Parathyroid Imaging: Current Concepts

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Disclosures

None
Objectives

- Ultrasound characteristics of parathyroid adenomas vs. lymph nodes
- 4D-CT evaluation of hyperparathyroidism
- Intraoperative support for minimally invasive parathyroidectomy and localization of transplanted parathyroid tissue
Embryology

Thyroid Gland

Expected Locations

Aortic Arch
Anatomy

Eutopia (normal position)

- 2 superior and 2 inferior parathyroid glands
- >4 glands 3-5%
- <4 glands 3%
- Normal glands not visible on imaging

Johnson et al. AJR:188, June 2007
Superior glands
- Consistently posterior to the mid-upper third of the thyroid (>90%)

Inferior glands
- More variable in location, with ectopia more common
- Most consistent location is inferior, posterior or lateral to the lower third of the thyroid (65%)

Johnson et al. AJR:188, June 2007
Anatomy

Ectopia - 20-25%

Superior glands

True ectopia is rare

- When large can migrate into the TE groove and retroesophageal or retropharyngeal locations

Inferior glands

Ectopic glands may occur from the angle of the mandible to mediastinum:

- Thymic tongue/cervical thymus (26%)
- Anterior mediastinum (2%)
- Intrathyroidal (<1%)
- Carotid sheath, AP window, pericardium
Pathology

Primary Hyperparathyroidism

- Single gland disease (89%)
- Hyperplasia of all four glands (6%)
- Double adenoma (4%)
- Parathyroid Carcinoma (rare)
Preoperative imaging

Goal:

To accurately localize parathyroid adenoma

To allow for minimally invasive parathyroidectomy

Complimentary multimodality imaging is essential

Comprehensive Pre-operative imaging at MD Anderson:

- 4D-CT of the neck
- Nuclear medicine Tc-99 Sestamibi SPECT CT
- US of the neck
Preoperative Imaging

Challenges

- Differentiation of parathyroid adenomas from lymph nodes
- Ectopic locations
- More than one abnormal parathyroid or parathyroid hyperplasia
- Intra-thyroid parathyroid adenoma
- Concurrent pathology in the neck
Imaging with Ultrasound

Limitations

- Deep or ectopic locations
- Differentiation from lymph node or exophytic thyroid nodule
- Intrathyroid parathyroid adenoma
- Atypical sonographic appearance
Ultrasound Technique

- High frequency (7-13 MHz) linear array transducers with gray-scale and color/power Doppler to evaluate the soft tissues of the neck

- Systematic evaluation of the thyroid and lateral neck compartments for the presence of co-existing thyroid disease or adenopathy
Parathyroid Imaging

Ultrasound characteristics

- Hypoechoic with respect to adjacent thyroid parenchyma
- Oval or bean shaped, although larger adenomas may be multilobulated
- Can have cystic change
- Color of power Doppler may show a feeding vessel with peripheral internal vascularity
  - Polar feeding vessel
Thyroid Ultrasound

Normal anatomy

Parathyroid
- hypoechoic compared to thyroid
Ultrasound Imaging of the Parathyroid

Parathyroid adenoma
Parathyroid adenoma vs. lymph node

Ultrasound characteristics
Ultrasound Imaging

Intra-thyroid parathyroid adenoma (ITPA)

- Ectopic Parathyroid gland completely surrounded on all sides by thyroid tissue
- Published incidence 0.5-4%
- 4D CT and Nuclear Medicine imaging cannot distinguish intra thyroid parathyroid adenoma from thyroid parenchyma
Intra-thyroid parathyroid adenoma

Sonographic features:

- Variable- Overlap with imaging findings of thyroid nodules
- Hypoechoic echotexture with respect to thyroid parenchyma
- Presence of polar feeding vessel – high sensitivity and specificity

Caution!
- FNA findings can be indistinguishable from thyroid and sample must be sent for PTH assay
Intra-thyroid parathyroid adenoma
Prospective study showed that 4DCT provides greater sensitivity than sestamibi imaging for accurate preoperative localization of parathyroid adenomas (88% vs 54%).

