Thyroid Scintigraphy – Reporting Document

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Chapter 1: Introduction

Thyroid scintigraphy and thyroid uptake studies are routinely used in nuclear medicine for the evaluation of thyroid nodule (s), diagnosing various conditions presenting with hypo- or hyper-thyroidism and ectopic thyroid. Whole-body scanning after radioactive iodine administration is routinely done while managing differentiated thyroid cancer.

The radiopharmaceuticals used in thyroid scintigraphy are described in table 1.

Table 1. Radiopharmaceuticals available for thyroid scintigraphy.

Radiopharmceutical	Administered activity MBq (mCi)	Advantages	Disadvantages
^{99m}Tc-pertechnetate	74–370 iv (2–10)	• Readily available with low cost • Rapid scanning	• Trapped but not organified • esophagus or vascular structures can be misleading • Poor image quality when uptake is low
Na^{123}I iodide	3.7–11.1 po (0.1–0.3)	• Better for visualization of retrosternal thyroid tissue • Better image quality when uptake is low.	• Expensive • Less convenient for patient as delayed imaging at 24 hr is often used • less readily available • Imaging times are generally longer
Na^{131}I iodide (usually not used in children)	0.15–0.37 po (0.004–0.01)	Treatment planning with ^{131}I	Large radiation dose to the thyroid

Chapter 2: Indications

Indications for a radionuclide thyroid scan have become more limited and well defined with the inclusion of newer imaging modalities like ultrasound, CT and MR.

Current indications include:

- Solitary nodule, solid on ultrasound and with normal or low TSH
- Suspected ectopic thyroid
- Post operatively for residual thyroid tissue
- Follow up to look at efficacy of ablation with I-131
- To differentiate the causes of hyperthyroidism
- To evaluate functional characteristic of a nodule. (a focus of intense radiotracer uptake (hot nodule) or accumulates the radiotracer at a level similar to or lower than the rest of the gland (warm or cold nodule).
- Suspected cases of thyroiditis
- Detection of retrosternal goitre
- In case of multiple nodules, scintigraphy can help to choose / select the biopsy site expected to give the highest yield. The most non-functioning solid nodule should be biopsied when several variously functioning nodules are present are seen.

Chapter 3: Imaging Protocols

3.1 Clinical details

3.1.1 History:

- Any query / concern raised by referring physician must be recorded and addressed in the report or impression
- Any factor which can change uptake or appearance of organ should be noted e.g. Antithyroid medications, iodine intake, thyroxine intake etc.
- History of pregnancy/ lactation in females. Female patients who are pregnant or breast feeding should be informed by nuclear medicine physician about precautions before taking a diagnostic test. Although the radiation exposure involved is very low, however, in case of pregnancy the procedure would be performed only if really needed at that point (benefit vs. risk evaluation).

3.1.2 Physical examination:

Examination is important to mark size and position of nodules on rough diagram of thyroid gland.

3.1.3 Investigations:

- Thyroid function tests should be available, along with normal values of the reporting lab.
- History of medication (time / duration, last dose).
- Any relevant imaging for correlation (USG neck should be available for correlation and meaningful reporting, prior thyroid imaging tests, Results of prior thyroid uptake measurement, etc.). All previous studies should be available for comparison before reporting.

3.2 Patient preparation:

- No prior patient preparation is needed for thyroid scintigraphy.
- Stop anti-thyroid drugs for appropriate number of days before scanning (3-5 days).
- Stop thyroid replacement therapy/ iodinated contrast media/ iodine rich food 4 weeks before scanning.

3.3 Dosage/ Administered activity

- ^{99m}Tc-pertechnetate = 74–370 Mbq (2–10 mCi) intravenously
- ^{123}I-Na Iodide = 3.7–11.1 Mbq (0.1–0.3 mCi) orally
- ^{131}I-Na Iodide = 0.15–0.37 Mbq (0.004–0.01 mCi) orally

3.4 Collimator:

Pinhole collimator and an aperture 5 mm or less in diameter is usually used.

Almost equally common is the use of a normal LEAP (Low Energy All Purpose) Collimator. The advantage of using this is that the upper chest can be included in the field for any retrosternal extension and uptake can be compared to the nasopharyngeal and salivary glands uptake. The main disadvantage is the small size of the thyroid on the screen and film with the resultant poorer resolution.

It might be possible to optimize the collimator use according to the indication for the scan, e.g., pinhole for palpable nodules, residual thyroid etc; LEAP for retrosternal extension, as part of whole-body protocol for functioning metastasis etc.

3.5 Patient positioning:

Patient should be supine with the neck extended and supported by a pillow placed under the shoulders. In patients who are unable to lie supine, the sitting position may be used.

3.6 Imaging time:

- When ^{99m}Tc pertechnetate is used, imaging should begin 15 to 30 min after injection.
- When ^{123}I is used, images can be obtained as early as 3 to 4 hr after ingesting the tracer. Images may be obtained at 16 to 24hr (lower back ground but the disadvantage of a lower count rate). Images can be obtained as long as 36 hr after ingestion.
- When ^{131}I is used, the images should be obtained at 16 to 24hr after ingesting the radioiodine.
- Oblique views as deemed appropriate in cases of retrosternal goitre
- Always confirm findings of examination on scan and go for neck ultrasound if needed for correlation
- Additional views with markers / tongue movement, shielding or after sip of water. May be needed.

