

Incidence of transient and chronic hypoparathyroidism after total thyroidectomy – the experience of a tertiary center

Cristian Velicescu^{1,2}, Stefana Catalina Bilha^{2,3,*}, Alexandra Teleman^{1,2}, Andrada Vitelariu^{1,2}, Laura Teodoriu⁴, Alexandru Florescu^{2,3}, Roxana Novac⁵

¹Surgery Department, “Sf. Spiridon” Emergency Hospital, Iasi, Romania. ²“Grigore T. Popa” University of Medicine and Pharmacy, Iasi, Romania. ³Endocrinology Department, “Sf. Spiridon” Emergency Hospital, Iasi, Romania. ⁴Endocrinology Department, Regional Institute of Oncology, Iasi, Romania. ⁵Endocrinology Department, Moinești Emergency Hospital, 605400 Moinești, Romania.

*Correspondence: Stefana Catalina Bilha, Endocrinology Department, “Grigore T. Popa” University of Medicine and Pharmacy, 16 Universității str., Iasi, Romania. Email: stefana.bilha@umfiiasi.ro

How to cite this article: Velicescu C, Bilha SC, Teleman A, et al. Incidence of transient and chronic hypoparathyroidism after total thyroidectomy – the experience of a tertiary center. Arch Clin Cases. 2024;11(3):93-97. doi: 10.22551/2024.44.1103.10296

ABSTRACT

Background: The most common cause of hypoparathyroidism (hypoPT) in adults is iatrogenic due to total thyroidectomy, while the ideal moment for considering it chronic is still under debate. Our study aims at reporting the prevalence of transient and permanent hypoPT following thyroid surgery in a tertiary surgical center, as well as serum Parathormone (PTH) variation up to 12 months after surgery stratified according to the type of thyroid disease. **Material and methods:** 519 patients who underwent total thyroidectomy in a tertiary surgical center from 2018 to 2023 were analyzed. Postoperative hypoPT was defined as low PTH (less than 15 pg/ml) and/or hypocalcemia (albumin-corrected levels less than 8.5 mg/dl) on day 1 after surgery. Patients were considered to have permanent hypoPT if they had not recovered completely within 1 year after total thyroidectomy. PTH levels were compared according to the underlying thyroid disease. **Results:** 140 patients (26.97%) had postoperative hypoPT. Twenty-two patients (4.23%) were considered to have permanent hypoPT 12 months after surgery. Approximately half of the patients recovered between 3 months and 12 months after surgery. HypoPT thyroiditis patients had higher PTH levels 3 months after surgery compared to papillary/follicular cancer and multinodular goiter, respectively, and all recovered 1 year after surgery. Papillary/follicular carcinoma was associated with a 29.4% rate of transient and 8.5% rate of chronic hypoPT, respectively. **Conclusion:** Most patients without incidental parathyroidectomy that still develop postoperative hypoPT will eventually recover; nevertheless, it can take up to 1 year for full resolution. Measuring serum PTH 3 months postoperative may be of interest.

KEYWORDS: total thyroidectomy; iatrogenic hypoparathyroidism; hypocalcemia; PTH; malignancy

INTRODUCTION

A widespread surgical procedure, thyroidectomy is performed either as lobectomy or total thyroidectomy, depending on the primary thyroid disease [1]. Total thyroidectomy is usually reserved for high suspicion of malignancy, Graves' disease or multinodular goiter that compresses the surrounding nerves or organs [2].

Iatrogenic injury of the parathyroid glands, as one can expect unintentionally, can be a consequence of total thyroidectomy. Parathormone (PTH) and serum calcium are measured the day after surgery to identify patients at risk for hypocalcemia. A low serum calcium accompanied by “inadequately” normal PTH concentrations often

characterizes transient hypoparathyroidism (hypoPT) [3]. Serum PTH concentrations below the lower normal limits are reported to vary considerably, between 7% to 37% [4]. Iatrogenic hypoPT can be transient, or permanent, and is due to inadvertent resection, fragmentation, devascularization, thermal injury or autotransplantation to the sternocleidomastoid muscle [5]. Indeed, the rate of transient hypoPT is quite high in dedicated meta-analyses, reaching 19-38% [6], while between 1-7% of total thyroidectomies have therefore chronic hypoPT [7]. However, there is a lack of agreement between different referral centers about how to differentiate between transient and chronic and what is the best definition for the restoration of the parathyroid function.

