Iperparatiroidismo: dal sospetto clinico alla terapia. Percorso multidisciplinare

Diagnosi di localizzazione: la radiologia

Aldo Carnevale

Department of Translational Medicine – section of Radiology
University of Ferrara
aldo.carnevale@unife.it

Topics

- **Computed Tomography (CT)**
  → including «4D-CT»
- **Magnetic Resonance (MR)**
- **Interventional Radiology**

What Radiology Offers in Parathyroid Localization

Radiology provides:

High-resolution anatomical imaging
→ Precise localization of parathyroid adenomas and hyperplastic glands
Functional-anatomical correlation
→ Integration of structural data (US, CT, MRI) with nuclear medicine findings
Preoperative planning support
→ Enhancing surgical outcomes in primary and recurrent hyperparathyroidism

What Radiology Offers in Parathyroid Localization

Minimally invasive diagnostic tools

→ Guiding targeted approaches (e.g., fine-needle aspiration with PTH assay)

Postoperative assessment

→ Monitoring residual or ectopic parathyroid tissue

Goal:

To **increase diagnostic accuracy**, **guide tailored surgical approaches**, and **reduce operative complications**

Which imaging technique

Guidelines for localization are **flexible**: imaging choice is based on regional imaging capabilities.

US in combination with ^{99m}Tc-sestamibi scanning or four-dimensional (4D) CT is recommended as **the most cost-effective approach** for initial investigation of parathyroid adenomas.

Each technique has advantages and disadvantages, with **complementary rather than competing roles**.

Second- and third-line modalities are considered in cases of difficult localization, repeat surgery, and contraindication to first-line techniques (MRI, PET/CT with radiotracers such as fluorine 18 (18F)-fluorocholine, venous sampling with or without parathyroid arteriography).

Wilhelm SM et al. The American Association of Endocrine Surgeons Guidelines for Definitive Management of Primary Hyperparathyroidism. JAMA Surg. 2016

Computed Tomography (CT)

PROS

- Excellent anatomic detail
- Fast acquisition
- Ectopic glands
- Multigland disease

Computed Tomography (CT)

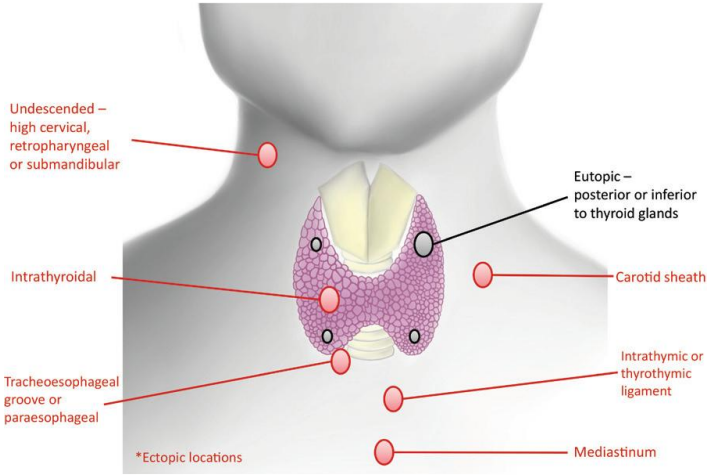
CONS

- Irradiation, especially to thyroid
  (10.4 mSv for three-phase protocol)
- Iodinated contrast material
- Technical artifacts

Computed Tomography (CT)

General principle:

Normal parathyroid glands are small and flat, measuring only a few millimeters transversely, and **are not readily identified at imaging**. **An easily visible gland is suspicious for underlying disease.**



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Computed Tomography (CT)

Where to look (I):

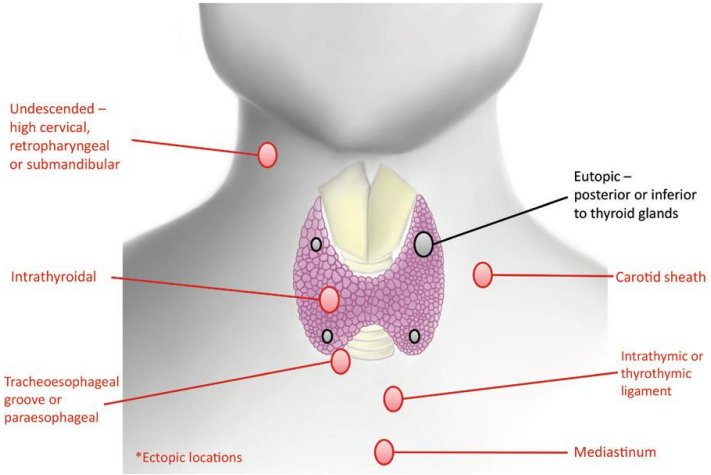
Inferior Parathyroid Glands (greater anatomic variability)

