



Anxiety and depression status prior to radioactive iodine therapy among differentiated thyroid cancer patients during the COVID-19 pandemic

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Abstract

Objective The psychological health of thyroid cancer patients cannot be ignored; however, few studies have been conducted on the psychological status and influencing factors of thyroid cancer patients before radioactive iodine (RAI) therapy. The aim of this study was to investigate the incidence and risk factors for anxiety and depression in thyroid cancer patients prior to RAI therapy.

Methods Clinical data were collected from patients with differentiated thyroid cancer (DTC) patients preparing for RAI therapy. Anxiety and depression were measured before RAI therapy using the Generalized Anxiety Disorder Questionnaire (GAD-7) and Patient Health Questionnaire (PHQ-9). We used the chi-square test and logistic regression analysis to identify independent risk factors for anxiety and depression.

Results A total of 112 patients with thyroid cancer were included. Of these, 72.32% ($n = 81$) were female, with a mean age of 41.50 years. Anxiety and depression were reported by 46 (41.08%) and 38 (33.93%) patients, respectively. Based on the chi-square test and univariate logistic regression analysis, being female and having ever-experienced RAI therapy were significant risk factors for anxiety and depression among DTCs prior to RAI therapy. On multivariable analysis, the results of model 2 which included age, sex, education level, and ever suffering radioactive iodine therapy showed that being female was markedly associated with anxiety and depression in these patients, while having ever undergone RAI therapy was significantly related to anxiety but not depression.

Conclusions The incidence of anxiety and depression among patients with DTC prior to RAI therapy were 41.08% and 33.93%, respectively. Being female and having ever experienced RAI therapy significantly influenced anxiety and depression. Based on these findings, anxiety and depression assessment should be an important part of pre-RAI therapy in patients with DTC, and appropriate psychological nursing intervention can be carried out for key patients.

Keywords Differentiated thyroid cancer · Radioactive iodine therapy · Anxiety · Depression · COVID-19

Abbreviations

RAI Radioactive iodine

DTC Differentiated thyroid cancer

GAD-7 Generalized Anxiety Disorder Questionnaire

PHQ-9 Patient Health Questionnaire

ORs Odd ratios

CI Confidence intervals

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Introduction

The poor psychological state of cancer patients will affect the quality of treatment and may even be related to poor prognosis [1–4]. At present, many studies on the psychological health status of cancer survivors have focused on who receives radiotherapy and chemotherapy [5–8]. Anxiety and depression are the most common psychological problems in the treatment of cancer patients and are related to the majority of medical diseases and physical symptoms. Moreover, anxiety and depression probably increase the risk of other diseases in cancer patients, such as acute radiation toxicities [9]. Interestingly, studies have shown that anxiety and depression are more prevalent in head and neck tumor patients than in other tumors and notably have a higher incidence before radiotherapy [5, 10].

In recent years, the incidence rate of thyroid cancer has increased worldwide [11, 12]. Thyroid cancer is one of the most common head and neck cancers and a major endocrine cancer. Although the prognosis of thyroid cancer patients is generally good and the 10-year survival rate exceeds 90%, life-long follow-up and medication are likely needed [13]. Previous studies have indicated that anxiety is a common problem among thyroid cancer survivors [14]. In addition, a study in North America showed that the diagnosis and treatment of thyroid cancer can lead to a decline in quality of life [15]. The diagnosis of thyroid cancer could also reportedly cause psychological distress in patients [16]. These psychosocial studies suggested that there is a substantial unmet need for psychosocial support in patients with thyroid cancer. Fortunately, psychological nursing intervention can effectively alleviate the psychological pain of thyroid cancer patients and improve their quality of life [17].

