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Computed Tomography for Evaluation of Adrenal Dysfunction: A 10-Year Follow-Up

Key Words

Cushing's disease
Addison's disease
Hyperandrogenism
Computed tomography

Abstract

Objective: To evaluate the computed tomography (CT) morphology of the adrenal glands of patients with adrenal dysfunction. **Methods:** CT examination of adrenal glands was performed in 331 consecutive patients with symptoms suggestive of adrenal dysfunction. CT was performed using 4-mm contiguous sections for the adrenal area. Intravenous contrast was injected in 78 cases of the adrenal mass lesions. **Results:** We analyzed 331 consecutive CT scans performed over a 10-year period. One hundred and twenty-seven patients had hypercortisolism, 23 had unilateral adrenal tumor, 18 had bilateral adrenal hyperplasia and 86 had normal adrenals. The CT diagnosis was confirmed at surgery in all 23 unilateral adrenal tumors except in 1 case (tuberculosis in a hyperplastic adrenal gland). Among the 91 cases of hypertension, 86 were being evaluated for pheochromocytoma and 5 for Conn's syndrome. Forty-three had adrenal pheochromocytoma (1 bilateral) and 10 had extra-adrenal pheochromocytoma detectable on CT. Two of the 5 cases of hyperaldosteronism (Conn's syndrome) had adrenal tumor. Adrenal enlargement was observed in 17 of the 33 cases of Addison's disease. Four of them were cases of histoplasmosis. **Conclusion:** CT scanning is a sensitive tool for the imaging of adrenal glands. Both neoplastic and inflammatory lesions can alter adrenal gland morphology. Our results highlight the importance of studying adrenal morphology. CT morphology is helpful to decide the modality of treatment.

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Table 1. CT findings of 331 patients of suspected adrenal dysfunction

Indication for scanning	Cases	CT findings				
		normal adrenal	adrenal hyperplasia	adrenal mass	small adrenal	extra-adrenal mass
Hypercortisolism	127	85	18	23 ^a	–	2 ^b
Hypertension pheochromocytoma	86	33		43 ^c	–	10
Conn’s syndrome	5	3	–	2	–	–
Hyperandrogenism	80	54	16	10	–	–
Addison’s	33	19	–	9 ^d	5 ^e	–

- ^a One case proved to be a case of adrenal hyperplasia with tuberculosis.
^b Case of islet cell carcinoma with ectopic ACTH excess.
^c One case had bilateral adrenal tumor.
^d Six cases had calcification.
^e Three cases had calcification.

Introduction

Computed tomographic scanning (CT) is a sensitive tool for the imaging of adrenal glands [1–5]. Both neoplastic and inflammatory lesions can alter adrenal gland morphology [6–7]. However most Western series on CT morphology of adrenal glands describe mainly adrenal tumors [8–12]. There is a scarcity of literature on the CT appearance of inflammatory lesions of the adrenal gland. This may be due to the relatively lower prevalence of infective disorders in these countries. Here we present a retrospective analysis of 331 CT scans of the adrenal performed during the last 10 years.

Materials and Methods

CT examination of adrenals was done in 331 consecutive patients with symptoms suggestive of adrenal dysfunction. Of these patients 179 were males and 152 were females with age ranging from 6 to 70 years. One third of these patients belonged to higher socio-economic groups and two thirds were from middle and

lower socio-economic status. CT scanning was performed with a Somatom DRH scanner at the Department of Radiology, AIIMS, New Delhi, India. Three hundred milliliters of 3% iodinated contrast was given orally prior to CT scanning to opacify the stomach and small bowel. Four-millimeter contiguous sections were obtained for the adrenal area. Two-millimeter contiguous sections were taken when the adrenals could not be visualized. Intravenous contrast was injected in 78 cases of the adrenal mass lesions.

Results

CT scanning of the adrenals was done in 127 cases of hypercortisolism, 91 cases of hypertension, 80 cases of hyperandrogenism and 33 cases of adrenal insufficiency. CT findings are given in table 1.

Among the patients with hypercortisolism 23 had adrenal tumor, 2 had extra-adrenal tumor and 18 had bilateral adrenal hyperplasia. Two patients with right adrenal cortical carcinoma had a tumor extending into the inferior vena cava. Another patient with Cushing’s disease (due to pituitary ACTH ex-

Fig. 1. CT scan showing right-sided large, well-defined adrenal mass with areas of necrosis and lipomatous changes. No recurrence of tumor after 8 years of follow-up suggesting a benign nature for the mass.

