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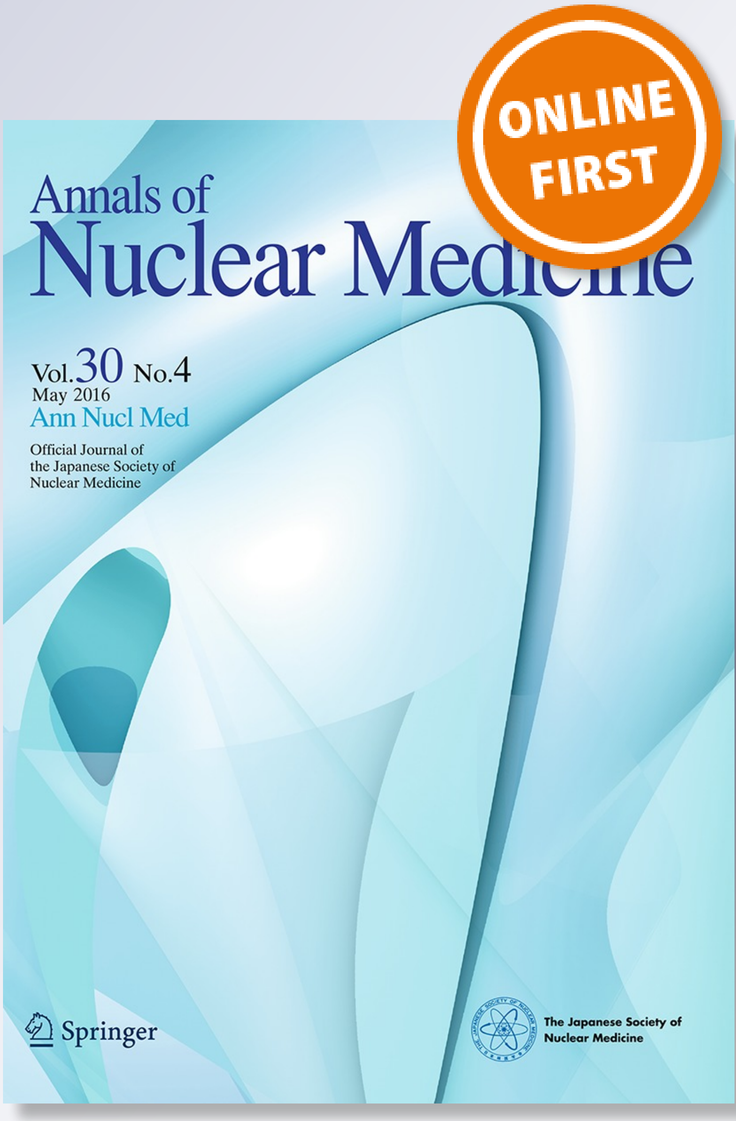

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ORIGINAL ARTICLE

Implication of different clinical and pathological variables in patients with differentiated thyroid cancer on successful ablation for 3700 MBq ^{131}I: a single Egyptian institutional experience over 14 years

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Abstract
Objective Is to investigate possible factors predicting success of ablation for 3700 MBq radioactive iodine 131 in patients with differentiated thyroid cancer (DTC) following near total thyroidectomy.
Methods This retrospective study enrolled 272 patients between 2000 and 2014. The success or failure of ablation was assessed 6 months after given the dose and our criteria for complete successful remnant ablation defined as: Negative ^{131}I whole body scan with no residual functioning thyroid tissue or distant functioning metastases and stimulated thyroglobulin (Tg) level less than 2 ng/ml. Different clinical and pathological factors, such as age, gender, tumor histology, grade and variants, size of primary malignant lesion, stage, and risk assessment according to the American (ATA) and European Thyroid Association (ETA) guidelines, associated pathology, tumor mutifocality, lymph node (LN) metastases and their number, invasiveness of the tumor (capsular invasion of the nodule, extra-thyroidal extension, and vascular invasion), baseline stimulated Tg level, and pre-ablative diagnostic scan were assessed.
Results There were 185 successful ablations (68 %). The baseline-stimulated Tg measured before the ablation was the only independent predictor of ablation success in multivariate analysis ($P < 0.0001$) with odds ratio (OR) of 2.64 (95 % CI: 1.54–4.54) and the optimal cutoff for this was 3.8 ng/mL. On the univariate analysis, LN metastases was predictor of ablation failure (P value = 0.03).
Conclusion Baseline-stimulated Tg level is clinically important and had a significant predictive value for successful ablation; therefore, higher pre-ablation Tg should potentially be incorporated in the decision making for ^{131}I dosage or other treatment. In accordance with other studies, this is also applicable to cervical lymph nodal involvement and thyroid capsule invasion.

