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A Multimodality Review of Adrenal Tumors

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Adrenal tumors are very commonly encountered in the practice of radiology. They may arise from the adrenal gland itself, either the cortex or the medulla, or they could be secondary lesions. They may be benign or malignant. The functioning adrenal tumors lead to hypersecretion of adrenal hormones leading to clinical syndromes. Computed tomography is the most common imaging modality used for the initial evaluation of adrenal tumors. Magnetic resonance imaging and functional scintigraphic techniques are frequently used for atypical presentations or further evaluation. We present a multimodality review of common and uncommon adrenal tumors. We highlight their characteristic and specific imaging features which help us in making a diagnosis and suggesting an appropriate follow up for further management. The spectrum of adrenal tumors is wide with varying appearances on different imaging modalities. Imaging techniques used for adrenal tumor imaging have their own strengths and weaknesses as it relates to the final diagnosis. It is important to be familiar with imaging characteristics of adrenal tumors for appropriate diagnosis and management. Differentiation of benign (leave alone) tumors from malignant (surgical) ones along with appropriate disposition of incidentalomas are some of the challenges facing the radiologist.

Introduction

Adrenal tumors are commonly encountered in the practice of radiology. They may be detected incidentally (incidentalomas) or imaging studies may be performed for characterization of a known adrenal mass. Some adrenal tumors are functional and may lead to clinically recognized syndromes (such as Cushing syndrome or hyperaldosteronism). Functional or molecular tests such as F-18 FDG positron emission tomography/computed tomography (PET/CT), I-123 metaiodobenzylguanidine (MIBG), and In-111 Octreotide imaging also have an essential role in the diagnostic algorithm of the adrenal masses. Daily challenges faced by the radiologists include recognition of benign (leave alone) tumors, potentially malignant (surgical) lesions, and adrenal metastasis (stage IV disease).

In this article, we present a pictorial review of common and rare adrenal tumors using the histological classification presented by Panda and Dhamija et al, to illustrate the characteristic imaging findings of each pathology.[1,2] The adrenal tumors can be classified as cortical or medullary cell origin, nonspecific histological origin, secondary tumors, and collision tumors. Under these categories, they can be further classified as benign or malignant tumors. Some tumors (such as pheochromocytomas) can present as benign or malignant. Cortical tumors can be functional or nonfunctional. The examples presented in this pictorial review, are either histologically proven or its diagnosis substantiated by follow up or functional imaging.

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Adrenal Adenoma

Adrenal adenoma is the most common adrenal tumor, the most common incidentaloma, and a benign tumor arising from the adrenal cortex, with increased incidence with age. These tumors can be functioning or nonfunctioning, which can be determined by the following laboratory tests: dexamethasone suppression test, a ratio of plasma aldosterone concentration to plasma renin activity, and androgen assays. On imaging these are range from 1 to 5 cm, and are homogenous and well defined. About 70% are lipid rich (with intracytoplasmic lipids or microscopic fat) and others (30%) are lipid poor. This property determines their imaging characteristics and confidence in imaging diagnosis. On CT imaging lipid rich adenomas typically have an attenuation of $<$10 HU on noncontrast enhanced study (Fig 1). For higher attenuating tumors (Fig 2), an Absolute Washout value of $>$60% and a Relative Washout value of $>$40% is characteristic of adenoma and requires no further follow up or imaging.[3–5] On magnetic resonance imaging (MRI) adenomas show signal drop on out-of-phase imaging due to presence of microscopic fat. Adrenal-to-spleen Chemical Shift Ratio and adrenal Signal Intensity Index can also be helpful in diagnosis. Chemical shift analysis is limited in the evaluation of lipid poor adenomas.[6,7] An incidentally discovered adrenal lesion in the absence of a history of malignancy is statistically likely to represent an adenoma. Adenomas are typically not hypermetabolic on F-18 FDG PET/CT imaging but may show faint FDG activity (Fig 3), which typically is less intense than the adjacent liver activity (average normal liver SUV measures about 2.5).[8,9]

Adrenal Hyperplasia

Hyperplasia of the adrenals is typically bilateral and could be ACTH dependent (due to overproduction of a pituitary hormone) or

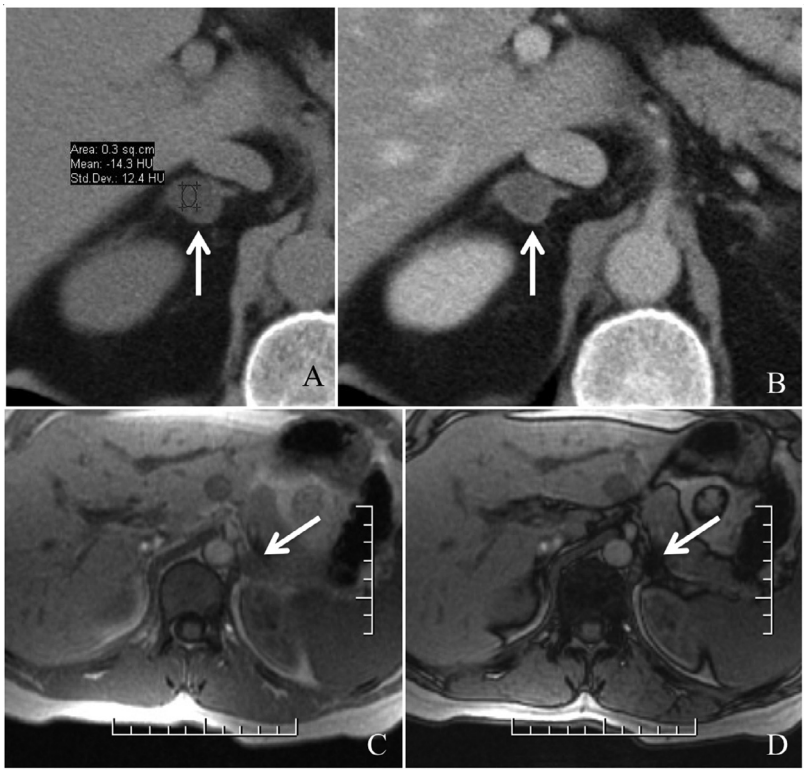

FIG 1. Lipid rich adenoma. A and B are transaxial images from noncontrast enhanced and portal-venous phase of CT showing a low attenuation right adrenal tumor, consistent with a lipid rich adrenal adenoma. C and D are transaxial in and out-of-phase GRE images (in another patient) from MRI showing signal drop on the out-of-phase image in the left adrenal nodule, consistent with an adrenal adenoma.

could be ACTH independent. Morphologically it could be diffuse or nodular (Fig 4). The diffuse form shows diffuse enlargement of both adrenals which maintaining the shape. The nodular from shows presence of multiple small hypoattenuating to isoattenuating bilateral adrenal nodules on CT.[10-12] It is important to differentiate between adenoma and hyperplasia, as the treatment of functioning adenoma is surgical and adrenal hyperplasia is managed medically. Laboratory tests and imaging are used for this determination.

