



CT AND MR IMAGING FEATURES OF ADRENAL NEOPLASMS

Essay submitted for partial fulfillment of
Master Degree in Radiodiagnosis

Submitted by
Caroline Wagdy Shaker
(M.B., B.Ch.)
Tanta University

Supervised by
Dr. Eman Soliman Metwally
Professor of Radiodiagnosis
Faculty of Medicine
Ain Shams University

Dr. Rania Mohammed Refaat AbdelHamid
Lecturer of Radiodiagnosis
Faculty of Medicine
Ain Shams University

Faculty of Medicine
Ain Shams University

2013

Table of Contents

Item	Page
1. Table of contents	I
2. Acknowledgement	II
3. List of tables.	III
4. List of figures.	IV
5. List of abbreviations.	X
6. Introduction & aim of work.	1
7. Gross and Radiological Anatomy of Adrenal Gland.	4
8. Pathology of Adrenal Gland.	21
9. Techniques of CT and MR imaging of the adrenal gland.	42
10. CT and MRI manifestations of adrenal neoplasm with illustrative cases.	52
11. Summary.	96
12. Conclusion.	102
13. References.	104
14. Arabic summary	117

Acknowledgement

Praise is to GOD who exalted in knowledge whom he wills but above those who have knowledge there is one more knowing; the cherisher and sustainer of all what is in heaven and what is on earth. To HIM is the goal and to him is the return of all.

*I would like to express my deepest gratitude to Professor **Dr. Eman Soliman Metwally**, Professor of Radiodiagnosis, Faculty of Medicine, Ain Shams University to whom I am deeply in debited. Her masterful teaching, continuous support, critical insight, enthusiastic encouragement and invaluable advice and criticism on every level are the cornerstones of this work. To me she is much more than a professor she is an idol. She is truly an example to follow.*

*Endless thanks to **Dr. Rania Mohammed Refaat AbdelHamid**, Lecturer of Radiodiagnosis, Faculty of Medicine, Ain Shams University, to whom I owe all my knowledge in this field of work. Her constructive help given to this essay will always be appreciated.*

I would like to extend my deep gratitude and cordial thanks to my family and friends for the support and help they provided.

List of Tables

No.	Table	Page
1	Classification of adrenal masses.	20
2	TNM Staging of Adrenocortical Carcinoma.	26
3	Staging System for Adrenocortical Carcinoma Proposed by the International Union Against Cancer in 2004.	27

List of Figures

No.	Figure	Page
1	Adrenal glands and the kidneys.	5
2	Shape of left adrenal glands: anterior (A) and posterior (B) aspects.	6
3	Shape of left adrenal glands: anterior (A) and posterior (B) aspects.	7
4	Relations of adrenal glands.	8
5	Arterial supply of the kidney and adrenal gland.	10
6	Venous drainage of adrenal glands.	11
7	Lymphatic drainage of adrenal glands.	12
8	Nerves of kidneys and adrenal glands.	13
9	CT of the abdomen showing position of the right and left adrenal glands.	15
10	Coronal reformate of adrenal gland.	16
11	Normal adrenal glands on computed tomography.	17
12	Normal adrenal gland by MRI.	18
13	Normal adrenal gland. T1-weighted breath-hold MR image demonstrates a normal left adrenal gland.	19
14	Gadolinium enhanced MRI for normal adrenal gland.	20
15	Adrenal adenoma with a rim of compressed normal adrenal tissue.	25
16	Adrenal cortical carcinoma showing areas of necrosis and cystic degeneration.	16
17	Unenhanced CT of adrenal glands showing irregular and nodular thickening of both adrenal glands keeping with congenital adrenal hyperplasia.	53
18	Axial post contrast CT images show that limbs of adrenal glands are enlarged bilaterally, but shape is adreniform, keeping with adrenal hyperplasia.	53
19	Coronal T1-weighted image demonstrating bilateral massive adrenal hyperplasia with preservation of the adreniform contour.	54

