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ORIGINAL RESEARCH

Dual Role of AITD in TgAb-Positive PTC: Delayed Antibody Clearance with Enhanced RAIT Response

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Background and Objective: Elevated thyroglobulin antibody (TgAb) levels in postoperative management of papillary thyroid carcinoma (PTC) are often attributed to tumor recurrence, while the potential impact of autoimmune thyroid disease (AITD) is overlooked. This study aims to clarify the comprehensive effects of AITD on baseline TgAb levels, antibody normalization kinetics, pre-RAIT persistent structural disease risk, and radioactive iodine therapy (RAIT) efficacy in PTC patients.

Methods: A retrospective cohort of 287 TgAb-positive (≥115 IU/mL) PTC patients who underwent total thyroidectomy and received RAIT with ≥6 months follow-up was enrolled. Based on postoperative pathology and thyroid peroxidase antibody (TPOAb) status, patients were divided into Group A0 (non-AITD, n=70) and Group A1 (AITD-concurrent, n=217). Clinicopathological characteristics, RAIT response, and TgAb normalization were compared.

Results: Among TgAb-positive PTC patients, 75.6% had concurrent AITD. Group A1 exhibited higher pre-RAIT TgAb levels (740.0 [450.0–1050.0] vs 520.5[300.0–800.0]IU/mL, $Z = -2.155$, $p = 0.031$) and pre-RAIT persistent structural disease rates (38.7% vs 25.7%, $p = 0.048$) than Group A0. Although the total RAIT dose and final therapeutic response were comparable between groups, patients in Group A1 received fewer RAIT cycles (median: 1 vs 2, $p = 0.042$). Notably, TgAb normalization time was significantly prolonged in Group A1 (median: 40.81 vs 33.55 months, Log-rank $p = 0.043$), with Cox regression confirming slower antibody clearance in AITD patients (HR = 0.667, 95% CI: 0.452–0.983).

Conclusion: Concurrent AITD is associated with elevated TgAb, delayed antibody clearance, and increased pre-RAIT persistent structural disease risk, yet does not compromise RAIT efficacy. This highlights the dual role of AITD in PTC prognosis.

Keywords: papillary thyroid carcinoma, thyroglobulin antibody, autoimmune thyroid disease, radioactive iodine therapy, prognosis

Introduction

Differentiated thyroid carcinoma (DTC) constitutes approximately 90% of all thyroid malignancies, with papillary thyroid carcinoma (PTC) being the most prevalent subtype. Prognostic assessment of PTC remains a critical focus in oncology research.[1] Thyroglobulin (Tg), a thyroid-specific glycoprotein, is widely recognized as the gold-standard tumor marker for postoperative diagnosis and monitoring of disease recurrence or metastasis in DTC.[2] However, its clinical utility is often compromised by the presence of thyroglobulin antibody (TgAb). When TgAb is positive, Tg levels cannot accurately reflect the tumor burden, thereby limiting its value in follow-up. TgAb also serves as a key biomarker in autoimmune thyroid disease (AITD). Elevated serum TgAb levels are frequently observed in PTC patients following radioactive iodine (RAI) therapy (RAIT). Notably, a significant cognitive gap persists in clinical practice: physicians predominantly attribute elevated TgAb to tumor recurrence or metastasis, while systemic screening for concurrent AITD is often neglected.

AITD arises from pathological activation of the immune system against the thyroid, involving complex interactions among genetic, epigenetic, and environmental factors.[3] Its hallmark features include lymphocytic infiltration and autoantibody production, primarily TgAb and thyroid peroxidase antibody (TPOAb), encompassing Graves' disease (GD) and Hashimoto's thyroiditis (HT). The role of inflammation and immunity in cancer progression is increasingly recognized. Epidemiologic studies report that approximately 23% (range: 5–85%) of PTC patients have concurrent HT,[4]

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with this proportion exceeding 50% in TgAb-positive cohorts.[1] Although AITD is linked to PTC pathogenesis, its prognostic implications remain contentious,[1,5,6] particularly regarding RAIT outcomes in postoperative PTC patients.