3.7 Findings

- Thyroid gland shape and location (only mention if abnormal),
- Degree of uptake (comparing to background),
- Tracer distribution: diffuse/ non-homogeneous (heterogenous)
- Comparison of uptake in two lobes, and describing uptake in thyroid nodules.
- Nodule(s)
- Most prominent nodule, especially cold / largest in dimensions should be marked or selected for fine needle aspiration.
- Comparison of distribution of tracer with manual sketch / and with USG if possible

3.8 Conclusion / Impression / Recommendation

- Differential diagnoses are not very diverse in thyroid unless findings are interpreted in the light of history, examination, laboratory investigations and other imaging modalities.
- Thyroid scan is not useful unless we address the concerns / queries of referring physician (ectopic, mass in neck/ oral cavity/ tongue, LN, Graves, Hashimoto).
- We may need to suggest Anti TPO, repeat laboratory tests, USG and sometimes thyroid scan (with same or different radioisotope / radiopharmaceutical—for discordant uptake or nodule characterization in thyroiditis, recurrent CA Thyroid patients etc.)

3.9 Normal thyroid appearance on scintigraphy

The normal thyroid gland has a homogenous tracer distribution in both lobes. There is usually slight asymmetry of the lobes (right lobe is usually larger than left lobe). Visualization of isthmus is also variable. The pyramidal lobe may occasionally be seen.

Chapter 4: Thyroid Scintigraphy Reporting – Examples

4.1 Case 1: Normal thyroid

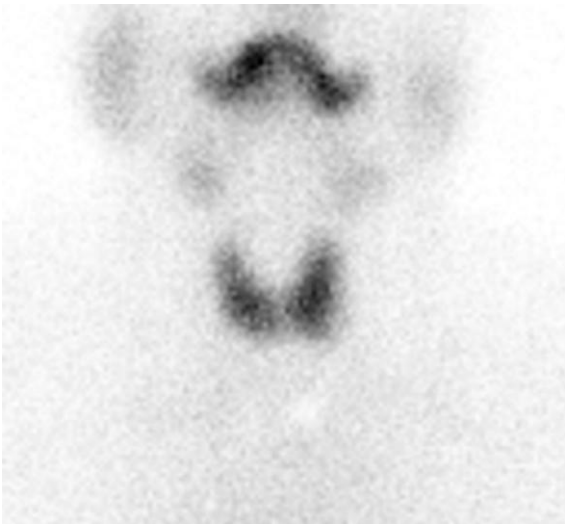


Figure 1: Normal thyroid with homogeneous tracer uptake.

Clinical details:

A 32-year-old male was referred in nuclear medicine department for thyroid scintigraphy with suspicion of thyroiditis.

Patient had complain of pain in neck and shoulders for 1 wk. There was no history of fever.

On physical examination, thyroid gland was not palpable.

USG neck revealed normal thyroid gland in situ, no clinically significant cervical lymphadenopathy appreciated.

TFTs were within normal limits

Procedure:

Tc-99m pertechnetate 3mCi was given intravenously and 20 minutes later anterior static spot view of neck was acquired by using gamma camera for 200 K counts.

Findings:

Scan shows normal sized thyroid gland with homogenous radiotracer distribution in both lobes. No definite hot or cold area is seen in any lobe.

Conclusion:

Normal size thyroid with homogeneous tracer uptake.

4.2 Case 2: Recurrent Nodular Goiter (a dilemma in nuclear imaging)

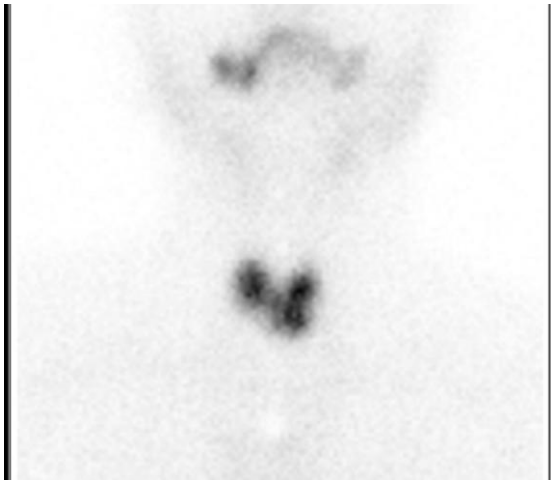


Figure 2: Recurrent Nodular Goiter

Clinical details:

H/O thyroid surgery 10 years back. No record was available. Recurrent neck swellings for long time. Referred for thyroid scan.

Procedure:

Tc-99m pertechnetate 3mCi was given intravenously and 20 minutes later anterior static spot view of neck was acquired by using gamma camera for 200 K counts.

Findings:

Thyroid scan shows nonhomogeneous uptake with multiple areas of abnormal increased and reduced tracer uptake in front of neck in the region of thyroid gland.

Conclusion:

Post-operative hypertrophic nodules in front of neck - recurrent nodular goitre

NB: Areas of relatively reduced tracer /absent uptake in a previously operated patient may either be nodules (with higher probability of harbouring malignant process) or absent thyroid tissue as a sequel of previous surgery. Such cases must be evaluated by funcion-independent anatomic imaging modalities like ultrasound to see if there is tissue in the "cold" areas of thyroid, or the cold areas repesent absent, excised tissue. If tissue is seen, cytology should be the next step.

