ORIGINAL ARTICLE

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Role of Nuclear Medicine in Diagnosing Different Patterns of Thyroid Abnormalities in Patients Referred for Thyroid Scintigraphy to Centre for Nuclear Medicine and Radiotherapy (CENAR) Quetta, Pakistan

Shagufta Kanwal[1], Hafiz KhushNaseeb Ahmad[2], Muhammad Sadiq[3], Imran Arif[4], Hameeda Naheed[5], Hina Manzoor[6], Shehla Iftikhar[7], Sunnia Shafiq[8]

1 *Medical Officer, Department of Nuclear Medicine, Centre for Nuclear Medicine & Radiotherapy (CENAR), Quetta Pakistan*
Contribution in the study

2 *Principal Medical Officer, Department of Nuclear Medicine, Centre for Nuclear Medicine & Radiotherapy (CENAR), Quetta Pakistan*
Contribution in the study

3 *Principal Medical Officer, Department of Nuclear Medicine, Centre for Nuclear Medicine & Radiotherapy (CENAR), Quetta Pakistan*
Contribution in the study

4 *Medical Officer, Department of Nuclear Medicine, Centre for Nuclear Medicine & Radiotherapy (CENAR), Quetta Pakistan*
Contribution in the study

5 *Principal Medical Officer, Department of Oncology, Centre for Nuclear Medicine & Radiotherapy (CENAR), Quetta Pakistan*
Contribution in the study

6 *Principal Scientist, Department of Medical Physics, Centre for Nuclear Medicine & Radiotherapy (CENAR), Quetta Pakistan*
Contribution in the study

7 *Principal Medical Officer, Department of Radiology, Centre for Nuclear Medicine & Radiotherapy (CENAR), Quetta Pakistan*
Contribution in the study

8 *Junior Scientist, Department of Medical Physics, Centre for Nuclear Medicine & Radiotherapy (CENAR), Quetta Pakistan*
Contribution in the study

CORRESPONDING AUTHOR
Dr. Sunnia Shafiq
Junior Scientist, Department of Medical Physics, Centre for Nuclear Medicine & Radiotherapy (CENAR) Quetta, Pakistan
Email: suniyakhan19@gmail.com

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ABSTRACT

Background: Nuclear Medicine has been playing a vital role in identifying different patterns of thyroid diseases for functional assessment using thyroid scintigraphy. **Objective:** This study aimed to diagnose different patterns of thyroid abnormalities using thyroid scintigraphy in our area for their proper management. **Study Design:** Retrospective study. **Settings:** study was conducted at the Centre for Nuclear Medicine and Radiotherapy (CENAR) Quetta, Pakistan. **Duration:** April 2023 and September 2023. **Methods:** The study population comprised 440 patients, with a mean age of 37± 13 years, who were referred to the CENAR Nuclear Medicine department for thyroid scintigraphy. Of these, 357 (81.1%) were female and 83 (18.9%) were male. **Results:** According to study findings, the highest proportion, i.e., 59.1% (80.4% females and 19.6% males) of total patients, were reported between 21-40 years of age. Out of 440 patients, thyroid scintigraphy findings were normal in 4.5 % (20 patients) and abnormal in 95.5% (420 patients). The scan patterns included, functioning nodule 42 (9.6%), multinodular goiter 34 (7.7%), diffuse goiter 9 (2%), diffuse goiter with increased uptake (Grave's disease) 145 (33%), multinodular goiter with dominant cold nodule 29 (6.6%), thyroiditis 25 (5.7%), cold nodule 83 (18.9%), extrathyroidal swelling 3 (0.7%), hot nodule 8 (1.8%), recurrent MNG 1 (0.2%), thyroid cancer post-surgical scans 41 (9.3%) and normal 20 (4.5%). **Conclusion:** This study concluded that radionuclide thyroid scintigraphy is complementary and offers data that can aid in the proper management of a range of thyroid-related disorders.

