Original Article

Correlation analysis between the quantitative parameters of iodine-131 single-photon emission computed tomography-computed tomography thyroid bed uptake and the efficacy of radioactive iodine adjuvant therapy for papillary thyroid cancer

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Background: Single-photon emission computed tomography-computed tomography (SPECT/CT) quantification has emerged as a valuable tool for assessing disease prognosis by accurately identifying and characterizing abnormal lesions with accumulated radionuclides. Papillary thyroid carcinoma (PTC) is the most prevalent type of thyroid cancer, and radioactive iodine (RAI) therapy is a standard treatment following total thyroidectomy. This study aimed to explore the potential utility the quantitative parameters of the thyroid bed under iodine-131 (I-131) SPECT/CT in the efficacy of RAI adjuvant therapy for patients with PTC.

Methods: The retrospective cohort study enrolled 107 patients with PTC who underwent RAI adjuvant therapy from June 2020 to January 2023. Three days after the RAI adjuvant therapy, all patients underwent I-131 whole-body scans and SPECT/CT imaging. The quantitative parameters, including maximum standardized uptake value (SUVmax), mean standardized uptake value (SUVmean), and percent injected dose (%ID), were measured using image analysis software based on I-131 SPECT/CT thyroid bed uptake. Successful therapy was defined as inhibitory thyroglobulin (Tg) <0.2 ng/mL with negative thyroglobulin antibody (TgAb) and negative imaging examination 6 months after RAI adjuvant therapy. The relationship between the quantitative parameters and the treatment efficacy, in addition to the potential influencing factors, were analyzed.

Results: The quantitative parameters from the successful group [SUVmax: median 6.15 g/mL, interquartile range (IQR) 2.34–13.80 g/mL; SUVmean: median 2.02 g/mL, IQR 0.89–4.93 g/mL; %ID: median 2.00%, IQR 1.00–4.00%] were significantly lower than those from the unsuccessful group (SUVmax: median 19.03 g/mL, IQR 5.31–45.10 g/mL, SUVmean 4.64 g/mL, IQR 2.07–19.05 g/mL; %ID: median 8.00%, IQR 3.00–18.00%) (SUVmax: Z=−3.755; SUVmean; Z=−3.671; %ID: Z=−4.070; all P values <0.001). SUVmax, SUVmean and %ID were positively correlated with the stimulated thyroglobulin (sTg) and inhibitory Tg at 6 months after RAI adjuvant therapy, respectively (all P values <0.001). SUVmax [odds ratio (OR) =1.045], SUVmean (OR =1.130), and %ID (OR =1.092) were predictive factors for the failure of RAI

adjuvant therapy (all P values <0.001).

Conclusions: Our study suggested that quantitative parameters (SUVmax, SUVmean, and %ID) derived from I-131 SPECT/CT imaging of the thyroid bed can serve as useful tools for predicting therapy outcomes following RAI adjuvant therapy.

Keywords: Iodine-131 single-photon emission computed tomography-computed tomography (I-131 SPECT/CT); papillary thyroid cancer (PTC); quantitative parameters; radioactive iodine adjuvant therapy (RAI adjuvant therapy)

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Introduction

In recent years, there has been a significant increase in the incidence of thyroid cancer worldwide, with a tendency for younger individuals to be affected (1). Thyroid cancer is classified into differentiated thyroid cancer (DTC), anaplastic thyroid cancer (ATC), poorly differentiated thyroid cancer (PDTC), and medullary thyroid carcinoma (MTC) based on tumor origin and differentiation. DTC includes subtypes such as papillary thyroid cancer (PTC), thyroid follicular cancer (FTC), eosinophil cancer (OCA), and differentiated high-grade thyroid cancer (DHGTC) (2). PTC is the most common subtype, accounting for 85–90% of all thyroid cancers. The treatment approaches for DTC mainly include surgical therapy, radioactive iodine (RAI) therapy, and thyroid-stimulating hormone (TSH) suppression therapy. RAI therapy plays a crucial role in the comprehensive treatment following total thyroidectomy for PTC and FTC. The goals of RAI therapy include remnant ablation, adjuvant therapy, or treatment for persistent disease (3). RAI adjuvant therapy aims to improve disease-free survival by potentially eliminating suspicious but unconfirmed residual diseases, especially in patients at high risk of disease recurrence (1).

Despite DTC being characterized by low malignancy, a low mortality rate, and a long survival period, it significantly impacts patients' quality of life and health. Therefore, standardized diagnosis, therapy, and follow-up are crucial. Serum thyroglobulin (Tg) level is a specific indicator reflecting the burden of thyroid tissue in the body, including normal tissue and the primary and metastatic tumors of DTC. Changes in serum Tg levels are often earlier and more sensitive than are imaging structural lesions, serving as an important indicator to assess tumor residue, recurrence, or metastasis. It not only reflects the postoperative disease status of DTC but can also be used to evaluate the risk of initial or dynamic recurrence and the response to therapy (4). According to the 2015 management guidelines of the American Thyroid Association (ATA), patients with low-risk and intermediate-risk DTC who have undergone remnant ablation or adjuvant therapy and exhibit negative outcomes on cervical ultrasound should have their serum Tg levels measured between 6–18 months while on thyroxine therapy via a sensitive Tg measurement (<0.2 ng/mL) or stimulated thyroglobulin (sTg) to confirm disease-free status (3). However, the presence of Tg antibodies (TgAb) can cause a decrease in serum Tg values and even lead to false negatives when immunological methods are used to measure serum Tg levels, thereby reducing the sensitivity of Tg for disease monitoring (5).