4.3 Case 3: Extra-thyroidal swelling

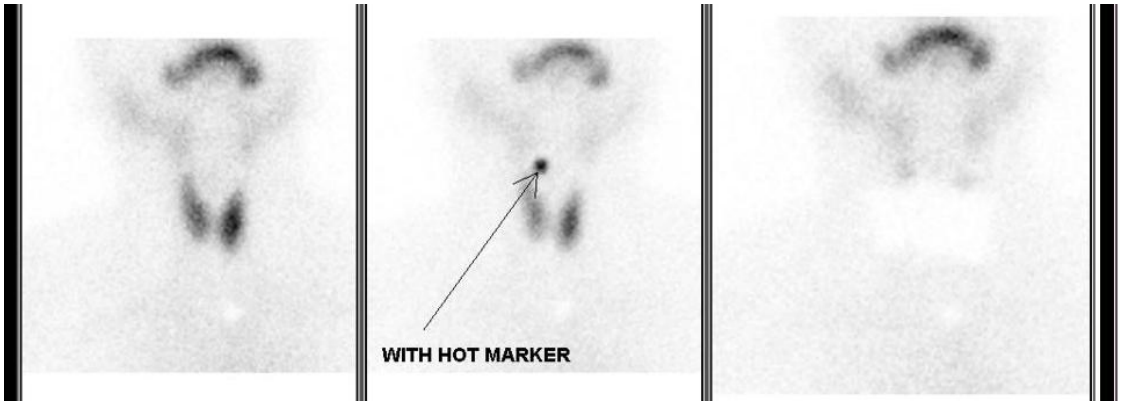


Figure 3: Normal size thyroid gland. Palpable neck swelling is extra-thyroidal.

Clinical details:

A 23-year-old female presented with neck swelling.

On physical examination thyroid gland was not palpable while the palpable neck swelling appeared to be extra-thyroidal, i.e. not moving with deglutition

TFTs were within normal limits

Procedure:

Tc-99m pertechnetate 3mCi was given intravenously and anterior static spot view of neck was acquired. The palpable area on the neck was marked with a radioactive marker

Findings:

Thyroid gland is located at its normal anatomical position. Thyroid image is of normal size with uniform distribution of radiotracer in both lobes of the gland.

Palpable neck swelling shows no radiotracer uptake.

Conclusion:

Extra-thyroidal swelling in the neck

Recommendations:

Correlation with Neck-USG and FNAC of extra-thyroidal swelling.

Teaching points: Differentials may include thyroglossal cyst, lymph nodes etc.

4.4 Case 4: MNG with Dominant Hot nodule

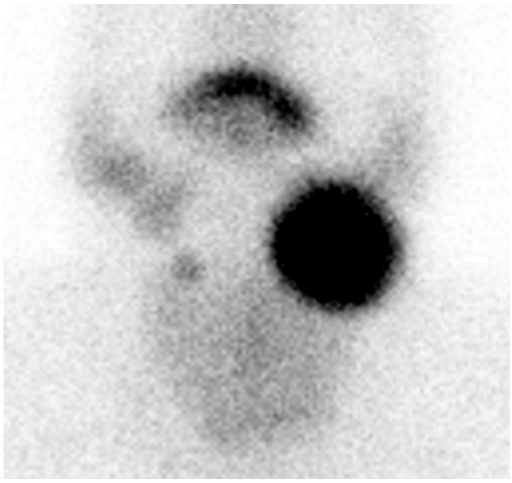


Figure 4: Multinodular goiter with prominent hot nodule in the left lobe

Clinical details:

A 65-year-old female patient presented with neck swelling for more than 5 years. She had complaint of tachycardia and weight loss. She was on neomercazole (3 tablets TDS) for 3 years.

Her laboratory results were as follows: thyroid-stimulant hormone (TSH), 0.01 (0.025–4 mIU/L); free T4 (fT4), 26.68 (9.03–23.22 pmol/L); and T3 7.87 (3.08-6.54 pmol/L). On presentation, her blood pressure was 150/90 mm Hg, and pulse was 120 beats per minute. On examination, there was enlarged thyroid with multiple nodules with a largest palpable nodule in left lobe.

Procedure:

Tc-99m pertechnetate 3mCi was given intravenously and 20 minutes later anterior static spot view of neck was acquired by using gamma camera for 200 K counts.

Findings:

Scan showed enlarged thyroid gland at its normal location, it showed a photon avid area in upper pole of the left lobe. The rest of the thyroid showed nonhomogeneous low uptake.

Conclusion:

MNG with dominant hot nodule in left lobe.

Recommendations:

- Correlation with Thyroid Function Tests and USG
- Surgical consultation

Discussion:

Hot nodules have a low risk of malignancy, and thyroid FNA is generally not recommended.