4D-CT of the parathyroid

Advantages

- Allows for detailed anatomic localization, superior to other imaging modalities, and helps aid surgery

- Accuracy of 87% as single modality in localizing adenoma
Imaging with 4D-CT

4D CT parameters

- 18 G angiocatheter placed in the antecubital fossa
- 120 cc contrast at 4cc/sec
- Images obtained at 1.25 mm from the mandible to carina
- Images reconstructed at 4mm as multiplaner maximal intensity projection images:
  - true axial
  - true coronal
  - true sagittal
  - bilateral sagittal oblique planes
Imaging with 4D-CT

4D CT parameters (cont)

Acquisitions:

1. Non-contrast
2. Arterial
3. Venous
4. Delayed-Venous
4D-CT Imaging

Anatomy
4D-CT Imaging

Anatomy
Parathyroid adenoma: 4D CT findings

- Parathyroid adenomas are lower in attenuation relative to adjacent thyroid parenchyma on non-enhanced CT images.

- Most parathyroid adenomas have rapid, arterial uptake with washout of contrast during subsequent venous phase images.

- Polar feeding vessel - secondary sign.
Imaging with 4D-CT

Pitfalls on 4D CT

False positive:
- Lymph nodes
- Thyroid tissue/exophytic thyroid nodules

False Negative:
- Ectopic glands
- Small adenomas
- Multiglandular disease/hyperplasia
4D-CT Parathyroid adenoma vs lymph node

Parathyroid adenoma
- Rapid uptake with washout

Lymph Node
- Slow continuous uptake with peak enhancement on delayed phase
4D-CT Parathyroid adenoma vs Thyroid nodule

Parathyroid adenoma
- Hypodense on Non-contrast CT images

Thyroid nodule
- Hyperdense on Non-contrast CT images
MDACC Nomenclature to organize and classify parathyroid adenomas

- Uniform and reliable description exact location of abnormal parathyroid glands
- Improves communication with surgeons
- Based on quadrants and the anterior-posterior depth relative to the recurrent laryngeal nerve and thyroid parenchyma

Imaging with 4D-CT

Case 1- Type A

A- Superior Gland
- Adherent to the posterior surface of thyroid parenchyma
- Along the superior thyroid pole
Imaging with 4D-CT

Case 1 - Type A
Imaging with 4D-CT

Case 2- Type B

B- Superior Gland

- Fallen posteriorly into tracheoesophageal groove.
- No contact with posterior surface of thyroid tissue.
- At the level of the superior thyroid pole
Imaging with 4D-CT

Case 2- Type B
Imaging with 4D-CT

Case 3- Type C

C - Superior Gland
- Fallen posteriorly into tracheoesophageal groove.
- No contact with posterior surface of thyroid tissue.
- At the level of or below the inferior thyroid pole
D (Dangerous)
- In mid region of posterior surface of thyroid parenchyma.
- Could be superior or inferior gland as nerve is not visible
- Junction of recurrent laryngeal n, inferior thyroid artery and middle thyroid vein
Imaging with 4D-CT

Case 5- Type E

E- Inferior Gland
- Close to the inferior thyroid pole
- In the AP plane of thyroid and anterior trachea
Imaging with 4D-CT

Case 5- Type E
Imaging with 4D-CT

Case 6- Type F

F - Inferior Gland
- Gland that has descended into Thyrothymic ligament.
- May appear to be “ectopic” or in mediastinum.
- AP view show it anterior/ near trachea
Imaging with 4D-CT

Case 6- Type F
Imaging with 4D-CT

Double parathyroid adenoma

Noncontrast

Contrast

Coronal MIP
Imaging with Sestamibi Tc-99

Technique:

- Early (30 min) and delayed (1.5 hour) planar imaging of the neck and chest
- Between the planar imaging we do SPECT/CT of the same area and 4DCT protocol
- CT done at 1.25 mm cuts
- SPECT images AC and non-AC processed with iterative reconstruction
Findings:

- Uptake in thyroid and salivary glands
- Parathyroid adenomas demonstrate avid uptake of tracer with retention of tracer on delayed imaging
- No uptake in normal parathyroid glands
Imaging with Sestamibi Tc-99