In recent years, single-photon emission computed tomography-computed tomography (SPECT/CT) has been proven to be capable of accurately quantifying the radioactive isotope uptake with the development of advanced software (6). These software packages allow for the measuring of quantitative parameters such as standardized uptake values (SUV) and absolute radioactivity concentration at uptake sites (7-9). For instance, a study using SPECT/CT uptake analysis identified the *BRAF* V600E mutation in PTC carcinoma as an independent factor that diminishes the effectiveness of postsurgical iodine-131 (I-131) therapy (10). Moreover, several recent studies have shown that the quantitative parameters of I-131 SPECT/CT may be valuable for predicting the efficacy of RAI therapy (11,12). However, few quantitative reports are available regarding I-131 adjuvant therapy, and the influencing factors of quantitative parameters have not been fully discussed. The aim of this study was to analyze the factors influencing the quantitative parameters [maximum standardized uptake value (SUVmax), mean

Table 1 Patients' characteristics

Characteristic	Value
Age (years), n	
≥50	37
<50	70
Sex, n (%)	
Male	38 (35.51)
Female	69 (64.49)
Histopathology, n (%)	
Papillary carcinoma	107 (100.00)
ATA risk category, n (%)	
Intermediate	88 (82.24)
High	19 (17.76)
8th edition of UICC staging, n (%)	
I	82 (76.64)
II	21 (19.63)
III	4 (3.74)
Therapeutic dose, n (%)	
5.55 GBq	107 (100.00)
Grouping by inhibitory Tg and TgAb, n (%)	
Inhibitory Tg <0.2 ng/mL and TgAb negative	56 (52.34)
Inhibitory Tg <0.2 ng/mL and TgAb positive	27 (25.23)
Inhibitory Tg ≥0.2 ng/mL	24 (22.43)
Grouping by TgAb, n (%)	
TgAb negative	80 (74.77)
TgAb positive	27 (25.23)
Follow-up, n (%)	
Successful	56 (52.34)
Unsuccessful	51 (47.66)

ATA, American Thyroid Association; UICC, Union for International Cancer Control; Tg, thyroglobulin; TgAb, thyroglobulin antibody.

standardized uptake value (SUVmean), and percent injected dose (%ID)] of I-131 SPECT/CT uptake in the thyroid bed and to investigate their correlation with the efficacy of RAI adjuvant therapy using quantitative analysis of I-131 SPECT/CT images obtained 3 days after I-131 adjuvant therapy. We present this article in accordance with the STROBE reporting checklist (available at https://qims.amegroups.com/article/view/10.21037/qims-23-1723/rc).

Methods

This retrospective cohort study included 107 patients with PTC who underwent RAI adjuvant therapy at the Second Hospital of Dalian Medical University from June 2020 to January 2023. Only patients with PTC were included in this study, and patients with aggressive subtypes of PTC (tall cell subtype, columnar cell subtype, hobnail subtype) were excluded since they are less sensitive to I-131 treatment. All patients underwent total thyroidectomy prior to receiving RAI adjuvant therapy. Patients were classified according to the 2015 ATA risk stratification system (3), and those with a low risk of recurrence were excluded because RAI is not recommended for these patients in the recent guidelines (3). A summary of the patients' characteristics is presented in *Table 1*. All patients were followed up at the Second Hospital of Dalian Medical University. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the Ethics Committee of The Second Hospital of Dalian Medical University. The requirement for individual consent for this retrospective analysis was waived.

All patients followed a low-iodine diet for 4 weeks before RAI adjuvant therapy to reduce the competitive inhibitory effect of stable iodine on I-131. Additionally, patients underwent thyroid hormone withdrawal, which involved discontinuing thyroxine for 3 weeks to achieve a serum TSH concentration >30 mIU per liter, as required for RAI pretherapy (3).

All patients in this study received an adjuvant therapeutic dose of 5.50 GBq, as per the recommended dose ranges in China (13). I-131 was purchased from Chengdu Xinke Pharmaceutical Co.

The sTg was measured 1 day before RAI adjuvant therapy. As in previous studies (14), an I-131 whole-body scan and SPECT/CT were conducted to visualize high-uptake lesions in the thyroid bed 3 days after RAI adjuvant therapy. All lesions with high uptake were located in the thyroid bed of I-131 SPECT/CT. Cases of occasional lymph node or distant metastasis detected in scintigraphy after adjuvant therapy were excluded.

