The contribution of CT, MR and MRI 3D post-process imaging in detecting ectopic parathyroid glands in primary hyperparathyroidism.

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Aims and objectives

Four parathyroid glands are usually present in human body (two superior and two inferior). The superior parathyroid glands in over 90% of population are located posteriorly to the superior pole of the thyroid near the cricothyroid junction and can be rarely found in retropharyngeal (1%), retroesophageal (1%) space or within the thyroid parenchyma (0.2%). Conversely, position of the inferior parathyroid glands varies in location and they are most commonly found inferior, posterior or lateral to the lower thyroid pole (69%). They can also be located in thymus gland (26%), less frequently in the anterior mediastinum (2%) or inferiorly to thymus gland in the mediastinum (0.2%). [1-3]

Primary hyperparathyroidism (PHPT) is defined as the presence of elevated serum calcium (hypercalcemia) and parathyroid hormone (PTH). In most cases it is caused by a solitary parathyroid adenoma at a juxtathyroid location in the neck (85%). Less frequently, it is attributed to secondary hyperplasia of parathyroid glands (10-15%), multiple adenomas (4%) and parathyroid cancer (1%). It most commonly affects women than men in the fifth to seventh decade of their life and it is frequently an asymptomatic disease (75% - 80%) [3].

Ectopic parathyroid adenomas located in the mediastinum have a very low incidence among patients with PHPT (1-2%) [4]. Most of these patients have an unsuccessful initial parathyroidectomy with persistent hypercalcemia and require further investigation for the exact location of the offending tissue and surgical re-exploration. According to literature, Radio-isotope scans using 99m-technetium-methoxybutilisonitrile (MIBI), contrast-enhanced CT scan and MRI are the imaging modalities of choice and contribute to the accurate detection of the ectopic pathological parathyroid gland pre-operatively, showing a sensitivity of approximately 73-96%, 46-87% and 77- 82% respectively. [5 - 10]

Axial contrast enhanced CT scan is more commonly used in cases of failed parathyroidectomy or in cases of altered anatomy, for the detection of suspected ectopic, especially mediastinal, parathyroid glands. CT demonstrates the hypervascular behavior of parathyroid adenomas, which appear as intensively enhanced lesions visualized early during the arterial phase with a prolonged enhancement in the delayed phase. MRI provides high spatial resolution, soft tissue contrast and can visualize the adjacent anatomic structures, however imaging of ectopic parathyroid tissue may vary in signal intensity on MRI. Reported signal typical characteristics include T1 weighted images typically demonstrates an intermediate to low signal lesion, T2 weighted images usually shows hyperintense lesion with rapid enhancement during the arterial phase and a prolonged enhancement in the delayed phase, after an IV injection of gadolinium- based contrast medium at T1 weighted with fat saturation images. Additionally, the use of high resolution 3D data sets can also provide additional imaging information and may be useful in identifying ectopic parathyroid glands. [11]
The purpose of this study is to assess the contribution of CT scan after contrast medium administration and the role of MRI with 3D post-process in the accurate localization of ectopic parathyroid glands in patients with PHPT.
Methods and materials

A TC 99m Sestamibi was performed in 8 patients with hypercalcemia and increased parathormone blood count (PTH) showing an increased uptake in the superior mediastinum indicating the presence of pathologic ectopic parathyroid gland. For the accurate detection of the pathology as well as the localization of the exact anatomic relation to adjacent mediastinal structures (e.g. vessels), a contrast enhanced CT scan and an MRI with 3-D reconstruction were carried out.

CT protocol consisted of thin-collimation axial images after IV contrast medium administration. MRI protocol included T1 weighted, T2 weighted and Short TI Inversion Recovery (STIR) images, as well as dynamic contrast enhanced axial T1- weighted fat saturated after IV contrast medium injection and 3D reconstruction images, in 15, 30 and 90 seconds, followed by 3D post-process and colored analysis.
Results

Contrast enhanced CT and MRI with 3D post-process revealed ectopic parathyroid adenoma in all patients.