Myelolipoma

Adrenal myelolipomas are uncommon benign tumors which consist of fatty tissue and interspersed bone marrow like hematopoietic tissue. They are nonfunctional, usually asymptomatic, and frequently discovered incidentally. They can range in size from 2 to 13 cm, and may cause symptoms from mass effect or hemorrhage. It has been postulated that metaplasia of reticuloendothelial cells of the adrenal capillaries may be responsible for their origin. Due to the presence of variable amount of fat, they are hyperechoic on ultrasound imaging, and show macroscopic fat on CT (less than −30 HU attenuation), along with foci of hyperattenuating hematopoietic elements (Fig 5). The areas of fat are hyperintense on T1 weighted images and there is loss of signal on fat suppressed sequence (indicative of macroscopic fat).[13-16] Differential diagnosis of other fat containing adrenal tumors include adenoma, angiomyolipoma, and lipoma. Follow up imaging is warranted to monitor size (tumors increasing in size or larger than 6 cm are resected surgically) and rule out occurrence of a collision tumor (coexisting second adrenal tumor).

Adrenal Cyst

Cystic lesions in the adrenal gland are rare. They are more common in females and have typical imaging features. When uncomplicated they are anechoic, well-defined, and thin walled, ranging from

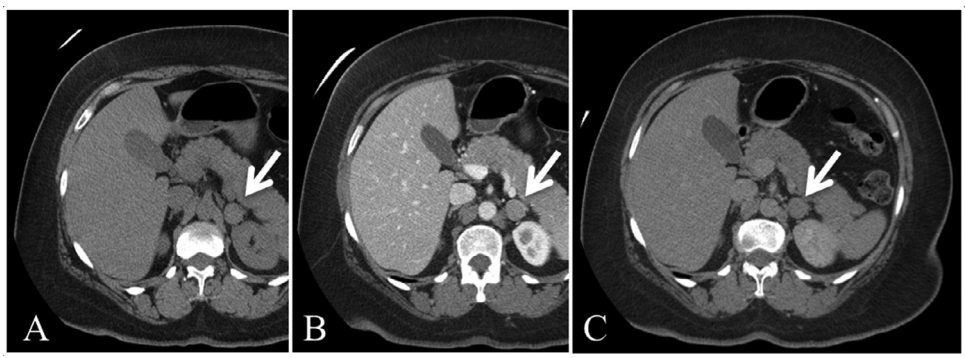

FIG 2. Lipid poor adenoma. Image A shows noncontrast enhanced CT showing a nodule in the left adrenal with an attenuation of 50 HU. On the portal-venous phase, it has an attenuation of 110 HU, and 60 HU on the 15-minute delayed image (C). The absolute washout ratio [AWR = (110−60/110-50) × 100 = 83%] and the relative washout ratio is [RWR = (110−60/110) × 100 = 45%]. AWR of >60%, and RWR of >40% represents lipid poor adenoma.

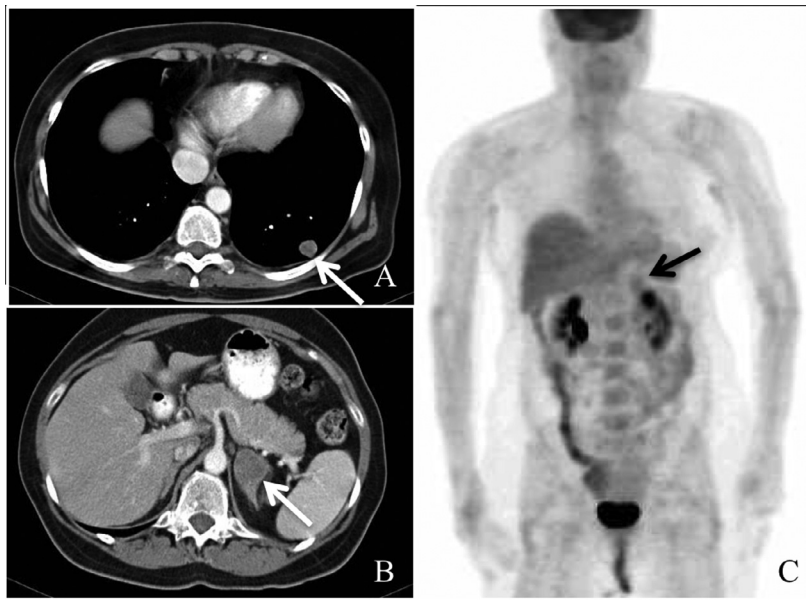

FIG 3. FDG PET/CT in adenoma. A patient with known left adrenal adenoma was referred for FDG PET/CT to evaluate a left lower lobe lung nodule (A). The lung nodule was not hypermetabolic and the PET showed mild activity in the left adrenal adenoma (less than liver activity) with an SUV(max) of 1.8.

few millimeters to 20 cm. On CT, they have water attenuation and may have rim like calcifications. Hemorrhage or infection can lead to hyperattenuation and contrast enhancement, respectively.[17,18] The 3 different subtypes described are endothelial cysts, pseudocysts, and parasitic cysts. Endothelial cysts are the most common with an imaging appearance of a "simple cyst." Pseudocysts may be caused by prior hemorrhage or infarction, and are lined by fibrous tissue rather than endothelial cells (Fig 6). Most common parasitic cysts are secondary to echinococcal infection and can have varying appearance depending on the stage of the disease. Other differentials for a cystic adrenal tumor include cystic malignancy such as metastases or a pheochromocytoma.

Adrenal Hemorrhage

Hemorrhage in the adrenal is usually associated with blunt abdominal trauma (the most common cause being motor vehicle accident) and nonaccidental injury must be considered in pediatric patients. Nontraumatic causes include coagulopathy, hemorrhagic neoplasm (adenoma, myelolipoma, pheochromocytoma, carcinoma, and metastases), stress (hypotension, sepsis, or surgery), and venous thrombosis (adrenal vein or inferior vena cava). The right adrenal is more frequently affected. Ultrasound shows a heterogenous mass with absent flow on Color Doppler imaging. Round hyperattenuating masses (50-90 HU) are visualized on CT and there is gradual decrease in size and attenuation on follow up. Hematomas may resolve, calcify, or become pseudocysts. Bilateral adrenal hemorrhages may be seen in Addison's disease. MRI appearance depends on the age of the hemorrhage with hypointense signal on T1 and T2 weighted images in the acute phase (<7days) and hyperintense signal on both T1 and T2 weighted images in the subacute phase (1-7 weeks). Chronic stage is characterized hemosiderin deposition, with hypointense rim on T1 and T2 weighted images, and "blooming" on gradient echo sequences.[16,19-21] Follow up imaging or contrast enhanced CT or MR may be used to rule out underlying tumor, and document decrease in size or resolution of the adrenal hemorrhage (Fig 7).