This retrospective study analyzed 287 TgAb-positive PTC patients stratified by AITD status (defined by histopathological confirmation or positive TPOAb). We aimed to compare baseline TgAb levels and antibody normalization kinetics between AITD-concurrent and non-AITD groups, evaluate the impact of AITD on pre-RAIT persistent structural disease risk and investigate whether AITD modifies RAIT treatment response. By integrating these dimensions, this study seeks to elucidate the dynamic characteristics of serum TgAb and prognostic significance of concurrent AITD in PTC patients, providing evidence for risk stratification and personalized management strategies.

Materials and Methods

Study Design and Ethical Compliance

This retrospective analysis was performed on 2795 PTC patients who underwent RAIT between January 2012 and September 2023. The study protocol was approved by the Ethics Committee of Shengli Clinical Medical College of Fujian Medical University, Fujian Provincial Hospital, Fuzhou University Affiliated Provincial Hospital (Approval No. K2023-09-002) in accordance with the Declaration of Helsinki. Written informed consent was obtained from all participants.

Patient Selection and Grouping

The inclusion criteria were: 1) patients underwent total thyroidectomy with histopathologically confirmed PTC; 2) received initial RAIT (ablation or adjuvant therapy) at our institution department; 3) had pre-RAIT TgAb ≥115 IU/mL; 4) completed ≥6 months of follow-up with serial serum tests (Tg, TgAb, TPOAb) and imaging studies. The exclusion criteria were: 1) postoperative pathology revealed PTC mixed with other thyroid malignancies and 2) concurrent non-thyroidal malignancies or severe systemic diseases.

Patients were stratified by AITD status into two groups: Group A0 (non-AITD) - defined by the absence of histopathological features of AITD (ie, no lymphocytic infiltration, lymphoid follicle formation, or thyroid follicular damage observed on postoperative pathology review) and negative serum TPOAb (n=70, 24.4%); Group A1 (concurrent AITD) - defined by the presence of either histopathological features of AITD or elevated serum TPOAb (n=217, 75.6%). The patient screening workflow is illustrated in Figure 1.

Data Collection and Definitions

Clinicopathological parameters were extracted from electronic medical records, including demographics (gender, age), tumor characteristics (primary tumor size, extrathyroidal extension, multifocality), nodal status (number of lymph node metastases, lymph node metastasis rate, extranodal extension), and TNM staging (AJCC 8th edition[7]). RAIT parameters encompassed total RAI dose given (GBq) and cycles of RAI.

Clinical responses were categorised into four categories based on the 2015 American Thyroid Association (ATA) guidelines[8] as follows: excellent response (ER) - no clinical, radiographic, or biochemical evidence of disease (typically with stimulated Tg <1 ng/mL or suppressed Tg <0.2 ng/mL); indeterminate response (IDR) - nonspecific findings on radiographic imaging without definitive structural or biochemical evidence of disease, or stable or declining Tg antibody levels; biochemical incomplete response (BIR) - abnormal Tg or rising Tg antibody levels in the absence of localizable disease; and structural incomplete response (SIR) - persistent or newly identified structural disease. TgAb seroconversion was defined as a transition from positive to persistent negative status (negative threshold: <115 IU/mL). For this study, structural diseases identified on imaging studies after total thyroidectomy but before or during the initial RAIT workup were defined as pre-RAIT persistent structural disease.