4.5 Case 5: Diffuse Goitre with increased tracer uptake

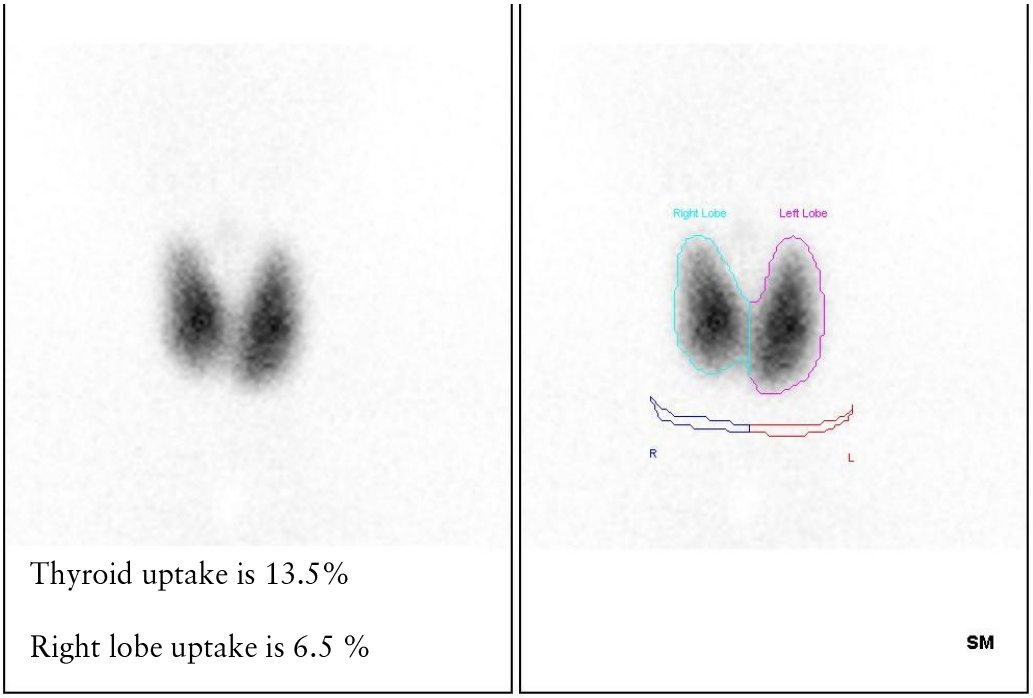


Figure 5: Diffuse Goiter with increased tracer uptake

Clinical details:

A 27-year-old woman attended the endocrine clinic with complaints of tachycardia, tremor, heat intolerance, weight loss, and fatigue for 6 months. On presentation, her blood pressure was 150/100 mm Hg, and pulse was 135 beats per minute. On physical examination, there was diffusely enlarged and firm goitre with bilateral exophthalmos and tremors.

The serum TSH level was 0.05 (0.25-4.00 mIU/L), free T4 (fT4), 50.25 (9.03–23.22 pmol/L); and T3 22.05 (3.08-6.54 pmol/L).

Ultrasonography of the thyroid gland revealed mild diffuse enlargement, with the parenchyma showing heterogeneous echogenicity. Doppler USG showed hypervascular thyroid tissue.

Procedure:

Tc-99m pertechnetate 3mCi was given intravenously and 20 minutes later anterior static spot view of neck was acquired by using gamma camera for 200 K counts.

Findings:

Thyroid image is larger than usual with homogenous increased tracer uptake of radiotracer in both lobes of thyroid gland. No definite hot or cold area is seen in any lobe.

Total thyroid uptake: 13.5 % (Normal range: 0.4%-4.5%)

Opinion:

Diffuse Goitre with increased uptake

NB: Diffuse increased uptake on the thyroid scintigraphy. D/D includes: Hyperthyroidism, Rebound after therapy withdrawal, Recovery phase of thyroiditis, Iodine deficiency.

Based on the clinical presentation and laboratory findings, we diagnosed the condition as thyrotoxicosis due to Graves' disease (GD).

Discussion:

Marine-Lenhart syndrome (nodular Graves Disease) is a variant of Graves' disease with incidentally functioning nodule(s) which are responsive to thyroid stimulating hormone but are not responsive to thyroid stimulating immunoglobulins.

4.6 Case 6: Low uptake

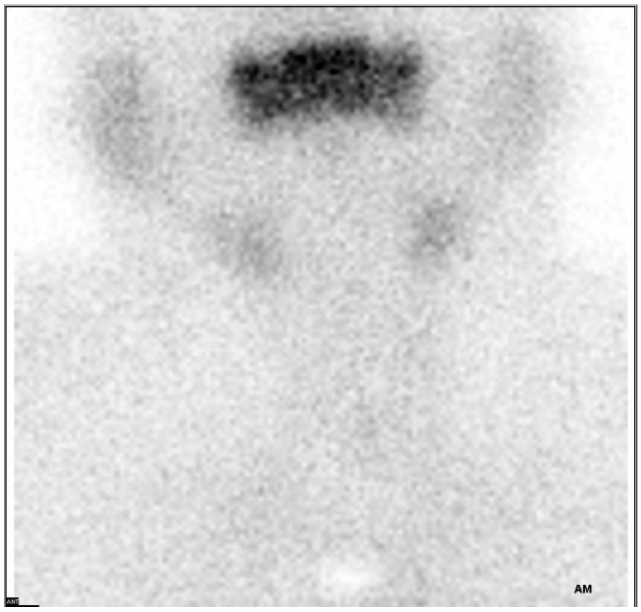


Figure 6: Low uptake in the region of thyroid bed

Clinical details:

A 27-year-old patient presented with pain in neck for 3 months. She had complaint of weight loss (5kg) in 2 months and fever for 2 months. Patient had 6 months old baby and she agreed to with-hold lactation for 24 hrs. Took some homeopathic medicine for 2 months and then left.

On examination there was tender nodular thyroid swelling. Otolaryngologic examination was normal. BP 110/70 mm Hg and Pulse 80/min

There were slight leukocytosis, 12,000 (4600–10,200); increased sedimentation rate, 52 mm/h (< 20 mm/hr), CRP 29.8mg/L (less than 1.0)

Anti-TPO 1.84 IU/mL (< 5.61 IU/mL). Anti-Thyroglobulin 12.95 IU/mL (< 4.11 IU/mL).

USG showed right lobe hyperechoic nodule measuring 17 X 18 mm. Left lobe showed hyperechoic nodule measuring 13 X 16 mm with cystic changes.

T-3, Total 128 ng/dL (84-172), T-4, (thyroxin) 10.1 µg/dL (4.5-12.5), TSH 0.089 µIU/mL (0.4-4).