Collision Tumor

Collision tumor is defined as 2 histologically different tumors coexisting in the same gland, with no significant tissue admixture. These adjacent tumors could both be benign (adenoma and myelolipoma) or one of them could be malignant (adenoma and metastasis). These are rare but frequently pose a diagnostic challenge (Fig 8). FDG PET/CT imaging may be helpful in further characterization and guiding biopsy.[13,22,23]

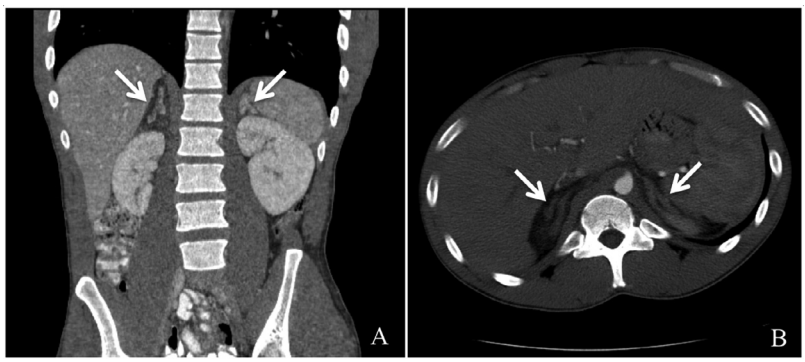

FIG 4. Adrenal hyperplasia. Contrast enhanced coronal CT (A) shows bilateral nodular adrenal enlargement consistent with nodular hyperplasia. Transaxial contrast-enhanced CT (in another patient) shows diffuse enlargement of both adrenals, consistent with diffuse hyperplasia.

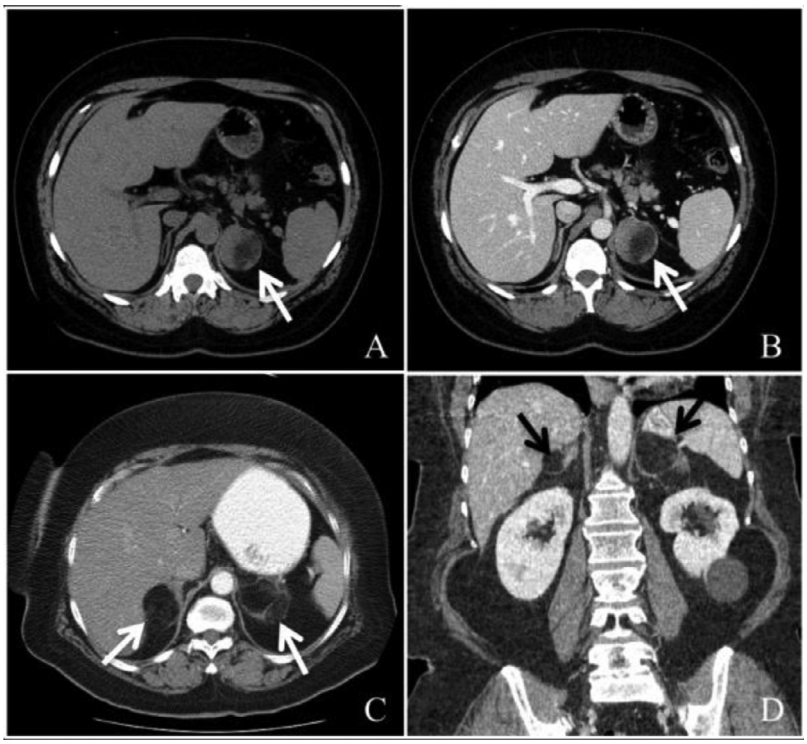

FIG 5. Myelolipoma. Noncontrast CT (A) showing a round left adrenal mass with both soft-tissue (27 HU) and fat tissue density (−28 HU), and portal-venous phase image (B) shows enhancement of the soft tissue density component with increase in attenuation to 74 HU. In another patient, bilateral nonenhancing fat density masses are seen in both adrenals on axial (C) and coronal (D) projections.

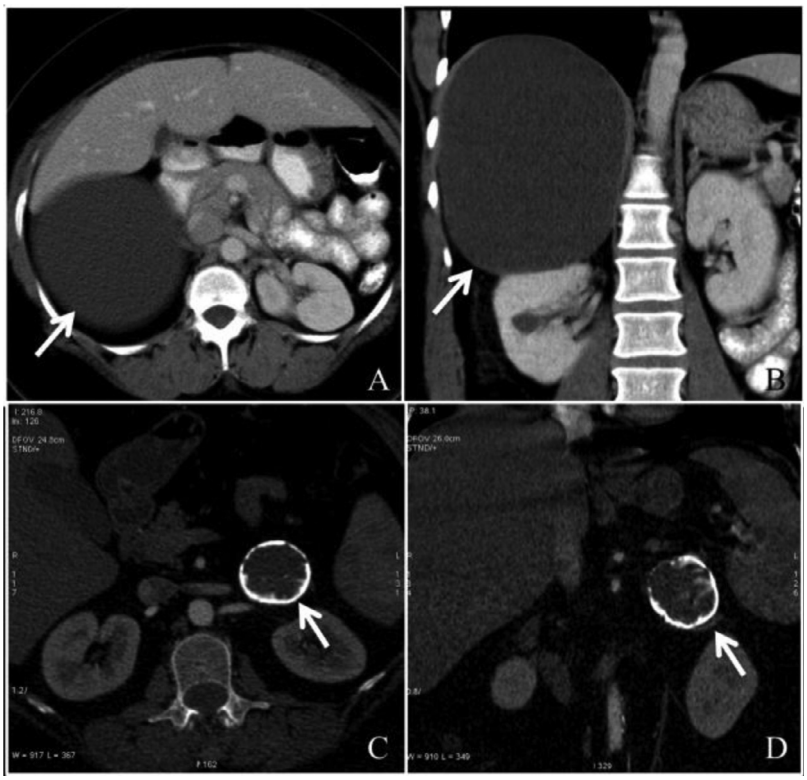

FIG 6. Adrenal cyst. Portal-venous phase axial CT (A) showing a large hypoattenuating mass arising from the right adrenal with thin wall and uniform fluid attenuation, with no internal septations, or enhancing soft tissue component, consistent with an endothelial cyst. The same mass in the coronal projection (B) shows mass effect the right kidney. In another patient (C axial and D coronal) a fluid attenuation mass is seen in the left adrenal with peripherial and internal calcifications, consistent with a pseudocyst, in this patient with prior history of trauma.