Keywords Differentiated cancer thyroid · Radioactive iodine 131 · Successful ablation · Thyroglobulin level

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Introduction

Radioactive iodine 131 (^{131}I) is considered a cornerstone therapy following thyroidectomy in patients with DTC [1]. Its main goal is to destroy thyroid remnants to remove their competition with cancer cells for the secretion of Tg or ^{131}I uptake, thereby increasing sensitivity and specificity of these follow-up tests [2]. It is also used as an adjuvant therapy or therapy of known persistent disease [3]. Successful remnant ablation is associated with better prognosis, regarding disease-free and overall survival, lower rate of distant metastases, and reduction in cancer mortality rates compared with only surgery, and better long-term follow-up of patients with DTC [2–7]. Unfortunately, the first dosage of ^{131}I is not always sufficient to achieve the complete ablation of thyroid remnants.

It is known that the ablation outcome depends upon many factors interlinked with each other, including the given ^{131}I dose, size of residual thyroid tissue, and tumor stage. Some reports stated that histopathology of non neoplastic thyroid tissue [8] as well as stunning effect [9]

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have an impact on ablation outcome. In addition to these factors, the variability in ablation outcome could also possibly explained by the another important factor, which is varying radiosensitivity of thyroid tissue to ^{131}I (biological variable) which is undefined, unpredictable, varies from one individual to another, and its measurement remains an elusive factor. This may be attributed to the fact that thyroid remnant exhibits different degrees of defective iodine organification in variable individuals, which may be due to different levels of expression of sodium iodide symporter (NIS) [5, 10]. The current study was carried out to evaluate the effect of different clinical and pathological variables on thyroid remnant ablation in patients with differentiated thyroid cancers, who were treated by near total thyroidectomy followed by 3700 MBq ^{131}I first ablation dose.

Patients and methods

This retrospective study included 272 patients (215 females and 57 males) with DTC [papillary thyroid cancer (PTC) and follicular thyroid cancer (FTC)] referred to nuclear medicine unit, Kasr Al-Ainy Hospital, during the last 10 years for ^{131}I remnant ablation following near total thyroidectomy with or without neck dissection. All patients included in the study had free surgical margins and received ablative dose of 3700 MBq of ^{131}I. We excluded the patients who had incomplete free surgical margins, distant metastases, or who had anti-Tg antibodies. Local institutional medical ethics committee approval was obtained for this retrospective study.

The tumor size was recorded in the largest diameter. Cervical lymph node dissection was performed in 81 patients (29.8 %) under a suspicion of lymph node involvement at the time of surgery. TNM stage was determined according to the classification system of the American Joint Committee on Cancer (AJCC-TNM staging), 2010 [11], post-operative risk assessment was initially defined according to the European Thyroid Association (ETA) [12] and the American Thyroid Association (ATA) [13].

All the patients had post-operative neck ultrasound and/or 99 mTc pertechnetate thyroid scan to ensure that they have comparable residual functioning thyroid tissues. Contrast-enhanced CT was not performed before therapy dose for any patient and if the patient underwent contrast enhanced CT outside our center, we excluded them from the study to eliminate the effect of Iodine-contained contrast agent on the absorption of ^{131}I in thyroid remnant.

Diagnostic whole body scan^{131}I (^{131}I WBS) was done 4–6 weeks following surgery for 132 patients using 111–185 MBq ^{131}I followed by whole body scan on the third day using dual-head gamma camera fitted with high-energy collimators and a bed speed of 6 cm/min for simultaneous anterior and posterior whole body images. The energy window was set at 15 % centered on 364 keV with a 256 × 1024 size matrix. Images were interpreted qualitatively by visual assessment of the size and tracer uptake intensity of the residual tissue. Blood samples were collected to measure serum Tg, anti-Tg, and TSH levels just before the administration of the diagnostic dose. Patients were then scheduled for ^{131}I ablation within 1 week after the diagnostic ^{131}I scan followed by post-therapy ^{131}I scans 5–7 days later. The other 140 patients were given the ablative dose 4–6 weeks after surgery without performed diagnostic ^{131}I WBS followed by post-therapy ^{131}I scans within 5–7 days after iodine intake. Post-therapy scans were evaluated qualitatively to exclude the patients who had evident difference in residual functioning thyroid tissue in the neck and those who had distant functioning metastases.