Assessment Methods

Serum TgAb, TPOAb, and Tg levels were quantified via electrochemiluminescence immunoassay (Roche Cobas 6000 analyzer). The measurement range for TgAb was 10–4000 IU/mL. Due to the heterogeneity of autoantibodies, which

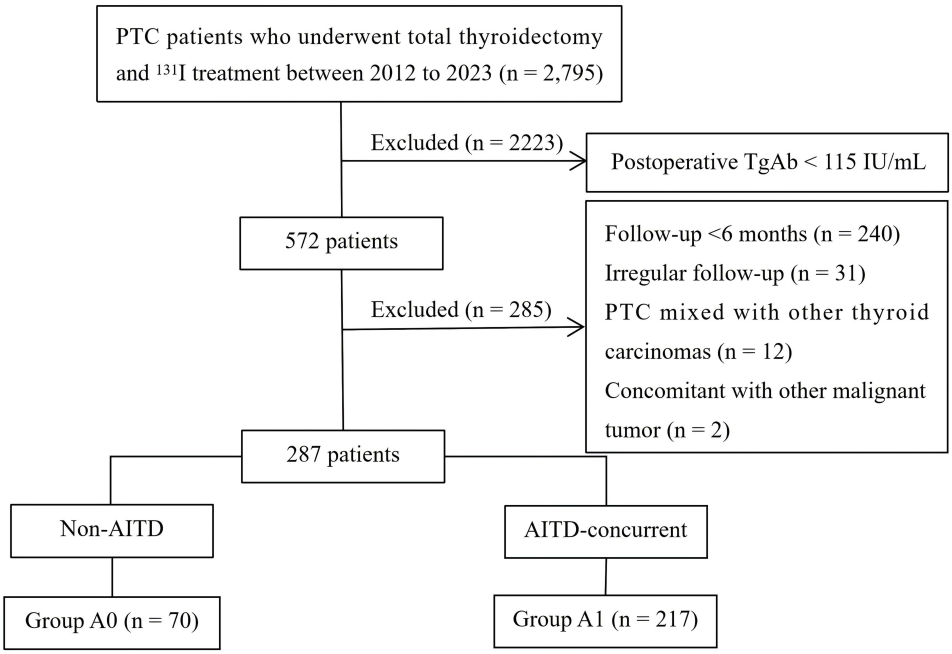

Figure 1 Diagram of the data collection process.
Abbreviations: PTC, papillary thyroid carcinoma; TgAb, thyroglobulin antibody; AITD, autoimmune thyroid disease.

could lead to non-linear sparse phenomena, samples exceeding the upper limit of detection were not diluted. For this study, TgAb levels ≥4000 IU/mL were recorded as 4000 IU/mL. Structural disease required concordant positive findings on ≥2 imaging modalities: neck ultrasound, chest CT, ^{131}I whole-body scan (^{131}I-WBS), or ^{18}F-FDG PET/CT (if indicated), with histopathological confirmation when feasible.

Statistical Analysis

Statistical analysis was performed using IBM SPSS Statistics (Version 26.0). Continuous variables were assessed for normality using the Shapiro–Wilk test. Normally distributed variables are expressed as mean ± standard deviation and were compared using the independent samples *t*-test. Non-normally distributed data are expressed as median (interquartile range, IQR) and were compared using the Mann–Whitney *U*-test. Categorical variables are presented as frequencies (%), and group differences were assessed using the χ^2-test or Fisher's exact test, as appropriate. TgAb seroconversion time were analyzed using Kaplan-Meier curves with the Log rank testing, and hazard ratios (HRs) were calculated using Cox proportional hazards models. Statistical significance was set at a two-sided $p < 0.05$.

Results

Cohort Characteristics and Baseline Findings

The final cohort comprised 287 TgAb-positive PTC patients (male: 51, 17.8%; female: 236, 82.2%) with a mean age of 41.7±13.0 years. Concurrent AITD was identified in 75.6% (217/287) of patients (Group A1), while 24.4% (70/287) were classified as non-AITD (Group A0).