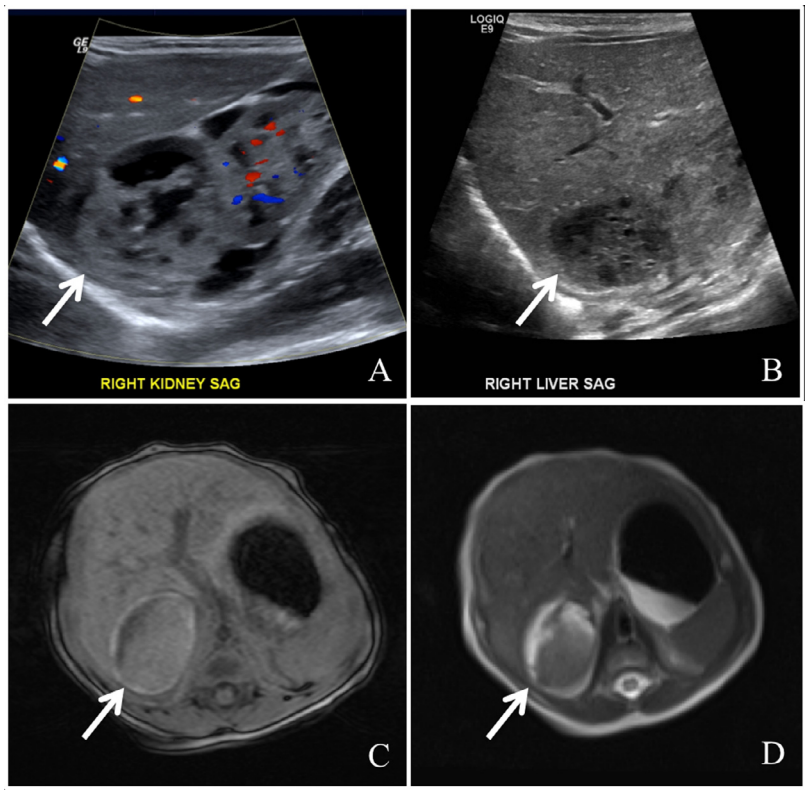

FIG 7. Adrenal hemorrhage: Ultrasound (US) images of the right upper quadrant in an infant showing a mass in the right adrenal with no color flow (A) and reduction in size on the follow up study (B). In the same patient, MRI showed a predominantly hyperintense subacute hemorrhage on T1 weighted image (A), and with peripheral T2 hyperintensity (hyperacute bleeding with reactive ascites).

Metastasis

Adrenal is one of the most common sites for metastasis, after lung, liver, and bone. Primary cancer could be in the lung, breast, gastrointestinal tract, prostate, kidney, liver, or melanoma. Isolated adrenal metastasis is rare. Also, metastasis as an incidental adrenal mass, in a patient with no known primary, is very rare. CT shows them as round soft tissue masses or with diffuse enlargement. They typically have an attenuation of >10 HU on noncontrast enhanced study and an APW and RPW of less than 60% and 40%, respectively. On chemical shift MRI, there is no signal drop on out-of-phase images, which also helps in differentiation from benign adenomas. Rarely metastasis from clear cell renal cell carcinoma or hepatocellular carcinoma may have microscopic fat leading to signal loss on chemical shift MRI. Metastasis from these tumors is hypervascular as well, showing enhancement after administration of IV contrast. Focal hypermetabolism seen on FDG PET/CT imaging can also be helpful in differentiating metastasis from benign adrenal tumors (Fig. 9 and 10). FDG uptake in an adrenal tumor more than liver favors of metastasis and no uptake is an indicator of benignity.[8,21,24-26]

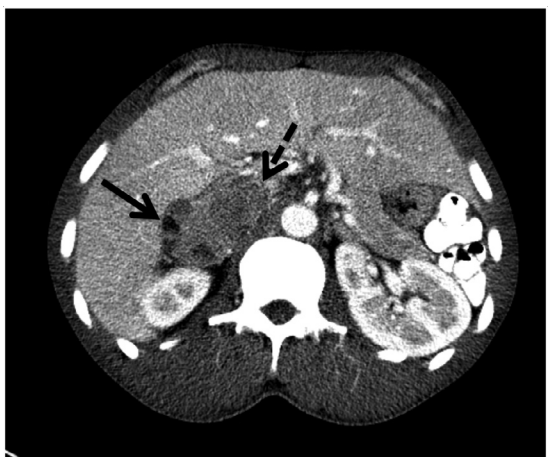

FIG 8. Collision Tumor: contrast-enhanced axial CT showing a heterogeneous mass in the right adrenal with soft tissue (dashed arrow) and focal fat attenuation (straight arrow). Patient was being evaluated for primary staging of lung cancer. Lung cancer metastasis to right adrenal with a coexisting adenoma was suspected.

Lymphoma

Lymphoma can occasionally involve the adrenals. Although the involvement is usually secondary to non-Hodgkin's lymphoma, rare primary adrenal lymphoma has been reported. In early involvement, adrenals may appear normal on CT, and diffuse infiltration or nodular involvement is commonly seen. Soft tissue masses may replace the adrenals or the adrenals be engulfed by retroperitoneal lymphadenopathy. Washout characteristics are nonspecific, but lymphomas demonstrate restricted diffusion on diffusion weighted MR images. They have low signal on T1 weighted images and high signal on T2 weighted images (Fig 11). Lymphomas are also FDG avid on PET/CT imaging.[14,16,27,28] Adrenal insufficiency may be seen with bilateral involvement and calcifications are rarely seen before therapy. Central necrosis may be seen and can confuse them with metastasis, adrenocortical carcinoma or pheochromocytomas.

Pheochromocytoma

Pheochromocytomas are adrenal medullary tumors that arise from chromaffin cells. They are also called the “10% tumor” as 10% are bilateral, 10% are malignant, 10% are seen in children, and 10% are extra-adrenal (paragangliomas). They may be associated with syndromes such as multiple endocrine neoplasia syndrome types IIa

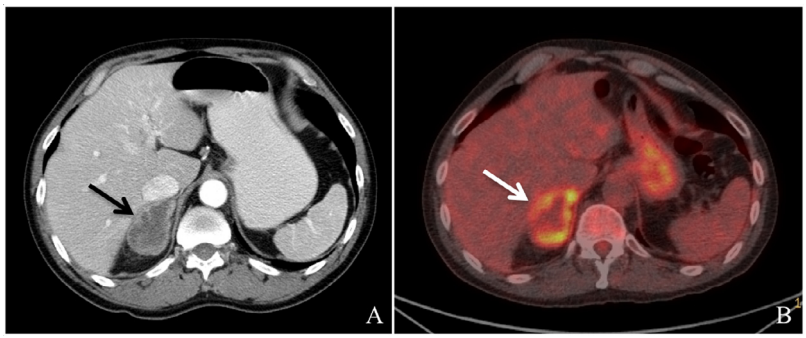

FIG 9. Metastasis. Contrast enhanced axial CT (A) showing a peripherally enhancing right adrenal mass and a corresponding PET/CT image showing peripheral hypermetabolism in the right adrenal metastasis from patient's known lung cancer.