Keywords: *Grave's disease, Hyperthyroidism, Scintigraphy, Cold nodule.*

INTRODUCTION

The thyroid gland resides in the front neck, just below the thyroid cartilage. It often weighs 15 to 20 grams and has two lobes joined by an isthmus with significant anatomical diversity. The pyramidal lobe, the remnant of the thyroglossal duct that extends superiorly from the isthmus, is present in about two-thirds of the individuals. Ectopic tissue can be found anywhere from the foramen cecum at the base of the tongue to the myocardium due to the thyroid's embryological derivation from pharyngeal pouches.[1] Throughout history, iodine-131 has played a pivotal role in advancing nuclear medicine and molecular imaging through its ability to measure thyroid functioning parameters and visualize the gland.[2]

In the 1930s, one of the earliest applications of nuclear medicine methods was to utilize the thyroid's radioiodine concentration to illustrate the physiology of radioiodine uptake. Later, in the 1940s, radioiodine was used to treat thyroid cancer and hyperthyroidism. Using nuclear imaging methods and Iodine-131 radioiodine therapy, these studies ushered in a new era in the treatment of thyroid disorders. Basic concepts of management, such as the use of radiopharmaceuticals for disease identification and localization, Iodine-131 for radioiodine treatment, and radioiodine Iodine-123 and Iodine-131 for iodine avidity testing, have not changed even if management has changed since the 1940s.[3]

Thyroid scintigraphy and radioiodine uptake tests are two common methods used to assess thyroid function based on the uptake of iodine by the thyroid cells.[4] Sodium pertechnetate Tc99m works in a similar way as iodine and is now widely used for imaging the thyroid gland.

One frequently occurring endocrine problem is goiter, an enlargement of the thyroid gland.[5] Congenital conditions, genetic predispositions, low dietary iodine intake, pregnancy, radiation therapy, viral infections, surgery, underlying illnesses like infiltrative disorders, or even autoimmunity can all contribute to thyroid disorders.[6]

The dietary availability of iodine, a crucial component of thyroid hormones, is the primary determinant of the extensive spectrum of benign thyroid disorders. Despite significant national and international efforts to raise iodine consumption, about one-third of the global population lives in iodine-deficient areas. However, iodine deficiency is becoming more widespread in industrialized nations that were previously deemed to be iodine-sufficient.[7]

The most common endocrine diseases are benign thyroid conditions, including hyper- and hypothyroidism. Toxic multinodular goiter (TMNG), autoimmune hyperthyroidism (Grave's disease, GD), and toxic thyroid adenoma (TA) are the most prevalent causes of hyperthyroidism, which leads to excessive amounts of thyroid hormones produced by the gland. Factitious hyperthyroidism and destructive thyroiditis (such as amiodarone-induced thyroid dysfunction) are less prevalent causes.[8]

On the other hand, hypothyroidism is consistent with low thyroid hormone production. The primary and most frequent cause of hypothyroidism is iodine insufficiency. In areas with enough iodine, Hashimoto's thyroiditis, which is known to be an autoimmune condition, is the primary cause of hypothyroidism. In addition, the thyroid gland is the source of nodules and a number of cancer types.[9]

Women are more likely than men to suffer from any type of thyroid condition, including nontoxic goiter, Grave's disease, Hashimoto's thyroiditis, and thyroid neoplasm. Thyroid gland diseases are frequent in adolescents, estimated to affect 3.7% of those between the ages of 11 and 18 years.[10]

In clinical practice, thyroid nodules (TN) are a frequent complaint and are common in the general population. The majority are symptomatic and have a 7%–15% chance of being malignant.[11]

Due to variations in dietary iodine consumption in various geographic regions, there is a well-established geographical dependency in thyroid illnesses.[12] Pakistan, a developing country, has a history of health issues due to iodine deficiency problems.[13]

Untreated thyroid disease can have major adverse impacts on the body, particularly on cardiovascular conditions. Therefore, in order for patients and their families to manage thyroid diseases, there has to be a greater public knowledge of thyroid conditions as well.[14]

Nuclear medicine is essential for the diagnosis of thyroid diseases. Thyroid scintigraphy offers data that cannot be obtained from anatomical imaging as it represents the gland's functioning status. In order to assess a patient who has hyperthyroidism, radioactive thyroid imaging is the preferred imaging modality.[15] The major nuclear tests in thyroid disorders are thyroid scan and uptake and thyroid hormone testing by radioimmunoassay (RIA). In standard nuclear medicine practice, thyroid scintigraphy with Tc^{99m} pertechnetate is a commonly carried out technique.[16] The adverse effects of thyroid disorders can be reduced with early detection and treatment.[10] This study aimed to diagnose different patterns of thyroid abnormalities using thyroid scintigraphy in our area for their proper management.