Procedure:

Tc-99m pertechnetate 3mCi was given intravenously and 20 minutes later anterior static spot view of neck was acquired by using gamma camera for 200 K counts.

Findings:

Scan showed generalized reduced tracer uptake in the region of thyroid gland.

Opinion:

Generalized reduced tracer uptake in front of neck; could be due to

- Thyroiditis
- Recent iodine intake (expanded iodine pool)
- Thyroid/antithyroid medication.

The presence of pain, increased ESR and low uptake suggest a high probability of thyroiditis.

NB: Thyroid scan cannot be commented for presence or absence of thyroid nodules with confidence in cases of generalized low uptake.

4.7 Case 7: I-131 Whole Body Scan

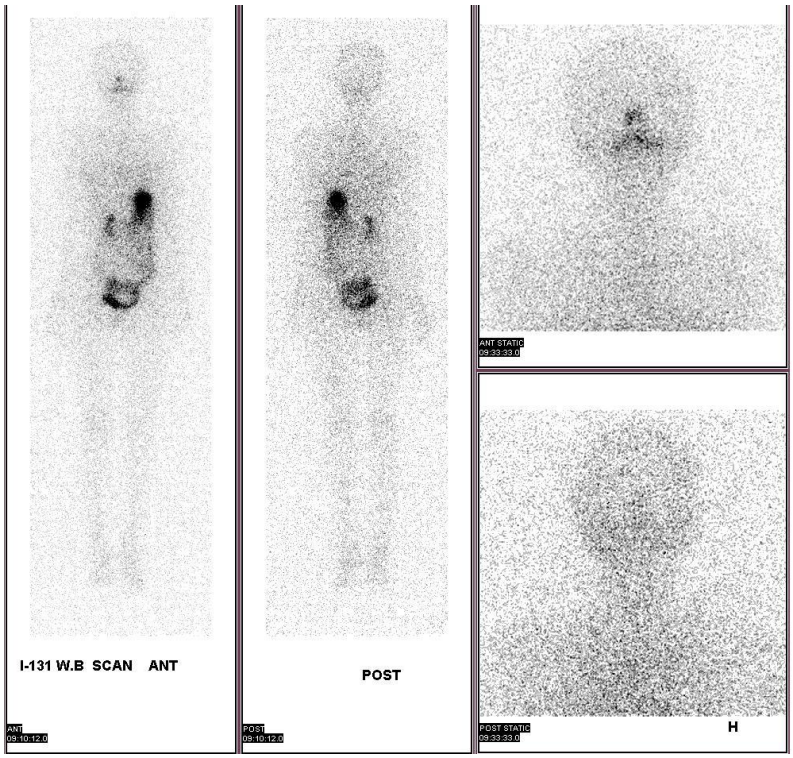


Figure 7: I-131 whole body scan with no evidence of functioning thyroid tissue/ mets.

Clinical details:

Papillary CA thyroid, off thyroxine for 4 weeks, history of thyroid surgery 1 year back, Radioiodine ablation done once, TG 0.53ng/ml (< 50 ng/mL), Anti-Tg 10 ng/ml (< 30 IU/mL). TSH?

Procedure:

The patient was given 3 mCi of I-131 and whole-body imaging was done after 72hrs.

Findings:

The scan reveals no suspicious radiotracer accumulation in the region of thyroid or elsewhere in the body.

Physiological tracer distribution is seen in stomach, bowel and urinary bladder

Conclusion:

No evidence of functioning thyroid tissue

No evidence of functioning metastasis

4.8 Case 8: I-131 whole body scan

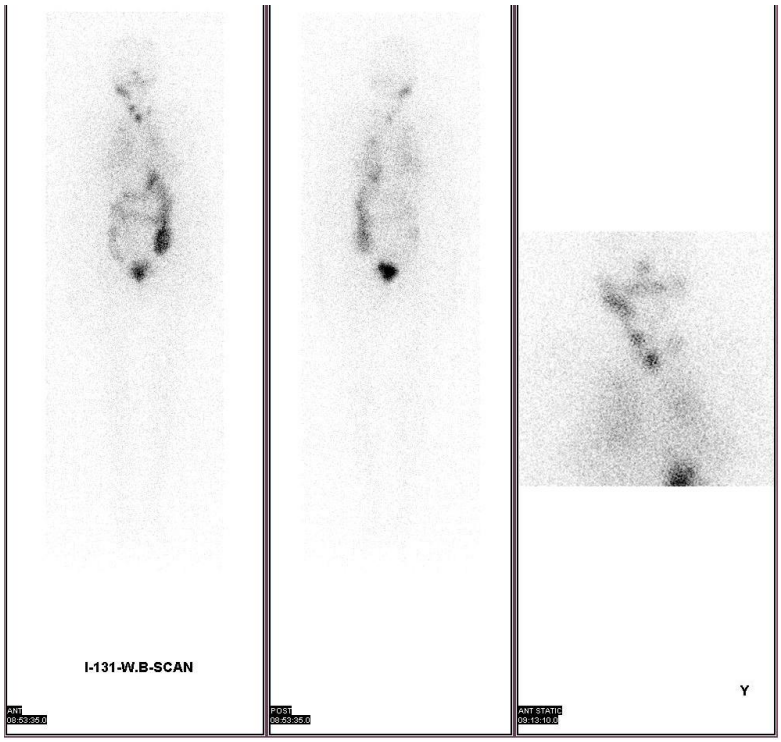


Figure 8: Evidence of functioning residual thyroid tissue and metastatic deposits in upper cervical region and lungs.

