

Blood parathormon and calcium changes after total thyroidectomy and concurrent parathyroid autotransplantation

Total tiroidektomi ve eş zamanlı paratiroid ototransplantasyonu sonrası kan parathormon ve kalsiyum değişiklikleri

Metin Serin, Türkey Kirdak, Halit Ziya Dundar, Serkan Ceylan, Barış Candan, Nazım Serhat Parlak, Nusret Korun

Uludağ Üniversitesi, Tıp Fakültesi, Genel Cerrahi Kliniği, Bursa

Abstract

Aim: Many studies related with parathyroid autotransplantation are more likely to include data about the number of cases with transient and permanent hypocalcemia. Changes occurred in blood parathormone (PTH) and calcium (Ca²⁺) values during early postoperative period are not sufficiently included. In the present study, changes of blood PTH and Ca²⁺ values in patients underwent concurrent total thyroidectomy and parathyroid autotransplantation; during early postoperative period were evaluated.

Materials and methods: Blood PTH and Ca²⁺ values of 39 consecutive patients underwent concurrent total thyroidectomy and parathyroid autotransplantation at the postoperative 6-12th hours, first day, between 1-4th weeks and sixth month were retrospectively evaluated. Median Percentage (%) Changes (PC) of subsequent measurements based on the first postoperative PTH and Ca²⁺ values between 6-12 hours were examined. In addition, the effect of age, presence of cancer and body mass index on the results of parathyroid autotransplantation were evaluated.

Results: Median blood PTH and median Ca²⁺ levels of 39 cases underwent concurrent total thyroidectomy and parathyroid autotransplantation at the first postoperative 6-12 hours were 9.9 ng/mL and 8.1 mg/dl; respectively. Based on these results, it was observed that median PC values of blood PTH at the postoperative first day did not change significantly whereas median PC values of blood Ca²⁺ still tended to decrease. However; it was

Özet

Amaç: Giriş: Paratiroid ototransplantasyonu ile ilgili mevcut çalışmalar daha çok geçici ve kalıcı hipokalsemi gelişen olgu sayıları ile ilgili veriler içermekte olup, ameliyat sonrası erken dönemde kan parathormon (PTH) ve Kalsiyum (Ca²⁺) değerlerindeki değişimlere yeterince yer vermemektedir. Bu çalışmada total tiroidektomi ile eş zamanlı paratiroid ototransplantasyonu yapılan olguların erken dönem kan PTH ve Ca²⁺ değişimleri incelenmiştir.

Gereç ve yöntem: Total tiroidektomi ve eş zamanlı paratiroid ototransplantasyonu yapılan ardışık 39 hastanın ameliyat sonrası ilk 6-12 saat arasında, 1. günde, 1-4 hafta arasında ve ameliyat sonrası 6. aydaki kan PTH ve Ca²⁺ değerleri geriye dönük olarak incelendi. Ameliyat sonrası ilk 6-12 saatler arasındaki PTH ve Ca²⁺ değerlerine göre daha sonraki ölçümlerin median yüzde (%) değişimleri (YD) incelendi. Ek olarak yaş, cinsiyet, kanser varlığı ve vücut kitle indeksinin paratiroid ototransplantasyonu sonuçlarına etkisi araştırıldı.

Bulgular: Total tiroidektomi ve eş zamanlı paratiroid ototransplantasyonu yapılan 39 olgunun ameliyat sonrası ilk 6-12 saat içindeki median kan Parathormon (PTH) düzeyleri 9.9 ng/mL ve median Ca²⁺ düzeyleri 8.1 mg/dl idi. Bu değerlere göre ameliyat sonrası 1. günde kan PTH median YD değerleri önemli bir değişikliğe uğramadan kalırken, Ca²⁺ median YD değerlerinde azalma yönünde değişimin devam ettiği görüldü. Ancak 1-4 haftalar arasında ve 6. aydaki PTH ve Ca²⁺ median YD değerlerinin artış yönünde değiştiği gö-

Yazışma Adresi | Correspondence: Türkey Kirdak
Uludağ University Medical Faculty Department of Surgery Gorukle
16059/ Bursa
e-mail: tkirdak@uludag.edu.tr

Başvuru tarihi | Submitted on: 21.02.2015

Kabul tarihi | Accepted on: 12.04.2015

observed that median PC values of PTH and Ca+2 at 1-4th weeks and sixth month were changed towards increasing. There were 2 (%5) cases of permanent hypoparathyroidism.