Group A1 exhibited significantly higher pre-RAIT TgAb levels (median: 740.0 [450.0–1050.0] vs 520.5 [300.0–800.0] IU/mL, Z = −2.155, $p = 0.031$) and pre-RAIT persistent structural disease rates (38.7% vs 25.7%, $p = 0.048$) compared to Group A0. Notably, no significant differences existed in gender, age, primary tumor size, extrathyroidal extension, multifocality, number of lymph node metastases, lymph node metastasis rate, extranodal extension, or TNM stage (all $p > 0.05$) (Table 1), indicating comparable baseline tumor pathology despite divergent immune status.

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Table 1 Comparative Analysis of Baseline Characteristics

Parameters	Group A0 (n=70)	Group A1 (n=217)	Statistic	*p*-value
Gender, n (%)			χ^2 = 1.640	0.200
Male	16 (22.9)	35 (16.1)		
Female	54 (77.1)	182 (83.9)		
Age, years (mean±SD)	43.5 ± 11.4	41.1 ± 13.4	*t* = 1.336	0.173
Primary tumor size, cm [M(Q1-Q3)]	1.4 (1.1–2.7)	1.5 (1–2)	*Z* = −0.223	0.823
Extrathyroidal extension, n (%)			X^2 = 1.112	0.292
Yes	25 (35.3)	63 (29.1)		
No	45 (64.7)	154 (70.9)		
Multifocality, n (%)			X^2 = 0.221	0.638
Yes	28 (39.6)	80 (36.7)		
No	42 (60.4)	137 (63.3)		
Number of lymph node metastases, n [M(Q1-Q3)]	5 (3–16)	6 (2–19)	*Z* = −0.82	0.412
Lymph node metastasis rate, %[M(Q1-Q3)]	20.0 (6.76–40.0)	29.57 (14.96–38.61)	*Z* = −0.397	0.692
Extranodal extension, n (%)			X^2 = 0.495	0.331
Yes	4 (5.7)	8 (3.9)		
No	66 (94.3)	209 (96.1)		
TNM stage, n (%)			χ^2 = 0.002	0.967
Stage I	55 (78.6)	171 (78.8)		
Stage II–IV	15 (21.4)	46 (21.2)		
Pre-RAIT TgAb levels, IU/mL [M(Q1-Q3)]	520.5 [300.0–800.0]	740.0 [450.0–1050.0]	*Z* = −2.155	0.031
Pre-RAIT Persistent Structural Disease, n (%)			χ^2 = 3.902	0.048
Yes	18 (25.7)	84 (38.7)		
No	52 (74.3)	133 (61.3)		

Notes: p < 0.05 was considered statistically significant.
Abbreviations: RAIT, radioactive iodine therapy; TgAb, thyroglobulin antibody.

Therapeutic Response and Antibody Kinetics

As shown in Table 2, While the total RAI dose was comparable between groups, patients in Group A1 received fewer cycles of RAI than those in Group A0 (median: 1 [1–2] vs 2 [1–3], p = 0.042). Final treatment response distribution showed no statistical difference (p = 0.235), with ER rates of 38.3% (A1) versus 33.9% (A0).

A pivotal finding emerged in antibody dynamics: Although ultimate TgAb normalization rates were similar (48.4% vs 39.0%, p = 0.205), Group A1 demonstrated significantly prolonged TgAb seroconversion time (median: 40.81 vs 33.55 months, Log-rank p = 0.043). Cox regression confirmed slower clearance in concurrent AITD patients (HR=0.667, 95% CI: 0.452–0.983), visually substantiated by Kaplan-Meier curves in Figure 2.

Table 2 Comparative Analysis of RAIT Efficacy and TgAb Kinetics

Parameters	Group A0 (n=70)	Group A1 (n=217)	Statistic	*p*-value
Total RAI dose given, GBq [M(Q1-Q3)]	3.7 (3.7–7.4)	7.4 (3.7–7.4)	*Z* = −1.638	0.101
Cycles of RAI, n [M(Q1-Q3)]	2 (1–3)	1 (1–2)	Z = −2.032	0.042
Therapeutic response, n (%)			X^2 = 4.306	0.235
ER	24 (33.9)	72 (38.3)		
IDR	26 (37.3)	45 (23.9)		
BIR	9 (13.1)	30 (16.0)		
SIR	11 (15.7)	41 (21.8)		
TgAb seroconversion status, n (%)			X^2 = 1.604	0.205
Seroconverted	27 (39.0)	105 (48.4)		
Not seroconverted	43 (61.0)	112 (51.6)		

Notes: p < 0.05 was considered statistically significant.
Abbreviations: RAI, radioactive iodine; ER, excellent response; IDR, indeterminate response; BIR, biochemical incomplete response; SIR, structural incomplete response.

