Ultrasound – first imaging modality in the detection of parathyroid adenomas

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Abstract

We present a series of 12 patients in whom the typical ultrasound (US) features of parathyroid adenomas were accurately demonstrated. High-resolution ultrasound in experienced hands is a highly sensitive, accurate, safe and non-invasive method of localising parathyroid adenomas, especially in patients with typically located glands and an absence of thyroid pathology. Our aim was to show that US can be used as a first imaging modality in the detection of parathyroid adenomas.

Introduction

Hyperparathyroidism is a term used to describe the consequences of excessive secretion of parathyroid hormone (PTH), either due to primary disease of the parathyroid gland or secondary to renal disease. Primary hyperparathyroidism is usually caused by a single parathyroid adenoma. Occasionally there may be multiple adenomas. Malignant transformation can also occur.

Parathyroid glands are usually four in number, each measuring 5 mm in diameter. The two superior glands tend to be posterior and the two inferior ones, anterior. They usually lie on the posterior aspect of the thyroid, embedded in its substance or within the sheath of the gland, and may be in relation to the cornu of the thymus. The inferior glands are supplied by the inferior thyroidal artery, and the superior glands by the superior thyroidal artery.[1]

In parathyroid adenomas with hypersecretion, there is an increase in urinary excretion of phosphorus and calcium and an increase in plasma calcium and alkaline phosphatase levels, which indicate osteoblastic activity.[2] PTH levels are also increased.

Method

Between January 2006 and June 2007, 12 patients (irrespective of sex and age) were documented (Fig. 1). We stated our experience with imaging of parathyroid adenomas at Kalafong and Pretoria Academic hospitals.

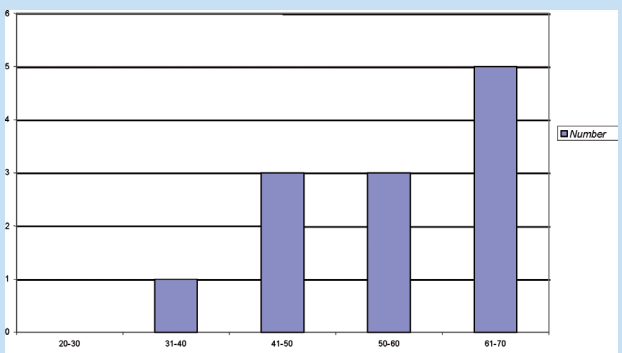


Fig. 1. Graphic representation of age distribution.

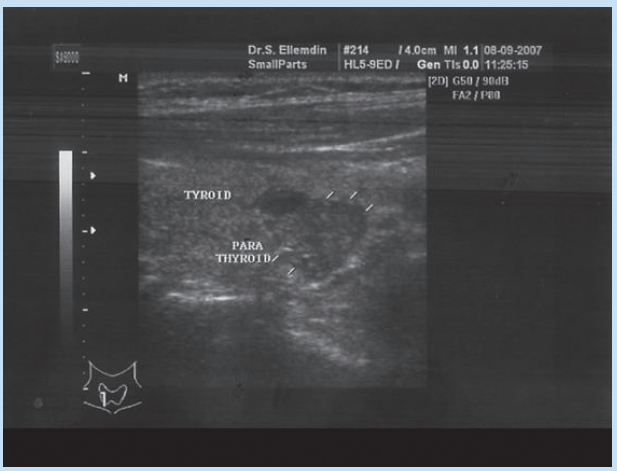


Fig. 2. Parathyroid adenoma. The lesion is postero-inferior to the thyroid with a thin highly reflective capsule.

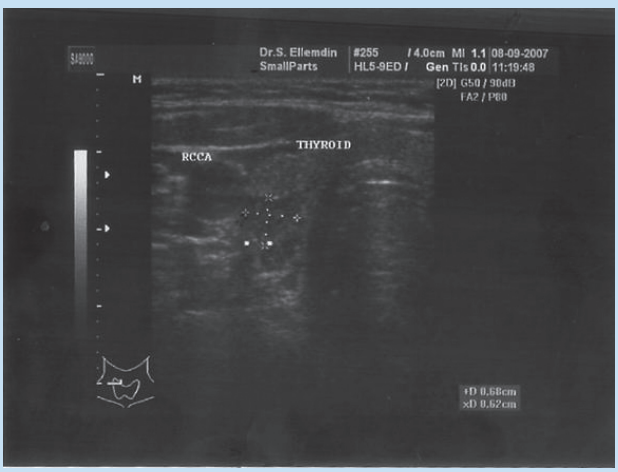


Fig. 3. Parathyroid adenoma of the same echogenicity as the thyroid parenchyma. The parathyroid mass can only be separated from the thyroid by the highly reflective capsule.