The SPECT/CT system was calibrated, and the system sensitivity was established at 159 cnt/min/uCi for calculating the quantitative parameters. System sensitivity denotes the conversion factor between radioactivity and counts per second. Three days after RAI adjuvant therapy, an I-131 whole-body scan and SPECT/CT imaging were conducted using a SPECT/CT system (GE HealthCare,

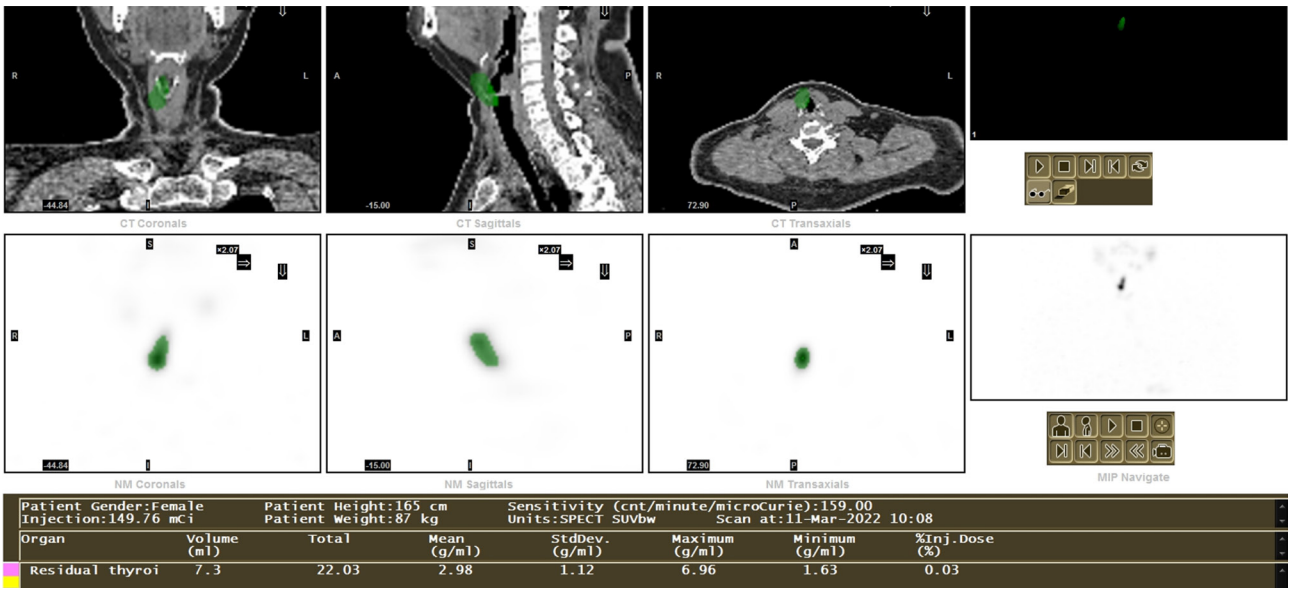

Figure 1 Therapeutic I-131 SPECT/CT images after RAI adjuvant therapy. The quantitative parameters of I-131 SPECT/CT thyroid bed uptake included an SUVmax of 6.96 g/mL, an SUVmean of 2.98 g/mL, and an %ID of 3.00%. The threshold value was 0.4 nm. CT, computed tomography; NM, nuclear medicine; MIP, maximum intensity projection; I-131 SPECT/CT, iodine-131 single-photon emission computed tomography-computed tomography; RAI, radioactive iodine; SUVmax, maximum standardized uptake value; SUVmean, mean standardized uptake value; %ID, percent injected dose.

IL, USA) equipped with a high-energy and high-resolution parallel hole collimator. The photo peak and energy window were set at 365%±10% keV. A planar whole-body scan was acquired with the patient in the supine position in both anterior and posterior views, with the parameters being a matrix size of 256×1,024, a speed of 13.3 cm/min, and a full width at half-maxima (FWHM) of 2.21 mm. Subsequently, SPECT images were immediately obtained after the whole-body scan under the following settings: matrix size 128×128; zoom 1.0; dual-probe acquisition; and probe rotation of 180°, 6°/frame, and 16 s/frame. CT images were captured under the following settings: a tube voltage of 120 kV, a tube current of 210 mA, a rotation time of 0.6 s, a table speed of 13.75 mm/rotation, a slice thickness of 3.75 mm, a pitch of 1.375:1, and a matrix size of 512× 512. No contrast agent was administered.

SPECT image reconstruction was performed by employing the ordered subset expectation maximization algorithm (OSEM) with 2 iterations and 10 subsets. Additional corrections, including scattering correction, sensitivity recovery, and attenuation correction based on CT data, were also performed (6).

Q.Metrix imaging quantitative software (GE HealthCare) was used for the automatic segmentation of three-dimensional volume of interest (VOI) of thyroid residues through 0.4 nuclear medicine (NM) thresholds, meaning that 40% of the maximum voxel was included for the determination of the region of interest (ROI). The NM thresholds referred to the threshold used for nuclear medicine image processing. By setting different thresholds, it could help distinguish tissues or structures and perform quantitative measurements on ROI. For most patients, the value of NM threshold was 0.4, but a few patients had the values adjusted to 0.2 to ensure that the halation observed in thyroid uptake in SPECT/CT included all lesions but excluded any halation extending outside the body. The software measured the SUVmax, SUVmean, %ID, and the volume of thyroid remnant VOIs (6). A typical graph is shown in *Figure 1*. SUV referred to the ratio of the total radioactive uptake in the VOIs to the total administered radioactive dose per unit of body weight. The %ID referred to the ratio of the total radioactivity of VOIs to the total administered radioactivity (6).