Conclusion: Considerable changes in blood PTH and Ca+2 values during early postoperative period occur in cases underwent parathyroid autotransplantation during total thyroidectomy. However; relationship between these changes in PTH and Ca+2 values and effects of other factors are still controversial.

Key words: Thyroidectomy, parathyroid autotransplantation, hypocalcemia, parathormone, calcium, percent change

rüldü. Kalıcı hipoparatiroidizm 2 (%5) olguda saptandı.

Sonuç: Total tiroidektomi sırasında paratiroid ototransplantasyonu yapılan olgularda ameliyat sonrası erken dönemde kan PTH ve Ca+2 değerlerinde önemli değişimler görülür. PTH ve Ca+2 düzeylerindeki bu değişikliklerin birbiri ile olan ilişkileri ve bunu etkileyen diğer faktörlerin etki miktarları hala araştırmaya açık bir konudur.

Anahtar kelimeler: Tiroidektomi, paratiroid ototransplantasyonu, hipokalsemi, parathormon, kalsiyum, yüzde değişim

Introduction

Symptomatic hypocalcemia and hypoparathyroidism are most common complications seen after thyroidectomy and they are the leading causes of re-hospitalization after surgery^{1,2}. Prevalence of hypocalcemia after thyroidectomy has been reported as %1.6-50. However; most of these cases are transient hypocalcemia in early period. Rate of permanent hypocalcemia has been reported as approximately %2 by most of the researches³. Hypocalcemia may cause prolonged hospitalization, administration of additional laboratory tests and treatment, delay in returning to work and increased financial burden⁴. Therefore, prevention of hypocalcemia after thyroidectomy is important.

Careful and meticulous surgical technique is essential for prevention of hypocalcemia^{3,5}. However; parathyroid glands may still be removed accidentally or vasculature of glands may be damaged⁶. In this case, parathyroid autotransplantation has been recommended for preventing permanent loss of parathyroid functions⁷. In some studies, it was reported that risk of permanent hypocalcemia after surgery can be zeroed by performing routine parathyroid autotransplantation⁸. On the other hand, it should be noted that probability of transient hypocalcemia in early period may be increased in these cases⁹.

Present studies related with parathyroid autotransplantation are more likely to include data about case numbers developed transient and permanent hypocalcemia; changes of blood PTH and Ca+2 in early postoperative period are not adequately represented. In this study, changes of blood PTH and Ca+2 values in early postoperative period and rates of permanent hypocalcemia in cases underwent concurrently total thyroidectomy and parathyroid autotransplantation were evaluated.

Materials and methods

Blood PTH and Ca+2 values of 39 consecutive patients underwent concurrent total thyroidectomy and parathyroid autotransplantation at the postoperative 6-12th hours, first day, between 1-4th weeks and sixth month between January 2007 and June 2014 were retrospectively evaluated.

Same team performed all surgical operations. All parathyroid glands seen during surgery were preserved. Parathyroid glands which were unintentionally removed during thyroidectomy or whose perfusion was impaired were implanted into sternocleidomastoid muscle on the same side in accordance with the autotransplantation technique. None of the patients underwent routine parathyroid autotransplantation.

8,4-10,2 mg/dl and 12-68 pg/ml were considered as normal laboratory values for total Ca+2 and PTH, respectively. Patients required oral calcium and vitamin D replacement therapy for six months or more were considered as "permanent hypocalcemia or hypoparathyroidism". Additionally, effects of presence of cancer, body mass index (BMI), age and gender on the results of parathyroid autotransplantation were evaluated.