METHODS

This was a hospital-based study conducted in the Center for Nuclear Medicine and Radiotherapy (CENAR) Quetta, Pakistan. Established in 1987, it is equipped with a dual-head Siemens Symbia gamma camera after approval from ERC vide letter No. letter number Dir-3(17)/24. The center serves patients from Baluchistan, nearby provinces, and countries like Iran and Afghanistan.

In this retrospective study, we included every patient referred to the CENAR Nuclear Medicine department for thyroid scintigraphy between April 2023 and September 2023. The data was collected with the permission of the institutional ethical committee.

Thyroid scintigraphy was acquired using a gamma-scintillation camera with a LEHR (low energy high resolution) collimator, 10–20 minutes following intravenous injection of 3–5 mCi of sodium pertechnetate Tc99m. A 2.67 zoom factor and a 256 x 256 matrix were used to acquire the data. The acquisition of imaging was stopped after 300k counts.

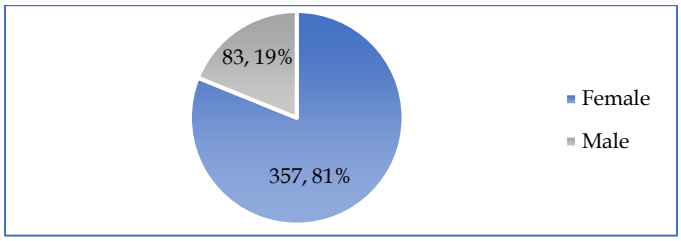
Diffuse goiter with increased uptake (Grave's disease) was diagnosed as an increase in tracer absorption throughout a diffusely enlarged thyroid gland. Short-interval signs and symptoms consistent with thyrotoxicosis were used to identify viral thyroiditis, altered Thyroid Function Tests (TFTs), and the scan showed reduced tracer uptake throughout the thyroid gland. In thyroid nodules that function autonomously, there are dominant areas of increased radiotracer uptake while the gland's overall uptake is suppressed. Nonhomogeneous areas of decreased and increased radiotracer uptake were identified as nodularity.

The IBM SPSS statistical program version 26 was used to do a descriptive analysis of the patient data in order to identify the patterns of thyroid diseases in our area.

RESULTS

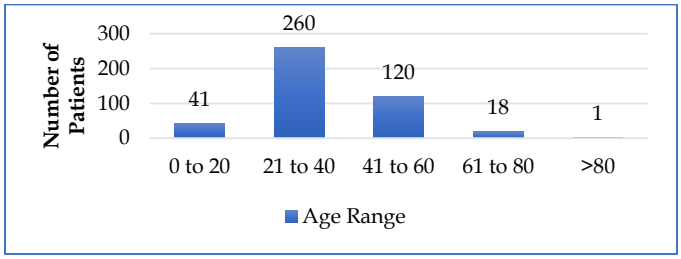
This research comprised 440 individuals who were referred for thyroid scans during the study period. There were 357 women and 83 men in the 4:1 female to male ratio. Gender distribution is shown in Figure 1.

Figure 1: Gender distribution of patients



The mean age was 37 ± 13.25 (8-83 years old). Out of 440 patients, 41 (9.3%) were in <20 years, 260 (59.1%) were in 21-40 years, 120 (27.3%) were in 41-60 years, 18 (4.1%) were in 61-80 years and 1 (0.2%) was in >80 years. (Fig. 2)

Figure 2: Patient distribution based on gender and age



The largest percentage of cases i.e. 260 (59.1%) was found in the age ranges from 21 to 40 years, among which male cases were 51 and female cases were 209. Table 1 displays the patients' distribution by age and gender grouping.

