Radiologic Differentiation of Adrenal Lesions and Its Impact on Patient Management

Elizabeth Chorney, MD, Ally Rosen, MD, Sara Lewis, MD, Eric Wilck, MD, and William Simpson, MD

After participating in this activity, the radiologist should be better able to recognize the appearance and distinguishing imaging features of common and distinctive adrenal lesions and become aware of the necessary follow-up recommendations.

Key Words: Imaging of Adrenal Lesions, Adrenal Adenoma, Adrenal Myelolipoma, Adrenal Hemorrhage, Pheochromocytoma, Adrenocortical Carcinoma, Adrenal Metastasis

Adrenal lesions are a relatively common incidental finding and are estimated to be present in 4.4% of all abdominal CT scans. The detection of an adrenal lesion often necessitates a thorough clinical evaluation that frequently requires a comprehensive patient history, biochemical studies, and radiologic studies such as dedicated adrenal protocol CT or MRI. The primary goal of additional radiologic studies is to differentiate benign from malignant adrenal lesions. It is, therefore, important for the radiologist to be familiar with a variety of benign and malignant adrenal lesions and to recognize distinctive imaging characteristics that can help make this distinction. This article reviews typical and useful imaging features of more commonly encountered benign and malignant adrenal lesions.

Evaluation With CT and MRI

CT and MRI are first-line imaging modalities used to evaluate incidental adrenal lesions. CT has the advantages of being accessible, quick, and relatively inexpensive, particularly noncontrast CT. If an adrenal lesion has a density of 10 HU or less, a diagnosis of lipid-rich adenoma can be made confidently with noncontrast CT. If the density of the adrenal lesion is above 10 HU, the addition of multiphase, contrast enhanced CT can be helpful to distinguish between adrenal adenomas and nonadenomas using absolute and relative contrast washout percentages. These are calculated from HU obtained during standard portal venous and 15-minute delay acquisitions, as follows:

Absolute Percentage Washout = \( \frac{\text{Enhanced CT (HU)} - \text{Delayed CT (HU)}}{\text{Enhanced CT (HU)} - \text{Unenhanced CT (HU)}} \times 100 \)

Relative Percentage Washout = \( \frac{\text{Enhanced CT (HU)} - \text{Delayed CT (HU)}}{\text{Enhanced CT (HU)}} \times 100 \)

An absolute percentage washout (APW) of more than 60% and a relative percentage washout (RPW) of more than 40% are typical of an adrenal adenoma.

In- and opposed-phase chemical shift imaging on MRI also can be useful to diagnose adrenal adenomas containing various amounts of microscopic intracellular fat. An adrenal adenoma can be diagnosed when there is loss of signal on T1 out-of-phase MR images compared with T1 in-phase MR images because of the presence of microscopic fat.
If quantitative measurement is desired, an adrenal signal intensity index can be calculated as follows:

$$\text{Adrenal Signal Intensity Index} = \frac{\text{SI on In-Phase} - \text{SI on Opposed-Phase}}{\text{SI on In-Phase}} \times 100$$

An adrenal signal intensity index greater than 16.5% is typical for a lipid-rich adrenal adenoma.

CT and MRI also are excellent imaging modalities to detect the presence of macroscopic fat, which is a distinguishing feature of adrenal myelolipomas. Other imaging characteristics that are not specific but can aid in assessment of incidental adrenal lesions include size, changes in size, enhancement, and morphology. CT and MRI analyses, in conjunction with a thorough clinical history that includes a history of nonadrenal malignancy, clinical biomarkers, and symptoms, also are important for the evaluation of incidental adrenal lesions.