Postsurgical radioactive iodine (RAI) therapy is a crucial and effective treatment for reducing the risk of recurrence and even the mortality of differentiated thyroid cancer (DTC) patients [18–20]. Notably, DTC patients with RAI therapy probably experience physical symptoms (such as a loss of appetite, fatigue, nausea, and neck pain) [21] and might experience various emotional symptoms in response (such as anxiety, depression, and uncertainty) [16]. Moreover, RAI therapy is associated with other adverse effects, such as salivary gland dysfunction and the induction of secondary primary malignancies [22]. For female patients with DTC, RAI therapy possibly may impact ovarian function and fertility [23]. Therefore, RAI therapy will inevitably increase the psychological burden of DTC patients. However, few studies have focused on the relationship between psychological health conditions and RAI therapy. This paucity may be related to the fact that RAI therapy is a specific treatment for thyroid cancer rather than a common therapy for most cancers. Although a previous study demonstrated that radiation exposure significantly influences thyroid cancer patients who

had significant distress [16], only 9 patients suffered radiation exposure in the study. Too few samples limited the research significance of radiation exposure in the psychosocial distress of thyroid cancer patients. Lee et al. demonstrated that DTC patients showed insecurity and depression after RAI treatment [24]. Additionally, many studies have shown that patients with tumors face more serious challenges, such as COVID-19 infection and psychological burdens, than the general population [25–27]. Numerous studies have reported the psychological health status of different cancer patients during the COVID-19 period [28–31]. For example, the incidence of psychological symptoms in Chinese patients with thyroid cancer markedly increased during the COVID-19 pandemic [32].

However, research on anxiety- and depression-related factors in thyroid cancer patients before RAI therapy during the COVID-19 pandemic in China is lacking. We first aim to describe the psychological status of DTC patients before RAI therapy and then explore the influencing factors of anxiety and depression to obtain useful information for the development of such psychological nursing interventions. Therefore, nuclear medicine physicians can screen out high-risk patients with poor psychological states through early intervention before RAI therapy to correct their unfavorable psychological status and improve quality of life in a timely manner.

Methods

Study participants

This work is a cross-sectional study performed via an online survey conducted from March to June 2021. In the nuclear medicine department of Shanghai Tenth People's Hospital, an online anonymous questionnaire survey was conducted on hospitalized patients diagnosed with DTC according to postoperative pathological reports. Patients completed questionnaires before RAI therapy and orally attested that the information provided was true. We excluded patients with a history of psychological disorders or who could not guarantee the authenticity of the information.

In online survey, the Generalized Anxiety Disorder Questionnaire (GAD-7) [33] and Patient Health Questionnaire (PHQ-9) [34] were used to assess anxiety and depression symptoms. Moreover, the patients' basic information, including age, sex, employment status, marital status, education level, alcohol consumption, smoking, the rounds of RAI therapy, and history of psychological disorders, were collected.

Mental health assessment

The GAD-7, a seven-item anxiety scale reported by Spitzer et al. with a score of 0 to 3 for each item, was used to measure anxiety symptoms in patients. The GAD-7 is one of the most

concise and clinically proven methods to evaluate the symptoms of generalized anxiety disorder. The PHQ-9 scale, a nine-item questionnaire with each item scored 0–3 and good reliability and validity, was administered to reflect the severity of depression symptoms. The total scores of GAD-7 and PHQ-9 were categorized as follows: GAD-7, no anxiety (0–4), mild anxiety (5–9), moderate anxiety (10–14), and severe anxiety (15–21); and PHQ-9, no depression (0–4), mild depression (5–9), moderate depression (10–14), and severe depression (15–27).