Embryologic descent with the thymus → ectopic positions

Common ectopic locations:

- **Submandibular** (undescended)
- **Intrathyroidal**
- **Anterior superior mediastinum**
- **Intrathymic**

Medial to the carotid arteries, below the **carotid bifurcation**



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Computed Tomography (CT)

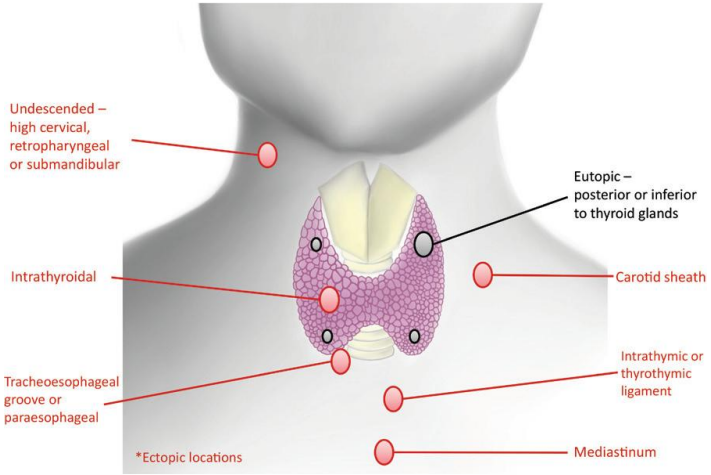
Where to look (II):

Superior Parathyroid Glands (less variable, more posterior)

Common ectopic locations:

- **Retroesophageal / paraesophageal space**
- **Tracheoesophageal groove**
- **Carotid sheath**
- **Posterior superior mediastinum**

Down to the **aortopulmonary window**



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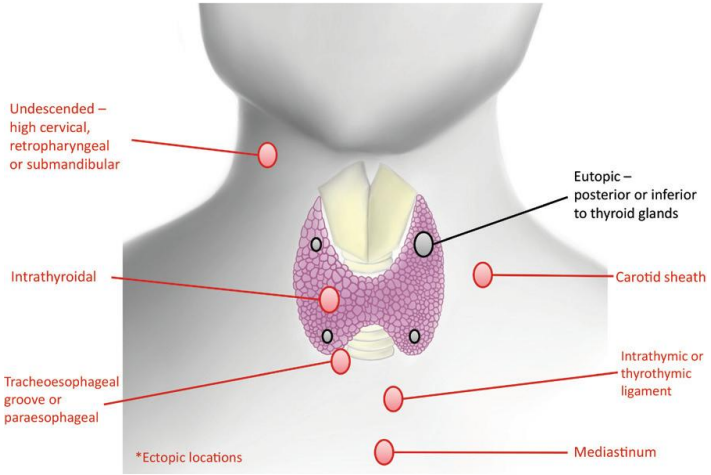
Computed Tomography (CT)

Where to look (III):

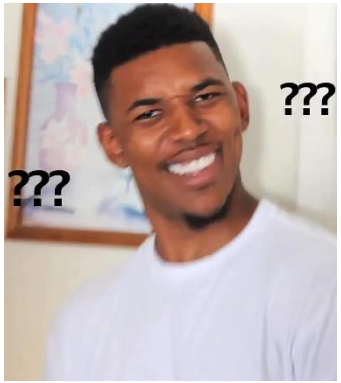
Prevalence of ectopic locations (Meta-analysis, 8 studies):

- **3–12%** in ectopic **cervical** locations
- Up to **5%** in **mediastinal**, mostly **intrathymic** positions



Naik M et al. Contemporary Multimodality Imaging of Primary Hyperparathyroidism. Radiographics. 2022
Taterra D et al. The prevalence and anatomy of parathyroid glands: a meta-analysis with implications for parathyroid surgery. Langenbecks Arch Surg. 2019

Computed Tomography (CT)



"**Standard X-ray CT** has limited value in the detection of enlarged parathyroid glands in pHPT.