Blood samples were taken to measure serum Tg, anti-Tg, and TSH levels just before administration of the ablative dose. All patients were hospitalized for three days in shielded rooms and discharged on levothyroxine suppressive therapy which was started on the fourth day.

Follow-up ^{131}I WBS was done 6 months after the ablative dose, all patients were prepared by withdrawal of levothyroxine medication 4 weeks before administration of 111–185 MBq of ^{131}I (TSH level should be >30 µIU/mL) and were asked to follow a low iodine diet 1 week before dose. Blood samples were taken to measure Tg, anti-Tg, and TSH levels few days before administration of the diagnostic dose. Images were performed on the third day after the intake of ^{131}I and interpretation of the images was made qualitatively. Our criteria for complete successful remnant ablation defined as: absence of residual functioning thyroid tissue in the thyroid bed with no functioning metastases and stimulated Tg level less than 2 ng/ml. Accordingly, two categories were identified: either complete or incomplete ablation. The latter means the presence of residual functioning thyroid tissue at the thyroid bed with or without elevated serum Tg more than 2 ng/mL.

Statistical analysis

Precoded data were entered on the computer using the statistical package of the social science software program, version 17 (SPSS Inc., Chicago, IL) to be statistically analyzed. Data were summarized using: mean ± SD, minimum, maximum, and range for quantitative variables, and number and percent for qualitative variables. Comparison between qualitative variables was accomplished using Chi-square test (Fisher's exact test) for qualitative variables. Independent *t*-test and nonparametric Kruskal–

Wallis were applied for quantitative variables; one-way anova was used to compare quantitative variables involving more than two categories. The receiver operator characteristic (ROC) curve was used to identify the best threshold for baseline Tg level to discriminate success and failure of ^{131}I ablative dose. Multivariate analysis was done using the forward stepwise logistic regression method for the significant factors affecting response on the univariate analysis. Odds ratio (OR) with 95 % confidence interval (CI) were used for risk estimation. A P value <0.05 was considered significant.

Results

The current study included 272 patients, 215 females (79 %), and 57 males (21 %) referred for ^{131}I ablation after near total thyroidectomy. Their age ranged from 19 to 77 years old (mean of 41 years). One hundred and fifty-four patients are less than 45 years, while the remaining 118 patients are in the older age group (≥45 years). The commonest histopathology was PTC, encountered in 241 patients (88.6 %). Thirty-one patients (11.4 %) had FTC (28 minimally invasive and 3 widely invasive).

Lymph node dissection was performed in 81 patients (29.8 %); out of them 33 patients (40.7 %) were negative for LN metastases, and 48 cases (59.3 %) showed positive LN involvement. For the purposes of risk group determination, the original N stage was adjusted according to the results of the post-ablation WBS (rxWBS): patients originally classified as N0/Nx were restaged to N1 if lymph node metastases were visible on rxWBS. Patients originally classified as Nx were classified as N0 if no lymph node metastases were visible.

Histo-pathological data analysis showed the presence of multifocal malignant lesion in 55 patients, capsular invasion in 85 cases, minimal extra-thyroidal extension in 36 patients, and vascular invasion in 11 cases. Associated pathology of the rest of the thyroid tissue was colloid/multi-nodular goiter in 106 patients (39 %), thyroiditis in 25 patients (9.2 %), and toxic goiter in 7 patients (2.6 %). The remaining 134 patients (49.3 %) had normal thyroid tissue. Mean ± SD for the baseline-stimulated Tg, maximum size of the primary lesion, and number of lymph nodes involved was 28. ± 63.5 ng/ml, 2.2 ± 1.8 cm, and 6.6 ± 7.8 LN, respectively. The detailed histo-pathological data analysis and risk stratification are showed in detail in Tables 1 and 2.

