NUCLEAR MEDICINE FOR THYROID DISORDERS - SCIENCE & TECHNOLOGY

NEWS: Nuclear medicine has emerged as a safe and precise method for diagnosing and treating thyroid disorders, especially **hyperthyroidism** and **thyroid cancers**.

WHAT'S IN THE NEWS?

What is Nuclear Medicine?

- **Specialised Branch of Imaging:** Nuclear medicine is a medical field that uses **small amounts of radioactive substances**, known as **radiotracers**, for **diagnosis and treatment** of various conditions.
- **Primary Applications:** It is especially useful for **cancers**, **thyroid disorders**, **cardiac problems**, and **bone-related diseases**, where early functional changes are more important than structural ones.

How Nuclear Medicine Works

- **Administration of Radiotracer:** A radioactive compound is either **injected into a vein**, **swallowed**, or **inhaled**.
- **Targeted Absorption:** The radiotracer travels through the bloodstream and gets absorbed by specific organs or tissues based on their biological activity.
- **Imaging Mechanism:** A **gamma camera** or **PET scanner** detects the radiation emitted from the tracer, creating **functional images** of the internal organs.
- **Dual Purpose:** It not only reveals structural abnormalities but also provides data on **organ function and metabolic activity**, enabling early detection of disease.

Commonly Used Radionuclides

- **Technetium-99m (Tc-99m):** Widely used for bone, kidney, heart, and thyroid imaging.
- **Iodine Isotopes:** Used specifically for thyroid-related scans and treatment.
- **Gallium, Thallium, Xenon:** Each has specific applications (e.g., gallium for inflammation/cancer, xenon for lung ventilation).

Common Types of Nuclear Medicine Scans

- **Renal (Kidney) Scan:** Evaluates kidney function, drainage, and blood supply.
- **Thyroid Scan:** Assesses **thyroid gland size, shape, and functional activity**; detects nodules or abnormal uptake patterns.
- **Bone Scan:** Helps in identifying **stress fractures, metastasis, arthritis**, or bone infections.
- **Cardiac (Heart) Scan:** Measures blood flow to the heart muscle, often used in **coronary artery disease** evaluation.

Understanding the Thyroid Gland

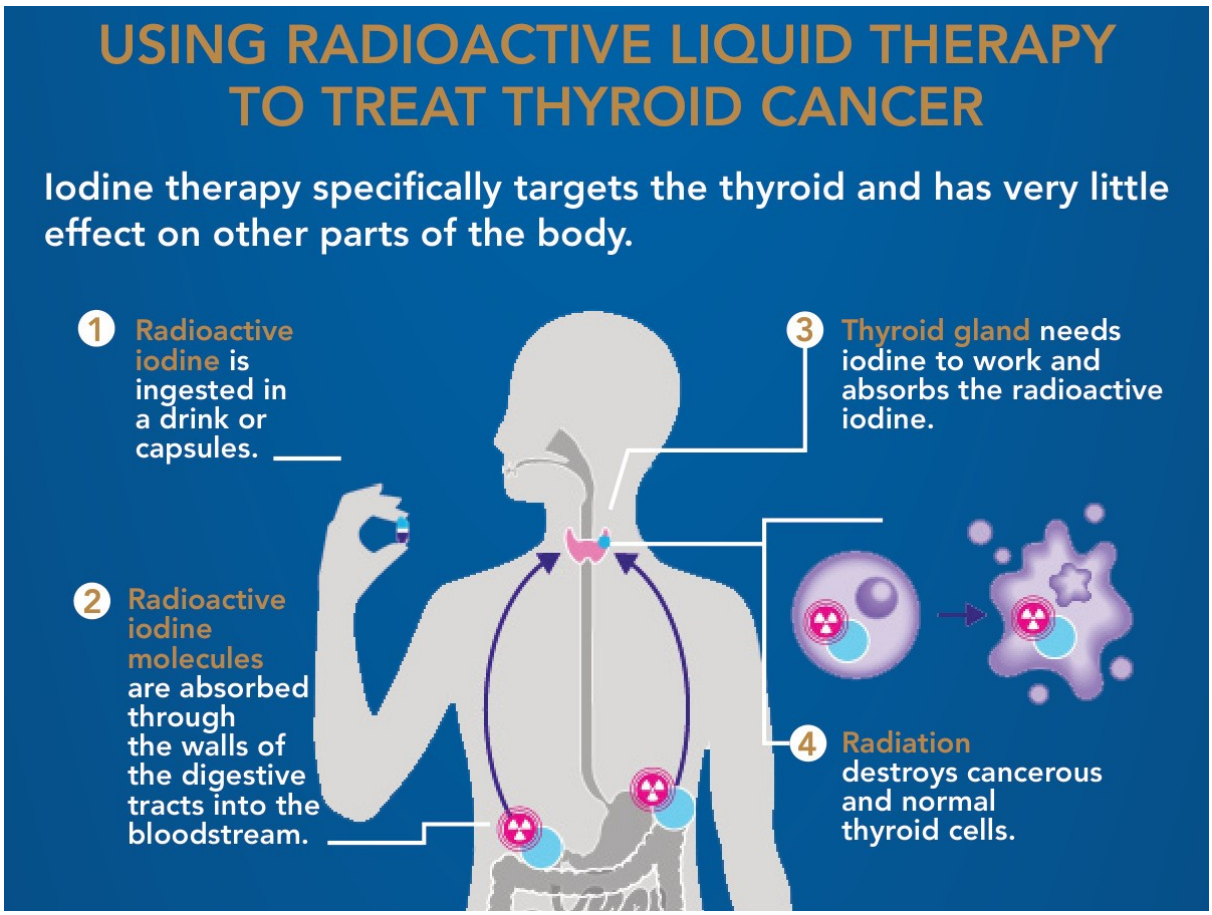
- **Location & Shape:** A **butterfly-shaped gland** located in front of the neck, just below the **Adam's apple**, sitting over the **trachea**.
- **Endocrine Function:** It produces hormones that regulate **metabolism, energy production, heart rate, and body temperature**.
- **Key Hormones:**
    - **Triiodothyronine (T3)**
    - **Thyroxine (T4)**