20	Coronal contrast-enhanced multiplanar reformation CT image shows bilateral adrenal enlargement and mild asymmetry of lateral limbs keeping with CAH.	54
21	(A) Axial CT non-contrast image shows homogenous solid left adrenal lesion containing intracellular fat being similar to the surrounding intraabdominal fat and measuring 8 HU. (B) Axial CT obtained 60 seconds after the administration of intravenous contrast displays enhancement of left adrenal gland lesion to 54 HU whereas (C) axial delayed CT image obtained 15 min after intravenous contrast administration demonstrates enhancement of left adrenal gland lesion to 9 HU. The calculated absolute percentage contrast washout was 73%, confirming a benign lipid rich adenoma.	55
22	Axial in-phase (A) and opposed-phase (B) chemical shift T1-weighted MRI images show a lipid-rich left adrenal adenoma.	56
23	(A) Axial T1 gradient echo in-phase and (B) opposed phase images shows well-defined left adrenal mass with marked relative signal intensity loss on out-of-phase images, indicative of fatty content - appearance consistent with adrenal adenoma.	57
24	Axial (A) and sagittal (B) contrast-enhanced images show large right suprarenal mass that is displacing inferior vena cava medially and right kidney inferiorly. Tumor contains flecks of coarse calcification and macroscopic fat (-20 HU) centrally, these findings are consistent with adrenocortical carcinoma.	58
25	Portal venous phase CT scan shows large, irregular right suprarenal mass with enhancing tumor thrombus extending into right renal vein and inferior vena cava resulting in luminal filling defect. At least two metastatic deposits are shown within adjacent liver; these findings are keeping with metastatic adrenocortical carcinoma.	59
26	Axial T2-weighted (A) and coronal MR venography (B) images show large heterogeneous left-sided ACC with tumor thrombus extending into adrenal vein and inferior vena cava , these findings are keeping with adrenocortical carcinoma vascular invasion.	61

27	Axial contrast-enhanced CT image shows bilobed pheochromocytoma consists of solid enhancing anterior component and cystic posterior component these findings are keeping with right adrenal pheochromocytoma.	62
28	Axial unenhanced CT image shows low-attenuation left adrenal pheochromocytoma with density of 10 HU which is similar to density of adenoma	63
29	(A) Coronal 60-second contrast-enhanced CT image. (B) Coronal 10-minute contrast-enhanced CT image shows left adrenal gland lesion exhibiting attenuation of 128 HU and 52 HU respectively. The calculated relative percentage washout is 59%. The lesion proved to be pheochromocytoma having relative washout similar to adrenal adenoma.	64
30	Axial (a) T1 and (b) fat-suppressed T2-weighted MRI images of a right adrenal pheochromocytoma. The tumor shows low T1 signal intensity and heterogeneous high T2 signal intensity comparable to cerebrospinal fluid d “light bulb” bright.	65
31	MRI T1 weighted image showing bilateral adrenal gland pheochromocytoma with salt and pepper sign.	66
32	Coronal T2-weighted image shows malignant right adrenal pheochromocytoma has invaded inferior vena cava (IVC).	67
33	Unenhanced CT image of the ganglioneuroblastoma showing hyperdense (hemorrhagic) focus within the tumor.	68
34	Contrast-enhanced CT of ganglioneuroblastoma shows a heterogenous soft-tissue mass with calcification in the central area. The abdominal aorta, splenic vein (SV) and left crura of diaphragm are invaded by the lesion. An upper-pole left renal cyst is present.	68
35	Axial post contrast CT image shows enhancing (hypervascularized) regions within the right adrenal lesion, this was proved to be ganglioneuroblastoma.	69
36	A Coronal T2-weighted image showing a large lobulated right adrenal mass with heterogenous signal intensity. B Coronal T1-weighted image with contrast enhancement and fat saturation. The mass is poorly enhancing and separate from the right kidney. Histologically this was a ganglioneuroblastoma.	70

