Adrenal Masses: How Imaging Plays a Vital Role in Diagnosis

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Advanced Clerkship in Radiology
BIDMC
June 21, 2010
Agenda

- Introduction to Our Patient
- Menu of Radiologic Tests
- Differential Diagnosis
- Our Patient’s Diagnosis
- Our Patient Revisited
- Summary
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Introduction to Our Patient:
H&P

• HPI:
  – 43-year old man with 3 months intermittent palpitations and headache. 3 wks of “chest burning.”

• PMH:
  – None

• SHx:
  – Recently immigrated from Cape Verde. No smoking/drinking/illicit drug use.

• Hospital Course:
  – Exercise MIBI done that showed normal perfusion and LVEF of 65%.
  – Thiamine deficient: CP thought to be due to high-output HF 2/2 wet beriberi.
  – CXR read as normal.
Introduction to Our Patient: Frontal CXR

On presentation

5-months later

2 PA Chest Radiographs. **Ill-defined density in RUQ.**
Introduction to Our Patient: Ultrasound

Transverse Section of Adrenal Mass

- Soft tissue component in periphery with similar echogenicity of liver

Sagittal Section of Adrenal Mass

- Hyperechoic central component with posterior shadowing
Introduction to Our Patient: Doppler Ultrasound

- Hypervascular soft tissue component
- Decreased blood flow in center, corresponding to calcification and necrosis
Differential for Adrenal Masses

- Adrenal Adenoma
- Metastatic Lesion
- Adrenal Carcinoma
- Myelolipoma
- Pheochromocytoma
- Hematoma
- Lymphoma
- Cyst
Introduction to Our Patient:
Lab Work-Up

- Referred to cardiology for CP and palpitations.
- 24-hour urine collection for fractionated metanephrines and catecholamines
  - METANEPHRINES 92 26-230 UG/24 HRS
  - NORMETANEPHRINES 14005 H 44-540 UG/24 HRS
  - EPINEPHRINE 25 H 2-24 UG/24 HRS
  - NOREPINEPHRINE 3410 H 15-100 UG/24 HRS
  - DOPAMINE 592 H 52-480 UG/24 HRS

- Very suspicious for pheochromocytoma.

Next Step... IMAGING
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Menu of Radiologic Tests: MRI

- T1/T2 WI characteristics
- Chemical Shift Imaging
MRI – T1/T2 WI characteristics

- Fat-abundant lesions will be bright on T1 WI
- Fluid-abundant lesions will be bright on T2 (mets, pheo)
Our Patient: T2-W Coronal MRI

- Heterogenous mass with hyperintense periphery, relative to skeletal muscle and hypointense central region.
  
- Hypointense regions isointense to cortex of bone.
  
- Fat planes are preserved between the mass and both the liver and kidney.
Our Patient: T1-W Coronal MRI

Coronal T1- Fat suppressed Gadolinium enhanced MR image showing paraganglioma with significant enhancement.
MRI: Chemical Shift Imaging

- More sensitive than T1/T2 characteristics
- Exploits difference in behavior of lipid and water protons when subjected to magnetic field
- In phase - addition of signal intensities (SI) from lipid and water protons contained within the same voxel
- Opposed phase - destructive signal intensities
- Loss of SI within adrenal mass on an opposed phase image when compared with in-phase image indicates presence of intracellular lipids
- India Ink Artifact – dark line indicative of fat-fluid interface when macroscopic fat is present

Siegelman, 2004
Our Patient:
Axial T1-W In/Out-of-Phase MRI

- No change in signal intensity between in/out-of-phase images.
- No India Ink artifact within mass. (Seen between mass and fat plane in out-of-phase).
Menu of Radiologic Tests: CT
- Non-Enhanced CT
- Delayed Contrast-Enhanced CT
CT: Non-Enhanced

- Can detect lipid content of mass using HU
- Fat approx -30 to -100 HU
- <10 HU diagnostic of adrenal adenoma
  - 71% Sensitivity 98% Specificity

Blake, et al. AJR 2010
CT: Delayed Contrast-Enhanced

- Performed in portal venous phase of enhancement (60-80 secs after start of administration)
- Many masses enhance early; however, can characterize mass by percentage of washout of contrast after certain period of time
- > 40% washout of contrast after 15 min is diagnostic of an adenoma
- Similar patterns seen with gadolinium enhancement in MRI
In Our Patient, a CT scan was performed, however, for a different complaint: abdominal pain.