Table 1: Age and gender-based patient distribution

Age Range (years)	Gender		Total (Percentage / 440)
	Female	Male	
<20	37	4	41 (9.3%)
21 to 40	209	51	260 (59.1%)
41 t0 60	95	25	120 (27.3%)
61 to 80	15	3	18 (4.1%)
>80	1	0	1 (0.2%)
Total	**357**	**83**	**440 (100%)**

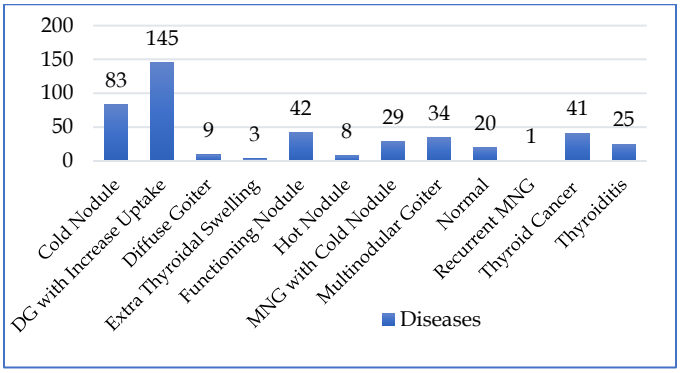
The most common pattern is diffuse goiter with increased uptake (Grave's Disease) i.e., 145 cases (32.9%), among which male cases were 43 and female cases were 102 and the second most common is cold nodule 83 (18.8%), followed by functioning nodule 42 (9.5%). (Table 2)

Table 2: Different patterns on thyroid scan with respect to gender

Disease	Gender		Frequency (Percentage)
	Male	Female	
Cold Nodule	6	77	83 (18.9%)
DG with increase uptake	43	102	145 (33%)
Diffuse Goiter	0	9	9 (2%)
Extra Thyroidal Swelling	0	3	3 (0.7%)
Functioning nodule	10	32	42 (9.6%)
Hot Nodule	1	7	8 (1.8%)
MNG with Cold Nodule	7	22	29 (6.6%)
Multinodular Goiter	1	33	34 (7.7%)
Normal	4	16	20 (4.5%)
Recurrent MNG	0	1	1 (0.2%)
Thyroid Cancer post-surgery	5	36	41 (9.3%)
Thyroiditis	6	19	25 (5.7%)
Total	**83**	**357**	**440 (100%)**

All the patterns of thyroid scans with frequencies are shown in Figure 3.

Figure 3: Patterns of thyroid scans with frequencies



Out of 440 patients, 41 (9.3%) patients diagnosed with thyroid cancer were referred for thyroid scan after thyroid surgery. All the patterns of thyroid scans with respect to age groups are shown in Table 3.

Table 3: Different patterns on thyroid scan with respect to age groups

Disease	Age (years)					Frequency (Percentage)
	<20	21-40	41-60	61-80	>80	
Cold Nodule	7	55	18	3	0	83 (18.9%)
DG with increase uptake	21	86	36	2	0	145 (33%)
Diffuse Goiter	2	5	2	0	0	9 (2%)
Extra Thyroidal Swelling	0	1	1	1	0	3 (0.7%)
Functioning nodule	4	20	14	4	0	42 (9.6%)
Hot Nodule	0	5	2	1	0	8 (1.8%)
MNG with Cold Nodule	1	17	9	2	0	29 (6.6%)
Multinodular Goiter	0	17	15	2	0	34 (7.7%)
Normal	1	12	7	0	0	20 (4.5%)
Recurrent MNG	0	1	0	0	0	1 (0.2%)
Thyroid Cancer post-surgery	2	27	9	2	1	41 (9.3%)
Thyroiditis	3	14	7	1	0	25 (5.7%)
Total	**41**	**260**	**120**	**18**	**1**	**440 (100%)**

Different Thyroid Patterns are shown in Figures 4-8.