Clinical details:

CA Thyroid (Papillary). Surgery done 10years ago, Histopathology report not available,

Patient on suppressive thyroxine. Stopped for 4-6 weeks. Tg? Anti Tg TSH?

FNAC of right upper anterior cervical swelling: metastatic papillary CA thyroid

Procedure:

I-131 whole body scan was performed with dual head gamma camera, 48 hours after 2 mCi oral dose of tracer.

Findings:

Scan showed iodine avid thyroid tissue in front of neck. Focal areas of increased tracer uptake are seen in upper anterior cervical region. Inhomogenous increased tracer uptake is noted in the lungs.

Physiological distribution of tracer is seen in the stomach, bowel and urinary bladder.

Opinion:

Evidence of functioning residual thyroid tissue in both lobes of thyroid.

Functioning metastatic deposits are seen in cervical region and lungs.

Recommendations

Soft tissue mass in anterior cervical region (metastatic) should be removed surgically if approachable as per international guidelines, otherwise radioactive iodine ablation will be second option.

Teaching Point:

The most common metastatic sites of differentiated thyroid cancer (DTC) are lymph node, lung and bone. Pulmonary metastases of thyroid carcinoma are often seen as micronodular or miliary spread throughout both lungs. However, solitary nodular metastasis from thyroid cancer is also reported.

4.9 Case 9: I-131 whole body scan

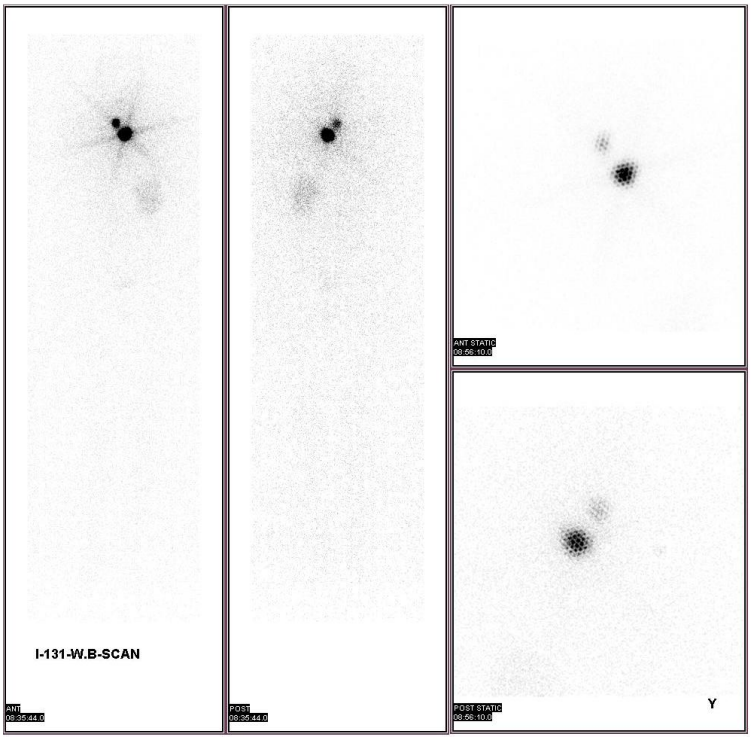


Figure 9: Evidence of functioning residual thyroid tissue in both lobes of thyroid.

Clinical details:

A 76-year-old female diagnosed case of Papillary CA Thyroid, surgery done twice. Right lobectomy and isthmectomy (on H/P papillary CA Thyroid extending into perithyroid soft tissue and muscles) followed by completion thyroidectomy. Patient has not started thyroxine yet.

Procedure:

I-131 whole body scan was performed with dual head gamma camera 48 hours after 03 mCi oral dose of tracer.

Findings:

Scan showed iodine avid thyroid tissue in front of neck. No evidence of functioning metastasis is seen elsewhere in the body.

Physiological distribution of tracer is seen in the stomach, bowel and urinary bladder.

Opinion:

Evidence of functioning residual thyroid tissue in both lobes of thyroid.
No evidence of functioning metastatic deposits is seen elsewhere in the body.

Plan:

RAI ablation

Teaching Point:

Star Artifact:

A star-shaped region of intense 131I uptake can be observed on whole body scans (WBSs) sometimes. This phenomenon is called a 'star artifact'. It is due to the penetration of the collimator's septa by the High energy γ-rays from RAI 131 in the thyroid bed.

High uptake of RAI that causes star artifacts could be due to

-Large amounts of remnant thyroid tissue after surgery

-Thyroid tissues with high expression of the sodium iodide symporter (NIS) may cause an intense uptake of RAI; active transport by the NIS leads to iodide uptake across the membranes of thyroid cancer cells