Thus adrenal protocol imaging was not done. However, his scans do show some interesting findings...
Our Patient:
Coronal and Sagittal CT

- In bone window, attenuation within mass corresponds to that of cortical bone.
- Mass bordering aorta. Corresponds to paraganglioma along sympathetic chain that runs besides aorta.
Menu of Radiologic Tests: Nuclear Imaging

• MIBG (iodine-131-meta iodobenzylguanidine)
Nuclear Imaging: MIBG

- NE analog
- Whole-body imaging after 24-72 hours after administration
- Increased uptake in pheochromocytomas and paragangliomas.
Our Patient: MIBG Scan

- Increased uptake in mass corresponding to viable soft tissue periphery.

- No uptake centrally, corresponding to necrotic, calcific portions.

- Second focus of tracer uptake slightly inferior in the para-aortic retroperitoneum.
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While our patient had findings very indicative of pheochromocytoma, let’s discuss some other types of adrenal masses mentioned in our first differential...
Differential Diagnosis of Adrenal Masses

- Adrenal Adenoma
- Metastatic Lesion
- Adrenal Carcinoma
- Myelolipoma
Companion Patient 1: Adrenal Adenoma on CT C-

- Lesion: Small (<2cm), homogeneous, no growth, smooth margins.
- CT: Low attenuation on non-enhanced (<10 HU). Relative % washout >40.
- MRI: Loss of signal in CSI

NECT, axial image; Left Adrenal Mass - 4 HU

Mayo-Smith et al. RadioGraphics 2001
Companion Patient 1: Adrenal Adenoma on CT C+

- **Lesion**: Small (<2cm), homogenous, no growth, smooth margins.
- **CT**: Low attenuation on non-enhanced (<10 HU). Relative % washout >40.
- **MRI**: Loss of signal in CSI

*Dynamic enhanced CT axial images.* Arterial phase (L) enhances to 54 HU. Delayed image (R) enhancement decreases to 23 HU. Over 50% drop in attenuation.

Mayo-Smith et al. RadioGraphics 2001
Companion Patient 2: Adrenal Adenoma on MRI

- **Lesion:** Small (<2cm), homogenous, no growth, smooth margins.
- **CT:** Low attenuation on non-enhanced (<10 HU). Relative % washout >40.
- **MRI:** Loss of signal in CSI

T1-W in-phase (up) and T1-W out-of-phase (down) axial MR images shows signal drop-off.

Mayo-Smith et al. RadioGraphics 2001
Companion Patient 3: Metastatic Lesion on CT C+

- Lesions: >4cm, heterogeneous, + growth, irregular borders.
- CT: >10 HU. Relative % Washout <40.
- MRI: High SI on T2 WI. No signal drop out on CSI.

CECT scan, axial image of 5.8-cm irregular, heterogeneous R adrenal metastasis invading the liver

Boland et al. Radiology 2008
Companion Patient 4: Metastatic Lesion on MRI

- Lesions: >4cm, heterogeneous, + growth, irregular borders.
- CT: >10 HU. Relative % Washout <40.
- MRI: High SI on T2 WI. No signal drop out on CSI.

T1-W in-phase (up) and out-of-phase (bottom) axial MR images of adrenal metastases. T1-W in-phase image: mass of similar SI as spleen. Unchanged SI in out-of-phase image

Boland et al. Radiology 2008
Companion Patient 5: Adrenal Cell Carcinoma on CT C+/-

- Lesion: 4-10cm, heterogeneous. Can have central necrosis, hemorrhage, and calcification.
- CT: >10 HU. Relative % Washout <40.
- MRI: No signal drop out on CSI. T1 hypointense. T2 hyperintense.