Data are presented as medians (minimum-maximum). Compatibility of data to the normal distribution was evaluated with Shapiro Wilk test. Mann-Whitney U test was used for comparison between groups and Chi-square test was used for analysis of associations between categorical variables. For performing comparison of measurements obtained in dependant time periods of variables between groups; percentage (%) change (PC) according to the measurements obtained between first postoperative 6-12 hours [(last measurement-first measurement)/(first measurement)] and obtained PC values were again compared between groups with Mann-Whitney U test. Analyses of the study were per-

Table 1: Demographic, clinical data and Percent Change values of PTH and Ca+2 after surgery of patients

Age	52 (19:66)
Female/Male, n	29 /10
BMI (kg/m ²)	28,04 (19,3:48,9)
Hyperthyroidism, n (%)	14 (%35,8)
Cancer, n (%)	12 (%30,8)
PTH (6-12. hr) pg/ml	9,9 (0,5:68,24)
PTH PC (1 st day)	%0 (-%0,3:%10,9)
PTH PC (1-4 weeks.)	%1,23 (-%0,6:%17,8)
PTH PC (6 th month)	%2,9 (-%0,3:%25,2)
Ca+2 (6-12.hr) mg/dl	8,1 (7:8,8)
Ca+2 PC (1 st day)	-%0,03 (-%0,16:%0,11)
Ca+2 PC (1-4 weeks.)	%0,11 (-%0,11:%0,25)
Ca+2 PC (6 th month)	%0,1 (-%0,08:%0,32)
P. hypocalcemia, n (%)	2 (%5,1)

Data on the table were expressed as percent change and median (min-max). Negative values in percent change indicate decrease relative to first measured value after surgery, positive values in percent change indicate increase relative to first measured value after surgery, **PC:** percent change, **BMI:** body Mass Index, **PTH:** parathormone, **Ca+2:** calcium, **P:** permanent

formed with SPSS v.21 program and p<0.05 values were considered as significant in statistical comparisons.

Results

It was observed that 115 (%11) of the 1048 consecutive patients underwent total thyroidectomy also concurrently underwent parathyroid autotransplantation. Among these cases; a total of 76 patients with history of thyroidectomy or parathyroidectomy, patients underwent concurrent cervical dissection, patients with hyperparathyroidism and patients with missing laboratory values in postoperative period were excluded. Demographics, clinical features and postoperative laboratory data and permanent hypocalcemia of the remaining 39 patients were evaluated.

Median age of the cases was 52 (19:66) and female/male ratio was 29/10. Median BMI was 28,04 (19,3:48,9) and 28 (%72) cases had BMI \geq 25 kg/m². Twelve (%30,8) of the cases underwent surgery for thyroid cancer. Blood median PTH and median Ca+2 values obtained at first postoperative 6-12th hours were 9,9 (0,5:68,24) pg/ml and 8.1 (7:8,8) mg/dl; respectively.

Blood median PTH values measured at first postoperative 6-12th hours were lowest in cases. When median PC value of blood PTH levels obtained later was evaluated, it was found that there were no significant changes at first postoperative median PC of PTH value compared with blood median PTH values obtained at first postoperative 6-12th hours. However; there was an increase in median PC value of PTH obtained at postoperative 1-4th weeks and sixth months compared with median PC value of PTH obtained at postoperative 6-

Table 2: Percent Change values of PTH and Ca+2 after surgery according to presence of cancer

Percent Change	Benign (n=27)	Malign (n=12)	p
PTH (6-12. hr) pg/ml	6,9 (1,8:55,8)	13,8 (0,5:68,2)	0,446
PTH PC (1st day)	%0 (-%0,29:%10,87)	%0 (-%0,13:%9)	0,663
PTH PC (1-4 weeks)	%1,74 (-%0,6:%12,33)	%0,81 (-%0,14:%17,8)	0,538
PTH PC (6th month)	%2,96 (-%0,3:%13,67)	%2,07 (-%0,08:%25,2)	0,663
Ca+2 (6-12.hr) mg/dl	7,9 (7:8,8)	8,25 (7,6:8,8)	0,226
Ca+2 PC (1st day)	-%0,03 (-%0,16:%0,11)	-%0,05 (-%0,13:%0,05)	0,358
Ca+2 PC (1-4 weeks.)	%0,1 (-%0,11:%0,25)	%0,09 (-%0,08:%0,22)	0,964
Ca+2 PC (6th month)	%0,09 (-%0,08:%0,25)	%0,12 (-%0,03:%0,32)	0,753