4.10 Case 10: I-131 whole body scan

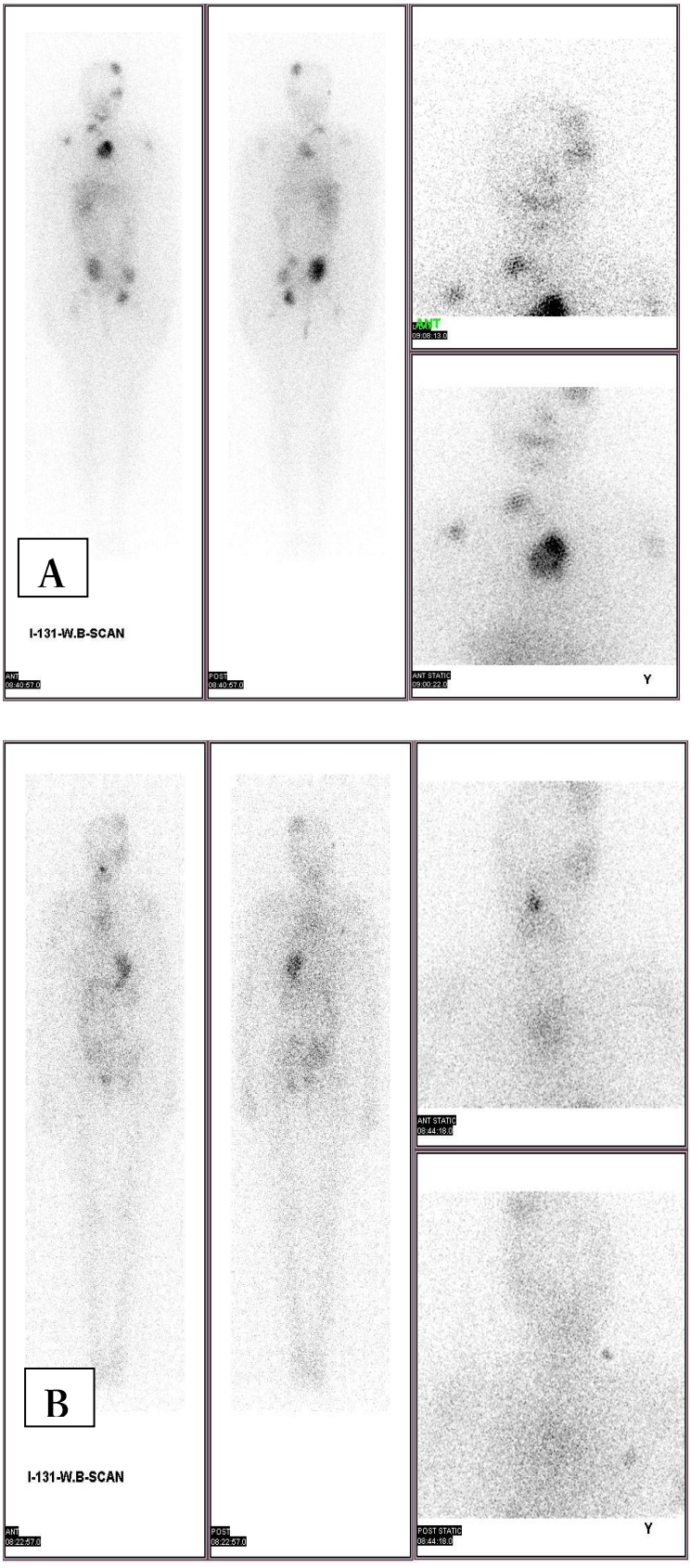


Figure 10 (A): Initial Scan – Evidence of functioning mets in skull, sternum, anterior chest, pelvic bones and bilateral femori. (B): Follow-up Scan – Evidence of functioning mets in skull, sternum and pelvic bones

Clinical details:

A 38-year-old female was operated for MNG, on H/P invasive follicular CA (invasion to sternocleidomastoid), RAI ablation done 4 times (150 mCi, 175 mCi, 200 mCi, 200mCi).

Procedure:

I-131 whole body scan was performed under gamma camera 48 hours after 03 mCi oral dose of tracer.

Findings:

Scan showed foci of abnormal tracer accumulation in left parietal and temporal regions of skull, sternum and pelvic bones.

Physiological distribution of tracer is seen in the stomach, bowel and urinary bladder.

Opinion:

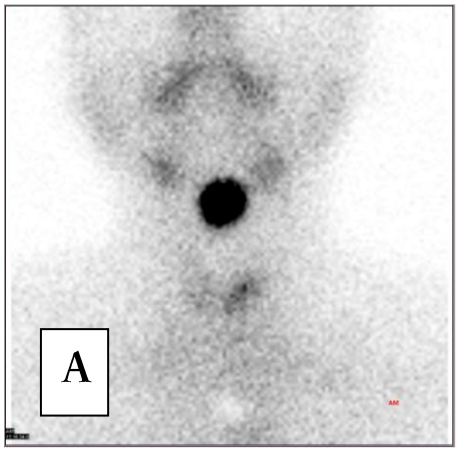
Evidence of functioning metastatic deposits is seen in left parietal and temporal regions of skull, sternum and pelvic bones.

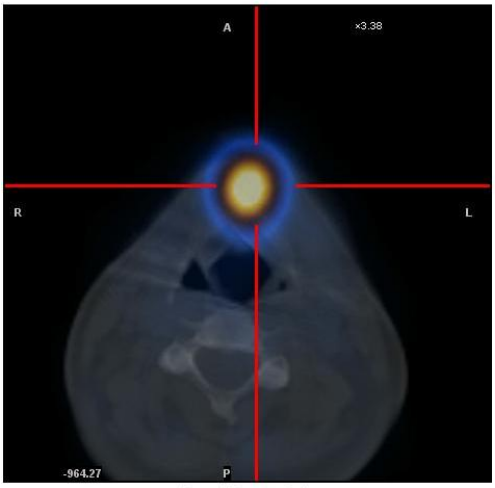
In comparison with previous scan, lesions in anterior chest and bilateral femora have regressed……. disease regression.