Both inhibitory Tg and TgAb were measured 6 months after I-131 administration to evaluate the efficacy of RAI adjuvant therapy, and cervical ultrasound and chest CT examinations were also conducted. The threshold for TgAb-negative status is a level less than 40 IU/mL (15,16).

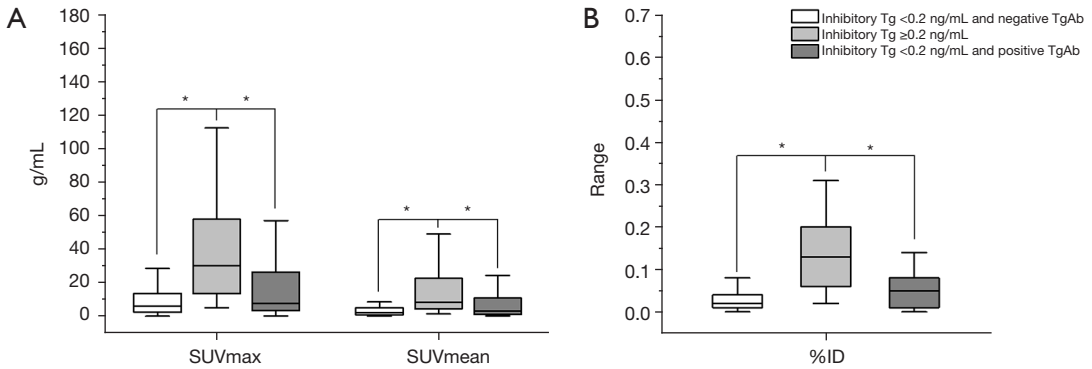

Figure 2 Comparison of SPECT/CT uptake parameters among the inhibitory Tg <0.2 ng/mL and TgAb-negative group, the inhibitory Tg ≥0.2 ng/mL group, and the inhibitory Tg <0.2 ng/mL and TgAb-positive group. (A) Comparison of SUVmax and SUVmean among the inhibitory Tg <0.2 ng/mL and TgAb-negative group, the inhibitory Tg ≥0.2 ng/mL group, and the inhibitory Tg <0.2 ng/mL and TgAb-positive group. (B) Comparison of %ID among the inhibitory Tg <0.2 ng/mL and TgAb-negative group, the inhibitory Tg ≥0.2 ng/mL group, and the inhibitory Tg <0.2 ng/mL and TgAb-positive group. *, P<0.001. The y-axis represents the unit of the corresponding variable, the unit of SUV is g/mL, and the %ID is unitless. SUVmax, maximum standardized uptake value; SUVmean, mean standardized uptake value; %ID, percent injected dose; Tg, thyroglobulin; TgAb, thyroglobulin antibody. SPECT/CT, single-photon emission computed tomography-computed tomography.

Successful therapy was defined as inhibitory Tg <0.2 ng/mL with negative TgAb and negative imaging examination 6 months after RAI adjuvant therapy (3). Imaging examination included chest CT and neck ultrasound. Cases that did not meet these criteria were considered unsuccessful. The relationship between the quantitative parameters and the treatment efficacy, along with the potential influencing factors, was analyzed.

Statistical analyses were performed using SPSS 25.0 software (IBM Corp., NY, USA). Data with nonnormal distribution are expressed as the median and interquartile range (IQR). Differences in quantitative parameters between groups were assessed using the Mann-Whitney test. Spearman correlation analysis was employed to examine the associations between quantitative parameters and inhibitory Tg levels at 6 months after RAI adjuvant therapy, sTg, TgAb, and the volume of thyroid remnant VOIs. To identify predictive factors for the efficacy of RAI adjuvant therapy, binary logistic regression analysis was performed. Separate logistic regression models were constructed for SUVmax, SUVmean, and %ID to address multicollinearity (the value of %ID was increased by a factor of 100). Receiver operating characteristic (ROC) curves were used to assess the predictive accuracy of the quantitative parameters for estimating the efficacy of RAI adjuvant therapy. A P value <0.05 was considered statistically significant.