Data on the table were expressed as percent change and median (min-max). Negative values in percent change indicate decrease relative to first measured value after surgery, positive values in percent change indicate increase relative to first measured value after surgery, **PC:** Percent change, **PTH:** Parathormone, **Ca+2:** calcium

12th hours. In contrast to the PTH, it was observed that there was still a trend towards decreasing at median PC values of blood Ca+2 obtained at postoperative first day compared with median Ca+2 values obtained at first postoperative 6-12th hours. However, there was an increase in median PC value of blood Ca+2 obtained at postoperative 1-4th week and sixth month (**Table 1**).

There were 2 (%5.1) cases of permanent hypocalcemia. These two cases were both older than 40 years and female. They had both undergone surgery for benign reasons and one of them had hyperthyroidism. There was no significant difference in comparisons between groups for permanent hypocalcemia, $p>0.05$.

When cases were grouped as benign and malign according to their histopathologic results, there was no statistically significant difference between these two groups according to median PC values of PTH and Ca+2 obtained at postoperative first day, 1-4th week and sixth month compared with blood median values of PTH and Ca+2 obtained at postoperative 6-12th hour, $p>0,05$ (**Table 2**).

When cases were grouped according to the genders; it was observed that Ca+2 values were still decreasing at first postoperative day in both groups. When median PC values of both of these groups obtained at first postoperative day were compared; it was observed that median PC value of blood Ca+2 obtained postoperatively were significantly towards decreasing in female patients ($p<0,05$). However; it was also observed that Ca+2 values at postoperative 1-4th week and sixth month started to increase and difference in median PC values. was re-

solved. There was no difference in comparison between male and female groups in terms of median PC values of PTH ($p>0.05$) (**Table 3**).

Patients were grouped as BMI <25 kg/m² and BMI ≥ 25 kg/m², then median PC values of postoperative PTH and Ca+2 were compared. It was found that increase in median PC values of blood Ca+2 obtained at postoperative 1-4th week in patients with BMI ≥ 25 kg/m² were less prominent than patients with BMI <25 kg/m² ($p<0,05$). However; it was observed that this difference was resolved in median PC values of Ca+2 obtained at postoperative sixth month ($p>0,05$). There was no difference between two groups in terms of median PC values of PTH ($p>0,05$) (**Table 4**).

Patients were grouped as aged ≤ 40 and >40 , then blood median PC values of PTH and Ca+2 obtained at first day, 1-4th week and sixth month compared with blood median PTH and Ca values obtained at postoperative 6-12th hour were calculated. There was no significant difference between median PC value of PTH obtained at postoperative first day. There were increases in both groups of the PTH values of postoperative 1-4th week. However; it was observed that median PC value of PTH was significantly higher in cases older than 40 years ($p=0,007$). On the other hand, it was also found that age had no effect on blood PTH values obtained at postoperative sixth month ($p>0,05$). When blood median Ca+2 values obtained at postoperative 6-12th hour were compared with median PC values of Ca+2 obtained later; there was no difference between these two groups ($p>0,05$) (**Table 5**).

Table 3: Percent Change values of PTH and Ca+2 after surgery according to sex

Percent Change	Benign (n=29)	Malign (n=10)	p
PTH (6-12.hr) pg/ml	9,9 (0,5:68,2)	8,9 (1,8:43,7)	0,465
PTH PC (1st day)	%0 (-%0,29:%10,87)	%0 (-%0,13:%5,56)	0,079
PTH PC (1-4 weeks)	%1,83 (-%0,6:%17,8)	%0,18 (-%0,11:%12,33)	0,208
PTH PC (6th day)	%2,96 (-%0,3:%25,2)	%01,67 (-%0,06:%13,67)	0,601
Ca+2(6-12. hour) mg/dl	8,1 (7:8,8)	8,2 (7,3:8,7)	0,141
Ca+2 PC (1st day)	-%0,05 (-%0,16:%0,09)	-%0,01 (-%0,11:%0,11)	0,028
Ca+2 PC (1-4 weeks.)	%0,1 (-%0,11:%0,25)	%0,09 (-%0,06:%0,22)	0,601
Ca+2 PC (6. month)	%0,09 (-%0,08:%0,32)	%0,13 (-%0,05:%0,25)	0,74