Figure 4: Thyroid scan showing Diffused Goiter with increased uptake

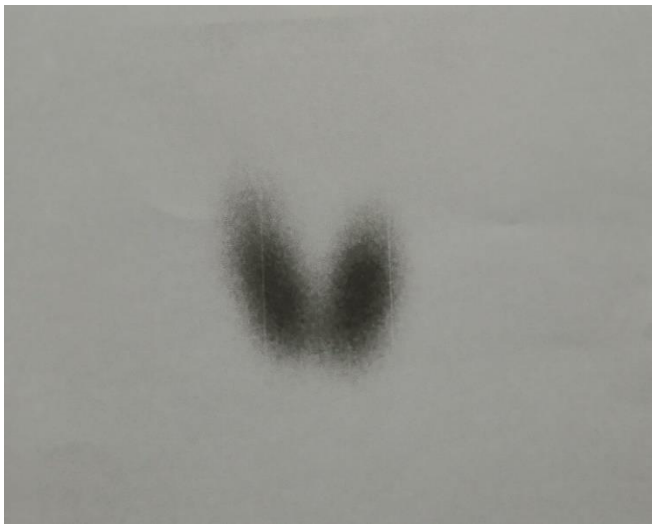


Figure 5: Thyroid scan showing Cold Nodule

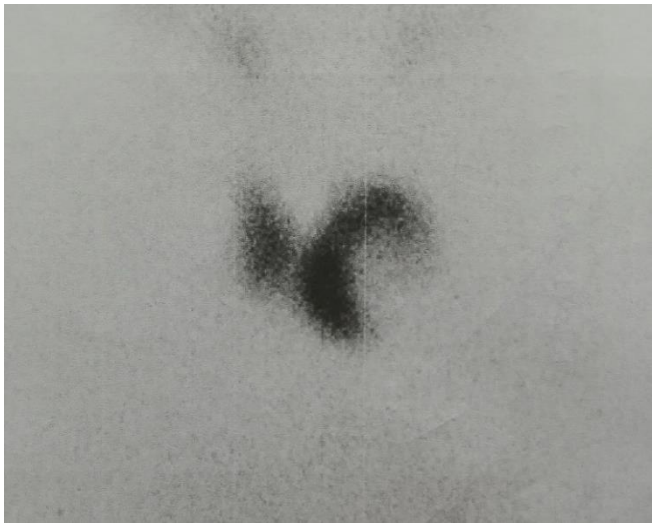


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Figure 6: Thyroid scan showing Multinodular Goiter

Figure 7: Thyroid scan showing Thyroiditis

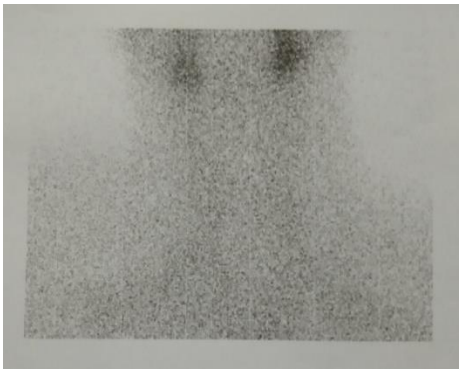
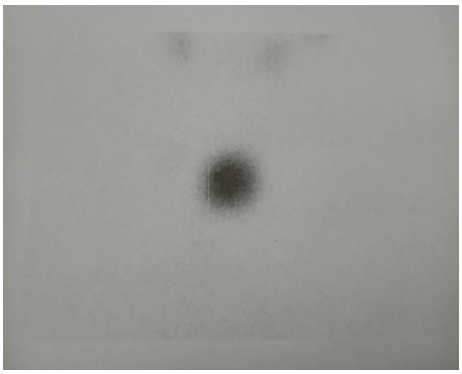


Figure 8: Thyroid scan showing Hot Nodule



DISCUSSION

A significant proportion of the patients in this study were female, aligning with numerous findings reported in the literature. Studies conducted globally have consistently shown a higher prevalence of thyroid disorders among women, as noted in several key publications.[17,18,19] The mean age of the patients in our study was 37 ± 13 years, with 59% of the 440 patients falling within the age range of 21 to 40 years. This demographic finding contrasts with the research by Antony, 14, and Rosemary Ikem,[20] where the highest prevalence of thyroid disease was observed in older patients, specifically those aged 40 to 60 years.

In this study, diffuse goiter with increased uptake emerged as the most common scintigraphic pattern, which is contrary to the findings of Elmandani *et al*[16] and Antony *et al*,[14] who reported that multinodular goiter was the predominant pattern. The variation in the common patterns observed may be attributable to differences in the patient populations, geographical factors, or diagnostic criteria used in these studies.

The thyroid radioactive uptake test has proven to be effective for differentiating between thyroiditis and Grave's hyperthyroidism in patients with low or suppressed TSH levels. This distinction is critical because the treatment approaches for these conditions are significantly different, as highlighted in the study by Elsayeed *et al*.[17] Grave's disease typically requires antithyroid medications, radioactive iodine therapy, or surgery. In contrast, thyroiditis may often be managed with symptomatic treatment alone.