Patients are considered “cured” in several reports when their serum PTH levels reaches 10 pg/mL and they do not have symptoms specific to hypocalcemia, although they might still have slightly low serum calcium [8,9]. HypoPT

Received: July 2024; **Accepted after review:** September 2024;

Published: September 2024.



remission is considered by other authors when the patient is free of symptoms despite stopping calcium and vitamin D analogs supplementation [10,11]. Finally, a normal serum PTH value together with the patient no longer requiring calcium and vitamin D analogs to prevent clinical hypocalcemia is accepted by others [12,13]. Nonetheless, misclassification as chronic hypoPT can occur, and thus vitamin D analogs and calcium supplements should be carefully tapered to confirm chronic hypoPT [14].

This study aims at reporting the prevalence of transient and permanent hypoparathyroidism following thyroid surgery in a tertiary surgical center, as well as serum PTH variation up to 12 months after surgery stratified according to the type of thyroid disease referred to surgery.

■ MATERIAL AND METHODS

We performed a retrospective study of 519 patients who underwent total thyroidectomy in a tertiary hospital between January 2018 and December 2023 for suspicion of malignant/malignant or benign thyroid disease (multinodular goiter, Graves’ disease). Demographic data of the patients, pre-operative biochemical values, surgical indications, intraoperative findings, post-operative 1st day calcium values, and results of pathology report were reviewed. We excluded patients who had a higher incidence of parathyroid tissue identified on their final pathology report, suggesting inadvertent removal of parathyroid tissue, patients that underwent parathyroid gland autotransplantation and those with abnormal calcium and PTH values before surgery.

All patients included in this study had their serum PTH levels measured within 24 hours, at 3 months and at 12 months after surgery, respectively. Low PTH was defined as a PTH measurement <15 pg/mL (normal limits of the assay 15-65 pg/ml). Hypocalcemia was defined as albumin-corrected calcium values less than 8.5 mg/dl. Patients exhibiting low PTH and/or hypocalcemia after neck surgery were classified as having post-operative hypoPTH.

Recovery of parathyroid gland function was defined as serum PTH ≥15 pg/mL, with the patient not requiring daily calcium and vitamin D analogs to maintain a low-normal albumin-corrected serum calcium. Patients were considered to have permanent hypoPT if they had not recovered completely within 1 year after total thyroidectomy.

Statistical analysis was performed using SPSS software (SPSS version 20.0 for Windows, IBM SPSS Inc.). Data are expressed as mean ± standard error of the mean (SEM). Cumulative incidence of hypoPT cases in the whole cohort and according to the underlying thyroid disease are reported. Differences between 3 months and 12 months PTH values were tested using the independent samples t-test. Subgroup analysis of age and PTH values according to thyroid disease type (group 1- papillary/follicular cancer, group 2- thyroiditis and group 3- multinodular goiter) was performed using analysis of variance (one way ANOVA). Chi-square test of independence was used to test whether there is an association between thyroid disease behavior and hypoPT (transient or chronic). The level of significance was established for p-value < 0.05.