Table I. Patients, symptoms and adenoma data

Case number	Age	Sex	Location of parathyroid adenoma	Symptoms and associated findings	Size (cm)	Mass (g)
1	31	F	Right superior gland (Figs 4a and 4b)	Mass in the left clavicle (brown tumour)	5 x 0.5 x 0.5	Not recorded
2	45	M	Right inferior gland	Kidney stone	2.2 x 1.5 x 0.8	2.46
3	47	F	Left inferior gland	Previous kidney stone	2 x 1.1 x 0.4	1.19
4	45	M	Atypical right superior gland	Kidney stone and constipation	2 x 1.5 x 1.5	24 (mass incl. right thyroid lobe)
5	51	F	Right inferior gland	Kidney stone	Declined surgery	
6	63	F	Right superior gland	Kidney stone, constipation and bone pain	Awaiting surgery	
7	55	M	Left inferior gland	Constipation and bone pain	3.5 x 1.5 x 0.6	3.58
8	72	F	Right superior gland	Constipation and bone pain	Not fit for surgery	
9	70	F	Left inferior gland	Diarrhoea and bone pain	Declined surgery	
10	66	F	Left inferior gland	Previous kidney stones	1 x 0.5 x 0.5	Not recorded
11	70	F	Left superior gland	Fatigue and bone pain	1.8 x 0.7 x .03	Not recorded
12	57	F	Left superior gland	Multi-nodular goitre	2.3 x 2 x 0.5	1.34

All patients presented with some of the symptoms of hypercalcaemia, as per the mnemonic, i.e. bone pains, fractures or brown tumours (bones); constipation (moans); tiredness/fatigue (groans); and renal calculi (stones) (Table I).

Biochemical analysis revealed elevated urinary calcium and phosphorus levels and an elevated corrected serum calcium of more than 2.5 mmol/l with elevated serum PTH (normal values are 15 - 68.3 pg/ml). Patients were examined on either the Toshiba Xario or Sono Ace 8000 EX PRIME using a 7.5 mHz high-resolution linear probe. The initial workup included correcting of serum calcium and PTH levels, and an US scan of the neck.

Technique

In all 12 patients whom we examined, the exact size, location and number of parathyroid adenomas was accurately diagnosed and was confirmed on ^{99m}Tc-MIBI parathyroid scan or computed tomography (CT) scan.

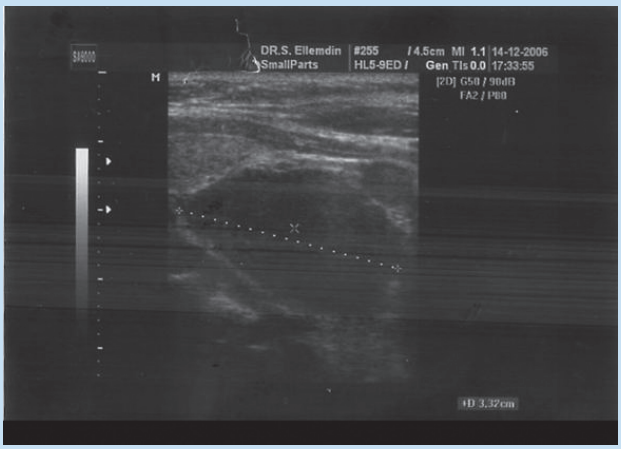
For US examination of the parathyroid glands, the patient is positioned supine with the neck hyperextended to bring the inferior margin of the thyroid up and out of the mediastinum. A pillow placed between the shoulder blades can help the hyperextension.[3]

The patient's thyroid is scanned with upper, mid- and lower transverse and mid-, medial and lateral longitudinal images obtained of both lobes. Although the parathyroid is often intimately associated with the thyroid gland, it might have migrated further afield; for this reason, scans are extended from the upper neck at the inferior margin of the submandibular glands out to the carotid sheaths, and down to the supraclavicular areas.