Data on the table were expressed as percent change and median (min-max). Negative values in percent change indicate decrease relative to first measured value after surgery, positive values in percent change indicate increase relative to first measured value after surgery. **PC:** Percent change, **BMI:** Body Mass Index, **PTH:** Parathormone, **Ca+2:** calcium

Tablo 4: Percent Change values of PTH and Ca+2 after surgery according to Body Mass Index

Percent Change	BMI (kg/m ²) < 25 (n=11)	BMI (kg/m ²) ≥25 (n=28)	p
PTH (6-12. hour) pg/ml	10,05 (2,89;68,24)	9,16 (0,5;55,8)	0,513
PTH PC (1st day)	%0 (-%0,02;%10,87)	%0 (-%0,29;%9)	0,678
PTH PC (1-4 weeks)	%0,39 (-%0,14;%7,58)	%1,79 (-%0,6;%17,8)	0,315
PTH PC (6th month)	%2,65 (-%0,08;%13,67)	%3,01 (-%0,3;%25,2)	0,528
Ca+2(6-12. hour) mg/dl	8,1 (7,4;8,6)	8,15 (7;8,8)	0,674
Ca+2 PC (1st day)	-%0,02 (-%0,1;%0,09)	-%0,05 (-%0,16;%0,11)	0,188
Ca+2 PC (1-4 weeks)	%0,15 (-%0,06;%0,21)	%0,07 (-%0,11;%0,25)	0,024
Ca+2 PC (6th month)	%0,14 (-%0,05;%0,21)	%0,08 (-%0,08;%0,32)	0,221

Data on the table were expressed as percent change and median (min-max). Negative values in percent change indicate decrease relative to first measured value after surgery, positive values in percent change indicate increase relative to first measured value after surgery. **PC:** Percent change, **BMI:** Body Mass Index, **PTH:** Parathormone, **Ca+2:** calcium

When cases were grouped as having hyperthyroidism or not; there was no difference between groups in terms of median PC values of PTH and Ca+2 ($p>0,05$).

Discussion

For re-function of parathyroid tissue after autotransplantation, functional vascularity must be re-occured. When parathyroid gland is implanted into muscle, it probably initiates an angiogenic response and creates a new microvascular circulation to itself from regional

vasculature in time¹⁰. After these events, tissue becomes competent for adequate PTH secretion to the circulation. If other parathyroid glands are negatively affected during surgery; probability of hypocalcemia may increase during time period passed until re-function of implanted parathyroid tissue. This condition may be an important cause of hypocalcemia occurred during early postoperative period in cases concurrently underwent thyroidectomy and parathyroid autotransplantation. In our study, it was found that median value of PTH which has a very short half-life were low in first postoperative

Tablo 5: Percent Change values of PTH and Ca+2 after surgery according to age

Percent Change	Age≤40 (n=10)	Age>40 (n=29)	p
PTH (6-12.hour) pg/ml	14,7 (3;68,2)	8,3 (0,55,8)	0,465
PTH PC (1st day)	%0 (-%0,29;%0)	%0 (-%0,13;%10,87)	0,04
PTH PC (1-4 weeks)	%0,3 (-%0,6;%1,75)	%2,23 (-%0,11;%17,8)	0,007
PTH PC (6th month)	%1,18 (-%0,08;%8,87)	%3,07 (-%0,3;%25,2)	0,196
Ca+2 (6-12. hour) mg/dl	8,1 (7,7;8,8)	8,1 (7;8,8)	0,692
Ca+2 PC (1st day)	-%0,02 (-%0,13;%0,11)	-%0,03 (-%0,16;%0,09)	0,495
Ca+2 PC (1-4 weeks)	%0,14 (-%0,01;%0,18)	%0,1 (-%0,11;%0,25)	0,601
Ca+2 PC (6th month)	%0,14 (-%0,08;%0,25)	%0,09 (-%0,07;%0,32)	0,987