■ RESULTS

Of 519 patients, 140 (26.97%) were identified as having postoperative hypoPT on day 1 after surgery (Figure 1). Mean age in this group was 59.35 ± 2.41 years and most patients were females (123 women and 17 men, female-to-male ratio 7:1). Patients with thyroiditis were younger compared to thyroid carcinoma

Four patients with hypoPT unfortunately were lost to follow-up (anaplastic carcinoma followed by *exitus*). A quarter (n=35) of patients in the hypoPT group showed resolution of parathyroid function within 3 months after surgery, while approximately half of them (n= 79, 56.4%) recovered in the first 12 months (Figure 1). Thus, the rate of transient hypoPT was 21.9 %. One year after neck surgery, 22 patients (4.23%) were considered to have permanent

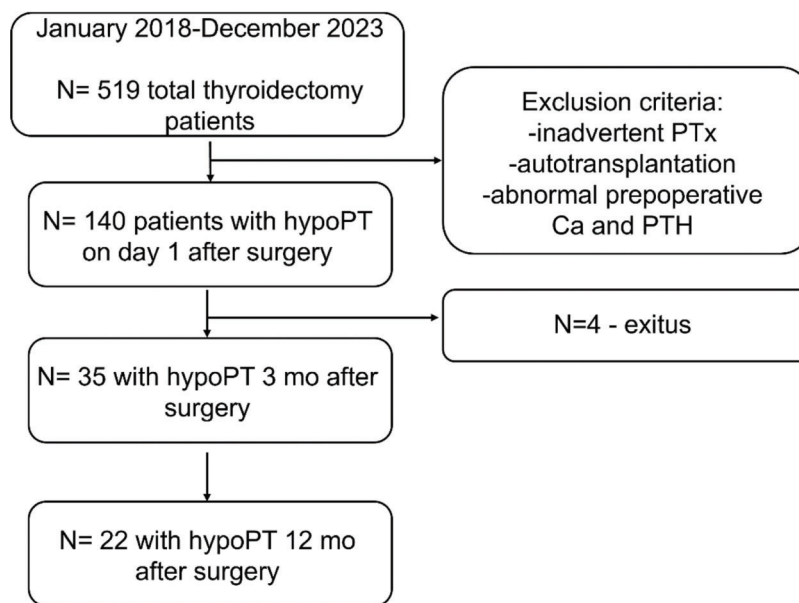


Fig. 1. Flow-chart presenting the selection criteria and evolution of patients with postoperative hypoparathyroidism up to 12 months after surgery. hypoPT= hypoparathyroidism, mo= months, PTX= parathyroidectomy, Ca= calcium, PTH= parathormone.

Table 1. Evolution of PTH values after total thyroidectomy according to the underlying thyroid disease.

	Total (n)	24 h hypoPT (n)	3 months hypoPT (n)	12 months hypoPT PTH (n)
Papillary/follicular carcinoma	129 cases	49	15	11
Medullary carcinoma	6 cases	2	1	0
Anaplastic carcinoma	5 cases	4	NA	NA
Thyroiditis	45 cases	16	5	0
Multinodular goiter	334 cases	69	14	11

PTH= parathormone; n= number; NA= not available; hypoPT= hypoparathyroidism.

Table 2. Age and PTH values at 3 months and 12 months postoperative in the overall hypoPT group and according to the type of thyroid disease.

	Age (years)	PTH 3 months after surgery (pg/ml)	PTH 12 months after surgery (pg/ml)
Overall group	59.35 ± 2.41	7.03 ± 0.92	17.84 ± 3.51*
Subgroup			
1. Papillary/follicular carcinoma	65.23 ± 3.81 ²	6.8 ± 1.38 ²	12.08 ± 3.66 ^{NS}
2. Thyroiditis	40.4 ± 4.3 ^{1,3}	12.18 ± 1.03 ^{1,3}	34.42 ± 8.9**
3. Multinodular goiter	58.6 ± 2.45 ²	5.53 ± 1.44 ²	18.24 ± 6.94 ^{NS}
P (between groups)	0.001	0.037	0.110

¹p<0.05 compared to subgroup 1, ²p<0.05 compared to subgroup 2, ³p<0.05 compared to subgroup 3.

*p<0.001 compared to 3 months PTH in the overall group.

**p= 0.066 compared to 3 months PTH in the thyroiditis subgroup.

^{NS}= non-significant compared to 3 months PTH value in the same subgroup.

hypoparathyroidism (Table 1). Thus, 84% percent of patients having postoperative hypoPT recovered 12 months after surgery.