Plan:

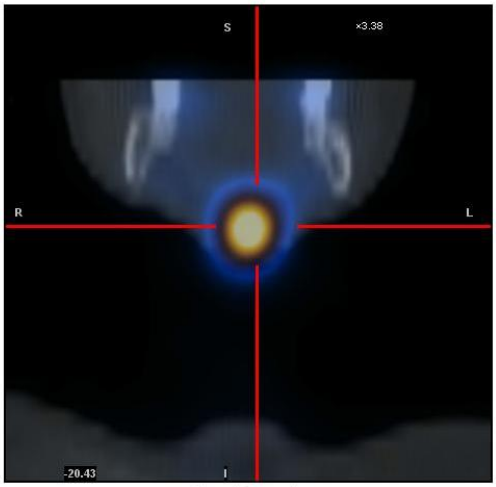
RAI ablation

4.11 Case 11: Ectopic Thyroid

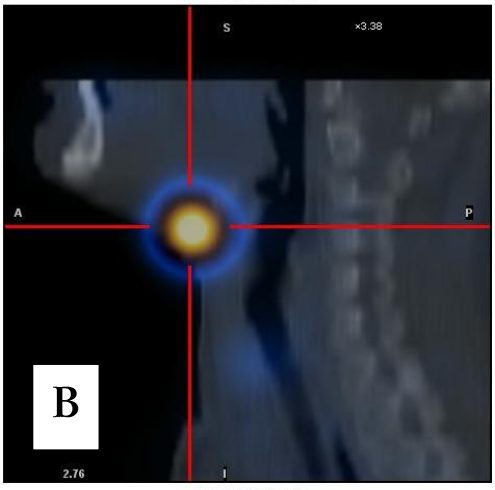




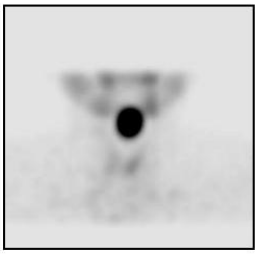
Fused Transaxials

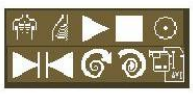


Fused Coronals



Fused Sagittals





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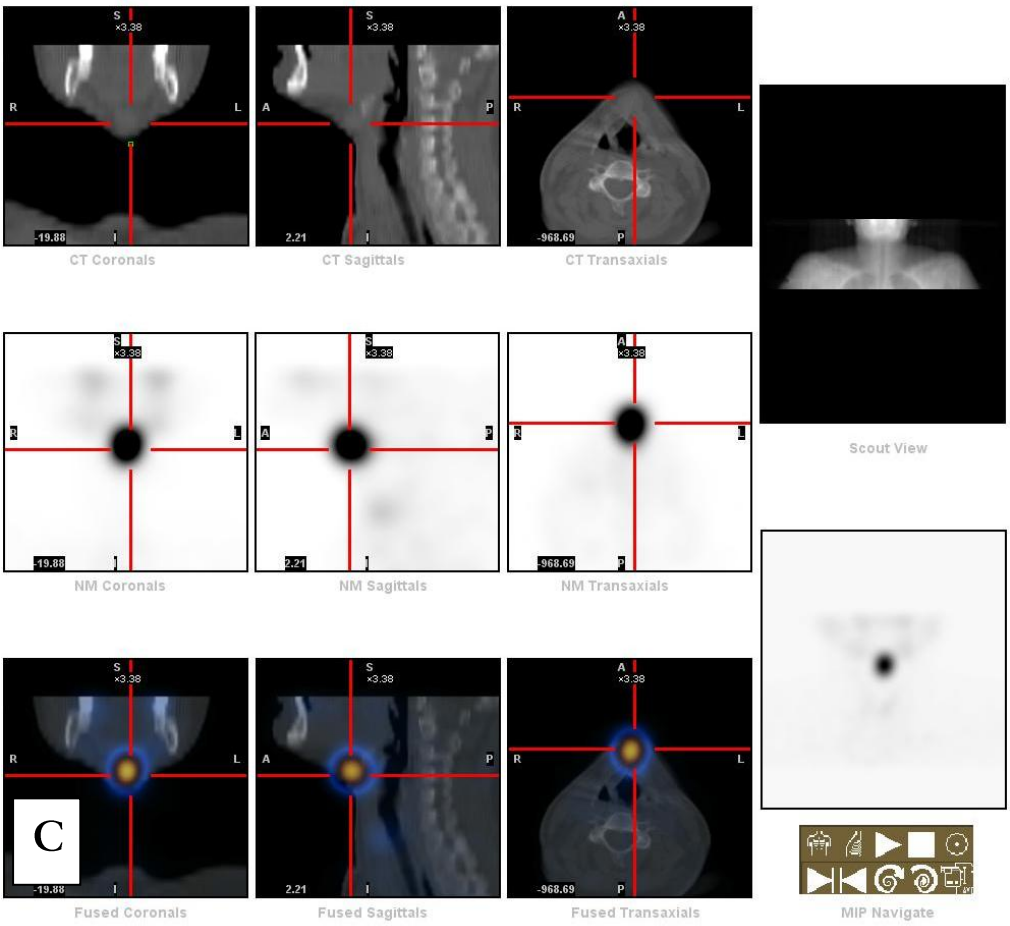

Clinical details:

A 50-year-old patient with swelling in neck. H/O thyroid surgery 28 yrs. back. H/P showed Multinodular goitre.

On physical examination swelling appeared to be extra thyroidal i.e. not moving with deglutition.

Findings:

Small patch of radiotracer uptake is seen in the region of thyroid gland.

A round focus of abnormal intense radiotracer uptake is seen in the mid-line - sub mental region.

Opinion:

Small patch of functioning thyroid tissue in thyroid bed

Focus of abnormal radiotracer uptake in the mid-line; indicative of ECTOPIC functioning

Suggestions:

Correlation with Thyroid Function Tests and neck ultrasonography. Consider workup for congenital hypothyroidism and lingual thyroid