All the patients received an ablative dose of 3700 MBq ^{131}I, 140 (51.5 %) patients received ablative dose after surgery without prior diagnostic ^{131}I WBS with a minimum period of 4 weeks following surgery and the other 132 (48.5 %) patients received the ablative dose 1 week after

Table 1 Patient characteristics of the study

	Number	Percent
Age (years)		
<45	154	56.6
≥45	118	43.4
Sex		
Female	215	79
Male	57	21
Pathology		
Papillary	241	88.6
Follicular	31	11.4
Follicular and aggressive variants		
Follicular variant	68	25
Aggressive histology	13	4.8
Histologic grading		
Well differentiated	70	25.7
Moderately differentiated	39	14.3
Poorly differentiated	1	0.4
Gx (cannot be assessed)	162	59.6
Primary tumor (T stage)		
Tx	66	24.3
T1	106	39
T2	48	17.6
T3	49	18
T4	3	1.1
Multi-focality		
Unifocal	153	56.3
Multifocal	55	20.2
Unknown	64	23.5
Regional lymph node (N stage)		
N1	48	17.6
N0	224	82.4
Invasive tumors		
Capsular nodular invasion	85	31.3
Thyroid capsule invasion	36	13.2
Vascular invasion	11	4
Associated pathology of the rest of the thyroid gland		
Multi-nodular/colloid goiter	106	39
Hashimoto's/lymphocytic thyroiditis	25	9.2
Toxic goiter	7	2.6
Baseline Tg		
Less than 3.8 ng/ml	124	45.6
More than 3.8 ng/ml	148	54.4
Post-operative diagnostic scan		
Yes	132	48.5
No	140	51.5
AJCC stage		
I	187	68.8
II	16	5.9
III	24	8.8
IV	22	8.1
Cannot be assessed	23	8.5

Table 2 Patient characteristics of the study

	Maximum	Minimum	Median	Mean ± SD
Age (years)	77	19	41	41.7 ± 13.7
Baseline Tg (ng/ml)	300	<2	5	28. ± 63.5
Size of the primary lesion (cm)	9	0.2	2	2.2 ± 1.8
Number of LN involved	37	1	4	6.6 ± 7.8

performing diagnostic ^{131}I WBS, the latter was done 4 week after surgery.

Successful complete ablation after single dose of 3700 MBq ^{131}I was reported in 185 (68 %) patients, while incomplete ablation was found in the remaining 87 (32 %) patients. All factors that may have an effect on successful thyroid remnant ablation were studied individually on the univariate logistic regression analysis, and showed a statistically significant difference in ablation outcome in relation to baseline-stimulated Tg level, thyroid capsule invasion, and LN metastases.

Patients with lower levels of baseline-stimulated Tg with no thyroid capsule invasion and negative LN metastases had significantly more successful ablation rate compared to those who had higher baseline stimulated Tg with thyroid capsule invasion and LN metastases (P value <0.0001, 0.03, and 0.03, respectively, Tables 3, 4, 5). Thyroglobulin level was analyzed using ROC curve to discriminate the group of patients who achieved success following 3700 MBq 131I, and we found Tg level of 3.8 ng/ml with a sensitivity of 70 % and specificity of 53 % (Fig. 1). Multiple logistic regression analysis was performed to assess the impact of the three independent variables (baseline-stimulated Tg level, thyroid capsule invasion, and LN metastases) on the response and only stimulated baseline Tg level was found to represent a unique significant predictor for the ablation failure with odds ratio (OR) of 2.6 (95 % CI: 1.54–4.55) (Table 6). No significant difference in ablation outcome was found regarding age, gender, tumor histology and variants, histologic grade, size of primary malignant lesion, stage, and risk stratification, associated pathology, tumor mutifocality, presence or absence of capsular invasion and vascular invasion, number of LN involved, and performing pre-ablative diagnostic scan (Tables 3, 4, 5).

Discussion

The use of 3700 MBq ^{131}I as a first ablation dose was stated in many reports to achieve a complete ablation rate range from 50 to 100 % [14]. Hackshaw et al. [15] stated that approximately half of the studies reported 80 % complete ablation rate. Maxon et al. [16] and Kukulska et al. [3] reported a complete ablation rate in 86 and 88.6 %, respectively. These figures are higher than 54 % that reported by Zaman et al. [17]. Our results showed that 68 % of the patients achieved complete successful ablation post 3700 MBq ^{131}I.