Nuclear scintigraphy is vital in identifying metabolically active versus inactive nodules and assessing overall thyroid function. This diagnostic approach has been frequently utilized to evaluate various thyroid conditions, including the differentiation of cold nodules, which are less likely to function metabolically.[21] Tindall's 1987 study emphasized the use of thyroid scintigraphy primarily in evaluating single cold nodules and identifying toxic nodules in patients with thyrotoxicosis, excluding cases of Grave's disease. Refining the criteria for requesting scintigraphy can reduce unnecessary investigations and associated healthcare costs.[18,22]

In our study, cold nodules were the second most common pattern identified on thyroid scans. Notably, approximately 15-20% of cold nodules have the potential to be malignant.[1] Among the 440 patients, 83 individuals presented with cold thyroid nodules. To mitigate the risk of missing a malignancy, we recommended fine needle aspiration cytology (FNAC) for all patients with cold nodules. If cytological analysis reveals malignancy or an indeterminate tumor, surgical intervention is advised. For those with cytologically benign nodules, vigilant follow-up is generally sufficient, which is consistent with the recommendations found in Elmandani's literature.[16]

The distribution of scan patterns observed in this study included: functioning nodules in 42 patients (9.6%), multinodular goiter in 34 patients (7.7%), diffuse goiter in 9 patients (2%), diffuse goiter with increased uptake (Grave's disease) in 145 patients (33%), multinodular goiter with a cold nodule in 29 patients (6.6%), thyroiditis in 25 patients (5.7%), cold nodules in 83 patients (18.9%), extra-thyroidal swelling in 3 patients (0.7%), hot nodules in 8 patients (1.8%), recurrent multinodular goiter in 1 patient (0.2%), thyroid cancer post-surgical scan in 41 patients (9.3%), and normal thyroid scans in 20 patients (4.5%).

CONCLUSION

Using scintigraphy, nuclear medicine is essential in identifying different thyroid abnormality patterns, providing valuable insights into thyroid function, and detecting conditions such as hyperthyroidism, hypothyroidism, and nodular thyroid disease. Its clinical significance guides accurate and personalized treatment strategies for patients with thyroid disorders. In this study, young females comprised the majority of the patients. Diffuse goiter with increased uptake (Grave's disease) is a common pattern in our area. Due to radiation risks and expense, thyroid scans should only be requested for specific patients who have thyroid disease. Nuclear Medicine provides information about functional conditions despite its high dosage. Therefore, it should be taken into consideration when detecting goiter.

LIMITATIONS

It's possible that the results of this study might not fully represent the population because it was conducted in a hospital. However, it has determined the prevalence of thyroid dysfunction in our area, and the findings can serve as a baseline for further research.

SUGGESTIONS / RECOMMENDATIONS

The current study suggested that knowing the functional status of thyroid disease is essential for properly managing it. According to the study's findings, radionuclide methods can offer data that can aid in properly treating various thyroid conditions.

CONFLICT OF INTEREST / DISCLOSURE

The Authors declare no conflict of interest.

FUNDING SOURCE

Nil.

ETHICAL REVIEW COMMITTEE

The Ethical Review Committee has reviewed and approved the ethical statement associated with the manuscript titled "Role of Nuclear Medicine in Diagnosing Different Patterns of Thyroid Abnormalities in Patients Referred for Thyroid Scintigraphy to Centre for Nuclear Medicine and Radiotherapy (CENAR) Quetta, Pakistan." This study complies with ethical guidelines, including obtaining informed consent, ensuring confidentiality, managing risks, maintaining data integrity, and disclosing conflicts of interest. This approval, letter number Dir-3(17)/24, confirms adherence to the highest ethical standards and supports the publication of your paper.