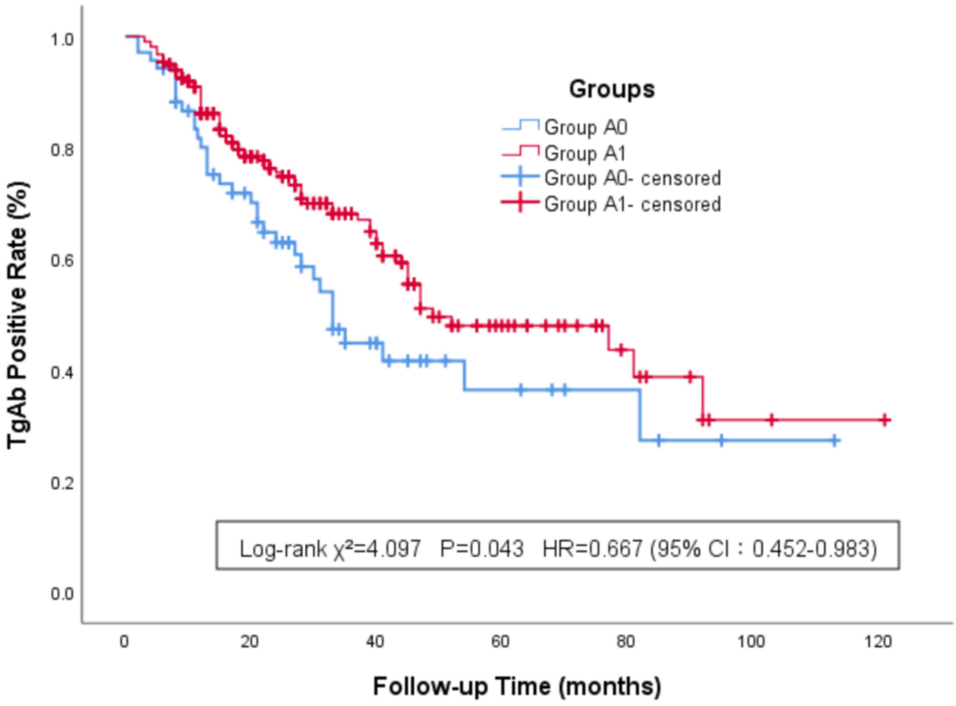

Figure 2 Kaplan-Meier curve of TgAb seroconversion over time in Group A0 and Group A1.

Discussion

In this study, approximately 75.6% of TgAb-positive PTC patients were found to have concurrent AITD, a proportion slightly higher than previously reported.[1] This discrepancy may be attributed to differences in diagnostic criteria for AITD across studies. While prior research primarily relied on postoperative pathological diagnosis to define AITD,[1,4] our study incorporated both serological markers and histopathological confirmation. An alternative explanation involves potential variations in disease incidence across different geographical regions and time periods.[9] This high prevalence serves as a critical reminder to clinicians: During postoperative follow-up of PTC patients receiving RAIT, elevated TgAb levels should not be automatically attributed to tumor recurrence or metastasis. Instead, a "tumor-centric" mindset must be overcome through systematic screening - including TPOAb testing and pathological review - to accurately determine the source of antibodies and achieve comprehensive disease assessment.