Results

Figure 2 shows significant differences in the distribution of quantitative parameters among three groups: the group with inhibitory Tg <0.2 ng/mL and negative for TgAb, the group with inhibitory Tg <0.2 ng/mL and positive for TgAb, and the group with inhibitory Tg ≥0.2 ng/mL. The quantitative parameters from the inhibitory Tg ≥0.2 ng/mL group [SUVmax: median 30.32 g/mL, IQR 13.41–58.36 g/mL; SUVmean: median 8.15 g/mL, IQR 4.38–22.81 g/mL; %ID: median 13.00%, IQR 6.00–20.00%] were significantly higher than the other two groups, and the difference was statistically significant (SUVmax: H=24.851; SUVmean: H=21.899; %ID: H=26.632; all P values <0.001). The quantitative parameters (SUVmax, SUVmean, and %ID) obtained from I-131 SPECT/CT showed a significant positive correlation with inhibitory Tg levels 6 months after RAI adjuvant therapy, with correlation coefficients of 0.464, 0.430, and 0.466, respectively (all P values <0.001). Moreover, the SUVmax, SUVmean, and %ID had significant positive correlations with sTg (*Figure 3*), with correlation coefficients of 0.610, 0.592, and 0.591, respectively (all P values <0.001). Additionally, the volume of thyroid remnant VOIs showed positive correlations with the quantitative parameters (SUVmax, SUVmean, and %ID), sTg, and 6-month Tg levels after RAI adjuvant therapy, with correlation coefficients of 0.356 (P<0.001),

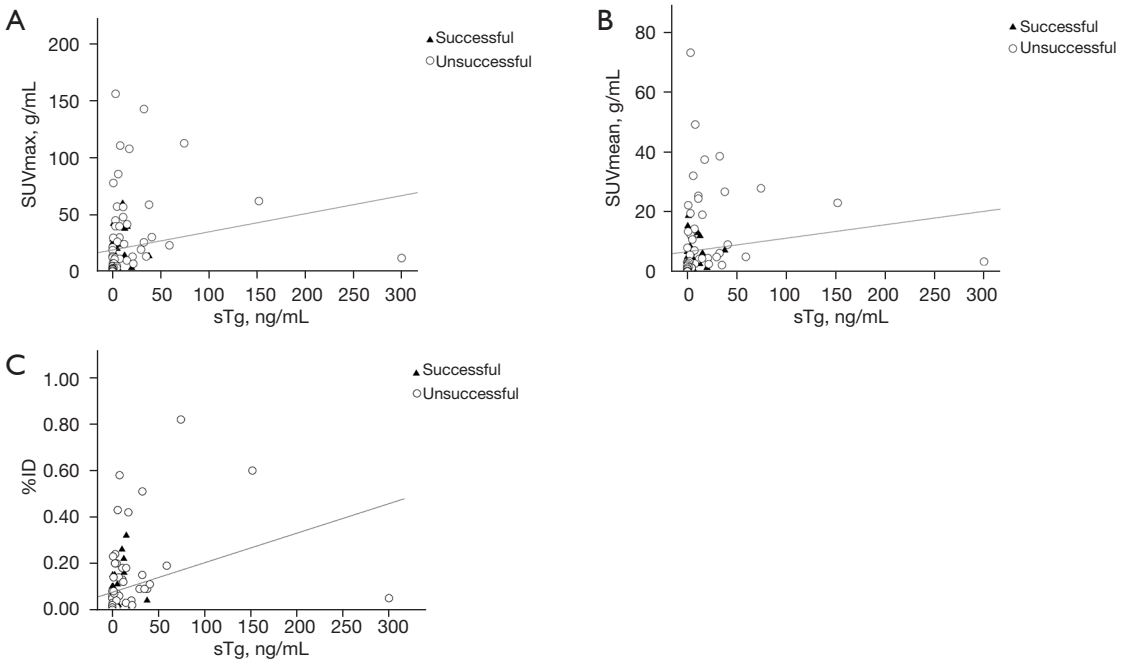

Figure 3 Scatter plots of significant positive correlation between quantitative parameters SUVmax (A), SUVmean (B), and %ID (C) with correlated coefficients of 0.610, 0.592 and 0.591, respectively (all P values <0.001). sTg, thyrotropin-stimulated thyroglobulin; SUVmax, maximum standardized uptake value; SUVmean, mean standardized uptake value; %ID, percent injected dose.

0.229 (P=0.02), 0.521 (P<0.001), 0.238 (P=0.02), and 0.271 (P=0.005), respectively.

Figure 2 shows the quantitative parameters from the groups with inhibitory Tg <0.2 ng/mL and positive for TgAb (SUVmax: median 7.51 g/mL, IQR 3.27–26.41 g/mL; SUVmean: median 3.01 g/mL, IQR 1.17–10.80 g/mL; %ID: median 5.00%, IQR 1.00–8.00%) were higher than those from the group with inhibitory Tg <0.2 ng/mL and negative for TgAb (SUVmax: median 6.14 g/mL, IQR 2.34–13.82 g/mL; SUVmean: median 2.02 g/mL, IQR 0.89–4.93 g/mL; %ID: median 2.00%, IQR 1.00–4.00%), but the difference was not statistically significant (SUVmax: Z=−1.128, P=0.26; SUVmean: Z=−1.348, P=0.18; %ID: Z=−1.599, P=0.11). When participants were grouped based on their TgAb expression, the quantitative parameters from the TgAb-positive group (SUVmax: median 11.12 g/mL, IQR 3.32–29.89 g/mL; SUVmean: median 3.04 g/mL, IQR 1.34–11.34 g/mL; %ID: median 5.00%, IQR 1.00–13.00%) were higher than those from the TgAb-negative group (SUVmax: median 9.71 g/mL, IQR 3.21–24.90 g/mL; SUVmean: median 2.78 g/mL, IQR 0.98–6.71 g/mL; %ID: median 3.00%, IQR 1.00–10.75%), but the difference was not statistically significant (SUVmax: Z=−0.344, P=0.73; SUVmean: Z=−0.344, P=0.60; %ID: Z=−0.775, P=0.44). Moreover, TgAb was not significantly correlated with the I-131 SPECT/CT parameters of SUVmax (P=0.79), SUVmean (P=0.70), and %ID (P=0.57). The above results indicated that quantitative parameters were correlated with Tg but not with TgAb.