This retrospective study demonstrates that pre-ablation-stimulated Tg is a good predictor of successful ablation, if it is higher than 3.8 ng/ml, the patients had around 2.64 times greater risk to have a positive ^{131}I WBS/or a stimulated Tg >2 ng/mL 6 months after the first ablative dose. This is in agreement with several studies showing the same relationship between pre-ablation Tg and the successful ablation, but with different cut-off values. Golger et al. [18] showed that if the stimulated values were greater than 12.5 ng/ml before radioactive remnant ablation (RRA), patients had an increased risk for residual/recurrent disease. Tamilia et al. [19] stated that patients with an ablation Tg of at least 6 ng/ml were at a more than five times greater risk ($P < 0.001$) to fail 30 mCi ^{131}I remnant ablation. In addition, Bernier et al. [20] found that Tg level just before ^{131}I administration (TgD0) <5 ng/ml and the ratio between TgD0 and 5 days after administration (TgD5/TgD0 ratio) ≥20 were independently associated with successful ablation. Kendler et al. [21] stated that individuals with Tg 18 ng/mL had 5.89 times greater chance of success than those with values exceeding 18 ng/mL ($P < 0.0001$). The latter study showed that high-risk staging was also a predictor of ablation failure, while we did not find this prediction in our study using the AJCC-TNM staging, ETA and ATA classification systems with P value 0.22, 0.54, and 0.09, respectively.

The different Tg cut-off values among the various reference studies and the current study may be explained by the presence of multiple factors that have an effect on postoperative Tg measurement, such as bulk of residual functional remnant thyroid tissues (normal and neoplastic), timing of venous sampling after thyroidectomy and serum TSH level [19], different kits used for its measurement with different sensitivities and cut-off values [22], detection method, presence of circulating thyroglobulin antibodies (TgAb) in the serum which may interfere in Tg measurement irrespective of the method selected for determination, the concentration of circulation TgAb, and their affinity, as well as their specificity [23].

The second factor that seems to affect successful remnant ablation in our study in a univariate analysis is the

Table 3 Factors affecting successful complete ablation

	Complete ablation	Incomplete ablation	*P* value
Age (years)			
<45	103 (66.9 %)	51 (33.1 %)	0.69
≥45	82 (69.5 %)	36 (30.5 %)	
Sex			
Female	144 (67 %)	71 (33 %)	0.53
Male	41 (71.9 %)	16 (28.1 %)	
Pathology			
Papillary	160 (66.4 %)	81 (33.6 %)	0.15
Follicular	25 (80.6 %)	6 (19.4 %)	
Follicular variant			
Positive	51 (75 %)	17 (25 %)	0.18
Negative	134 (65.7 %)	70 (34 %)	
Aggressive histology			
Positive	10 (76.9 %)	3 (23.1 %)	0.56
Negative	175 (67.6 %)	84 (32.4 %)	
Histologic grade			
Well differentiated	45 (64.3 %)	25 (35.7 %)	0.53
Moderately differentiated	22 (56.4 %)	17 (43.6 %)	
Poorly differentiated	1 (100 %)	0 (0 %)	
Primary tumor (T stage)			
T1	66 (62.3 %)	40 (37.7 %)	0.06
T2	34 (70.8 %)	14 (29.2 %)	
T3	40 (81.6 %)	9 (18.4 %)	
T4	3 (100 %)	0 (0 %)	
Size of primary malignant lesion			
Less than 4 cm	108 (67.5 %)	52 (32.5 %)	0.36
More than 4 cm	34 (75.6 %)	11 (24.4 %)	
Multi-focality			
Unifocal	106 (69.3 %)	47 (30.7 %)	0.87
Multifocal	39 (70.9 %)	16 (29.1 %)	
Lymph node (N stage)			
N1	26 (54.2 %)	22 (45.8 %)	0.03
N0	159 (71 %)	65 (29 %)	
Capsular nodular invasion			
Negative	54 (64.3 %)	30 (35.7 %)	0.13
Positive	64 (75.3 %)	21 (24.7 %)	
Thyroid capsule invasion			
Negative	155 (65.7 %)	81 (34.3 %)	0.03
Positive	30 (83.3 %)	6 (16 %)	
Vascular invasion			
Negative	19 (55.9 %)	15 (44.1 %)	0.74
Positive	7 (63.6 %)	4 (36.4 %)	
Baseline Tg			
Less than 3.8 ng/ml	98 (79 %)	26 (21 %)	<0.0001
More than 3.8 ng/ml	87 (58.8 %)	61 (41.2 %)	

presence of LN metastases with significant difference in thyroid remnant ablation rate between patients without LN metastases (71 %) and those with LN involvement (54.2 %) ($P = 0.03$). This is in accordance with other studies that showed a negative impact of LN metastases on successful remnant ablation, such as those done by