and IIb, neurofibromatosis type 1, von Hippel-Lindau syndrome, Sturge-Weber syndrome, and tuberous sclerosis. Since they secrete catecholamines, patients may present refractory hypertension along with episodes of flushing, palpitation, and headache. Diagnosis is suggested by elevated levels of metanephrines and VMA (vanillylmadelic acid) in 24 hours urine sample or elevated plasma catecholamine levels. On CT imaging, they are seen as a solid mass with avid contrast enhancement and rapid washout (APW and RPW more than 60% and 40% respectively), overlapping with adenoma (Fig 12). They are typically larger than an adenoma, and smaller than an adrenocortical carcinoma. Larger tumors are heterogenous, with central necrosis, hemorrhage, or degeneration. Calcification and venous invasion favors a diagnosis of adrenocortical carcinoma rather than a pheochromocytoma. Malignant tumors are characterized by local invasion or metastatic disease. On MRI, these tumors are T2 hyperintense (light bulb sign), T1 hypointense, and show contrast enhancement. Functional imaging with I123 labeled MIBG is useful in confirming the diagnosis and whole body staging/restaging (Fig 13). Neuroendocrine tumors express somatostatin receptors and take up In111-pentetreotide. Pheochromocytomas are hypermetabolic on FDG PET/CT imaging, which may be helpful in evaluation of tumors which are not MIBG avid. When percutaneous biopsy is planned, it is important to be prepared for adrenergic crisis by advance consultation with anesthesia and endocrine service, for adequate hemodynamic monitoring and endocrine blockage. Surgical resection is the optimal management of pheochromocytomas.[17,29-36]

Adrenocortical Carcinoma

Although rare, but aggressive, adrenal cortical carcinoma is the most common malignant tumor, and adrenal tumor in a patient without an underlying malignancy. With a bimodal age distribution, it is seen in first and fourth/fifth decades. It may also be associated with syndromes such as Li-Fraumeni syndrome, Beckwith-Weidemann syndrome, Carney Complex, Familial adenomatous polyposis coli, and

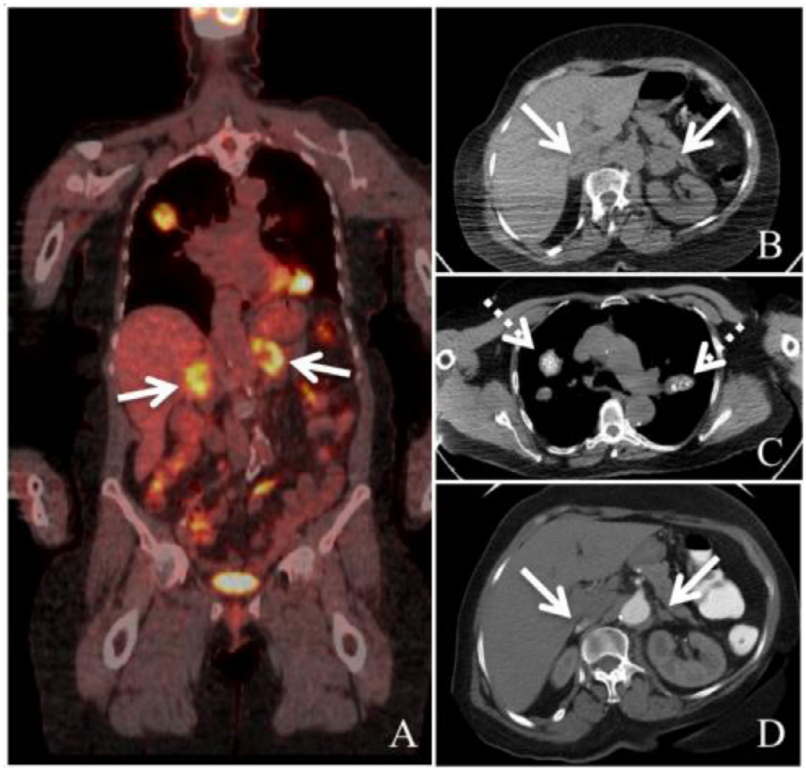

FIG 10. Metastasis. Coronal fused PET/CT image showing bilateral hypermetabolic adrenal metastases (A). Axial low dose CT in the same patient show bilateral adrenal masses (B) and bilateral calcified lung metastases (C) in this patient with colon cancer. Follow up scan after chemotherapy (D) shows interval response with decrease in the size of bilateral adrenal metastases.

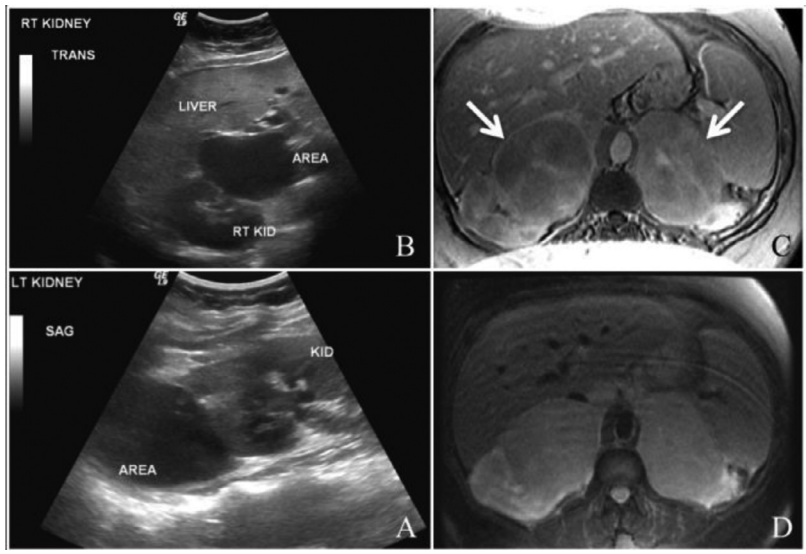

FIG 11. Adrenal lymphoma. Patient with lymphomatous involvement of bilateral adrenals, seen on the US (A and B) as hypoechoic masses. MRI shows hypo-enhancing masses on contrast enhanced T1 (C) and uniformly high signal on T2 weighted images.

multiple endocrine neoplasia type I. When functional, which is more common in children than in adults, they may present with Cushing's syndrome, feminization, virilization, or hyperaldosteronism. They usually present as large tumors (more than 6 cm) and may metastasize to liver, lung, or bones. On CT imaging, they are heterogenous soft tissue density mass with internal hemorrhage or necrosis (Fig 14). Calcification may be present and rarely there may be macroscopic fat. Contrast enhancement may be peripheral and the APW and RPW are typically less than 60% and 40% respectively. Venous invasion is a characteristic of adrenocortical carcinoma. On MRI, these tumors show heterogenous signal on T1 and T2 weighted images with central necrosis, contrast enhancement, and possible venous invasion. T1 hyperintensity from internal hemorrhage or T2 hyperintensity from central necrosis is frequently seen. Adrenocortical carcinomas are hypermetabolic on FDG PET/CT imaging, which has a role in whole body staging and restaging. Percutaneous biopsy is discouraged due to the risk of tumor seeding. Surgical resection is the mainstay of treatment, along with radiofrequency ablation, mitotane therapy, and radiotherapy as needed.[32,37-41]