As illustrated in *Figure 4* and *Table 2*, the quantitative parameters from the successful therapy group (SUVmax: median 6.15 g/mL, IQR 2.34–13.80 g/mL; SUVmean: median 2.02 g/mL, IQR 0.89–4.93 g/mL; %ID: median 2.00%, IQR 1.00–4.00%) were lower than those from the unsuccessful therapy group (SUVmax: median 19.03 g/mL, IQR 5.31–45.10 g/mL; median: SUVmean 4.64 g/mL, IQR 2.07–19.05 g/mL; %ID: median 8.00%, IQR 3.00–18.00%), with these differences representing a significant difference (SUVmax: Z=−3.755; SUVmean: Z=−3.671; %ID: Z=−4.070; all P values <0.001).

Table 3 presents the results of binary logistic regression analysis, which revealed that unsuccessful RAI adjuvant therapy could be predicted by SUVmax [odds ratio (OR) =1.045; 95% confidence interval (CI): 1.018–1.075; P=0.001], SUVmean (OR =1.130; 95% CI: 1.048–1.217; P=0.001), %ID (OR =1.092; 95% CI: 1.032–1.155;

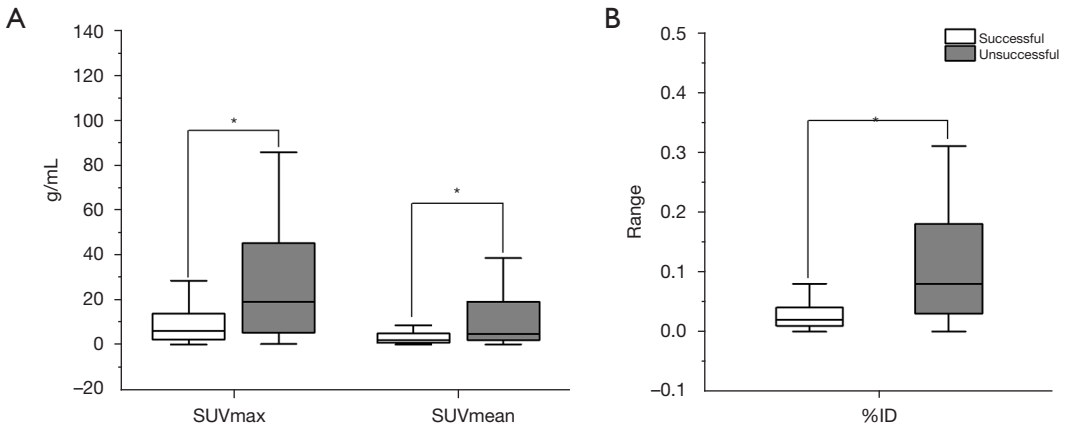

Figure 4 Comparison of SPECT/CT uptake parameters between successful and unsuccessful therapy group. (A) Comparison of SUVmax and SUVmean between the successful and unsuccessful therapy group. (B) Comparison of %ID between the successful and unsuccessful therapy group. *, P<0.001. The y-axis represents the unit of the corresponding variable, the unit of SUV is g/mL, and the %ID is unitless. SUVmax, maximum standardized uptake value; SUVmean, mean standardized uptake value; %ID, percent injected dose; SPECT/CT, single-photon emission computed tomography-computed tomography.

Table 2 Comparison of the quantitative parameters of I-131 SPECT/CT thyroid bed uptake between the successful and unsuccessful therapy group

Parameter	Successful	Unsuccessful	Z	P
SUVmax	6.15 (2.34, 13.80)	19.03 (5.31, 45.10)	–3.755	<0.001
SUVmean	2.02 (0.89, 4.93)	4.64 (2.07, 19.05)	–3.671	<0.001
%ID	2.00% (1.00%, 4.00%)	8.00% (3.00%, 18.00%)	–4.070	<0.001

Data are represented as mean (interquartile range). I-131 SPECT/CT, iodine-131 single-photon emission computed tomography-computed tomography; SUVmax, maximum standardized uptake value; SUVmean, mean standardized uptake value; %ID, percent injected dose.

Table 3 Binary logistic regression analysis of unsuccessful therapy

Parameter	OR (95% CI)	P
SUVmax	1.045 (1.018–1.074)	0.001
SUVmean	1.130 (1.048–1.217)	0.001
%ID	1.092 (1.032–1.155)	0.002
sTg	1.072 (1.019–1.129)	0.008

OR, odds ratio; CI, confidence interval; SUVmax, maximum standardized uptake value; SUVmean, mean standardized uptake value; %ID, percent injected dose; sTg, stimulated thyroglobulin.

