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Computed tomography and magnetic resonance imaging in diseases of the thyroid and parathyroid

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Abstract

Disease of the parathyroid glands presents most often with hypercalcaemia secondary to excess parathormone (PTH) production. This is due to a solitary functioning parathyroid adenoma. The role of imaging is primarily to localise the functioning adenoma. Disease of the thyroid may present with a neck mass or thyroid dysfunction. This paper focuses on the approach and choice of imaging techniques in the evaluation of hypercalcaemia and thyroid masses.

Keywords: Hypercalcaemia; Multinodular goitre; Papillary carcinoma; Follicular carcinoma

1. Parathyroid gland imaging

1.1. Anatomy

There are usually four parathyroid glands (paired superior and inferior) but this can vary from two to six. They typically lie posterolateral to the upper and lower poles of the two thyroid lobes. They migrate caudally through the neck in utero and if the lower glands undergo overdescent they may come to lie ectopically within the mediastinum.

Disease of the parathyroid glands usually presents with a biochemical abnormality; rarely with a neck mass.

1.2. Hypercalcaemia

Excess production of parathormone (PTH) results in hypercalcaemia. The commonest cause of hyperparathyroidism is a solitary parathyroid adenoma (around 74–96% of cases). Less commonly hyperplasia of all the parathyroid glands (3–14%) or multiple (usually two) parathyroid adenomas (2–12%) are responsible [1–3]. Parathyroid carcinoma is a rare cause, reported in up to 4% in some series but less than 1% in others [3,4].

First line imaging of hyperparathyroidism is ultrasound of the neck and/or radionuclide scanning, in particular $^{99}Tc^{m}$ sestamibi. A wide range of accuracies has been quoted for each modality, reflecting the particular skills and experience of the reporting institution but it would be reasonable to expect an accuracy of at least around 87% for a radionuclide study, 80% for ultrasound and 95% for both modalities combined [3,5]. This will demonstrate the majority of adenomas prior to surgery. CT and MRI in the neck show similar accuracy to ultrasound, all three being modestly less accurate than $^{99}Tc^{m}$ sestamibi scanning [6,7]. Technical improvements in all modalities, particularly radionuclides, mean that the detection rate has risen significantly when comparing data before and after 1988 [6].

In difficult cases, for example following failed surgery (i.e. removal of adenoma with persistent hypercalcaemia or failure to find an adenoma) CT or MRI may be employed to search in particular for a mediastinal lesion. In this setting these modalities have a reported accuracy up to the order of 73–84% and are demonstrably superior to ultrasound although still showing little or no advantage over $^{99}Tc^{m}$ sestamibi scanning and certainly being less specific [8,9].

On CT parathyroid adenomas are typically well defined and intensely enhancing with intravenous contrast (Fig. 1). On MRI they are similarly well defined and show high signal on T2 weighted (T2W), intermediate on T1 weighted (T1W) sequences and intense enhancement with contrast (Fig. 2).

If the facilities are available the optimum use of CT is combined with $^{99}Tc^{m}$ sestamibi scanning as SPECT/CT. This has the advantage that there may be a small increase in the detection rate of parathyroid adenomas but, potentially more importantly, there

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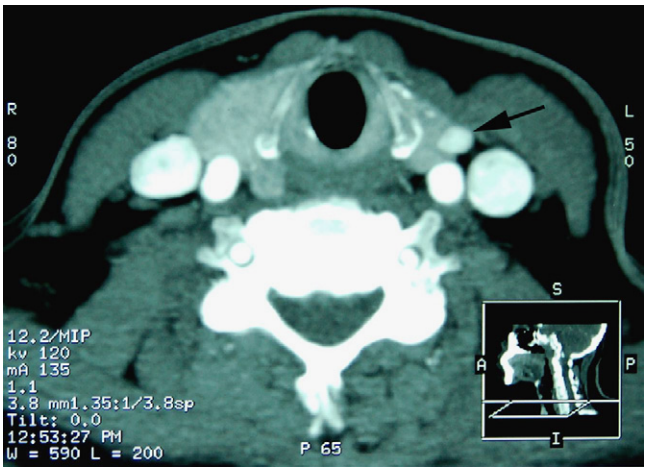

Fig. 1. Post-contrast CT image of small parathyroid adenoma indenting the lateral aspect of the left lobe of thyroid (arrow). Image courtesy of Dr. Polly Richards, Saint Bartholomew's Hospital, London.

is improved localisation of detected adenomas in more difficult sites for surgical access, for example retrotracheal adenomas [10,11].