Hemangioma

Cavernous hemangiomas are extremely rare, benign, and nonfunctional tumors of the adrenal gland. On imaging, they present as a large soft tissue density mass which shows characteristic nodular, peripheral, and discontinuous enhancement with central fill in on delayed images (Fig 15). Internal phleboliths may be seen as calcified foci.[13,14,23]

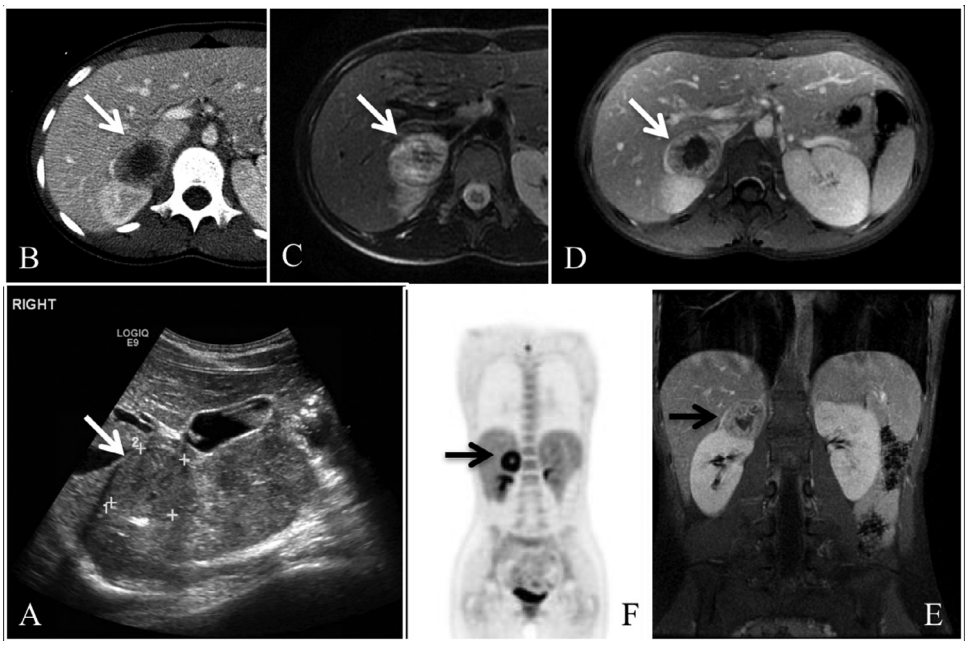

FIG 12. Pheochromocytoma. A young male presented with episodes of hypertension and headaches. US (A) showed a heterogeneously hypoechoic right adrenal mass. CT (B) shows peripheral thick rind of enhancement and central necrosis. MRI showed high T2 (C) signal (light bulb sign) and peripheral enhancement on T1 weighted images (D). Coronal image (E) shows the right adrenal pheochromocytoma and its relationship with the right kidney. FDG PET/CT performed for staging showed intense peripheral hypermetabolism (SUV max of 10.8) and central photopenia (necrosis). No evidence of metastatic disease was seen and the patient underwent surgical resection.

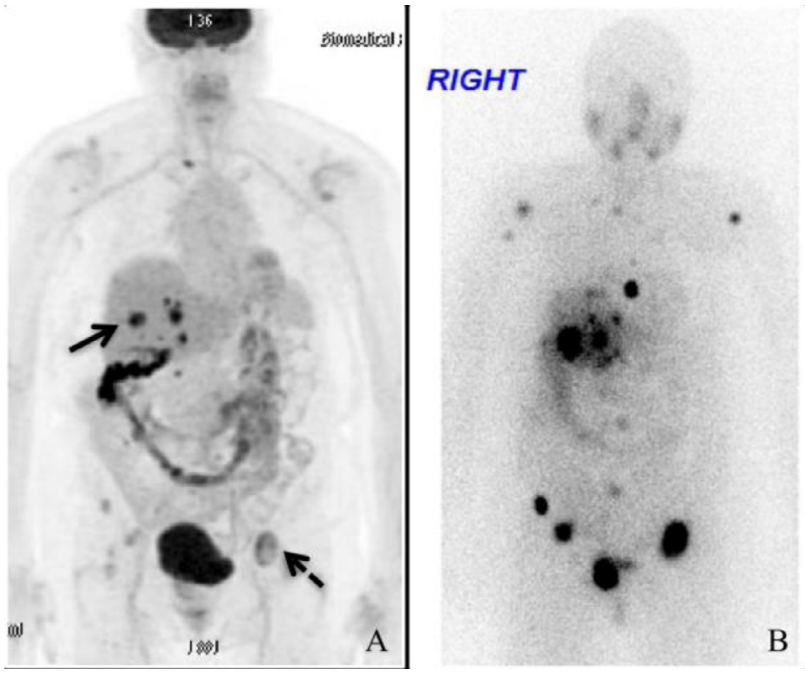

FIG 13. Metastatic pheochromocytoma. A patient with prior history of treated breast cancer and previously resected right adrenal pheochromocytoma. Patient presented with bone pain and CT showed lytic lesions suggesting bone metastasis (not shown). FDG PET/CT (A) was first performed which showed multiple bone and soft tissue hypermetabolic foci consistent with recurrent disease. Foci at the site of surgical resection suggested recurrent pheochromocytoma which was proven noninvasively with uptake of I-123 MIBG on the whole body I-123 MIBG scan (B).

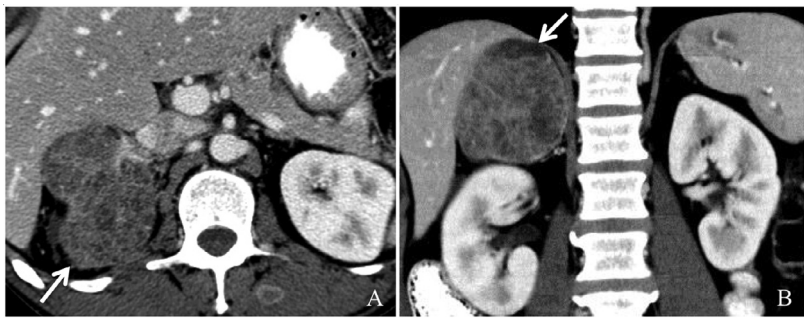

FIG 14. Adrenocortical carcinoma. Contrast enhanced CT in axial (A) and coronal (B) projections in a patient with adrenocortical carcinoma showing a large heterogeneously enhancing right adrenal mass.