37	Axial, enhanced CT image shows an extensive right adrenal neuroblastoma (arrows) that crosses the midline, invades the retroperitoneum and encases the aorta, coeliac axis (CA), common hepatic artery (CHA) and splenic artery (SA).	72
38	Axial IV contrast-enhanced CT shows multiple areas of low attenuation throughout the liver. There is also a heterogeneous right adrenal gland mass (arrows) that crosses the midline this was proved to be neuroblastoma with massive metastasis.	73
39	STIR examination showing left adrenal gland mass, diffuse bone marrow disease and bilateral para-aortic adenopathy	74
40	CT of adrenal myelolipoma showing a well-defined heterogeneous adrenal mass.	75
41	Axial T1-weighted MR images obtained without fat suppression (B) and with fat suppression (A) show typical MR imaging features of right adrenal myelolipoma. The fatty component of the myelolipoma (arrow in A) shows a decrease in signal intensity on the fat-suppressed image.	76
42	Axial CT images of the abdomen performed without (A) and then with intravenous contrast (B and C), demonstrate an enlarged heterogeneous hypoenhancing mass arising from the right adrenal encasing the right renal artery as well as both renal veins and abutting the aorta and inferior vena cava. A CT coronal image (D) demonstrates mass effect on the right kidney from this mass.	78
43	Axial, T2-weighted MRI image shows a larger, ill-defined, left adrenal tumor and a smaller, ovoid, right adrenal tumor are present. Both tumors show similar heterogeneous intermediate to high T2 signal intensities.	79
44	Axial contrast-enhanced CT image shows: a 5 x 4 cm in diameter, hypo dense, lobulated and well-marginated and none is enhancing cystic mass of the right adrenal gland. These imaging features are keeping with adrenal lymphangioma.	80
45	Axial contrast-enhanced CT image shows a homogenous cystic mass with a thin wall in right adrenal gland consistent with lymphangiomatous cyst of right adrenal gland.	80

46	Spin-echo T2-weighted MR image show clear septa inside due to the high signal intensity of the cystic fluid. The pathology proved to be lymphangiomatous cyst.	87
47	Enhanced axial CT scan of multiple cavernous hemangiomas shows multiple phleboliths, characteristic of hemangioma, in the left adrenal mass (arrow) and in the liver (curved arrows). The patient also had hemangiomas in the small bowel.	82
48	Axial T1-weighted postgadolinium MR image demonstrates a well-circumscribed mass in the left adrenal gland, which shows peripheral nodular enhancement compatible with a hemangioma (arrow).	83
49	A CT of the abdomen of angiosarcoma of right adrenal gland demonstrates a large, heterogeneous, hypodense mass of the right retroperitoneum, with irregular septations, compressing the hepatic parenchyma. B After intravenous contrast administration, enhancement is visualized along a thin peripheral rim and in the irregular anterior septa with non-enhancement of the predominantly hypodense component which represent extensive necrosis.	84
50	Contrast-enhanced CT of angiosarcoma shows a mass with soft-tissue attenuation and punctate calcifications. Intense peripheral enhancement is seen with non-enhanced necrotic center associated intrahepatic hematoma (*) due to local hemorrhage is also noticed.	85
51	Coronal two-dimensional gradient-echo contrast enhanced T1-weighted MR image shows intense peripheral enhancement, which reveals the necrotic center. The adjacent hematoma appears as a cystic lesion. These findings are keeping with angiosarcoma	85
52	Contrast-enhanced CT of primary malignant melanoma shows a necrotic and calcified adrenal mass (*) with associated hepatic metastases (arrow).	86
53	Coronal T1 MRI of primary malignant melanoma of right adrenal gland completely pushing the IVC away.	87
54	Unenhanced CT of right adrenal gland lipoma shows a large well-circumscribed fat density mass with internal areas of hemorrhage.	88

55	(A) Coronal FLASH two-dimensional gradient-echo T1-weighted MR image shows a heterogeneous mass with some well-limited hyperintense areas (arrow). (B) T2-weighted MR image shows that these areas (arrow) have the same high signal intensity as retroperitoneal fat. (C) T1-weighted MR image obtained with fat suppression shows heterogeneous enhancement and the lipidic nature of the corresponding areas (arrow). Picture is consistent with collision tumor with associated myelolipoma and adenoma.	89
56	Portal venous phase CT image shows large left suprarenal mass with regions of necrosis (arrows) seen centrally. Mass was confirmed to be collision or composite tumor on pathologic examination and contained both pheochromocytoma and ganglioneuroma tissue.	90
57	(A) Baseline CT in this patient presenting with lung cancer shows normal adrenals. (B) Follow-up 8 months later shows a homogeneous 4-cm mass in the right adrenal (arrow). The appearance is not inconsistent with an adenoma, but, because it is new, it is clearly a metastasis.	91
58	(A) Numerous liver metastases as well as left adrenal mass are shown on enhanced computed tomography (CT). Although the appearance of the adrenal mass not definitive, biopsy is not needed. (B) In another patient, unenhanced CT shows somewhat irregularly shaped mildly heterogeneous left adrenal mass. (C) On enhanced CT image, a thick enhancing rim is shown, a finding seen in metastases.	92
59	Axial, T2-weighted MRI image shows bilateral adrenal metastases (stars) and a liver metastasis (arrow) in a patient with primary lung cancer. The adrenal metastases and the liver metastasis have ill-defined outlines and share similar heterogeneous high T2 signal intensities.	94
60	MRI of adrenal metastases. (A) T1 weighted image shows both lesions (arrows) to have intermediate signal intensity. (B) There is no signal drop of the nodules (arrows) on opposed phase T1 image. Diagnosis of metastases to both adrenal glands was confirmed by follow up.	95