Fig. 2. Contrast-enhanced CT scan showing bilateral adrenal mass lesions with rim enhancement and areas of necrosis. Ultrasound-guided aspiration established the diagnosis of tuberculosis.

cess) had an extensive thrombus in the inferior vena cava starting from below the opening of the renal vein extending into the right atrium. One case diagnosed as adrenal adenoma was a case of Cushing's disease with adrenal hyperplasia and Cushing's syndrome, and histology confirmed radiological diagnosis. Ninety-one patients with hypertension (86 cases of suspected pheochromocytoma and 5

cases of hyperaldosteronism) were scanned. There were 43 cases of adrenal and 10 extra-adrenal pheochromocytoma. One case had bilateral adrenal tumor. Among the 5 patients with Conn's syndrome 2 had adrenal tumor. A false positive diagnosis of the left adrenal mass was made in 1 of the patients. Subsequent MRI studies revealed this to be the tail of the pancreas.

Fig 3. CT of adrenal glands showing bilateral enlarged adrenals with areas of calcification suggesting tuberculosis.

Diagnosis of the adrenal tumor was made on CT in 12 of the 80 cases of hyperandrogenism. Surgery and histology confirmed diagnosis of primary adrenal tumor in 10 of these cases. One was a case of nodular transformation in a hyperplastic adrenal (case of congenital adrenal hyperplasia previously reported) [13], the other was a case of cystic renal cell carcinoma of the upper pole of the kidney which was mistaken for an adrenal mass. Two patients with hirsutism who had undergone lienorenal shunt for portal hypertension earlier had grossly enlarged veins in the supra-renal area which could have been mistaken for bilateral adrenal masses. One of the patients with hyperandrogenism and a large adrenal tumor (>9 cm) with lipomatous changes (fig. 1) has completed 8 years of follow-up. She has had two uneventful pregnancies following the surgery. The second child had multiple skeletal malformation. Of the 33 patients with adrenal insufficiency, 16 had bilateral enlargement of adrenals (fig. 2), 1 had unilateral enlargement, 6 had atrophic adrenals and 10 patients had normal adrenals on CT.

Seven of the 16 patients with bilateral adrenal enlargement had areas of calcification in the adrenal glands (fig. 3). One patient with unilateral adrenal enlargement underwent surgery and histology confirmed it to be tuberculosis. Five other patients had present or past evidence of tuberculosis. Among cases without calcification 4 were diagnosed to be cases of histoplasmosis (3 by histology and 1 by clinical response to ketoconazole therapy, fig. 4).

Discussion

Adrenocortical dysfunction manifests clinically with either hyperfunction or hypofunction. Adrenal cortex produces glucocorticoids, mineralocorticoids and sex steroids [6]. Overproduction of glucocorticoids manifests clinically with Cushing’s disease characterized by obesity, hypertension, skin changes, glucose intolerance, osteoporosis and menstrual irregularity in females and loss of libido in men [7]. In 80–85% of these cases there is

Fig. 4. CT scan showing bilateral enlargements of adrenal glands maintaining normal configuration without any calcification and necrosis. CT-guided biopsy established the diagnosis of histoplasmosis.

pituitary ACTH excess causing bilateral adrenal hyperplasia. This hyperplasia may not be of the degree that can be appreciated on CT scanning. Other conditions that can produce features of Cushing's disease are adrenal adenoma, adrenal carcinoma and malignancies where ACTH is produced ectopically. In the present study of the 127 cases of hypercortisolism, unilateral adrenal mass was documented in 23 cases, and bilateral adrenal hyperplasia was seen in 16 cases. In the rest, CT morphology of the adrenals was unremarkable. One of these with unilateral adrenal mass, CT revealed adrenal hyperplasia and tuberculosis on histology. These findings are in accordance with earlier reports in the literature, except the findings of incidental tuberculosis, and a large thrombus in the inferior vena cava and pulmonary emboli in 2 cases, respectively.

Patients with hypertension undergo urine catecholamine estimation for screening of pheochromocytoma. Those with urine catecholamine levels more than $60 \mu\text{g}$ are considered abnormal and suggestive of pheochro-

mocytoma. Eighty-six such patients were included in this group. Of these 43 were found to have adrenal tumors (42 unilateral and 1 bilateral) and 10 were extra-adrenal tumors.

Mineralocorticoid excess manifests with hypertension and unexplained hypokalemia [11]. Plasma aldosterone levels are high and plasma renin activity is depressed. Adrenals in these cases may have a single adenoma or are hyperplastic. Five such cases were included in this series where adrenal adenoma was documented in 2. Excess secretion of sex steroids (adrenal androgens or estrogens) manifests clinically with hirsutism, menstrual irregularity and virilization in women, loss of libido and gynecomastia in men and accelerated growth and sexual development in children. Conditions that can produce one or more of these features are non-neoplastic ovarian hyperandrogenism, congenital adrenal hyperplasia, ovarian and adrenal tumors and idiopathic hirsutism [12]. Eighty patients with hyperandrogenism are included in this series. Of these 10 patients had adrenal tumor, and 16 had bilateral adrenal hyperplasia.

The adrenals were unremarkable in the rest. Two of these tumors measured more than 6 cm in diameter (7 and 9 cm each). There was no evidence of metastasis on radiology or histology. Both patients showed no evidence of recurrence after 4.5 and 8 years of follow-up.