To assess the evolution of the parathyroid function according to the type of thyroid disease referred to surgery, HypoPT patients were further divided according to the primary indication for surgery and/or pathology report (Tables 1 and 2). The incidence of hypoPT was 29.4% for transient and 8.5% for chronic in papillary and/or follicular thyroid carcinoma, and 19.5% for transient and 2.9% for chronic in benign thyroid disease (thyroiditis and multinodular goiter), respectively. One third of patients with medullary thyroid carcinoma developed transient hypoPT, but all of them recovered (Table 1).

However, when only considering patients undergoing thyroidectomy for thyroiditis (e.g. Graves' disease), they were younger compared to the other subgroups (multinodular goiter and thyroid carcinoma patients), had significantly higher PTH levels 3 months after surgery compared to papillary/follicular cancer and multinodular goiter patients and all of them had normal parathyroid function 1 year after surgery (Tables 1 and 2).

PTH was significantly higher 12 months after surgery compared to 3 months postoperative in the overall group (p<0.001, Table 2), as well as in the thyroiditis subgroup (p= 0.066, Table 2); however, PTH concentrations did not differ significantly one year after surgery in the papillary/follicular carcinoma versus thyroiditis versus multinodular goiter group (p= 0.110, Table 2). Mean PTH also tended to be higher at 12 months compared to 3 months after surgery in the papillary/follicular cancer (p= 0.195) and multinodular subgroup (p= 0.096), respectively, but the difference did not reach statistical significance (Table 2).

No association was found between type of thyroid disease behavior (benign versus malignant) and duration of hypoparathyroidism (transient versus chronic) (Chi-square test $\chi^2(1) = 2.33$, p= 0.127).

Nevertheless, a higher prevalence for hypoPT was observed in patients with aggressive thyroid cancer: 4 out of the 5 patients with anaplastic carcinoma developed postoperative hypoPT, in whom we unfortunately could not tell if it was transitory because none of them survived at 1 year after neck surgery.

DISCUSSION

Iatrogenic hypoPT often occurs after total thyroidectomy [14]. In our study, day 1 postoperative low PTH was encountered in a quarter of patients, with transient hypoPT rates varying between 19.5% for benign disease and 29.4% for papillary and/or follicular thyroid cancer. However, most patients regained normal parathyroid gland 3 months after surgery. Finally, chronic hypoPT was established in 8.5% of patients with papillary/follicular carcinoma and 2.9% of patients with benign disease. Thyroiditis patients tended to recover earlier, as PTH was significantly higher 3 months after surgery in this subgroup compared to thyroid carcinoma and multinodular goiter, respectively.

The 26.97% incidence of a low postoperative PTH on day 1 after neck surgery is in accordance with the hypoPT incidence range of up to 46% - 60% found in the literature [7,15]. Various definitions employed to identify patients as having transient hypoPT after total thyroidectomy may contribute to the discrepancies.

The fact that we considered a higher value for PTH, defining hypoparathyroidism as <15 pg/ml can lead to a higher number of cases, as generally most of the studies refer to a value of <10 pg/ml [16-18]. Thomusch et al. [4] defined postoperative hypoPT considering only the clinical criteria, such as the need for calcium and/or vitamin D supplementation to control hypocalcemia symptoms. Disregarding asymptomatic patients having serum PTH <10 pg/mL may explain the low incidence rate of 7% for hypoPT in their study [4]. On the other hand, lowering the cut-off for

postoperative low PTH to less than 10 pg/ml led to a higher incidence of 37% for hypoPT in the study of McCullough et al. [17] compared to what we found, probably due to this cutoff [17].