Statistical analysis

All data were analyzed using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA). The internal consistency of the PHQ-9 and GAD-7 scales was tested with Cronbach's alpha coefficient, and the validity of the scales was analyzed with the Bartlett sphere test. The Pearson correlation coefficient was calculated among the different items of the two scales, and if the correlation coefficient was less than 0.3, the item lacked strong correlation with the other items and could be removed. Frequencies and percentages were used for count data, and the chi-square test was used to compare the data for different categorical variables. Univariate and multivariable logistic regression analyses with odd ratios (ORs) and confidence intervals (CIs) were carried out to evaluate the association between psychological status and potential predictors. We performed multivariable regression analysis after merging current smoker and former smoker in smoking status and merging current drinker and former drinker in alcohol drinking status because the numbers of participants in the two categories were small. Model 1 included sex, ever suffering radioactive iodine therapy, age, education level, marital status, employment status, smoking status and alcohol drinking status, while model 2 only included sex, ever suffering radioactive iodine therapy, age and education level. A *P* value < 0.05 was considered statistically significant.

Results

Basic demographic characteristics and psychological status

After excluding 8 patients who were unwilling to guarantee the authenticity of information, a total of 112 DTC patients who completed the questionnaire were enrolled. Overall, the majority of patients were female (72.32%), employed (63.39%), married (80.36%), had a college degree or higher (52.68%), never smoked (87.50%), never drank (82.14%), and had no experience with radioactive iodine therapy (77.68%). Detailed basic demographic characteristics are shown in Table 1.

The questionnaire results showed that the mean GAD-7 scale score was 4.25 (0–21, IQR 0–7) and the mean PHQ-9

Table 1 Patients' demographic and clinical characteristics

Variables	Participants
Age (years), Mean (SD)	41.50 (12.24)
Sex, <i>n</i> (%)	
Female	81 (72.32)
Male	31 (27.68)
Education level, <i>n</i> (%)	
High school or lower	53 (47.32)
College degree or higher	59 (52.68)
Marital status, <i>n</i> (%)	
Married	90 (80.36)
Single/divorced/widowed	22 (19.64)
Employment status, <i>n</i> (%)	
Employed	71 (63.39)
Not working	41 (36.61)
Smoking status, <i>n</i> (%)	
Current smoker	5 (4.46)
Ex-smoker	9 (8.04)
Never	98 (87.50)
Alcohol drinking status, <i>n</i> (%)	
Current	7 (6.25)
Former	13 (11.61)
Never	92 (82.14)
Ever suffered radioactive iodine therapy, <i>n</i> (%)	
Yes	25 (22.32)
No	87 (77.68)
GAD-7, <i>n</i> (%)	
0–4 (asymptomatic)	66 (58.92)
5–9 (mild)	28 (25.00)
10–14 (moderate)	9 (8.04)
15–21 (severe)	9 (8.04)
PHQ-9, <i>n</i> (%)	
0–4 (asymptomatic)	74 (66.07)
5–9 (mild)	24 (21.43)
10–14 (moderate)	8 (7.14)
15–21 (severe)	6 (5.35)

Abbreviations: SD standard deviation. GAD-7 Generalized Anxiety Disorder Questionnaire, PHQ-9 Patient Health Questionnaire.

scale score was 4.19 (0–27, IQR 0–7). In total, 46 patients (41.07%) had anxiety symptoms, including 28 (25.00%) mild, 9 (8.04%) moderate, and 9 (8.04%) severe anxiety patients. The prevalence of depression symptoms in patients with DTC was 38 (33.93%), including 24 (21.43%) mild, 8 (7.14%) moderate, and 6 (5.35%) severe depression patients.

Reliability and validity test of scales

The Cronbach's alpha coefficient for the GAD-7 was 0.927 and retained good values (0.913–0.932) even if we deleted any one item (Table 2), indicating excellent

Table 2 Cronbach alpha and correlation coefficient of different items on the GAD-7 scale

	Cronbach alpha if item deleted	G1	G2	G3	G4	G5	G6	G7
G1	0.932	1.000	0.715	0.598	0.521	0.452	0.526	0.556
G2	0.917	0.715	1.000	0.717	0.706	0.592	0.685	0.663
G3	0.913	0.598	0.717	1.000	0.797	0.715	0.726	0.684
G4	0.914	0.521	0.706	0.797	1.000	0.836	0.703	0.639
G5	0.921	0.452	0.592	0.715	0.836	1.000	.682	0.651
G6	0.919	0.526	0.685	0.726	0.703	0.682	1.000	0.693
G7	0.922	0.556	0.663	0.684	0.639	0.651	.693	1.000