TgAb is a specific autoantibody induced by Tg released from thyroid cancer cells or residual thyroid tissue.[10] Theoretically, following total thyroidectomy and RAIT, TgAb should progressively decline to undetectable levels as thyroid follicular cells - the source of Tg antigen - are eradicated. Contrary to this expectation, our data revealed significantly prolonged TgAb seroconversion time in patients with concurrent AITD. This persistent antibody elevation suggests sustained immune activation beyond tumor elimination. Two mechanistic pathways may underlie this phenomenon: 1) Chronic Antigen Stimulation. Residual thyroid tissue (including microscopic cancerous foci or metastatic lesions) may continuously release Tg antigen, perpetuating B-cell activation and antibody production.[5] 2) Expanded Immunological Memory. AITD-associated enlargement of autoreactive lymphocyte pools could prolong antibody generation cycles.[4] Critically, persistent TgAb positivity correlates with higher risks of structural disease persistence or recurrence.[11,12] Consequently, for PTC patients with concurrent AITD, monitoring TgAb dynamics - particularly seroconversion time - holds significant prognostic value, necessitating extended surveillance periods.

Notably during baseline pre-RAIT assessment, patients with concurrent AITD exhibited significantly higher incidence of persistent structural disease than non-AITD counterparts, a finding that is consistent with Lubin et al[13] and Zeng et al.[14] This observation appears paradoxical when contrasted with prior reports suggesting more indolent tumor biology in AITD-associated PTC (eg, younger age, smaller tumors, earlier TNM stages).[4,15] Two interconnected factors likely resolve this discrepancy: First, the superior diagnostic sensitivity of ^{131}I-WBS SPECT/CT fusion imaging employed in this study - integrating functional metabolic data with anatomical localization - significantly enhanced detection of micronodular metastases (particularly

subcentimeter lymph node involvement) compared to conventional ultrasound or chest CT,[2,16] thereby more accurately quantifying true disease burden. Second, the dual nature of the AITD immune microenvironment: While lymphocytic infiltration in AITD (especially HT) may restrict primary tumor growth through cytotoxic T-cell and NK cell-mediated antitumor immunity,[4,17,18] chronic inflammation concurrently promotes invasiveness and metastatic potential by inducing reactive lymph node hyperplasia, increasing multifocality, extranodal extension, and nodal metastasis incidence.[13,19,20]

Notably, despite exhibiting higher pre-RAIT persistent structural disease rates, patients with concurrent AITD demonstrated no statistically significant difference in final RAIT response compared to the non-AITD group but required fewer cycles of RAI. A nuanced interpretation of this finding must account for the significantly higher pre-existing disease burden in the AITD group. The observed numerical trend of a lower ER rate and a higher SIR rate in the AITD group can be explained by its greater initial tumor burden, which poses a greater challenge to achieving an ER even with effective RAIT. This suggests that concurrent AITD does not negatively impact the ultimate prognosis of RAIT. Furthermore, the observed reduction in treatment cycles may be interpreted as an indicator of a more efficient treatment process; however, the influence of potential clinical management bias cannot be ruled out. Collectively, these findings aligns with the conclusions of Lau et al[6] who observed favorable responses to RAIT in such patients. Similarly, Chen et al[21] demonstrated that HT correlates with better disease-free survival rates and lower recurrence risk post-RAIT.

The potential mechanisms underlying this observation are multifaceted and likely involve an interplay between biological effects and clinical practices. 1) enhanced antigen presentation: The hyperactive immune state associated with AITD may augment the presentation of tumor antigen (eg, Tg), thereby improving immune recognition of antigens released by RAIT;[5,6] 2) immune cell synergism: Lymphocytes infiltrating HT lesions may directly or indirectly (via cytokine secretion) target and eliminate residual tumor cells;[5,17] 3) antibody-dependent cellular cytotoxicity (ADCC) effect: Elevated anti-thyroid antibodies (TgAb, TPOAb) could potentiate the ADCC effect, collaborating with immune cells to clear antigen-expressing tumors.[22] Additionally, clinical management bias may constitute a significant contributing factor. In practice, clinicians may have adopted more aggressive initial treatment strategies (eg, more extensive lymph node dissection, higher initial RAI dose) or stricter follow-up regimens (eg, lower TSH suppression targets) for patients with known concomitant AITD. This could lead to earlier termination of RAI therapy upon achieving a comparable or more satisfactory therapeutic response, consequently manifesting as a reduction in treatment cycles.