Table 4 Factors affecting successful complete ablation

	Complete ablation	Incomplete ablation	*P* value
Associated pathology			
Multi-nodular/colloid goiter	67 (63.2 %)	39 (36.8 %)	0.14
Hashimoto's/lymphocytic thyroiditis	14 (56 %)	11 (44 %)	
Toxic goiter	6 (85.7 %)	1 (14.3 %)	
Normal thyroid tissues	98 (73.1 %)	36 (26.9 %)	
Associated pathology			
Autoimmune	14 (56 %)	11 (44 %)	0.14
Non autoimmune	73 (64.6 %)	40 (35.4 %)	
Normal thyroid tissue	98 (73.1 %)	36 (26.9 %)	
AJCC Stage			
I	125 (66.8 %)	62 (33.2 %)	0.22
II	11 (68.8 %)	5 (31.3 %)	
III	20 (83.3 %)	4 (16.7 %)	
IV	12 (54.5 %)	10 (45.5 %)	
ETA classification			
Very low	52 (61 %)	16 (39 %)	0.54
Low	65 (70.7 %0	27 (29.3 %)	
High	60 (68.2 %)	28 (31.8 %)	
ATA classification			
Low	83 (68 %)	39 (32 %)	0.09
Intermediate	35 (77.8 %)	10 (22.2 %)	
High	29 (65.9 %)	22 (43.1 %)	
Diagnostic ^{131}I WBS before the ablative dose			
Performed diagnostic ^{131}I WBS	86 (65.2 %)	46 (34.8 %)	0.36
Not performed diagnostic ^{131}I WBS	99 (70.7 %)	41 (29.3 %)	

Table 5 Factors affecting successful complete ablation

	Complete ablation	Incomplete ablation	*P* value
Mean age and SD (years)	42.4 ± 13.	40.2 ± 13.7	0.20
Mean baseline Tg and SD (ng/ml)	20.1 ± 52.7	45.2 ± 49.5	0.002
Mean size of primary lesions and SD (cm)	2.3 ± 1.8	2 ± 1.7	0.23
Mean number of LN involved and SD	7.2 ± 9.2	5.8 ± 5.9	0.62

Verkooijen et al., who found that ablative dose of ^{131}I up to 5000 MBq failed to achieve a complete response in 60 % of the patients with N1 tumors [24], and Verburg et al., who found that patients with LN metastases had lower chance of achieving successful ablation with the initial dosage of ^{131}I ($P = 0.04$) [4]. Tamilia et al. [19] stated that the nodal micrometastases and presence of limited microscopic extra-thyroidal extension was associated with failure to ablate thyroid remnant with 1110 MBq ^{131}I. Rosaria et al. [25] found a clear relationship between ablation failures and the presence of LN metastases and tumors larger than 4 cm in diameter. However, in the present study, complete successful ablation of the tumors larger than 4 cm was 75.6 % compared to 67.5 % in tumors less than 4 cm ($P = 0.36$).

The impact of histopathology of non neoplastic thyroid tissue on ablation outcome in patients with DTC was evaluated by Wagih et al. [8], and they found incomplete ablation of 65.1 % (28/43) in patients with thyroid disorders of autoimmune origin (Hashimoto's thyroiditis and lymphocytic thyroiditis) compared to 34.4 % (21/61) for all other non autoimmune histopathologies collectively, and this difference was statistically significant. Our results showed that 44 % (11/25) patients with autoimmune thyroid disorders have incomplete ablation compared to 35.4 % (40/113) in those with other non autoimmune histopathologies collectively ($P = 0.17$).