Decreased production of adrenocortical hormones (glucocorticoid and mineralocorticoids) manifests with clinical features of Addison's disease. There is significant weight loss, easy fatigability, hypoglycemia, hypotension and increasing skin pigmentation. Plasma cortisol levels are low and cortisol response to ACTH is inadequate [14–16]. Thirty-three patients of Addison's disease underwent CT. Seventeen had adrenal enlargement (16 bilateral and 1 unilateral). Of these 5 patients had evidence of pulmonary tuberculosis in the past and 1 had histopathological confirmation of adrenal tuberculosis. Four were cases of histoplasmosis (3 diagnosed by CT-guided adrenal biopsy and the 4th on clinical grounds). Six patients had small atrophic glands with specks of calcification in it. In 10, adrenals appeared unremarkable.

Up until approximately 50 years ago tuberculosis was the predominant cause for Addison's disease in the West. With the advent of antitubercular drugs, tuberculosis has become less common there. The major cause is autoimmune adrenalitis. In these cases adrenals

appear normal or atrophic. Our findings are in accordance with those in the literature except for a few situations peculiar to our population. These are:

(1) Tubercular adrenalitis was seen in different stages of evaluation, i.e. from unilateral adrenal enlargement (on CT) without adrenal insufficiency to bilateral adrenal calcification with chronic adrenal insufficiency. Tubercular adrenalitis was an incidental finding in 1 of our patients with Cushing's disease.

(2) Patients with noncirrhotic portal hypertension and lienorenal shunt had collaterals mimicking suprarenal mass lesions.

(3) Patients with classical congenital adrenal hyperplasia (simple virilizing form) often presented in the 2nd and 3rd decade. These patients had adrenal enlargement with nodular transformation which could be mistaken for adrenal adenoma.

Clearly we need to keep these issues in mind while interpreting CT images of the adrenal glands.

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References

1 Brownlie K, Kreel L: Computer assisted tomography of normal suprarenal glands. *J Comput Assist Tomogr* 1978;2:1–10.

2 Korobkin M, White EA, Kressel HY, Moss AA, Montagne JP: Computed tomography in the diagnosis of adrenal diseases. *AJR Am J Roentgenol* 1979;132:231–238.

3 Freitac JE: Adrenal cortical and medullary imaging. *Semin Nucl Med* 1995;25:235–280.

4 Adams JE, Johnson RJ, Rickards D, Isherwood I: Computed tomography in adrenal disease. *Clin Radiol* 1983;34:39–49.

5 Korobkin M, Francis JR: Adrenal imaging. *Semin Ultrasound CT MR* 1995;16:317–330.

6 Hauser H, Battikha JB, Wettstein P: Pathology of the adrenal glands: Common and uncommon findings in computed tomography. *Eur J Radiol* 1981;1:215–226.

- 7 Cushing H: The basophil adenoma of the pituitary body and their clinical manifestation. *Bull Johns Hopkins Hosp* 1932;50:137.
- 8 Dunnick NR, Schaner EG, Doppman JL, Stroot CA, Gill JR, Javadpour N: Computed tomography in adrenal tumors. *AJR Am J Roentgenol* 1979;132:43–46.
- 9 Miyake H, Maeda H, Tashiro M, Suzuki K, Nagatomo H, Aikawa H, Ashizawa A, Jechika S, Moriuchi A: CT of adrenal tumors: Frequency and clinical significance of low attenuation lesions. *AJR Am J Roentgenol* 1989;152:1005–1007.
- 10 Fishman EK, Deutch BM, Hartman DS, Goldman SM, Zerhouni EA, Siegelman SS: Primary adrenocortical carcinoma: CT evaluation with clinical correlation. *AJR Am J Roentgenol* 1987;148:531–535.
- 11 Eonn JW: Primary aldosteronism, a new clinical syndrome. *J Lab Clin Med* 1985;45:3.
- 12 Givens JR: Hirsutism and hyperandrogenism. *Adv Intern Med* 1976; 21:221–247.
- 13 Harinarayana CV, Renu G, Ammini AC, Ved P, Karmarkar MG, Ahiya MM, Berry M: Computed tomography in untreated congenital adrenal hyperplasia. *Pediatr Radiol* 1991;21:103–105.
- 14 Liddle GW: The adrenals; in Williams RH (ed): *Textbook of Endocrinology*. Philadelphia, Saunders, 1981, pp 249–292.
- 15 Eason RJ, Croxson MS, Perry MC, Sommerfield SD: Addison's disease, adrenal auto-antibodies and computerised adrenal tomography. *NZ Med J* 1982;95:565–573.
- 16 Ammini AC, Gupta R, Mukhopadhyay C, Shah P, Sandhu MS, Vijayaraghaven M, Berry M: Computed tomography morphology of adrenal glands of patients with Addison's disease. *Australas Radiol* 1996;40: 38–42.