Four-dimensional CT (4D-CT) consists of **standard CT imaging with 3 vascular phases** (non-enhanced, arterial, and venous), and the **fourth dimension that allows enhancement evaluation over time**."

Ovčariček PP. The EANM practice guidelines for parathyroid imaging. European Journal of Nuclear Medicine and Molecular Imaging (2021)

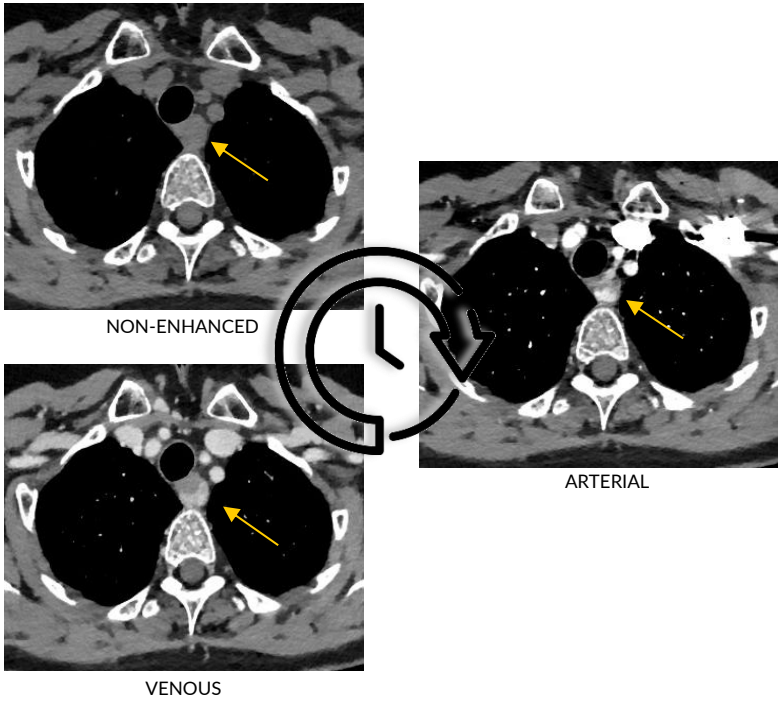
Computed Tomography (CT)

Multiphasic CT protocol:

Three-phase protocol:

- noncontrast
- arterial
- delayed (venous) phase

On 4D-CT images, a classic adenoma shows **peak enhancement** greater than that of the thyroid gland **during the arterial phase**, with **washout in the delayed phase.**



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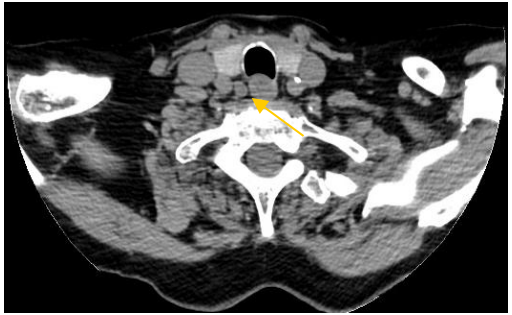
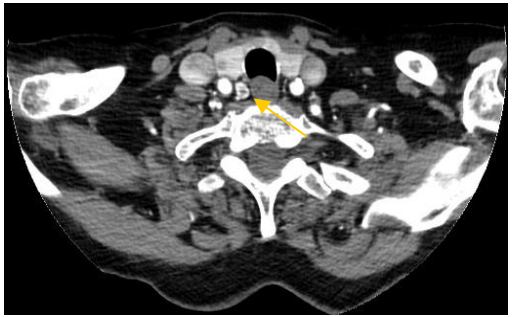
Computed Tomography (CT)

The enhancement pattern alone is not sufficient for accurate diagnosis.



NON-ENHANCED



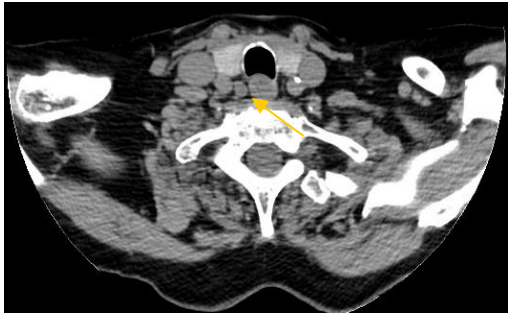
ARTERIAL

Computed Tomography (CT)

Noncontrast phase: parathyroid adenomas and hyperplastic glands have low attenuation compared with the iodine-rich thyroid gland (excepted for thyroiditis).