Given the retrospective nature of our study, it is challenging to definitively disentangle the respective contributions of biological effects and potential clinical management bias. Collectively, the dual role of AITD in PTC suggests that AITD status should be considered when formulating treatment plans to select the most effective therapeutic strategies.[23]

Limitations

This study is a single-center retrospective investigation, its results may be susceptible to selection bias, and future validation through multicenter prospective large-scale cohort studies is warranted. The analysis primarily relies on postoperative data, lacking detailed preoperative information such as the duration of AITD in patients. Although histopathology remains the gold standard for AITD diagnosis and serum TPOAb has well-established diagnostic value, the accuracy of histopathological diagnosis may be influenced by observer variability, diagnostic focus, and patient-specific factors including disease stage and treatment status. Therefore, future research should adopt more standardized and unified diagnostic criteria and conduct long-term prospective follow-up to address these limitations.

Conclusion

In summary, this study demonstrates that concurrent AITD, present in approximately 75.6% of TgAb-positive PTC patients, is associated with a higher risk of pre-RAIT persistent structural disease and prolonged TgAb persistence, yet does not hinder favorable long-term responses to RAIT. These findings challenge the conventional view of AITD as a uniformly adverse prognostic factor.

Disclosure

The authors report no conflicts of interest in this work.

This paper has been uploaded to ResearchSquare as a preprint: https://www.researchsquare.com/article/rs-7359604/v1.