Table 3 Cronbach alpha and correlation coefficient of different items on the PHQ-9 scale

	Cronbach alpha if item deleted	P1	P2	P3	P4	P5	P6	P7	P8	P9
P1	0.859	1.000	0.580	0.610	0.604	0.397	0.459	0.501	0.430	0.280
P2	0.863	0.580	1.000	0.346	0.486	0.477	0.571	0.329	0.668	0.402
P3	0.865	0.610	0.346	1.000	0.576	0.506	0.430	0.518	0.296	0.357
P4	0.858	0.604	0.486	0.576	1.000	0.587	0.392	0.514	0.397	0.358
P5	0.864	0.397	0.477	0.506	0.587	1.000	0.426	0.458	0.451	0.359
P6	0.866	0.459	0.571	0.430	0.392	0.426	1.000	0.460	0.566	0.517
P7	0.864	0.501	0.329	0.518	0.514	0.458	0.460	1.000	0.427	0.469
P8	0.867	0.430	0.668	0.296	0.397	0.451	0.566	0.427	1.000	0.596
P9	0.874	0.280	0.402	0.357	0.358	0.359	0.517	0.469	0.596	1.000

internal consistency. Similarly, the Cronbach's alpha coefficient of the PHQ-9 scale was 0.878, and the coefficients exceeded 0.85 after deleting any one item (Table 3). Additionally, the validity test showed that the KMO of the GAD-7 and PHQ-9 was all above 0.85, and the Bartlett sphericity test showed that all *P* values were < 0.001 (Table 4), demonstrating that the GAD-7 and PHQ-9 have excellent validity and reliability in this study.

Factors influencing anxiety and depression

Overall, the factors that influenced depression and anxiety in DTC patients were similar, as shown in Table 5. The chi-square test showed that sex and the rounds of RAI therapy were associated with anxiety and depression among patients (Table 5, $P < 0.05$). The prevalence of anxiety was significantly higher among female patients than among male patients. Patients who had ever undergone RAI therapy were more likely to have anxiety symptoms than those who were prepared for RAI therapy for the first time. Notably, being female and having ever undergone RAI therapy patients were also associated with depression (Table 5, $P < 0.05$). The prevalence of anxiety and depression was not significantly different among patients of different ages, educational levels, marital statuses, and employment statuses (all $P > 0.05$).

In the univariate logistic regression analysis (Table S1), compared with male sex, female sex was an independent risk factor associated with anxiety (ORs, 3.184; 95% CIs, 1.234–8.216; $P = 0.017$) and depression (ORs, 3.575; 95% CIs, 1.245–10.265; $P = 0.018$). Having ever undergone RAI therapy was a significant risk factor for developing anxiety (ORs, 2.710; 95% CIs, 1.088–6.749; $P = 0.032$) and depression (ORs, 2.687; 95% CIs, 1.080–6.686; $P = 0.034$) symptoms.

Notably, in multivariable analysis (Table 6), the results of model 1 showed that only being female was significantly associated with anxiety (ORs, 3.486; 95% CIs, 1.155–10.520; $P = 0.027$) and depression (ORs, 4.390; 95% CIs, 1.275–15.123; $P = 0.019$) in these patients, indicating that female patients had a higher risk of anxiety and depression symptoms. In model 2, significant independent variables from the chi-square test, including being female and

Table 4 Validity test of GAD-7 and PHQ-9

Scale	KMO value	Bartlett sphericity test	
		Approximate chi-square	Significance
GAD-7	0.881	581.712	0.000
PHQ-9	0.857	491.503	0.000