According to the European consensus on parathyroid disorders [14], permanent hypoPT should be established at least 6 months after neck surgery, as the need to use vitamin D analogs to ensure a low-normal serum calcium. Nevertheless, the guidelines state that the recovery of the parathyroid function can occur even later than 6 months [14]. In our study, most of the patients regained their normal parathyroid activity between 3 months and 1 year after surgery. At 12 months after surgery, PTH levels were similar across all thyroid disease subgroups in our study, although mean PTH was still under the cut-off of 15 pg/ml in the papillary/follicular cancer subgroup. Using an earlier time frame could result in misclassifying some patients that could still regain their parathyroid function as having permanent hypoPT. Chow et al. [12] reported a 2.8% incidence of permanent hypoPT – using similar criteria as our study – 6 months after surgery. Still, the here-in reported incidence of chronic hypoPT is in accordance with literature reported incidence up to 8-10% [15].

According to dedicated guidelines [14], risk factors for developing chronic hypoPT include thyroid cancer with central neck dissection and Graves' disease, obesity, repeated surgery, co-existent thyroid and parathyroid disorders. Therefore, parathyroid function evaluation should be part of preoperative thyroid evaluation undergoing elective surgery. We also found a higher incidence of chronic hypoPT in malignancy – probably due to extensive neck surgery. However, there was no significant association between duration of hypoparathyroidism (transient versus chronic) and type of thyroid disease (benign versus malignant). This may be partly explained by the surprising finding of all patients undergoing total thyroidectomy for Graves' disease having normal parathyroid function 12 months after surgery. The higher incidence of permanent hypoPT in multinodular goiter patients compared to Graves' disease patients undergoing thyroidectomy may be explained either by the extensive and compressive nature of the underlying nodular goiter, or by the more radical approach due to suspected thyroid carcinoma. Also, patients undergoing surgery for medullary thyroid carcinoma that developed early postoperative hypoPT, recovered fully afterwards.

Various PTH thresholds on day1 after neck surgery have been proposed to predict either the development of chronic hypoPT, or, on the contrary, of normal parathyroid function. Values less than 5.5 pg/ml were considered risk factor in some studies [19,20]. A decrease in PTH of more than 70% compared to presurgical values was proposed as an alternative to predict chronic hypoPT [21–23]. Conversely, values higher than 10 pg/ml predicted recovery at 6 months after surgery [14]. In our study, approximately 84% of the patients having PTH less than 15 pg/ml on day 1 postoperative eventually recovered. Determining serum PTH 3 months after surgery may add considerable information, as the thyroiditis subgroup had significantly higher serum PTH (above 10 pg/ml) compared the other subgroups (less than 10 pg/ml) at this time point and finally fully recovered.

Our study is limited by its retrospective nature, the relatively small number of patients in the subgroup analysis, as well as the heterogeneity of these subgroups. Also, patients with aggressive forms of cancer were lost to

follow-up. Finally, extrathyroidal extension in differentiated thyroid carcinoma requires more aggressive surgical techniques, which can inadvertently affect the nearby parathyroid glands [24]. However, the grade of surgery extension in papillary/follicular carcinoma was not assessed in our study.

■ CONCLUSION

Most patients without incidental parathyroidectomy associated to neck surgery for thyroid disease but still having a low day 1 postoperative PTH value will eventually recover; nevertheless, it can take up to 1 year for full resolution. It is also possible that a small part of them will recover even after this first year. Measuring 3 months postoperative serum PTH may be considered when evaluating the risk of chronic hypoPT. The rate of recovery from transient hypoPT is higher in neck surgery performed for benign thyroid disease. However, the rate of chronic hypoPT was higher for multinodular goiter than for thyroiditis in our study, probably due to large and/or compressive disease or a more radical surgical approach due to suspicion of malignancy. This may finally explain the lack of association between transient/chronic hypoPT and behavior of thyroid disease (benign or malignant).

Conflict of interest

The authors declare that they have no competing interests.

Ethics Committee approval

The study adhered to the Declaration of Helsinki and was approved by the Ethics Committee of "Sf. Spiridon" Emergency County Hospital, Iasi, Romania (1260/22.11.2023).