**Benign Adrenal Lesions**

**Adrenal Adenomas.** Adrenal adenomas comprise the majority of incidentally detected adrenal lesions. Two key characteristics of adrenal adenomas that aid in radiologic diagnosis include the presence of intracellular fat and rapid washout of IV contrast medium. Lipid-rich adrenal adenomas contain various amounts of intracellular fat, which can be evaluated using noncontrast CT and chemical shift MRI as described in the previous section. The majority of adrenal adenomas are lipid rich and can be characterized as lipid-rich adenomas with noncontrast CT or chemical shift MR imaging (Figures 1 and 2). Some adrenal adenomas contain inadequate amounts of intracellular lipid and are indeterminate on noncontrast CT and chemical shift imaging; these adrenal lesions are considered lipid-poor adrenal adenomas, and they represent approximately 10% to 40% of all adrenal adenomas. Rapid washout of IV contrast medium is a reasonably sensitive and specific way to diagnose an adrenal adenoma.

Other, less-specific imaging features of adrenal adenomas include smooth, well-defined margins; homogeneous attenuation; and relatively small size. After the administration of

![Figure 1](image1.png)

**Figure 1.** Axial, noncontrast CT scan demonstrates a smooth, well-delineated right adrenal mass (arrow) with homogeneous internal attenuation and a density of 4 HU, compatible with an adrenal adenoma.

![Figure 2](image2.png)

**Figure 2.** A: Axial, T1-weighted, in-phase MR image demonstrates a round, well-delineated right adrenal lesion (arrow). B: Axial, T1-weighted, out-of-phase MR image demonstrates loss of signal because of the presence of microscopic fat, compatible with an adrenal adenoma.
contrast medium, enhancement is typically homogeneous and may demonstrate an arterial blush. It is important to remember that adrenal adenomas may hemorrhage, which can alter the attenuation characteristics. Compared with other adrenal lesions such as metastasis, pheochromocytoma, and adrenocortical carcinoma, adenomas are typically smaller, with an average size of 2 to 2.5 cm; the largest adenomas measure approximately 3 cm.

Biochemical analysis is required to distinguish between functional and nonfunctional adrenal adenomas. Radiologic studies are unable to distinguish between them; however, contralateral adrenal gland atrophy may suggest the presence of a functioning lesion. Fortunately, the vast majority of adrenal adenomas are hormonally nonfunctioning.

**Adrenal Myelolipomas.** Adrenal myelolipomas are benign tumors that contain macroscopic fat and hematopoietic tissue. The presence of macroscopic fat is their key distinguishing feature on CT and MRI (Figures 3 and 4). The majority of adrenal myelolipomas have a pseudocapsule and contain various amounts of soft tissue and macroscopic fat. Myelolipomas are typically asymptomatic; however, they may become clinically apparent if they undergo hemorrhage or are symptomatic because of mass effect. Calcifications within them also may be present. A potential pitfall to recognize is that in rare cases, other adrenal tumors have been reported to contain macroscopic fat, including adrenal adenomas, adrenocortical carcinoma, pheochromocytomas, and adrenal metastases.

**Adrenal Hemorrhage.** Adrenal hemorrhage has a variety of etiologies but often is associated with an acute physiologic stress such as shock, sepsis, and surgery; and anticoagulation and hemorrhagic diathesis. Neonates are at a relatively higher risk of adrenal hemorrhage compared with older children and adults. Adrenal hemorrhage can have a variable imaging appearance depending on the age of the hemorrhage and size of the hemorrhage. Acute and subacute hemorrhage will appear hyperattenuated on CT with progressive decrease in attenuation over time as the hemorrhage evolves (Figure 5). Chronic hematomas may develop calcifications. On MRI, adrenal hemorrhage will have variable T1 and T2 signal depending on the age of the hematoma. Over time, a T1-hypointense rim may develop around the hemorrhage because of the presence of hemosiderin (Figure 6). The size of the adrenal hemorrhage should decrease over time and demonstrate no postcontrast enhancement. Bilateral adrenal hemorrhage is caused more typically by systemic etiologies, such as sepsis and shock; whereas unilateral adrenal hemorrhage is caused more frequently by blunt trauma. Posttraumatic and neonatal stress-related adrenal hemorrhage more often involves the right adrenal gland, which has been attributed to the compression of the right adrenal gland between the

---

**Figure 3.** Axial, contrast enhanced CT scan demonstrates a left adrenal mass with hazy soft tissue attenuation, fat attenuation, and a pseudocapsule (arrow), compatible with an adrenal myelolipoma.

