplementation alone or with vitamin D in preventing post-thyroidectomy hypocalcaemia: A meta-analysis. Medicine (Baltimore) 2019;98:e14455.
24. Lee JW, Kim JK, Kwon H, et al. Routine low-dose calcium supplementation after thyroidectomy does not reduce the rate of symptomatic hypocalcemia: a prospective randomized trial. Ann Surg Treat Res 2019;96:177-84.
25. Sekar S, Belavendra A, Jacob PM. Early Discharge and Selective Calcium Supplementation after Thyroidectomy Based on Post-Operative Day 1 Parathormone and Calcium Level: A Prospective Study. Indian J Endocrinol Metab 2020;24:319-24.
26. Kim BW, Kim SY, Lee YS, et al. Parathyroid score can predict the duration of required calcium supplementation after total thyroidectomy. PLoS One 2017;12:e0174088.

(English Language Editor: A. Kassem)

Cite this article as: Huang T, Zhong X, He T, Zhang W, He Z. Establishing a predictive model of hypoparathyroidism after total thyroidectomy and central lymph node dissection for postoperative calcium supplementation selectively. Ann Transl Med 2022;10(12):678. doi: 10.21037/atm-22-1779