References

1. Jia X, Pang P, Wang L, et al. Clinical analysis of preoperative anti-thyroglobulin antibody in papillary thyroid cancer between 2011 and 2015 in Beijing, China: a retrospective study. *Front Endocrinol*. 2020;11:452. doi:10.3389/fendo.2020.00452
2. Nuclear Medicine Association of Chinese Medical Association. ^{131}I guidelines of the treatment of differentiated thyroid cancinoma (2021 edition). *Chin J Nucl Med Mol Imaging*. 2021;41(4):218–241. doi:10.3760/cma.j.cn321828-20201113-00412
3. Vargas-Uricoechea H. Autoimmune thyroid disease and differentiated thyroid carcinoma: a review of the mechanisms that explain an intriguing and exciting relationship. *World J Oncol*. 2024;15(1):14–27. doi:10.14740/wjon1728
4. Xue X, Wu D, Yao H, Wang K, Liu Z, Qu H. Mechanisms underlying the promotion of papillary thyroid carcinoma occurrence and progression by hashimoto's thyroiditis. *Front Endocrinol*. 2025;16:1551271. doi:10.3389/fendo.2025.1551271
5. Ferrari SM, Fallahi P, Elia G, et al. Thyroid autoimmune disorders and cancer. *Semin Cancer Biol*. 2020;64:135–146. doi:10.1016/j.semcancer.2019.05.019
6. Lau J, Lee J, Mahipal M, et al. Hashimoto's thyroiditis on outcomes in papillary thyroid cancer revisited: experience from South East Asia. *Ann R Coll Surg Engl*. 2022;104(6):465–471. doi:10.1308/rcsann.2021.0224
7. Amin MB, Edge SB, Greene FL, et al. *AJCC Cancer Staging Manual*. 8th ed. New York: Springer; 2017:3–30.
8. 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;26(1):1–133. doi:10.1089/thy.2015.0020
9. Ieni A, Vita R, Magliolo E, et al. One-third of an archivial series of papillary thyroid cancer (Years 2007-2015) has coexistent chronic lymphocytic thyroiditis, which is associated with a more favorable tumor-node-metastasis staging. *Front Endocrinol*. 2017;8:337. doi:10.3389/fendo.2017.00337
10. Sanjari M, Ordooei M, Amirkhosravi L, Naghibzadeh-Tahami A, Nazemi S. The effect of positive thyroglobulin antibodies on the prognosis and treatment response in patients with papillary thyroid carcinoma. *Heliyon*. 2024;10(4):e26092. doi:10.1016/j.heliyon.2024.e26092
11. Ge H, Chen W, Lin Z, Li Y, Chen S. Analysis of the prognostic value of thyroglobulin antibody change trends during follow-up after 131I treatment in patients with differentiated thyroid carcinoma. *Front Oncol*. 2025;15:1496594. doi:10.3389/fonc.2025.1496594
12. Wu K, Shi L, Wang J, Xie L. Association between papillary thyroid carcinoma and lymphocytic thyroiditis: a retrospective study. *Oncol Lett*. 2023;25(4):148. doi:10.3892/ol.2023.13734
13. Palella M, Giustolisi FM, Modica Fiascaro A, et al. Risk and prognosis of thyroid cancer in patients with graves' disease: an umbrella review. *Cancers*. 2023;15(10):2724. doi:10.3390/cancers15102724
14. Zeng B, Min Y, Feng Y, Xiang K, Chen H, Lin Z. Hashimoto's thyroiditis is associated with central lymph node metastasis in classical papillary thyroid cancer: analysis from a high-volume single-center experience. *Front Endocrinol*. 2022;13:868606. doi:10.3389/fendo.2022.868606
15. Osborne D, Choudhary R, Vyas A, et al. Hashimoto's thyroiditis effects on papillary thyroid carcinoma outcomes: a systematic review. *Cureus*. 2022;14(8):e28054. doi:10.7759/cureus.28054
16. Issa PP, Omar M, Buti Y, et al. Hashimoto's Thyroiditis: a protective factor against recurrence in BRAF-wild type differentiated thyroid carcinoma. *Cancers*. 2023;15(8):2371. doi:10.3390/cancers15082371
17. Min Y, Wang X, Chen H, Yin G. The exploration of hashimoto's thyroiditis related miscarriage for better treatment modalities. *Int J Med Sci*. 2020;17(16):2402–2415. doi:10.7150/ijms.48128
18. Lee I, Kim HK, Soh EY, Lee J. The association between chronic lymphocytic thyroiditis and the progress of papillary thyroid cancer. *World J Surg*. 2020;44(5):1506–1513. doi:10.1007/s00268-019-05337-9
19. Cappellacci F, Canu GL, Lai ML, et al. Association between hashimoto thyroiditis and differentiated thyroid cancer: a single-center experience. *Front Oncol*. 2022;12:959595. doi:10.3389/fonc.2022.959595
20. Premoli P, Tanda ML, Piantanida E, et al. Features and outcome of differentiated thyroid carcinoma associated with Graves' disease: results of a large, retrospective, multicenter study. *J Endocrinol Invest*. 2020;43(1):109–116. doi:10.1007/s40618-019-01088-5
21. Chen XY, Tan Y, Wang D, Wei ZX. Radioactive iodine therapy for thyroid cancer coexisting with hashimoto's thyroiditis: a systematic review and meta-analysis. *Br J Radiol*. 2024;97(1160):1423–1430. doi:10.1093/bjr/tqae118
22. Tang Q, Pan W, Peng L. Association between hashimoto thyroiditis and clinical outcomes of papillary thyroid carcinoma: a meta-analysis. *PLoS One*. 2022;17(6):e0269995. doi:10.1371/journal.pone.0269995
23. Yao S, Zhang H. Papillary thyroid carcinoma with hashimoto's thyroiditis: impact and correlation. *Front Endocrinol*. 2025;16:1512417. doi:10.3389/fendo.2025.1512417