Bold indicates $p < 0.05$

Table 5 The Questionnaire results of GAD-7 and PHQ-9

	GAD-7			PHQ-9		
	No-anxiety (n, %)	Anxiety (n, %)	P value	No-depression (n, %)	Depression (n, %)	P value
Total	66 (58.92)	46 (41.08)		74 (66.07)	38 (33.93)	
Gender			<i>P</i> =0.014			<i>P</i> =0.014
Male (<i>n</i> =31)	24 (77.42)	7 (22.58)		26 (83.87)	5 (16.13)	
Female (<i>n</i> =81)	42 (51.85)	39 (48.15)		48 (59.26)	33 (40.74)	
Education level			<i>P</i> =0.391			<i>P</i> =0.420
High school or lower (<i>n</i> =53)	29 (54.72)	24 (45.28)		33 (62.26)	20 (37.74)	
Bachelor's degree or higher (<i>n</i> =59)	37 (62.71)	22 (37.29)		41 (69.49)	18 (30.51)	
Marital status			<i>P</i> =0.986			<i>P</i> =0.816
Married (<i>n</i> =90)	53 (58.89)	37 (41.11)		59 (65.56)	31(34.44)	
Single/divorced/ widowed (<i>n</i> =22)	13 (59.09)	9 (40.91)		15(68.18)	7(31.82)	
Employment status			<i>P</i> =0.949			<i>P</i> =0.652
Employed (<i>n</i> =71)	42 (59.15)	29 (40.85)		48 (67.61)	23 (32.39)	
Not working (<i>n</i> =41)	24 (58.54)	17 (41.46)		26 (63.41)	15 (36.59)	
Smoking status			<i>P</i> =0.484			<i>P</i> =0.720
Current smoker (<i>n</i> =5)	3 (60.00)	2 (40.00)		3 (60.00)	2 (40.00)	
Ex-smoker (<i>n</i> =9)	7 (77.78)	2 (22.22)		7 (77.78)	2 (22.22)	
Never (<i>n</i> =98)	56 (57.14)	42 (42.86)		64 (65.31)	34 (34.69)	
Drinking status			<i>P</i> =0.517			<i>P</i> =0.618
Current (<i>n</i> =7)	3 (42.86)	4 (57.14)		4 (57.14)	3 (42.86)	
Former (<i>n</i> =13)	9 (69.23)	4 (30.77)		10 (76.92)	3 (23.08)	
Never (<i>n</i> =92)	54 (58.70)	38 (41.30)		60 (65.22)	32 (34.78)	
Ever suffered radioactive iodine therapy			<i>P</i> =0.029			<i>P</i> =0.030
Yes (<i>n</i> =25)	10 (40.00)	15 (60.00)		12 (48.00)	13 (52.00)	
No (<i>n</i> =87)	56 (64.37)	31 (35.62)		62 (71.26)	25 (28.74)	

having ever undergone RAI therapy, were included in the multivariable regression analysis, and education level was included in model 2 because education level was associated with poorer psychological health among patients with thyroid cancer in previous study [32], also, age was also associated with anxiety in thyroid cancer patients [35]. The results of model 2 (Table 6) showed that being female was

significant risk factor for suffering anxiety (ORs, 3.047; 95% CIs, 1.140–8.141; *P*=0.026) and depression (ORs, 3.433; 95% CIs, 1.160–10.160; *P*=0.026), while having ever undergone RAI therapy was significantly related to anxiety (ORs, 2.664; 95% CIs, 1.007–7.047; *P*=0.048) but not depression (ORs, 2.639; 95% CIs, 0.995–7.005; *P*=0.051).