**Figure 4.** A: Axial, T2-weighted, HASTE MR image demonstrates a right adrenal lesion with a pseudocapsule (arrow). B: Axial, fat-saturated, T2-weighted, HASTE MR image demonstrates loss of signal on the fat-suppressed image because of the presence of macroscopic fat in an adrenal myelolipoma (arrow). HASTE, half-Fourier acquisition single-shot turbo spin-echo.

**Figure 5.** Coronal, noncontrast CT scan demonstrates a large right adrenal hemorrhage with mixed internal attenuation, with areas of more acute high-attenuation hematoma (white arrow) and areas of more low-attenuation chronic hematoma (black arrow). The linear calcifications indicate a more chronic hematoma.
The majority of pheochromocytomas are benign; however, approximately 10% of pheochromocytomas are malignant. Although both benign and malignant pheochromocytomas typically follow nonadenoma washout characteristics (APW < 60% and RPW < 40%), it is important to recognize that pheochromocytomas may have washout characteristics that can mimic those of a benign adrenal adenoma. Pheochromocytomas may be associated with familial syndromes such as multiple endocrine neoplasia 2, neurofibromatosis type 1, and von Hippel-Lindau disease. The clinical and familial history and coexisting lesions in other organs (e.g., thyroid nodules, renal and pancreatic cysts, enlarged parathyroid glands, and central nervous system hemangioblastomas) may offer clues to this diagnosis.

Adrenal Metastasis. The imaging features of adrenal metastases are nonspecific. Adrenal metastases may be bilateral or unilateral. Some adrenal metastases may have internal hemorrhage or necrosis (Figure 9). Typically, adrenal metastases will have slower washout compared with adrenal adenomas on delayed contrast imaging (APW < 60% and RPW < 40%). However, it is important to recognize that hypervascular metastases, such as renal cell carcinoma and hepatocellular carcinoma, may have similar washout to adrenal adenomas, particularly lipid-poor adrenal adenomas, on delayed contrast imaging. Other highly suspicious imagining features of adrenal metastasis include large lesions (>4 cm) or interval growth between imaging studies. An adrenal lesion in a patient older than 60 years or with a personal history of a malignancy should be scrutinized for metastasis.

Adrenocortical Carcinoma. Similar to adrenal metastases, the imaging features of adrenocortical carcinoma are nonspecific. Typically, adrenocortical carcinoma will be a large adrenal mass with heterogeneous enhancement (Figure 10). Hormonally functional adrenocortical carcinoma may present at smaller sizes because of clinically apparent symptoms such as liver and the right kidney. It is important to exclude an underlying adrenal lesion, such as an adenoma or myelolipoma, as the source of adrenal hemorrhage.

**Malignant Adrenal Lesions**

**Adrenal Pheochromocytoma.** Pheochromocytomas are catecholamine (e.g., epinephrine and norepinephrine)-secreting tumors. Patients may have subclinical symptoms or present with symptoms of catecholamine excess including paroxysmal hypertension, diaphoresis, tachycardia, flushing, and headache. Classically, pheochromocytomas appear hyperintense on T2-weighted MR images and can have internal areas of cystic necrosis (Figure 7). Pheochromocytomas are vascular tumors and typically avidly enhance after the administration of contrast medium. On T1- and T2-weighted MR images, prominent vessels can create low-signal flow voids against a hyperintense background, resulting in a classically described “salt and pepper” appearance (Figure 8).