Data on the table were expressed as percent change and median (min-max). Negative values in percent change indicate decrease relative to first measured value after surgery, positive values in percent change indicate increase relative to first measured value after surgery. **PC:** Percent change, **PTH:** Parathormone, **Ca+2:** calcium

6-12th hour and it remained low without significant difference at postoperative first day. Therefore, blood Ca²⁺ values were found as low and median PC values tended to decrease at postoperative first day. However; when median PC values at postoperative 1-4th weeks and sixth month were evaluated, it was found that there were increases in PTH and Ca²⁺ values. These findings are likely to suggest aforementioned hypothesis.

Hypocalcemia after thyroidectomy is a frequent complication. Actually, development of hypocalcemia is related with multiple factors. These factors causing hypocalcemia include biochemical factors such as perioperative PTH levels, preoperative vitamin D levels, postoperative Ca²⁺ values as well as clinical factors such as female gender, Graves disease, presence of parathyroid autotransplantation or removal of parathyroids unintentionally¹¹. Patients concurrently underwent thyroidectomy and parathyroid autotransplantation are also affected by similar factors. Hypocalcemia in early period is even frequent in these cases.

Series with preservation of parathyroid glands have rates of permanent hypocalcemia as %0-%32 whereas this rate has been reported as %0-%43 in cases underwent parathyroid autotransplantation¹⁰. However, studies related with this issue have been reported considerable reduction of permanent hypocalcemia if parathyroid autotransplantation was performed in cases suspected for impaired function^{7-9,12}. In our study, we found the rate of permanent hypocalcemia in cases underwent parathyroid autotransplantation as %5. In the light of rate of permanent hypocalcemia as %2 after total thyroidectomy, this rate seems a little higher. We couldn't present results of cases without transplantation due to lack of control group. However, rate of detecting parathyroid gland was found to be %9 in histopathologic evaluations after thyroidectomy. In recurrent cases, this rate was doubled¹³. Therefore, it should be noted that there is also increased risk of injury for other parathyroid glands in cases required transplantation and probability of hypocalcemia may be increased.

Various factors play role in hypocalcemia after thyroidectomy. Risk factors reported by various studies related with this issue sometimes interfere with each other. For example, a study reported that gender had no effect on hypocalcemia whereas in another study reported female gender as a risk factor^{1,5}. In our study, there was no significant difference between male and female patients in terms of blood PTH and Ca²⁺ levels obtained at first 6-12th hour. However, median PC value of Ca²⁺ levels obtained at postoperative first day tended to decrease more prominently in women. Median PC values of both PTH and Ca²⁺ obtained at postoperative 1-4th week and sixth month tended to increase and there was no difference between groups. This finding is likely to

support data about increased risk of hypocalcemia in early postoperative period in female cases.

Probability of hypocalcemia has been reported as increased in young patients¹. In our cases, patients were grouped as aged older than 40 years and younger than 40 years. When median PC values of PTH and Ca²⁺ were compared, it was found that there were no significant differences ($p > 0.05$) in comparison of all median PC values except only significantly ($p < 0.05$) more increased blood median PC values of PTH obtained at postoperative 1-4th week in young patients than the patients older than 40 years. This finding is consistent with the literature.

Risk of hypocalcemia is correlated with extent of the surgery. For example, hypocalcemia is more frequently observed after total thyroidectomy than hemithyroidectomy or subtotal thyroidectomy⁵. Addition of central region dissection to the thyroidectomy further increases risk of hypocalcemia¹⁴. However, there are also several studies reporting this addition as inefficient on the risk of postoperative hypocalcemia¹. In our study; it was observed that there was no significant difference between benign and malign cases in terms of median PC values of PTH and Ca²⁺. This may be related with exclusion of cases of cancer performed cervical dissection and performing total thyroidectomy in all cases.

When cases were grouped as BMI < 25 kg/m² and BMI ≥ 25 kg/m²; it was observed that increase of median PC values of Ca²⁺ obtained at 1-4th week was less prominent in overweight patients ($p < 0.05$).