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REFERENCES

1. O'Malley JP, Ziessman HA. Nuclear Medicine and Molecular Imaging: The Requisites E-Book. Elsevier Health Sciences; 2020.
2. Mettler FA, Guiberteau MJ. Essentials of Nuclear Medicine and Molecular Imaging E-Book. Elsevier Health Sciences; 2018.
3. Donohoe KJ, Aloff J, Avram AM, Bennet KG, Giovanella L, Greenspan B, et al. Appropriate Use Criteria for Nuclear Medicine in the Evaluation and Treatment of Differentiated Thyroid Cancer. J Nucl Med. 2020 Mar;61(3):375-396.
4. Garberoglio S, Testori O. Role of Nuclear Medicine in the Diagnosis of Benign Thyroid Diseases. Front Horm Res. 2016;45:24-36.
5. Mariani G, Tonacchera M, Grosso M, Fiore E, Falcetta P, Montanelli L, et al. The Role of Nuclear Medicine in the Clinical Management of Benign Thyroid Disorders, Part 2: Nodular Goiter, Hypothyroidism, and Subacute Thyroiditis. J Nucl Med. 2021 Jul;62(7):886-895.
6. Khan SA, Sah SK, Sapkota S, Bataju M, Kunwar S, Lamsal M. Pattern of thyroid disorders in a tertiary care centre, BPKIHS, Dharan. Ann Thyroid Res. 2017;3(2):105-108.
7. Vanderpump MP. Epidemiology of thyroid disorders. In: The Thyroid and Its Diseases: A Comprehensive Guide for the Clinician. Springer International Publishing; 2019. pp. 75-85.
8. Mariani G, Tonacchera M, Grosso M, Orsolini F, Vitti P, Strauss HW. The Role of Nuclear Medicine in the Clinical Management of Benign Thyroid Disorders, Part 1: Hyperthyroidism. J Nucl Med. 2021 Mar;62(3):304-312.
9. Bafaraj SM. Assessment of Sensitivity, Specificity, and Accuracy of Nuclear Medicines, CT Scan, and Ultrasound in Diagnosing Thyroid Disorders. Curr Med Imaging. 2020;16(3):193-198.
10. Hyder SW, Nagra SA. A study of goiter among female adolescents referred to Centre for Nuclear Medicine, Lahore. 2005;56-62.
11. Bernet VJ, Chindris AM. Update on the Evaluation of Thyroid Nodules. J Nucl Med. 2021 Jul;62(Suppl 2):13S-19S.
12. Knudsen N, Bülow I, Jørgensen T, Laurberg P, Ovesen L, Perrild H. Comparative study of thyroid function and types of thyroid dysfunction in two areas in Denmark with slightly different iodine status. Eur J Endocrinol. 2000 Oct;143(4):485-491.
13. Khattak R. Epidemiology of Iodine Deficiency Disorders in Pakistan and North-East Germany. Doctoral dissertation; 2018.
14. Antony J, Celine TM, Chacko M. Spectrum of thyroid disorders: A retrospective study at a medical college hospital. Thyroid Res Pract. 2014;11(2):55-59.
15. Intenzo C, Miller J, Gulati A, Colarossi D, Parekh M. The Role of Nuclear Medicine in Benign Thyroid Disease. Semin Nucl Med. 2023 Jul;53(4):469-474.
16. Elmadani A, Gasmelseed N, Abuidris D, Hamdoun A. Pattern of thyroid diseases in central Sudan: Nuclear medicine perspective. Sudan J Med Sci. 2009;4(4).
17. Elsayeed WA, Ali RA, Ahmed ME, Bakheet RA, Hassan MM. Thyroid scintigraphy indications based on clinical experience. Egypt J Neck Surg Otorhinolaryngol. 2019;5(3):6-13
18. Eltom H. Characterization of radioimmunoassay and scintigraphy as diagnostic tools for goiter in Sudanese patients. [Unpublished thesis]. 2012.
19. Afsheen M, Mirza Mohammad S, Ruqaiya S, Anwar A. Spectrum of thyroid gland disorders in Karachi-DDRRL experience. [Conference proceedings]. 2012:12-5.
20. Ikem R, Adebayo J, Soyoye D, Burolaojo, Ugwu E, Kolawole B. Spectrum of thyroid disorders in Obafemi Awolowo University teaching hospital complex. Endocrine. 2010;21:366.
21. Ahmed AB, Yousef M, Fadhlalah SA. Study of thyroid abnormalities using scintigraphy. J Biomed Eng Med Imaging. 2018 Nov 3;5(5):01.
22. Tindall H, Griffiths AP, Penn ND. Is the current use of thyroid scintigraphy rational? Postgrad Med J. 1987 Oct;63(744):869-71.