Informed consent

Written informed consent for data processing and publication was obtained from the patients included in the study cohort.

■ REFERENCES

- Xu S, Huang H, Huang Y, et al. Comparison of Lobectomy vs Total Thyroidectomy for Intermediate-Risk Papillary Thyroid Carcinoma With Lymph Node Metastasis. *JAMA Surg.* 2023 Jan 1;158(1):73-9. PMID: 36449303; PMCID: PMC9713681. doi: 10.1001/jamasurg.2022.5781.
- Haugen BR, Alexander EK, Bible KC, et al. 2015 American Thyroid Association Management Guidelines for Adult Patients with Thyroid Nodules and Differentiated Thyroid Cancer: The American Thyroid Association Guidelines Task Force on Thyroid Nodules and Differentiated Thyroid Cancer. *Thyroid.* 2016 Jan;26(1):1-133. PMID: 26462967; PMCID: PMC4739132. doi: 10.1089/thy.2015.0020.
- Abate EG, Clarke BL. Review of Hypoparathyroidism. *Front Endocrinol (Lausanne).* 2017 Jan 16;7:172. PMID: 28138323; PMCID: PMC5237638. doi: 10.3389/fendo.2016.00172.
- Thomusch O, Machens A, Sekulla C, et al. The impact of surgical technique on postoperative hypoparathyroidism in bilateral thyroid surgery: a multivariate analysis of 5846 consecutive patients. *Surgery.* 2003 Feb;133(2):180-5. PMID: 12605179. doi: 10.1067/msy.2003.61.
- Sitges-Serra A. Etiology and Diagnosis of Permanent Hypoparathyroidism after Total Thyroidectomy. *J Clin Med.* 2021 Feb 2; 10(3):543. PMID: 33540657; PMCID: PMC7867256. doi: 10.3390/jcm10030543.
- Edafe O, Antakia R, Laskar N, et al. Systematic review and meta-analysis of predictors of post-thyroidectomy hypocalcaemia. *Br J Surg.* 2014 Mar;101(4):307-20. PMID: 24402815. doi: 10.1002/bjs.9384.