Hyperthyroidism was found to be an independent risk factor both for transient and permanent hypocalcemia^{5,15}. In cases with subtotal thyroidectomy; it was reported that rate of biochemical hypocalcemia was %46 and rate of symptomatic hypocalcemia was %21. However, hypoparathyroidism is not the only reason of increased frequency of hypocalcemia in patients underwent thyroidectomy due to hyperthyroidism. Hungry bone syndrome may also cause hypocalcemia in these cases¹⁵. However, when we grouped our cases as having hyperthyroidism or not; there was no significant difference in median PC values of PTH and Ca²⁺. One of the two cases with permanent hypocalcemia had hyperthyroidism. However; there was no significant difference between groups.

In conclusion, there are considerable changes in consecutive blood PTH and Ca²⁺ values obtained in early postoperative period. Relations between these changes and other factors affecting these relations are still an issue for research and evaluation.

References

1. Bhattacharyya N, Fried MP. Assessment of the morbidity and complications of total thyroidectomy. *Arch Otolaryngol Head Neck Surg.* 2002;128(4):389-392.

2. Iannuzzi JC, Fleming FJ, Kelly KN, Ruan DT, Monson JR, Moalem J. Risk scoring can predict readmission after endocrine surgery. *Surgery*. 2014; 156(6):1432-1440.
3. Reeve T, Thompson NW. Complications of thyroid surgery: how to avoid them, how to manage them, and observations on their possible effect on the whole patient. *World J Surg*. 2000; 24(8):971-975.
4. Testini M, Gurrado A, Lissidini G, Nacchiero M. Hypoparathyroidism after total thyroidectomy. *Minerva Chir*. 2007; 62(5):409-415.
5. Thomusch O, Machens A, Sekulla C, Ukkat J, Brauckhoff M, Dralle H. The impact of surgical technique on postoperative hypoparathyroidism in bilateral thyroid surgery: a multivariate analysis of 5846 consecutive patients. *Surgery*. 2003; 133(2):180-185.
6. Erbil Y, Barbaros U, Ozbey N, Aral F, Ozarmağan S. Risk factors of incidental parathyroidectomy after thyroidectomy for benign thyroid disorders. *Int J Surg*. 2009; 7(1):58-61.
7. Lo CY, Lam KY. Postoperative hypocalcemia in patients who did or did not undergo parathyroid autotransplantation during thyroidectomy: a comparative study. *Surgery*. 1998; 124(6):1081-1087.
8. Zedenius J, Wadstrom C, Delbridge L. Routine autotransplantation of at least one parathyroid gland during total thyroidectomy may reduce permanent hypoparathyroidism to zero. *Aust N Z J Surg*. 1999; 69(11):794-797.
9. Trupka A, Sieneł W. Autotransplantation of at least one parathyroid gland during thyroidectomy in benign thyroid disease minimizes the risk of permanent hypoparathyroidism. *Zentralbl Chir*. 2002; 127(5):439-442.
10. Lo CY. Parathyroid autotransplantation during thyroidectomy. *ANZ J Surg*. 2002; 72(12):902-907.
11. Edafe O, Antakia R, Laskar N, Uttley L, Balasubramanian SP. Systematic review and meta-analysis of predictors of post-thyroidectomy hypocalcaemia. *Br J Surg* 2014; 101:307-320.
12. Abboud B, Sleilaty G, Zeineddine S, et al. Is therapy with calcium and vitamin D and parathyroid autotransplantation useful in total thyroidectomy for preventing hypocalcemia? *Head Neck*. 2008; 30(9):1148-1154.
13. Lin DT, Patel SG, Shaha AR, Singh B, Shah JP. Incidence of inadvertent parathyroid removal during thyroidectomy. *Laryngoscope*. 2002; 112(4):608-611.
14. Sancho JJ, Lennard TW, Paunovic I, Triponez F, Sitges-Serra A. Prophylactic central neck dissection in papillary thyroid cancer: a consensus report of the European Society of Endocrine Surgeons (ESES). *Langenbecks Arch Surg*. 2014; 399(2):155-163.
15. See AC, Soo KC. Hypocalcaemia following thyroidectomy for thyrotoxicosis. *Br J Surg*. 1997; 84(1):95-97.