In complicated hyperparathyroidism (i.e. persistent after failed surgery) referral to a specialist centre for selective parathyroid venous sampling (PVS) should be considered. In this group of patients PVS is reported as correctly localising the underlying adenoma in 59% of cases compared with 39% for ultrasound, 36% for sestamibi and an amazingly poor 17% for MRI or CT [12].

1.3. Neck mass/swelling

Untreated parathyroid adenomas have the capability to enlarge sufficiently to present as a mass detectable on clinical examination of the neck or on barium swallow. Historically patients presented with adenomas of this size and would suffer profound bone disease because of the prolonged and extreme nature of the hyperparathyroidism. This is extremely rare in current practice.

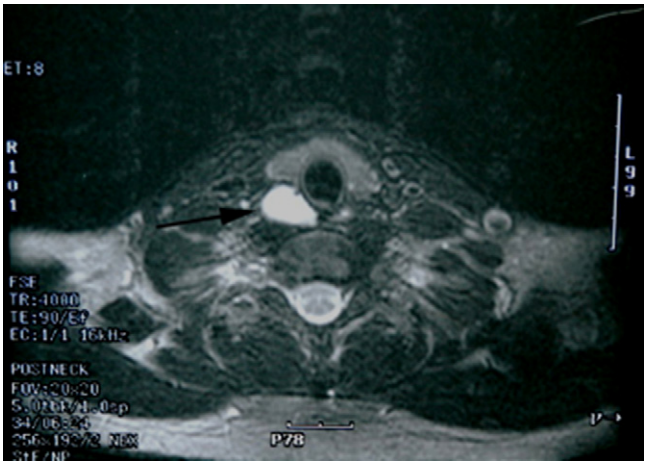

Fig. 2. MRI (transverse T2W image) showing a large parathyroid adenoma posterior to the right lobe of thyroid (arrow). Image courtesy of Dr. Polly Richards, Saint Bartholomew's Hospital, London.

Parathyroid cancer is uncommon. A minority of cases present as neck masses or are found incidentally in thyroidectomy specimens. The majority however still present as hypercalcaemia due to hyperparathyroidism [13]. Even if localised in advance, cancer is not usually diagnosed until at or after surgery since the imaging appearances of parathyroid cancers are similar to parathyroid adenoma (Fig. 3). Invasion of local structures includes the prevertebral muscles and the recurrent laryngeal nerve. Since all reported studies are small the rate of local invasion is uncertain but it seems to occur relatively early and in a sizable proportion. Reports suggest anything from 18 to 67% show local invasion at presentation [4,14,15]. Lymph node involvement and distant metastases are rare.

2. Thyroid gland imaging

2.1. Anatomy

The thyroid gland is a bilobed endocrine gland that lies anteriorly in the infrahyoid neck within the visceral space. This space is surrounded and defined by the middle layer of the deep cervical fascia. In addition to the thyroid it contains the parathyroid glands, the larynx and trachea, the recurrent laryngeal nerves, the cervical oesophagus and para-oesophageal lymph nodes. The two lobes of the thyroid are joined across the midline by the isthmus of the thyroid which lies immediately anterior to the trachea. Each lobe relates posterolaterally to the carotid space (which contains the carotid artery medially and the jugular vein laterally), anterolaterally to the sternocleidomastoid muscles and anteriorly to the strap muscles of the neck (sternothyroid and sternohyoid). The four parathyroid glands are usually situated posterior to the upper and lower pole of each lobe of thyroid.

Thyroid dysfunction (over or under production of thyroid hormones) is relatively common but investigation and management relies mainly on biochemistry, ultrasound and radionuclides. CT and MRI have no real role in this context.

Neck masses/swelling due to thyroid disease is common, potentially arising from a variety of conditions, usually benign but related to malignancy in a minority.

2.2. Developmental abnormalities

The thyroid originates embryologically at the site of the foramen caecum in the base of the tongue. Between the sixth and eighth week it descends to its normal position through the neck, passing anterior to the hyoid bone. The course of the descent is marked by the thyroglossal duct which normally involutes by the eighth week in utero. Cystic duct remnants may be found anywhere along the course of embryological descent but most commonly immediately anterior to the hyoid bone in a fairly midline position (Fig. 4). These are usually confidently identified with ultrasound, although it is important to be able to recognise them when they are incidentally demonstrated on CT or MRI performed for other indications. Occasional complex cases may require MRI to supplement the ultrasound demonstration (Fig. 5).