Table 6 Multivariable regression analysis of factors influencing patients' anxiety and depression

	GHD-7 (anxiety)			PHQ-9 (depression)		
	ORs	95% CIs	P value	ORs	95% CIs	P value
Model 1						
Gender	3.486	1.155–10.520	0.027	4.390	1.275–15.123	0.019
Model 2						
Gender	3.047	1.140–8.141	0.026	3.433	1.160–10.160	0.026
Ever suffered radioactive iodine therapy	2.664	1.007–7.047	0.048	2.639	0.995–7.005	0.051

Model 1 included sex, ever suffering radioactive iodine therapy, age, education level, marital status, employment status, smoking status and alcohol drinking status; model 2 included sex, having ever-experienced RAI therapy, age and education

Abbreviations: ORs odds ratios, CIs confidence intervals, GAD-7 Generalized Anxiety Disorder Questionnaire, PHQ-9 Patient Health Questionnaire.

Discussion

The study investigated the psychological status including anxiety and depression symptoms among 112 DTC patients before RAI therapy during the COVID-19 pandemic. Overall, 41.08% had symptoms of anxiety and 33.93% had symptoms of depression. We also explored the influence of demographic and clinical characteristics on psychological health status, showing that being female and having ever suffered RAI therapy were potential factors associated with poorer psychological health.

Cancer patients not only have physical symptoms due to the disease itself and treatment process, but also suffer from psychological distress caused by economic burden and social factors [36–39]. Thus, cancer patients are likely to have varying degrees of negative psychological states, such as anxiety and depression [40–43]. Psychological symptoms, including anxiety and depression, could cause a decline in treatment adherence in cancer patients. Furthermore, anxiety and depression in cancer patients are associated with poorer quality of life [44, 45] and unfavorable prognosis [3, 46]. Radiotherapy, chemotherapy and other treatments can further increase the psychological burden of cancer patients [6, 47, 48]. Therefore, the psychological health of cancer patients before and during the treatment process must be evaluated.

Pre-COVID-19 studies have suggested that anxiety and depression are common in patients with thyroid cancer [14, 15, 17]. During the COVID-19 period, the psychological burden of cancer patients further increased [27, 28]. Data from a survey of Chinese thyroid cancer patients showed that during the COVID-19 crisis, thyroid cancer patients had higher levels of psychological symptoms, such as anxiety and depression, than Chinese cancer patients before the COVID-19 pandemic [32]. This finding demonstrated that the COVID-19 pandemic has had a significantly negative impact on psychological health in thyroid cancer survivors. Currently, RAI therapy is a commonly used treatment for patients with a high risk of thyroid cancer and can improve the survival rate in advanced

or metastatic patients [18], but the need for RAI therapy and the dose of RAI remain controversial in some patients [22]. In addition, some side effects caused by radiation exposure due to RAI therapy cannot be ignored, such as radiation salivary gland damage [21]. As a result, thyroid cancer patients who are preparing for RAI treatment may experience higher psychological distress due to the unknown course of treatment and the fear of adverse effects of radiation exposure. Although a few previous studies have investigated the association between mental health and RAI therapy in thyroid cancer patients, the results were contradictory. Wu, HX, et al. [49] and Yoo, SH, et al. [50] suggested that psychological and behavioral interventions for thyroid patients receiving RAI may improve their psychological status, while Seyedshahab, Banihashem, et al. [51] thought that psychological interventions might be limited. After a comprehensive literature search, few studies on the psychological state of DTC patients before RAI therapy were identified, especially during the COVID-19 pandemic.

In the present study, our results clearly showed a higher incidence of psychological symptoms including anxiety and depression among these DTC patients prior to RAI therapy during the COVID-19 pandemic. We believe that this phenomenon is related not only to the increased psychological burden of DTC patients due to RAI therapy itself, but also to the fact that patients stop thyroid hormone supplementation before RAI therapy and that hypothyroidism might lead to psychological symptoms. However, some studies have suggested that hypothyroidism is not significantly related to depression or anxiety [52, 53]. Therefore, anxiety and depression in these patients are more likely to be related to fear of RAI therapy.