Four patients had an ectopic parathyroid adenoma situated behind the origin of the left subclavian artery in the posterior-upper mediastinum (figure 1-3). A parathyroid adenoma was detected behind the trachea and the confluence of brachiocephalic veins in the middle mediastinum in three patients (figure 4, 5) and in the last patient the adenoma was located in the pulmonary-aortic window (figure 6-8).

In all patients an exploratory surgery was performed, confirming the imaging findings.
Fig. 1: [First row] Image obtained 20 min after intravenous injection of Tc 99m sestamibi shows uptake in the lower pole of the right thyroid lobe and superior mediastinum (red arrow). Delayed imaging (after 3 hours) confirms that the area of uptake in right superior mediastinum is an ectopic parathyroid gland (black arrow). [Second row] CT images after IV administration of contrast medium, demonstrated a hypervascular lesion, characteristic of an ectopic parathyroid gland (red arrows), in the right upper mediastinum, with a head-caudal diameter ~ 4.5 cm.
**Fig. 2:** MRI transverse precontrast T1-weighted, T2-weighted and Short TI Inversion Recovery (STIR) images in the same patient as in fig. 1, with recurrent HPT after neck exploration. The adenoma (red arrows) is in a location typical for parapharyngeal parathyroid adenomas and demonstrates characteristic signal intensity patterns on all three images. In the inferior row, MRI T1-weighted fat saturated after IV contrast medium injection and 3D reconstruction images were obtained, (in 15, 30 and 90 seconds), where an oval lesion with progressive enhancement is depicted.

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Fig. 3: MR images with 3D post process analysis in the same patient (fig.1-2), demonstrates an ectopic parathyroid gland (yellow) in relation to surrounding structures. Exploratory surgery confirmed these findings.

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**Fig. 4:** Ectopic parathyroid adenoma (2.0 x 2.5cm) in the right paratracheal space, dorsally to the junction between right brachiocephalic vein and superior vena cava. CT image (upper left) after contrast medium administration and T1 weighted, T2 weighted and Short TI Inversion Recovery (STIR), precontrast images, with characteristic signal intensity patterns (low signal at T1 and high at both T2 and STIR images).

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Fig. 5: MR images after 3D post process in another patient, reveal the anatomical situation of the parathyroid adenoma and its relation to great vessels in the mediastinum.

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Fig. 6: Image after intravenous injection of Tc 99m sestamibi (upper left), in a delayed phase (1 hour 30 min after administration) shows multiple focal uptake within and near thyroid gland as well as retrosternal in the midline and slightly to the left. CT postcontrast, images (coronal- upper right and axial - lower middle) showed a hypervascular lesion, typical of an ectopic parathyroid gland, in the aortopulmonary window.

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Fig. 7: MR images in the same patient as in fig.6, confirmed CT and SPECT findings. T1 weighted and T2 weighted, first row images, show the ectopic parathyroid gland without the typical signal pattern, low signal at T1 and intermediate signal at T2 weighted images, (white arrows). Second row, T1 weighted with fat saturation after IV contrast medium injection in 15, 30 and 90 seconds axial images, show progressive enhancement of the lesion (red arrows).

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Fig. 8: Ectopic parathyroid adenoma (yellow) of fig. 7. Adenoma is 2.0 x 1.1 x 1.0 cm in size and located in the aortopulmonary window (white arrow). Surgical resection confirmed the diagnosis.

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Conclusion

Ectopic parathyroid glands appear to be a relatively rare cause of PHPT. However, it may result in unsuccessful parathyroidectomy or cause persistence or relapsing primary hyperparathyroidism. Preoperative localization with imaging is essential for the exact detection of this entity, showing a significant decrease of the intraoperative time, the size of surgical incisions and the complication rates.

Contrast enhanced CT and MRI images provide useful anatomical information for the accurate localization of ectopic parathyroid glands formerly identified on TC 99m Sestamibi imaging. The use of 3D reconstruction and the chromatic analysis is an adding technology in mapping these lesions that contributes in the surgical approach and management. More studies are required before the appropriate usefulness of this combined technique is established.
References