A high-resolution linear array transducer of 7 - 13 MHz with a relatively small footprint is ideal, using acoustic gel as the couplant, but such transducers have only 4 - 5 cm depth of penetration. For patients with enlarged thyroid glands, a lower frequency transducer may be necessary to see the posterior portion of the thyroid, since this is a common location for parathyroid adenoma. However, the use of a low-frequency transducer, such as a 5 MHz, may not have the resolution to detect a small (<1 cm) hyperplastic parathyroid gland at depth. In patients with goitre, the inferior portion of the thyroid may extend below the neck into the mediastinum, and an inferior parathyroid adenoma may migrate with it. In these instances, nuclear scintigraphy is the study of choice since sonography will be impeded by air in the lungs.[3]

Results

US accurately diagnosed the position and size of the parathyroid adenoma in all 12 patients. This was confirmed by doing a ^{99m}Tc-MIBI parathyroid scan or CT scan. The parathyroid adenomas varied in size from 10 mm to 30 mm in diameter, and in position. They were hypoechoic, well outlined, solid, inhomogeneous masses with a hyperechoic reflective capsule (Figs 2 - 4) distinguishing them from the thyroid parenchyma.



Figs 4a and 4b. Very large right superior parathyroid adenoma associated with brown tumour of the left clavicle.

Fig. 5. Parathyroid adenoma. This encapsulated tan brown tumour has a lighter brown Nubian of attached normal glandular tissue.

In all the adenomas that were surgically excised and available for histopathological review, morphology demonstrated circumscription with, focally, the presence of a variably thick connective tissue capsule. The predominant cell type was chief cells arranged in sheets and occasionally small follicles (Figs 5 and 6). Cells with a clearer cystoplasm and occasionally oncocytic cells were also seen (Fig. 7).

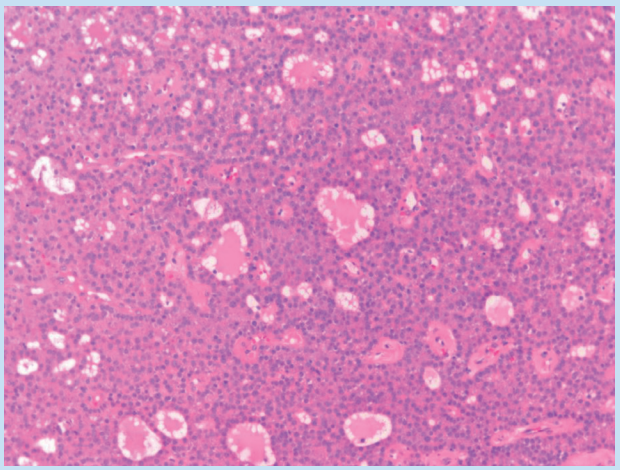


Fig. 6. Parathyroid adenoma: sheets of chief cells; some arranged in small follicles are present.

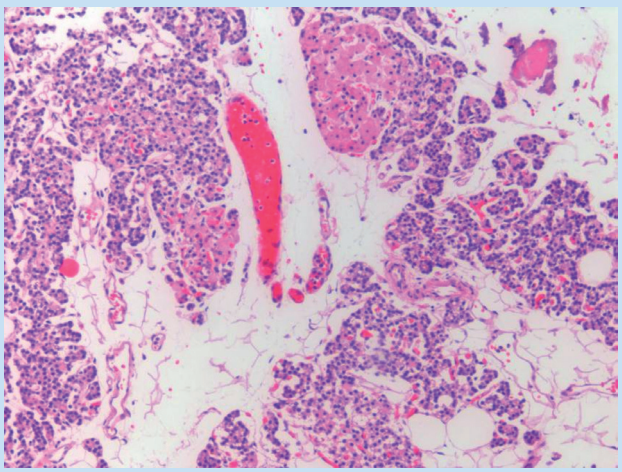


Fig. 7. Normal appearance of a parathyroid gland. Note the presence of dispersed mature adipose tissue admixed with chief cells and, more focally, an aggregate of oncocytic cells.