Images:
Imaging with Sestamibi Tc-99

Ectopic mediastinal parathyroid adenoma
Imaging with Sestamibi Tc-99

Pitfalls/limitations

- Cannot reliably differentiate between thyroid adenoma and parathyroid adenoma when tracer uptake is contiguous with thyroid parenchyma.
- Small parathyroid adenomas may not accumulate enough tracer to be detectable.
- Less sensitive in multigland hyperplasia.
- Other malignancy can have tracer uptake and result in false positives- including thyroid cancer.
Intraoperative Ultrasound localization

- Used to help facilitate targeted, minimally invasive surgery, particularly in the reoperative neck
- Localize ectopic adenomas or transplanted parathyroid adenomas
Intraoperative Ultrasound localization

Case 1

- 41 y/o female with recurrent primary hyperparathyroid disease
- Patient had undergone 2 prior neck explorations for parathyroid disease
Intraoperative Ultrasound localization

Ectopic Parapharyngeal Parathyroid adenoma
Intraoperative Ultrasound localization

Case 1: Ectopic parapharyngeal parathyroid adenoma

Axial 4DCT with arterially enhancing parathyroid adenoma medial to the carotid space and posterior to the submandibular gland.

Noted pre-operatively is the depth of the lesion from skin surface and relationship to vessels.
Intraoperative Ultrasound localization

Case 1: Ectopic parapharyngeal parathyroid adenoma

Pre-resection localization - skin marking

- Transverse IOUS with Doppler demonstrates the adenoma and relationship to the carotid artery
- Skin marked overlying the ectopic parathyroid adenoma during IOUS
Intraoperative Ultrasound localization

Case 1: Ectopic parapharyngeal parathyroid adenoma

Intraoperative photographs

- The site of skin marking and planned incision 10 cm superior to the previous incision
- Offending parathyroid gland wedged between the facial vein and salivary gland
Intraoperative Ultrasound localization

Case 1: Ectopic parapharyngeal parathyroid adenoma

- Photograph of the resected parathyroid adenoma placed on a template drawing
- Ruler documenting the size of the lesion
Intraoperative Ultrasound localization

Case 2

- 82 year old female with parathyromatosis and recurrent primary parathyroid disease
- Patient had undergone 5 prior neck dissections
Intraoperative Ultrasound localization

Case 2: Multiple parathyroid adenomas

(A) Left pectoralis major parathyroid adenoma where parathyroid tissue previously autotransplanted

IOUS was performed for localization and skin marking of multiple parathyroid adenomas
Intraoperative Ultrasound localization

Case 2: Multiple parathyroid adenomas

(B) Left pretracheal/sternal notch implant

IOUS was performed for localization and skin marking of multiple parathyroid adenomas
Intraoperative Ultrasound localization

Case 2: Multiple parathyroid adenomas

(C) Anterior right suprasternal implant

IOUS was performed for localization and skin marking of multiple parathyroid adenomas
Intraoperative Ultrasound localization

Case 2: Multiple parathyroid adenomas

(D) Midline suprasternal implant

IOUS was performed for localization and skin marking of multiple parathyroid adenomas
Intraoperative Ultrasound localization

Case 3

- 36 year old female with recurrent primary hyperparathyroidism
- Patient had undergone 2 prior parathyroidectomies
- Previous debulking of autotransplanted parathyroid tissue in the forearm with removal of surgical clip marking site of transplanted tissue
- 4D-CT, sestamibi and MR negative
Intraoperative Ultrasound localization

Case 3: IOUS localization for re-operation debulking of left forearm

Level of antecubital scar

- Three subtle areas of nodularity in the subcutaneous soft tissues of the forearm were marked intraoperatively
- No surgical clips to identify site of autotransplanted tissue was seen
Intraoperative Ultrasound localization

Case 3: IOUS localization for re-operation debulking of left forearm
Intraoperative Ultrasound localization

Case 3: IOUS localization for re-operation debulking of left forearm
Intraoperative Ultrasound localization

Case 3: IOUS localization for re-operation debulking of left forearm
Case 3: IOUS localization for re-operation debulking of left forearm
Summary

- Imaging is imperative for accurate localization of parathyroid adenomas facilitating minimally invasive parathyroidectomy
- Multimodality imaging complimentary
- Common nomenclature enables smooth communication between radiologist and surgeon
- Intraoperative US support can be key in challenging cases with ecopic locations or in the reoperative neck