7. Hillary SL, Chooi JE, Wadsley J, et al. Quality of Life in Post-Surgical Hypoparathyroidism (PoSH) in Thyroid and Parathyroid Surgery. *World J Surg.* 2022 Dec;46(12):3025-33. PMID: 36184675; PMCID: PMC9636109. doi: 10.1007/s00268-022-06730-7.
8. Youngwirth L, Benavidez J, Sippel R, et al. Parathyroid hormone deficiency after total thyroidectomy: incidence and time. *J Surg Res.* 2010 Sep;163(1):69-71. PMID: 20605611. doi: 10.1016/j.jss.2010.03.059.
9. Al-Dhahri SF, Mubasher M, Mufarji K, et al. Factors predicting post-thyroidectomy hypoparathyroidism recovery. *World J Surg.* 2014 Sep;38(9):2304-10. PMID: 24728582. doi: 10.1007/s00268-014-2571-6.
10. Almquist M, Hallgrímsson P, Nordenström E, et al. Prediction of permanent hypoparathyroidism after total thyroidectomy. *World J Surg.* 2014 Oct;38(10):2613-20. PMID: 24791907. doi: 10.1007/s00268-014-2622-z.
11. Karamanakos SN, Markou KB, Panagopoulos K, et al. Complications and risk factors related to the extent of surgery in thyroidectomy. Results from 2,043 procedures. *Hormones (Athens).* 2010 Oct-Dec;9(4):318-25. PMID: 21112863. doi: 10.14310/horm.2002.1283.
12. Chow TL, Choi CY, Chiu AN. Postoperative PTH monitoring of hypocalcemia expedites discharge after thyroidectomy. *Am J Otolaryngol.* 2014 Nov-Dec;35(6):736-40. PMID: 25091178. doi: 10.1016/j.amjoto.2014.07.006.
13. Nawrot I, Pragacz A, Pragacz K, et al. Total thyroidectomy is associated with increased prevalence of permanent hypoparathyroidism. *Med Sci Monit.* 2014 Sep 19;20:1675-81. PMID: 25234952; PMCID: PMC4179543. doi: 10.12659/MSM.890988.
14. Bollerslev J, Rejnmark L, Zahn A, et al. European Expert Consensus on Practical Management of Specific Aspects of Parathyroid Disorders in Adults and in Pregnancy: Recommendations of the ESE Educational Program of Parathyroid Disorders. *Eur J Endocrinol.* 2022 Jan 13;186(2):R33-R63. PMID: 34863037; PMCID: PMC8789028. doi: 10.1530/EJE-21-1044.
15. Bollerslev J, Rejnmark L, Marcocci C, et al. European Society of Endocrinology Clinical Guideline: Treatment of chronic hypoparathyroidism in adults. *Eur J Endocrinol.* 2015 Aug;173(2):G1-20. PMID: 26160136. doi: 10.1530/EJE-15-0628.
16. Ritter K, Elfenbein D, Schneider DF, et al. Hypoparathyroidism after total thyroidectomy: incidence and resolution. *J Surg Res.* 2015 Aug;197(2):348-53. PMID: 25982044; PMCID: PMC4466142. doi: 10.1016/j.jss.2015.04.059.
17. McCullough M, Weber C, Leong C, et al. Safety, efficacy, and cost savings of single parathyroid hormone measurement for risk stratification after total thyroidectomy. *Am Surg.* 2013 Aug;79(8):768-74. PMID: 23896242. doi: 10.1177/000313481307900816.
18. Khan AA, Bilezikian JP, Brandi ML, et al. Evaluation and Management of Hypoparathyroidism Summary Statement and Guidelines from the Second International Workshop. *J Bone Miner Res.* 2022 Dec;37(12):2568-85. PMID: 36054621. doi: 10.1002/jbmr.4691.
19. Zheng J, Cai S, Song H, et al. Measurement of serum intact parathyroid hormone concentration 1 day after total thyroidectomy to assess risk of permanent hypoparathyroidism. *J Int Med Res.* 2020 Jun;48(6):300060520927199. PMID: 32527180; PMCID: PMC7294503. doi: 10.1177/0300060520927199.
20. Calvo Espino P, Rivera Bautista JÁ, Artés Caselles M, et al. Serum levels of intact parathyroid hormone on the first day after total thyroidectomy as predictor of permanent hypoparathyroidism. *Endocrinol Diabetes Nutr (Engl Ed).* 2019 Mar;66(3):195-201. English, Spanish. PMID: 30392997. doi: 10.1016/j.endinu.2018.08.006.
21. Suwannasarn M, Jongjaroenprasert W, Chayangsu P, et al. Single measurement of intact parathyroid hormone after thyroidectomy can predict transient and permanent hypoparathyroidism: a prospective study. *Asian J Surg.* 2017;40:350-6. doi: 10.1016/j.asjsur.2015.11.005.
22. Lončar I, Dulfer RR, Massolt ET, et al. Postoperative parathyroid hormone levels as a predictor for persistent hypoparathyroidism. *Eur J Endocrinol.* 2020 Aug;183(2):149-59. PMID: 32580147. doi: 10.1530/EJE-20-0116.
23. Lim ST, Jeon YW, Gwak H, et al. Incidence, Risk Factors, and Clinical Implications of Delayed Hypoparathyroidism on Postoperative Day two Following Total Thyroidectomy for Papillary Thyroid Carcinoma. *Endocr Pract.* 2020 Jul;26(7):768-76. PMID: 33471646. doi: 10.4158/EP-2019-0544.
24. Pasięka JL, Wentworth K, Yeo CT, et al. Etiology and Pathophysiology of Hypoparathyroidism: A Narrative Review. *J Bone Miner Res.* 2022 Dec;37(12):2586-601. PMID: 36153665; PMCID: PMC10364481. doi: 10.1002/jbmr.4714.