Common Thyroid Disorders

- **Hypothyroidism:** Underactive thyroid leading to fatigue, weight gain, and cold intolerance due to **low hormone production**.
- **Hyperthyroidism:** Overactive thyroid causing weight loss, anxiety, and rapid heartbeat due to **excess hormone secretion**.
- **Thyroid Cancer:** May require surgery followed by radioactive iodine treatment to destroy remaining cancerous tissue.
- **Goitre:** Visible or non-visible **enlargement** of the thyroid gland, sometimes linked to iodine deficiency.

Importance of Iodine

- **Essential Micronutrient:** Critical for the production of thyroid hormones.
- **Daily Requirement:**
    - **Adults:** ~150 micrograms/day
    - **Children:** ~120 micrograms/day
    - **Pregnant/Lactating Women:** ~300 micrograms/day
- **Iodine Storage:** The thyroid gland stores more than **80% of the body's iodine**.
- **WHO Definition:** Iodine deficiency is diagnosed when **urinary iodine levels fall below 100 µg/L**.



Development of Radioactive Iodine (RAI) Therapy

- **Early Research:** Concept proposed in the 1930s for therapeutic applications.
- **Pioneered by Saul Hertz** at Massachusetts General Hospital, who applied it in treating thyroid diseases.
- **Iodine-131:** A radioisotope that emits both **gamma rays** (for imaging) and **beta particles** (for tissue destruction).

Radioactive Iodine Isotopes

- **Stable Isotope:** Iodine-127 (naturally occurring and non-radioactive).
- **Radioactive Isotopes:** Over **40 artificially produced isotopes**, mainly via **nuclear reactors or cyclotrons**.
- **Medically Significant Ones:**
    - **Iodine-123:** Ideal for imaging.
    - **Iodine-124:** Used in PET imaging.
    - **Iodine-125:** Used in brachytherapy.
    - **Iodine-131:** Used for both imaging and treatment; discovered in 1938; has an **8-day half-life**.

Therapeutic Uses of RAI in Thyroid Disorders

a. Hyperthyroidism

- **Indications:** Toxic goitre, Graves' disease, or hyperactive thyroid nodules.
- **Mode of Use:** Taken **orally as a capsule or liquid**, it is selectively taken up by the overactive thyroid tissue.
- **Effect:** Destroys overactive cells with beta radiation, bringing hormone levels to normal.

b. Thyroid Cancer

- **Post-Surgical Application:** After thyroidectomy, small doses are used for **whole-body scans** to detect residual cancer cells.
- **High-Dose Treatment:** Larger doses of Iodine-131 are given to **ablate remaining thyroid tissue** or to treat **metastatic thyroid cancers**.
- **Theranostics:** A combined approach where the same radioactive compound is used for both **diagnosis (gamma rays)** and **therapy (beta particles)**.

Radioactive Iodine Therapy in India

a. Diagnosis

- **Technetium-99m:** Used for thyroid scans to assess benign conditions; chosen for its **short half-life and low radiation risk**.

b. Treatment

- **Iodine-131:** Administered under strict clinical settings to treat hyperthyroidism and thyroid cancers.

c. Safety and Protocols

- **Isolation Post-Treatment:** Patients are kept in specialized radiation-safe rooms to minimize exposure to others.
- **Safety Guidelines:** Patients receive clear instructions on radiation hygiene and precautions after discharge.

d. Pregnancy and Breastfeeding Restrictions

- **Contraindicated:** Treatment is strictly **not permitted during pregnancy or lactation** due to potential harm to the fetus or infant.
- **Precaution:** Mandatory pregnancy tests for women of childbearing age prior to administration.

e. Side Effects

- **Mild & Temporary:** Include dry mouth, neck tenderness, or slight swelling.
- **Hydration & Monitoring:** Patients are advised to **drink fluids** and are **monitored every 6–8 weeks** after therapy.

Significance of Radioactive Iodine Therapy (RAI)

- **Non-Surgical Option:** Offers a **less invasive alternative to surgery** for treating certain thyroid conditions.

- **Highly Effective:** Proven success in managing both **benign and malignant thyroid disorders**.
- **Supports Personalised Medicine:** Fits into modern approaches where **treatment is tailored** to individual functional and biological parameters.