Primary Adrenal Angiosarcoma

Primary adrenal angiosarcoma is an extremely rare tumor which originates from vascular smooth muscle. Diagnosing is challenging as they are seen on imaging as a large mass with heterogeneous enhancement, necrosis, hemorrhage, cystic change, or irregular calcification. On CT hyperattenuating foci may be from hemorrhage or calcifications and hypoattenuating areas represent necrosis (Fig 16). In MRI, hyperintense area on T1 weighted images and hypointense area on T2 weighted images illustrate hemorrhage. MRI is preferred due to high soft tissue contrast resolution, and diffusion weighted imaging can evaluate tumor aggressiveness.[13] Metastasis are rare and surgical resection is the treatment of choice.

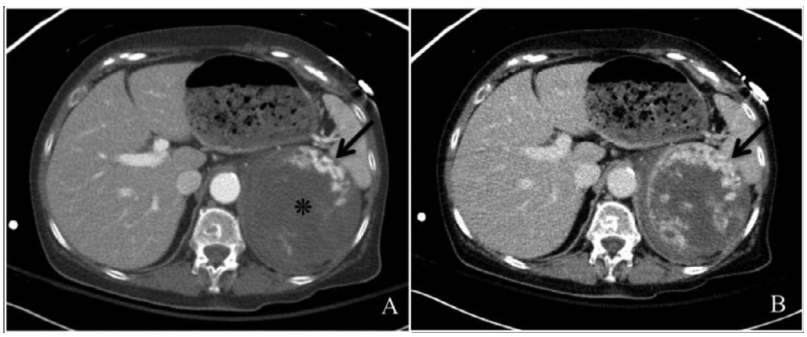

FIG 15. Adrenal hemangioma. Axial contrast enhanced CT (A) during the portal venous phase shows a large hypodense mass arising from the left adrenal (*) and shows peripheral discontinuous enhancement. Delayed image (B) shows peripheral fill in consistent with a hemangioma. On both phases the enhancement attenuation is similar to the aorta.

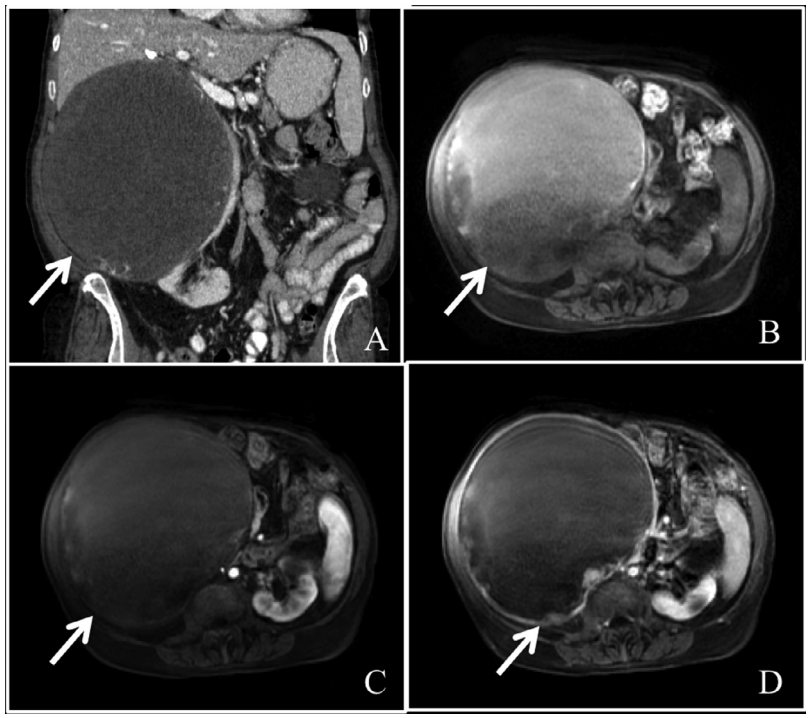

FIG 16. Primary adrenal angiosarcoma. Coronal contrast enhanced CT (A) shows a large right adrenal mass with peripheral enhancement and central fluid attenuation (necrosis). MRI from the same patient shows central high T2 signal (B) inside the mass and progressive peripheral enhancement (C and D) on T1 weighted images.

Ganglioneuromas/Ganglioneuroblastomas/Neuroblastomas

These tumors are grouped together as they all arise from sympathetic ganglia in the adrenal medulla, and are in a spectrum from more benign characteristic (ganglioneuroma), to an intermediate/potentially malignant one (ganglioneuroblastoma), to the malignant tumor (neuroblastoma). Ganglioneuromas are typically seen in teenagers and adults, and are benign nonfunctioning tumors that are incidentally seen on imaging as enhancing soft tissue masses on CT, low T1 signal and heterogenous increased T2 MR signal. Ganglioneuroblastomas are uncommon tumors, seen mainly in pediatric age group, and have a malignant potential. Neuroblastomas are one of the most common pediatric malignancies, which usually arise from the adrenal medulla, but may occur anywhere along the paraspinal sympathetic chain. They commonly present as an abdominal mass, and imaging shows soft tissue tumor with a tendency to encase major blood vessels, cross the midline, extend into the spinal canal, calcify and demonstrate heterogeneous appearance with necrosis and hemorrhage (Fig 17). Metastases are frequently seen to the liver, lymph nodes, bones, and lungs. I123 MIBG is used for whole body staging and restaging. FDG PET/CT imaging is performed when there is limited MIBG uptake. Bone imaging with Tc99m MDP is also performed for diagnosis and follow up of osteoblastic bone metastases.[16,18,34,42-45]

Granulomatous Infections

Adrenal glands may be involved with granulomatous infections such as tuberculosis and histoplasmosis. Usually there is bilateral involvement and imaging features may include soft tissue masses, cystic changes, or calcifications.[46,47]

Adrenal Lymphangioma

Presenting on CT as multiloculated, fluid attenuation cysts with thin intervening septa, cystic lymphangiomas are rare and incidental adrenal tumors. MR imaging shows T1 hypointensity and T2 hyperintensity in the cysts. These tumors do not show enhancement with IV contrast.[14,16]

Adrenal Incidentalomas

Asymptomatic adrenal masses, measuring more than 1 cm, and detected incidentally on imaging performed for reasons unrelated to adrenal disease, are called incidentalomas. Their incidence is approximately 4%-5%, with most being benign and adenomas. The goal of imaging is to characterize and differentiate the benign “leave alone” tumors from masses that require treatment. Several authors have published algorithms for evaluation of incidentalomas.[7,25,48] Patient's history of a malignancy is the most important determinant in the evaluation of an incidentaloma. In the absence of another malignancy, it is very rare that an adrenal incidentalomas represents metastatic disease. In this situation, imaging characteristics, comparison to prior study, and temporal follow up would help in further characterization. When there is history of malignancy, with presence of metastatic disease in other organs, diagnosis of adrenal metastases is unlikely to change patient management, but if adrenal gland is potentially the only source of metastasis in a patient with malignancy, further evaluation is worthwhile. Percutaneously biopsy and surgical resection for tumors more than 4 cm may be necessary depending on the clinical situation.[25,48-50]