The results of this study showed that sex was an independent factor associated with anxiety and depression, which was consistent with previous studies showing that female patients with DTC bear greater psychological burden [54]. Previous studies have shown that being female is an important risk factor for the decline of quality of life in the diagnosis and treatment of thyroid cancer [15]. In addition, many previous publications have indicated that female cancer patients seem to be more

vulnerable [55]. Therefore, female cancer patients be universally be more likely to develop psychological problems.

Interestingly, we found that having ever experienced RAI therapy was an independent risk factor for anxiety and depression in DTC patients, which has rarely been reported in previous studies. Generally, multiple rounds of RAI therapy indicate a higher risk in DTC patients with tumor progression, recurrence or distant metastasis, poor treatment effect, or even refractory diseases after RAI therapy [18]. Importantly, previous research suggested that anxiety in thyroid cancer patients may depend not only on the real threat of thyroid cancer itself, but also on subjective assumptions about the threat of cancer [14]. We proposed that anxiety and depression in these patients are associated with the fear of thyroid cancer progression, metastasis, and recurrence, leading to lower confidence in disease recovery and resulting in greater psychological pain. Moreover, financial burden, self-cognitive dissonance, and a lack of social support may also be important factors that significantly and negatively modulate the psychological state of patients receiving multiple rounds of RAI therapy. Overall, we identified independent factors associated with the symptoms of anxiety and depression, which allows patients at higher risk for psychological distress to be identified earlier and more accurately in the future. DTC patients with higher levels of mental health problems need to be screened and identified during the COVID-19 pandemic. In addition to current public health interventions during the COVID-19 crisis, psychological nursing and intervention should be implemented to support people with thyroid cancer in coping with depression and anxiety.

This study has some limitations. First, although the GAD-7 and PHQ-9 scales are common approaches to evaluate patients' anxiety and depression, these two scales have certain limitations, and the evaluation of anxiety and depression with only a single scale is also limited. The patient's psychological symptoms and the severity of said symptoms can be more reliably reflected if multiple recognized and valid psychological scales are used simultaneously. Second, the long-term psychological health and associated influencing factors of DTC patients after RAI therapy should be further investigated in follow-up studies. Finally, since this study was a single-institution study with a small patient sample size, a larger sample size and multicenter study may be required for a more representative prospective study.

Conclusion

To our knowledge, our study is the first to observe the psychological status of DTC patients before RAI therapy during the COVID-19 pandemic and to investigate the impact of different factors on anxiety and depression, thus enriching a research gap in this field. We found that DTC patients are

prone to symptoms of anxiety and depression prior to RAI therapy, and the incidence of these symptoms is closely associated with sex and having ever experienced RAI therapy. We recommend that nuclear medicine physicians focus on the psychological status of key populations, including female DTC patients and patients who have undergone RAI therapy; at the same time, psychological nursing and intervention can be conducted. In addition, further large-scale prospective multicenter studies should be performed to investigate the effect of psychological care on improving the psychological status of patients with DTC.

Supplementary information The online version contains supplementary material available at <https://doi.org/10.1007/s00520-022-07422-7>.

Authors' contributions All authors contributed to the study conception and design. Tingting Qiao, Dingwei Gao, Yun Shen, and Jiayue Ma conceived the study and participated in research design and data interpretation. Tingting Qiao and Dingwei Gao contributed significantly to analysis and manuscript preparation. Tingting Qiao and Junyu Tong performed the data analyses. Tingting Qiao and Dingwei Gao prepared figures and tables. Tingting Qiao wrote the first draft of manuscript. Dan Li and Zhongwei Lv helped perform the analysis with constructive discussions. Dan Li and Zhongwei Lv helped revise the article. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability The data that support the findings of this study are available from the corresponding author, LD, upon reasonable request.

Declarations

Ethics approval The study was approved by the Ethics Committee of Shanghai Tenth People's Hospital (ethics no.: shsy-IEC-ki-4.0/16-18/01).

Consent to participate All individual participants consented to participate in the study.

Consent for publication All individual participants consented to having their data published.

Conflict of interest All the authors declare that they have no conflicts of interest.

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