List of Abbreviations

3D	Three dimension
ACC	Adrenocortical carcinoma
ACTH	Adrenocorticotrophic hormone
APW	Absolute percentage washout
CAH	Congenital adrenal hyperplasia
CECT	Contrast enhanced CT
cm	Centimeter
CT	Computed Tomography
DTPA	Diethylenetriamine-penta-acetic acid
FLASH	Fast low-angle shot
g	gram
Gd-DTPA	Gadolinium diethylenetriamine-penta-acetic acid
GE	Gradient echo
HU	Hounsfield unit
HVA	Homovanillic acid
IV	Intravenous
IVC	Inferior Vena Cava
MEN	Multiple Endocrine Neoplasia
mm	millimeter
MRI	Magnetic Resonance Imaging
ms	millisecond
NF-1	Neurofibromatosis type 1
PAA	Primary adrenal angiosarcoma
ROI	Region Of Interest
RPW	Relative percentage washout
SGE	Spoiled gradient echo
T	Tesla
TE	Echo time
TNM classification	Tumor, lymph node, and metastasis classification
UICC	Union for International Cancer Control
VHL	von Hippel-Lindau
VMA	Vanillyl mandelic acid
vs.	Versus
WHO	World Health Organization

INTRODUCTION & AIM OF WORK



Introduction

The adrenal gland is a frequent site of clinically silent mass. Many adrenal masses can arise from adrenal gland. The “incidentaloma” are increasing in parallel with the increased use of cross sectional imaging by CT and magnetic resonance imaging (MRI). The work-up of the incidentaloma patient should aim to differentiate between benign and malignant lesions (*Sundin, 2012*).

Non-contrast enhanced computer tomography (CT) is a modality of choice used for the differential diagnosis of adrenal lesions. It allows the detection of 95% of adrenal masses and the characterization of most of them. Magnetic resonance imaging (MRI) is a good modality for cases in which CT examination cannot determine the character of an adrenal tumor (*Podgorska et al., 2012*).

The decision on a surgical versus a non-surgical management of patients with incidentaloma was previously governed primarily by the tumors size and all lesions larger

than approximately 4 cm were removed because of the risk of a malignant tumor. Currently this decision is increasingly influenced by the imaging characterization of the incidentaloma according to its radiographic features which likely support a benign tumor include rounded, well delineated tumor borders, clear separation of the tumor from surrounding structures, no evidence of tumor extension into adjacent organs and homogenous internal structure (**Sundin, 2012**).

In practice, a combination of CT, MRI, and PET is used to characterize adrenal masses in the oncology patient (**Freeman et al., 2008**).

The key role of CT is to distinguish “leave-alone” lesions from those requiring further evaluation or representing specific disease processes. Correct characterization of benign entities that do not require intervention (i.e., longstanding calcification or pseudocyst) is important to properly guide patient management (**Johnson et al., 2009a**).

MR imaging is highly recommended for differentiation of incidental adrenal lesions since its high tissue contrast and multiplanar imaging capabilities provide a detailed display of adrenal glands and their adjacent anatomic structures. MR imaging can often determine the nature of the lesion in cases which are indeterminate on CT (*Kulawska-Didoszak and Krestin, 2011a*).

Aim of work

Is to detect the value of CT and MRI in diagnosis and characterization of adrenal neoplasms and to differentiate benign from malignant lesions as well as primary from secondary adrenal tumors.