Bilateral Adrenal Tumors

Both benign and malignant pathologies can lead to bilateral adrenal involvement. Bilateral adrenal tumors are commonly secondary to metastases, lymphomatous involvement, granulomatous infection, or adrenal hemorrhage. Occasionally, bilateral involvement can be due to adenomas, neuroblastoma, pheochromocytomas, or adrenocortical hyperplasia. Clinically, bilateral involvement suggests higher probability of malignant disease and association with adrenal insufficiency and likelihood of Addison's crisis. Focal bilateral calcifications suggest granulomatous infection or Wolman disease (a rare autosomal recessive inborn error of metabolism). MRI may be helpful by

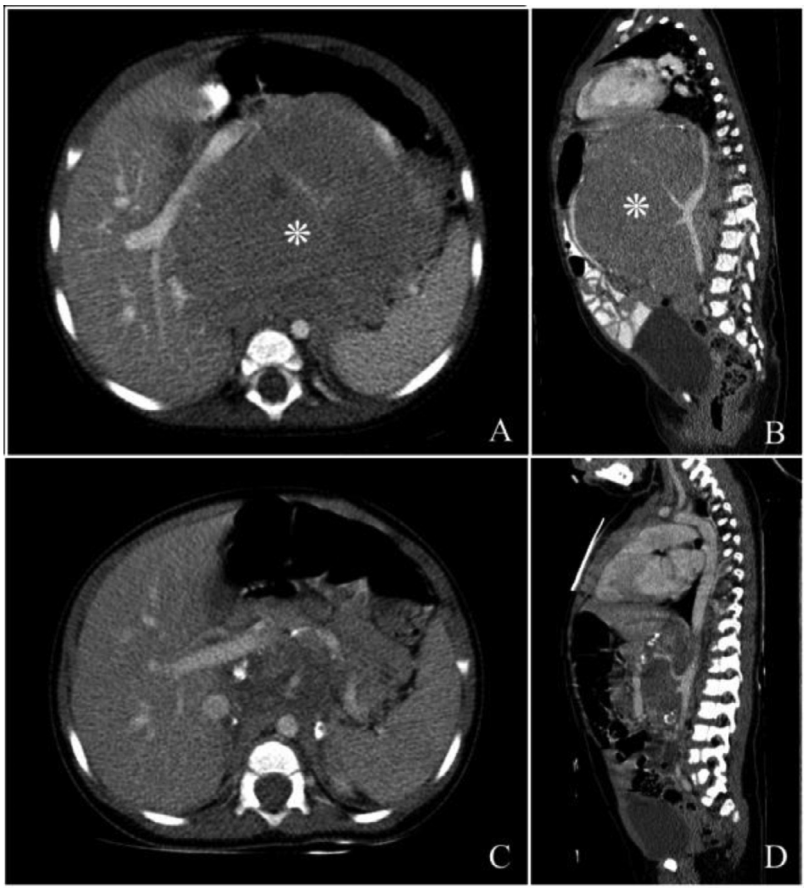

FIG 17. Neuroblastoma. Contrast enhanced axial and sagittal CT in a 2 years old with neuroblastoma, before (A and B) and after (C and D) chemotherapy. The large abdominal soft tissue mass (*) envelops the vessels, crosses the midline, and does not show any focal calcifications. Post therapy scans show good response with significant decrease in size of the tumor.

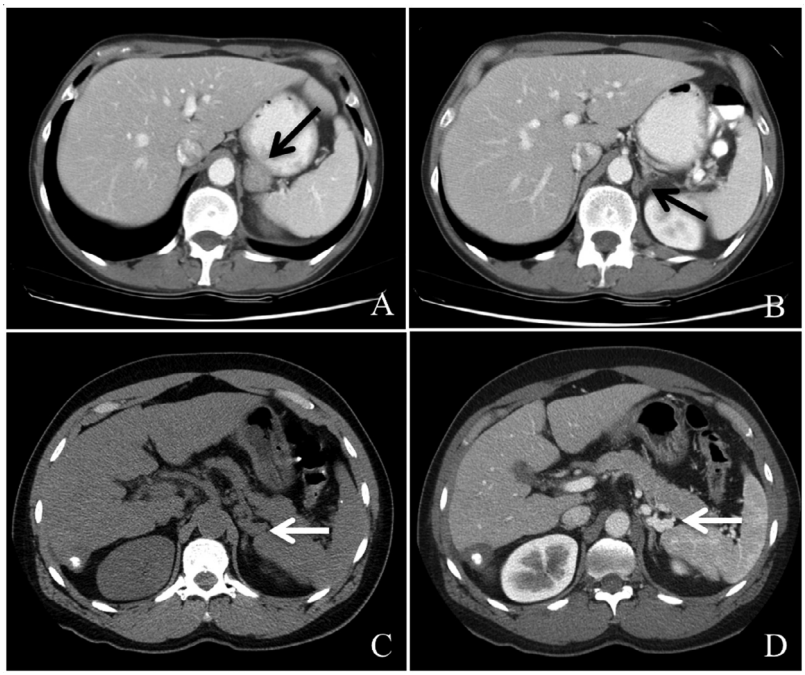

FIG 18. Pseudomass. Axial contrast enhanced CT (A) shows a gastric diverticulum mimicking a left adrenal mass. Slightly inferiorly (B) a normal left adrenal is identified. In another patient varices mimic adrenal pathology on the noncontrast enhanced CT (C) and show vascular enhancement and an adjacent normal left adrenal in a patient with cirrhosis and portal hypertension, on the contrast enhanced phase (D).

showing restricted diffusion in malignant lesions, but percutaneous biopsy may be needed to confirm diagnosis.[2,19,27]

Pseudomasses

Various causes of adrenal pseudomasses have been described including tortuous splenic vessels, upper pole renal masses, pancreatic masses, prominent diaphragmatic crura, and fluid-filled gastric fundus.[51] In patients with portal hypertension, the left inferior phrenic vein which passes anterior to the left adrenal, may serve as a collateral from splenic to renal vein, and may be mistaken for an adrenal tumor.[52] Pseudomasses can be recognized as anatomically distinct from the adrenal by acquiring thin section scans after administration of oral and intravenous contrast (Fig 18). In equivocal cases MRI may be needed.

Summary

Adrenal tumors have diverse and varied imaging appearance on various imaging modalities. CT is the primary imaging modality for characterization of adrenal tumors. MRI and functional imaging techniques such as I-123 MIBG and F-18 FDG PET/CT are helpful in difficult or atypical presentations. It is important to recognize benign (leave alone) tumors and recommend appropriate imaging follow up when an adrenal incidentaloma is encountered. Definitive diagnosis for adrenal tumors is provided by either a percutaneous biopsy or surgical resection.

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