Axial CT scans of R adrenal carcinoma with central necrosis and calcification

Boland et al. Radiology 2008
Companion Patient 5: Myelolipoma on CT

- Lesion: Benign, echogenic at US
- CT: Low attenuation (-30 to -100 HU)
- MRI: Hyperintense on T1 WI. Focal areas of signal loss on out-of-phase imaging. India ink artifact surrounding macroscopic fat.

Axial CT image showing heterogeneous mass of L adrenal containing areas of macroscopic fat with low attenuation.

Blake et al. AJR, 2010
Companion Patient 5: Myelolipoma on MRI

- Lesion: Benign, echogenic at US
- CT: Low attenuation (-30 to -100 HU)
- MRI: Hyperintense on T1 WI. Focal areas of signal loss on out-of-phase imaging. India ink artifact surrounding macroscopic fat.

Axial T1-W MR images, in-phase (top) and out-of-phase (down). Loss of fat saturation on CSI of periphery of mass. India ink artifact.

Blake et al. AJR, 2010
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Pheochromocytoma: Background

- Catecholamine-secreting tumor arising from chromaffin cells of adrenal medulla or extra-adrenal ectopic tissue (paraganglioma)
- Clinical symptoms: Headache, Sweating, Tachycardia
- Part of syndromes: MEN IIa/b, NF, VHL, Sturge Weber
- Rule of 10’s
- Can be difficult to characterize on imaging
Let us now discuss the typical imaging findings of pheochromocytomas using images from another BIDMC patient...
Pheochromocytoma: Imaging Findings - General Features

- Smooth, solid, round, hypervascular
- Atypical lesions can have macroscopic fat, calcifications, hemorrhage and necrosis
- Growth 0.5-1cm/year
Companion Patient 6: Pheochromocytoma on CT C-

- Increased attenuation (most >25 HU) on NECT.
Companion Patient 6: Pheochromocytoma on CT C+

- Delayed washout: less than 40% after 15 mins.

Axial CECT in portal venous phase (L) and delayed phase (R). 20% relative washout after 15 mins.
Companion Patient 6: Pheochromocytoma on MRI

- High SI on T2-WI – “Light-bulb sign” (70%)
- “Salt and Pepper” Enhancement (pepper = tumor vessel punctate signal voids; salt = brightly enhancing background)

Coronal T2-W MR image (L) and axial T2-W enhanced MR image (R). Mass has heterogeneous high signal intensity on T2 WI and salt and pepper enhancement.

PACS, BIDMC
Companion Patient 6: Pheochromocytoma on CSI MRI

- No signal drop-out CSI

Axial T1 W MR in-phase (L) and out-of-phase (R) images. No loss of signal intensity. No India Ink artifact in out-of-phase image.
Companion Patient 6: Pheochromocytoma on MIBG

- 90-100% specificity, 80-90% sensitivity.
- Good for localizing / confirming pheo or to exclude metastatic lesions.

Coronal whole body image. Mass brightly enhances at outer portion.
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To summarize his clinical course...
Our Patient Revisited

- Patient had R Adrenalectomy and excision of retroperitoneal paraganglioma
- Pathology revealed
  - Pheochromocytoma
    - 9.8 cm
    - Necrotic center
    - Chromaffin-1 type tissue
  - Paraganglioma
    - 2.5 cm
    - Chromaffin-1 type tissue
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- Imaging tests for adrenal imaging exploit 3 physiologic principles:
  - 1. intracellular lipid concentration
  - 2. perfusion differences
  - 3. metabolic activity

- Imaging Recommendations:
  - Helical NE + CECT
  - MR and T1 CSI
  - MIBG

- DDX includes adenoma, mets, ACC, and myelolipoma

- Pheochromocytomas
  - Can vary in radiographic appearance, but typically highly enhancing on T2 WI and no loss of SI on CSI
  - Must correlate with clinical picture
References

My.statdx.com
Acknowledgements

- Gillian B. Lieberman, MD
- Michael Powell, MD
- Aarti Sekhar, MD
- Johannes Roedl, MD
- Justin Kung, MD
- Maria Levantakis
- Kapil Verma
- Sebastian Darr