P=0.002), and sTg (OR =1.072; 95% CI: 1.019–1.129; P=0.008). The ROC curve analysis results in *Figure 5* demonstrate that SUVmax, SUVmean, and %ID had good predictive efficacy for unsuccessful RAI adjuvant therapy, with AUC values of 0.711 (95% CI: 0.612–0.809), 0.706 (95% CI: 0.608–0.804), and 0.727 (95% CI: 0.630–0.825), respectively. The optimal thresholds for identifying unsuccessful treatment were an SUVmax of 9.71 g/mL with a sensitivity of 68.6% and a specificity of 66.1%, an SUVmean of 2.73 g/mL with a sensitivity of 68.6% and a specificity of 62.5%, and an ID% of 3.5% with a sensitivity 70.6% and a specificity 73.2%. We further found that the predictive value of quantitative parameters for efficacy would further increase only in cases where TgAb was negative, with AUC values of 0.829 (95% CI: 0.734–0.924), 0.805 (95% CI: 0.705–0.905), and 0.826 (95% CI: 0.726–0.925) for SUVmax, SUVmean, and %ID, respectively (all P values <0.001).

Discussion

SPECT/CT imaging has gradually become widely accepted

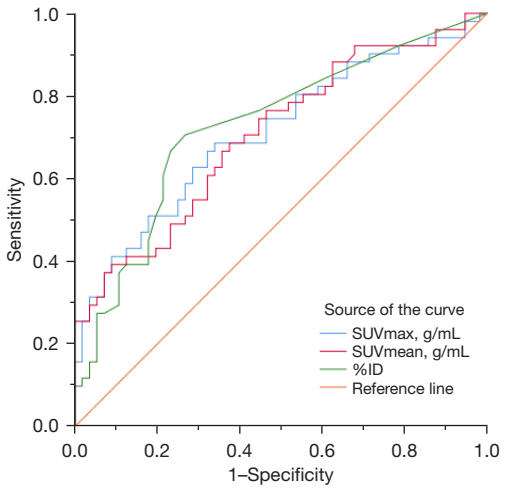

Figure 5 ROC curve analysis of the I-131 SPECT/CT uptake parameters. SUVmax, SUVmean, and %ID to predict the unsuccessful therapy of RAI therapy. ROC, receiver operating characteristic; SUVmax, maximum standardized uptake value; SUVmean, mean standardized uptake value; %ID, percent injected dose; I-131 SPECT/CT, iodine-131 single-photon emission computed tomography-computed tomography; RAI, radioactive iodine.

in the evaluation of DTC due to its ability to accurately locate and characterize abnormal lesions with accumulated radioactive nuclides, which affects staging, risk stratification, and clinical therapy (17). With the advancement of imaging technology, quantitative parameters of SPECT/CT have become vital imaging markers for disease diagnosis (18), therapy response evaluation (19,20), therapy guidance (9,21), and disease monitoring (22,23). However, research on the quantitative parameters of SPECT/CT imaging 3 days after RAI adjuvant therapy has been relatively limited. Recently, studies have found that these parameters are associated with the efficacy of ablation therapy, and %ID was found to be a predictor of the successful outcome of ablation therapy in patients with DTC (6). Additionally, quantitative evaluation could serve as a predictive indicator for the disappearance of RAI accumulation in the thyroid bed after RAI adjuvant therapy (14).

In this study, we found that there was a correlation between the quantitative parameters of I-131 SPECT/CT of the thyroid bed and Tg but not TgAb. It is widely accepted that serum Tg level reflects the amount of thyroid tissue, making it a valuable tumor marker for patients with DTC who have undergone total thyroidectomy and RAI adjuvant therapy (24). The predictive value of postoperative Tg levels could be affected by various factors, with the most important factor being the presence of TgAb. In the early postoperative stage, approximately 25% of patients with DTC may have significantly altered Tg levels due to the presence of TgAb, which is often associated with coexisting thyroid autoimmune diseases (24-26). In this study, we grouped patients based on the combination of inhibitory Tg and TgAb levels. We found that the quantitative parameters (SUVmax, SUVmean, and %ID) of the inhibitory Tg ≥0.2 ng/mL group were significantly higher than those of the group with inhibitory Tg <0.2 ng/mL and positive for TgAb and the group with inhibitory Tg <0.2 ng/mL and negative for TgAb, indicating significant statistical differences. Additionally, both sTg and inhibitory Tg at 6 months after RAI were positively correlated with SUVmax, SUVmean, and %ID. Interestingly, we also found that the quantitative parameters of the TgAb-positive group were not statistically different from those of the TgAb-negative group, and the quantitative parameters obtained from I-131 SPECT/CT did not correlate significantly correlate with TgAb. Based on this, we inferred that the parameters related to the uptake in the thyroid bed were only correlated with Tg levels and not influenced by TgAb. These findings suggest that unlike Tg levels, the quantitative parameters (SUVmax, SUVmean, and %ID) of I-131 SPECT/CT thyroid bed uptake are not influenced by the presence of TgAb. Considered in tandem with the high efficacy of I-131 therapy in the low-uptake group, our results suggest that the quantitative parameters of the I-131 SPECT/CT thyroid bed can be used as early and sensitive indicators of risk stratification and prognostic evaluation. This supports the potential usefulness of these parameters in the evaluation of patients with DTC, regardless of their TgAb status. The correlation was the same for the TgAb-positive and -negative patients and could be applied for both patient types.