Three distinct patterns of enhancement defined in comparison to adjacent thyroid gland tissue have been described.

Parathyroid adenomas can usually be distinguished from lymph nodes by their **differential enhancement and morphology**.



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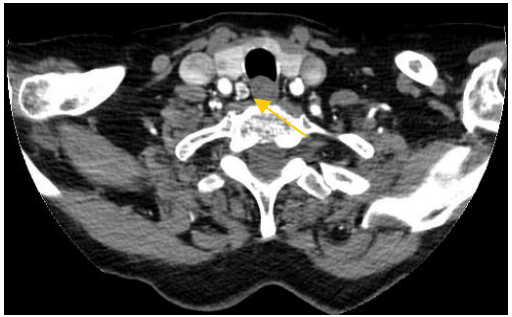

ARTERIAL

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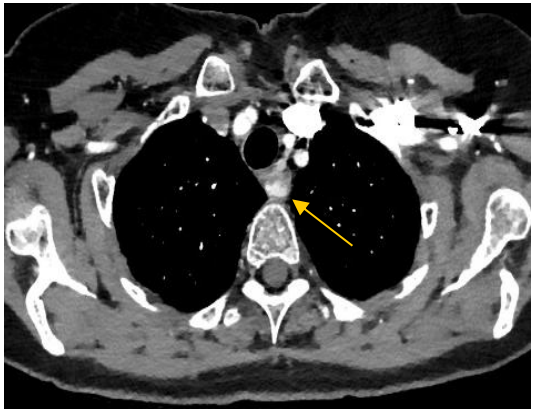
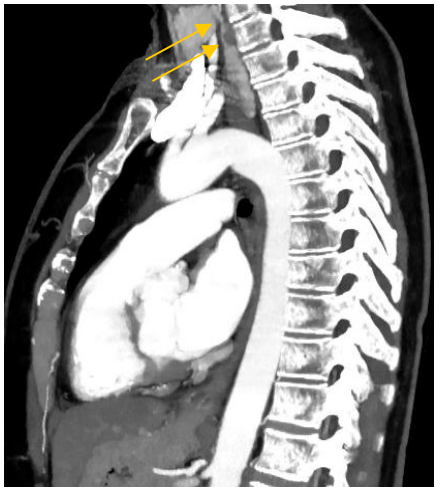
Computed Tomography (CT)

A **vascular pedicle**, or “polar vessel,” is identified in up to two-thirds of cases



AXIAL



SAGITTAL MIP RECONSTRUCTION

Computed Tomography (CT)

Imaging report:

- location (eutopic vs ectopic), size, number;
- depth of the lesion from the skin surface;
- relationship of the lesion with neighboring structures (major vessels, thyroid gland, trachea, esophagus);
- variant anatomy;
- vascular supply (if identified).

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Magnetic Resonance (MR)

PROS

- No radiation
- Ectopic glands

Magnetic Resonance (MR)

CONS

- Limited sensitivity
- Artifact from thoracic inlet and movement
- Lower spatial resolution than CT
- Implanted medical devices
- Longer acquisition time

Magnetic Resonance (MR)

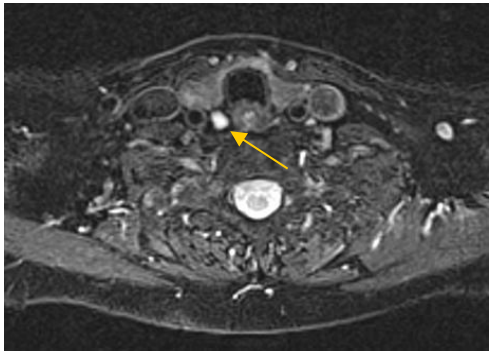
MRI may be helpful when other modalities yield equivocal findings or 4D-CT is contraindicated.

Signal intensity characteristics are not unique to parathyroid adenomas.