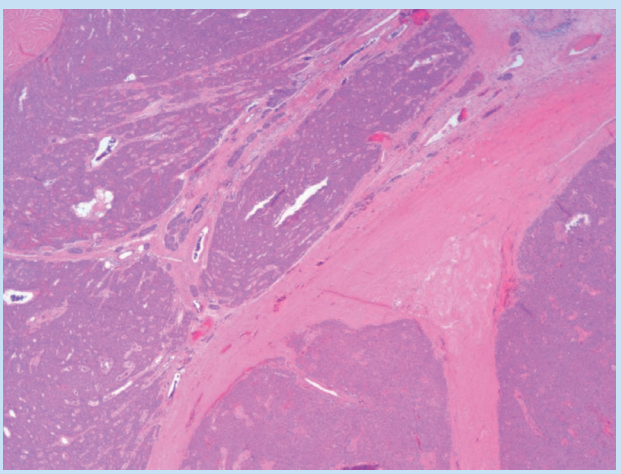


Fig. 8. A typical parathyroid adenoma, comprising nodules of neoplastic chief cells. Note the transecting thick fibrous bands and haemosiderin pigment.

In the one case diagnosed as an atypical parathyroid adenoma, the tumour had a prominent multinodular growth pattern. Thick fibrous bands, haemosiderin pigment and signs of elastotic degeneration were seen. There was variability in nuclear size, but no obvious pleomorphic features or mitotic activity were noted (Fig. 8).

All the adenomas reviewed showed no equivocal capsular or vascular transgression.

Discussion

US is the ideal means to ascertain preoperatively the location of parathyroid adenomas or hyperplastic lesions in the neck, and is especially useful in complicated instances of recurrent or persistent disease.[3,7]

Hyperparathyroidism, which results from a parathyroid adenoma or parathyroid hyperplasia, is a disease of adults. US of the parathyroid is used to confirm an adenoma/s, once screening tests indicate raised serum calcium and serum PTH. Most patients have 4 parathyroid glands – 2 inferior (anterior) and 2 superior (posterior). A normal parathyroid gland is not visible via US, and an abnormal adenoma is usually not palpable.[4] As it enlarges, an abnormal gland appears as a hypoechoic, and often anechoic, lesion, often posterior in location to the thyroid. As the gland enlarges, it can develop lobularity and foci of echogenicity.[5]

Parathyroid glands of at least 1 cm display vascularity by colour Doppler or power Doppler characterised by low resistance waveforms on spectral analysis. An extrathyroidal artery that feeds the parathyroid adenoma is commonly noted by sonography with both colour and power Doppler, and its visualisation helps in the parathyroid delineation.[2]

Calcifications in the parathyroid adenoma are infrequent. Giant adenomas may be several centimetres in size. The larger the parathyroid gland, the greater the concentrations of elevated serum calcium and PTH tend to be. As with any large neoplasms, giant parathyroid tumours (usually benign) often develop areas of cystic change and necrosis.[3] Associated conditions include pancreatitis and MEN (multiple endocrine neoplasia).[4]

Pre-operative localisation of the parathyroid glands in patients suspected of primary hyperparathyroidism (HPT) is useful for several reasons:[6,8]

1. Identification of a single abnormal parathyroid gland allows unilateral neck exploration, thus reducing operative time and complications, such as laryngeal nerve palsy. It also permits more favourable conditions for re-operation.
2. In the postoperative evaluation of persistent or recurrent HPT, localisation of the parathyroid tumour is particularly important because the complication rate on re-operation is relatively high and the success rate decreased.
3. A negative US neck survey can greatly aid in the differential diagnosis of hypercalcaemia, which can be related to diseases other than HPT.
4. In dubious cases, especially in the presence of concomitant thyroid pathology, US can guide fine-needle aspiration biopsy (FNAB) for cytological study and parathyroid hormone assay.[5]

Parathyroid adenoma, hyperplasia and carcinoma have similar US appearances. Typically, they give rise to an oval, echo-poor lesion in the neck, often posterior to the thyroid, from which it is separated by a thin, reflective capsule. It has a smooth periphery and is usually <30 mm in any dimension. Posterior enhancement is absent.

Conclusion

In experienced hands, with state-of-the-art equipment, US is extremely sensitive in detecting the source of primary HPT in a normal thyroid gland, and should be used as the first imaging modality for parathyroid adenomas. Although hyperplastic glands cannot be differentiated from adenoma, detection of more than one enlarged gland is very suggestive of hyperplasia.

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