In our evaluation of treatment efficacy using serological indicators and imaging modalities, we found that the quantitative parameters (SUVmax, SUVmean, and %ID) of I-131 SPECT/CT thyroid bed uptake in the unsuccessful therapy group were significantly higher than those in the successful therapy group. Furthermore, these parameters were identified as predictive factors for the unsuccessful therapy of RAI adjuvant therapy, especially when TgAb was negative, which is different from the findings of previous research conducted by Konishi *et al.* (14). In their study, they found that the uptake parameters of SUV and kBq/mL were lower in the not-disappeared-uptake group than in the

disappeared-uptake group after RAI therapy. They proposed that quantitative evaluation could serve as predictive indicators for the disappearance of RAI accumulation in the thyroid bed. However, a limited number of patients were enrolled in that study, and the patients' urine iodine levels were not evaluated before I-131 therapy. A different I-131 dose (diagnostic dose or therapeutic dose) was used in the evaluation of therapy efficacy in the study by Konishi *et al.*, which might have influenced the visualization of the thyroid tissue. Another study by Zhang *et al.* also found that the quantitative parameters (SUVmax, SUVmean, and %ID) in the unsuccessful group were significantly lower compared to those in the successful group and found that %ID could be used as a predictive factor for successful ablation (6). However, only 15 patients were included in the unsuccessful ablation group in Zhang *et al.*'s study. Moreover, the influence of the volume of the thyroid remnant and TgAb was not taken into consideration in either of these two studies.

In our study, we observed a positive correlation between quantitative parameters and the volume of the thyroid remnant VOIs. This finding is consistent with a previous phantom study (27) and a proof-of-concept study which suggested that lesion shape and size could influence quantitative parameters (28). The influence of volume to the quantitative parameters might be more apparent when only a small amount of thyroid remnant remained after total thyroidectomy. This could explain the higher quantitative parameters observed in the unsuccessful therapy group, as higher SUV and %ID indicate more residual thyroid tissue and less effective therapy of RAI therapy (29). Furthermore, this study also found a positive correlation between the quantitative parameters of I-131 SPECT/CT and sTg levels, supporting the relationship between quantitative parameters and remnant volume. High SUV and sTg level could potentially be used as predictive factors for unsuccessful therapy after RAI therapy. First, as previous studies have proposed, quantitative parameters could reflect the degree of residual thyroid uptake of RAI and the kinetic characteristics (6). Second, our results suggest new possibility that the quantitative parameters may also reflect the amount of residual thyroid to some extent. Higher values of quantitative parameters indicated a larger amount of residual thyroid tissue, which implied a lower success rate of RAI therapy. However, the relationship between uptake parameters and the efficiency of RAI therapy requires further investigation.

Despite its promising findings, this study has several limitations that should be discussed. First, the efficacy of RAI therapy was determined solely based on serological indicators, chest CT, and ultrasound examination, which may not provide a complete evaluation. A few studies used diagnostic I-131 whole-body scans in their evaluation, which could provide additional information in some cases (6,14). Second, we employed a retrospective design with a limited number of cases, which could reduce the generalizability of the conclusions. Larger studies with a greater number of follow-up cases are needed to further evaluate the efficacy of RAI therapy. Finally, although various corrections were applied during image reconstruction, further exploration is still required to determine the reliability of quantitative parameters using imaging analysis software for the thyroid bed.

Conclusions

Our findings suggest that the quantitative parameters (SUVmax, SUVmean, and %ID) of I-131 SPECT/CT thyroid bed uptake can serve as useful tools in predicting therapy outcomes following RAI therapy, especially when patients are negative for TgAb. The correlation between these parameters and Tg levels support their potential usefulness in evaluating residual thyroid tissue and treatment efficacy. Furthermore, the independence of these parameters from TgAb status points to the practicability in a broader patient population. However, further research with larger sample sizes and comprehensive evaluation protocols is needed to validate these findings and to fully characterize the relationship between quantitative parameters and therapy outcome in patients with DTC.

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Footnote

Reporting Checklist: The authors have completed the STROBE reporting checklist. Available at https://qims.amegroups.com/article/view/10.21037/qims-23-1723/rc

Conflicts of Interest: All authors have completed the ICMJE uniform disclosure form (available at https://qims.amegroups.com/article/view/10.21037/qims-23-1723/coif). The 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. This study was conducted in accordance with the Declaration of Helsinki (as revised in 2013) and was approved by the Ethics Committee of The Second Hospital of Dalian Medical University. The requirement for individual consent in this retrospective analysis was waived.

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