The importance of the stunning phenomenon is that it may influence the rate of successful ablation through decrease in the iodine uptake potential of thyroid cells as

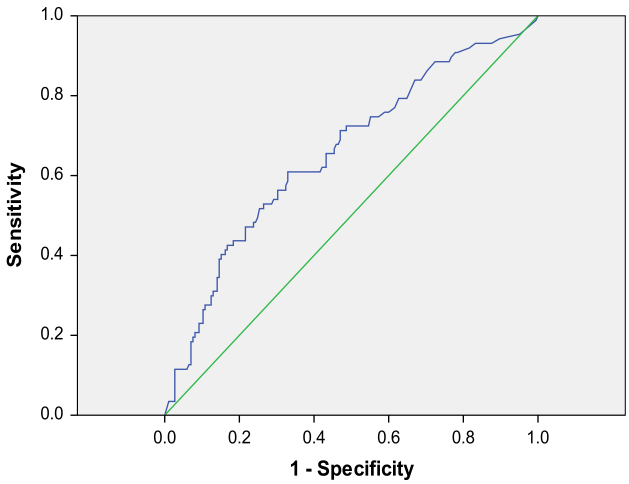

Fig. 1 Receiver operating characteristic (ROC) curves of the baseline-stimulated pre-ablation-Tg levels to define cut-off value related to failure to achieve complete successful remnant ablation

well as a change in iodine turnover [26]. Cellular damage caused by beta emission of ^{131}I which results in apoptosis activity with a subsequent reduction of the number of functional thyroid cells with intact NIS and iodine uptake. Alternatively, the release of iodinated compounds may compete with the thyroidal ^{131}I intake or reduced expression of NIS. Finally, the impairment of the iodide transport mechanisms by low-dose ^{131}I irradiation might contribute to thyroid stunning without influencing cell survival [27].

However, data about thyroid stunning are controversial, regarding whether it actually exists and whether it actually affects therapeutic outcome. Some reports stated that stunning effect due to diagnostic dose of ^{131}I given before ablative doses [9, 28–32] has an impact on ablation outcome. On the other hand, there are studies that did not support the stunning phenomenon, as those conducted by Karam et al. [33], Bajen et al. [34], and Morris et al. [35]; the latter authors found that no difference in outcome exists between a group who had a prior diagnostic scan using doses of 111–185 MBq of ^{131}I, and another group who did not (65 versus 67 %, respectively). Our results matched the latter ones, as 65.2 % of the patients who underwent diagnostic scan using doses of 111–185 MBq of ^{131}I, followed by ablative dose achieved complete successful ablation compared to 70.7 % in the other group who did not underwent pre-ablative diagnostic scan (P value = 0.36).

Although the specific factors that may account for the discordant observations, regarding stunning effect between the various studies cannot be precisely identified, there are some factors may produce these discordant results, such as dose of diagnostic scan, time interval from the administered diagnostic dose to the time of administered ablative dose, volume of thyroid tissue remnant, whether the remnant consists of normal thyroid cells or malignant cells, uptake of radioiodine by the thyroid remnant, variability of residence time of radioiodine in the thyroid remnant and radiation-absorbed dose, and varying radiosensitivity of thyroid tissue, as well as the method used to confirm or disprove stunning either qualitatively or quantitatively. In the present study, we evaluate stunning effect through the impact of diagnostic dose on the rate of successful complete ablation which depends not only upon one single factor but also upon many factors. These factors are somehow interlinked with each other; among them the varying radiosensitivity of thyroid tissue. This biological variable is unknown, undefined, and unpredictable and varies from individual to individual [5].

No significant association was found with age, gender, different pathological variables, histological grading, size of the primary lesion, multi-focality, invasiveness of the tumor (capsular nodular and vascular invasion), and number of lymph nodes involved and successful ablation. This was also shown by other studies [33].

In conclusion, stimulated pre-ablation-Tg level constitutes a prognostic indicator in predicting those patients with DTC who are less likely to achieve complete successful ablation by 3700 MBq ^{131}I. It can be used to help in the decision making for ^{131}I treatment, such as giving larger doses for patients with a higher pre-ablation Tg or applying other treatment options for patients denying radioiodine ablation. This is also applicable to cervical lymph nodal involvement and thyroid capsule invasion.

Table 6 Logistic regression for factors affecting ablation rate

	P value	OR	95.0 % CI for EXP (*B*)		*B*	SE
Baseline Tg	<0.0001	2.64	1.54	4.54	0.972	0.277

B regression coefficient, *SE* standard error, *OR* odds ratio, *CI* confidence interval

Compliance with ethical standards

Conflicts of interest None.

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