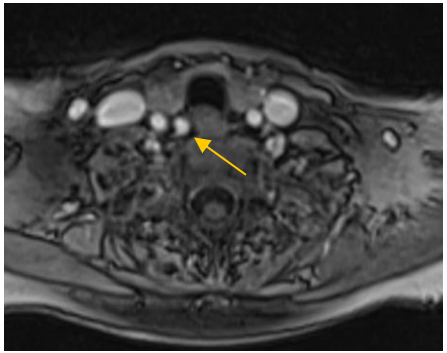
Parathyroid adenomas have:

- **intermediate to low** signal intensity on **T1**-weighted images;
- **high** signal intensity on **T2**-weighted images.

Sensitivity can be improved with **contrast-enhanced multiparametric dynamic MRI**, exploiting the hypervascular nature of adenomas.



FAT SUPPRESSED T2-WI



POST-ADC T1-WI

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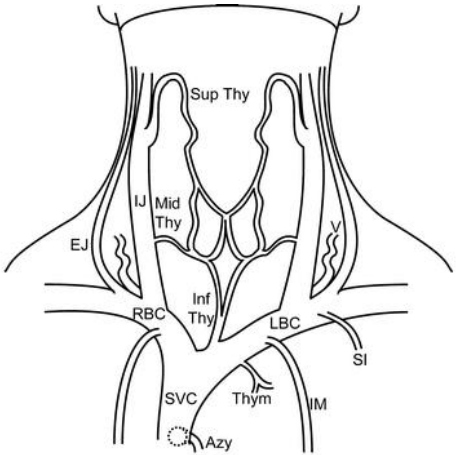
Selective Venous Sampling

Targeting elusive or ectopic glands



How it works:

Up to **30 venous samples** via **femoral vein approach**

Target veins: superior, middle, inferior thyroid veins

Also samples mediastinal veins (e.g., thymic, internal mammary) for ectopic glands

Diagnostic criteria:

PTH gradient >2× systemic level → positive localization

Optional: citrate-induced hypocalcemia to stimulate PTH release → Gradient ≥1.4× baseline considered positive

Naik M et al. Contemporary Multimodality Imaging of Primary Hyperparathyroidism. Radiographics. 2022
Taslakian B et al. The Essentials of Parathyroid Hormone Venous Sampling. Cardiovasc Intervent Radiol. 2017

Selective Venous Sampling

Advantages:

Highly sensitive for **ectopic or reoperative cases**

Guides **quadrant-specific localization**

Limitations:

Technically demanding, time-consuming

Requires **interventional expertise**

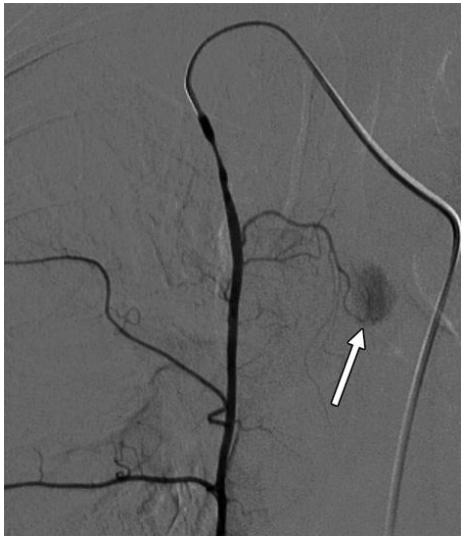
Naik M et al. Contemporary Multimodality Imaging of Primary Hyperparathyroidism. Radiographics. 2022

Parathyroid Arteriography

Technique:
Selective catheterization of:
→ **Brachiocephalic**, **subclavian**, **superior/inferior thyroid**, **internal mammary arteries**
Contrast injection → observe **vascular blush** from adenoma

Key findings:
Oval blush in neck/upper mediastinum during arterial phase
Venous phase imaging can reveal drainage patterns useful for interpreting venous sampling (e.g., **contralateral drainage** post-surgery)

Why it's rare today:
Invasive, risk of **stroke**
High expertise required



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Conclusions

- Localization of parathyroid glands in surgical candidates is challenging and requires an integrated multidisciplinary approach.
- The strategy is often guided by local expertise, patient factors, and the surgeon’s preference.
- Preoperative radiological imaging is crucial for patients who are going to have parathyroid surgery in order to locate the abnormal parathyroid glands.

Thank you for your time and interest!

Contact me at: aldo.carnevale@unife.it