The majority of pheochromocytomas are benign; however, approximately 10% of pheochromocytomas are malignant. Although both benign and malignant pheochromocytomas typically follow nonadenoma washout characteristics (APW < 60% and RPW < 40%), it is important to recognize that pheochromocytomas may have washout characteristics that can mimic those of a benign adrenal adenoma.

Pheochromocytomas may be associated with familial syndromes such as multiple endocrine neoplasia 2, neurofibromatosis type 1, and von Hippel-Lindau disease. The clinical and familial history and coexisting lesions in other organs (e.g., thyroid nodules, renal and pancreatic cysts, enlarged parathyroid glands, and central nervous system hemangioblastomas) may offer clues to this diagnosis.
Lesion size is an important but imperfect predictor of adrenal malignancy. Smaller lesions tend to be benign, whereas larger lesions (>4 cm) are more likely to be malignant. Therefore, adrenal lesions larger than 4 cm typically are considered for resection. A patient with no history of malignancy and an adrenal mass that is smaller than 4 cm with benign features generally is monitored. The frequency of surveillance is variable depending on which organization’s consensus statement is followed. The American Association of Clinical Endocrinologists recommends that patients with an adrenal incidentaloma not meeting criteria for surgical resection should have radiologic reevaluation at 3 to 6 months and then annually for up to 1 to 2 years. The American College of Radiology recommends a 12-month follow-up to confirm stability if there are no prior studies for comparison. It should be noted that more long-term biochemical follow-up may be necessary to evaluate autonomous function. If an adrenal myelolipoma or a simple adrenal cyst can be diagnosed, there is usually no additional follow-up; however, surgical evaluation may be necessary if the lesion is symptomatic or large. If a lesion is indeterminate or has suspicious characteristics, including but not limited to large size, increase in size, heterogeneous enhancement, or necrosis, further evaluation with biopsy or surgery may be necessary. It is important for the radiologist to recognize and consider typical imaging characteristics of a pheochromocytoma because hemorrhage and hypertensive crisis have been reported as biopsy complications.

**Conclusion**

Adrenal lesions are a relatively common finding in abdominal imaging, and the majority of adrenal lesions are benign. Familiarity with the imaging features of common benign and malignant adrenal lesions is important to help guide patient management and follow-up. This CME activity emphasizes distinguishing imaging features of the more common benign and malignant adrenal lesions that radiologists should recognize.

**References**


Cushing syndrome, virilization, or feminization. Adrenocortical carcinoma may have areas of necrosis, and up to 33% will have calcifications. As mentioned previously, it is important to recognize that in rare cases, adrenocortical carcinoma may contain macroscopic or microscopic fat, and it should not be mistaken for an adrenal myelolipoma or adenoma, respectively. Invasion of an adrenocortical carcinoma into the inferior vena cava is an important and well-known complication to observe.

**Patient Management**

Key questions that guide patient management in the evaluation of an adrenal lesion include: what is the size of the lesion; and can the lesion be characterized as benign or malignant?
CME QUIZ: VOLUME 39, NUMBER 3

To earn CME credit, you must read the CME article and complete the quiz and evaluation on the enclosed answer form, answering at least seven of the 10 quiz questions correctly. Select the best answer and use a blue or black pen to completely fill in the corresponding box on the enclosed answer form. Please indicate any name and address changes directly on the answer form. If your name and address do not appear on the answer form, please print that information in the blank space at the top left of the page. Make a photocopy of the completed answer form for your own files and mail the original answer form in the enclosed postage-paid business reply envelope. Only two entries will be considered for credit. Your answer form must be received by Lippincott CME Institute, Inc., by January 30, 2017. At the end of each quarter, all CME participants will receive individual issue certificates for their CME participation in that quarter. These individual certificates will include your name, the publication title, the volume number, the issue number, the article title, your participation date, the AMA credit awarded, and any subcategory credit earned (if applicable). For more information, call (800) 638-3030.

All CME credit earned via Contemporary Diagnostic Radiology will apply toward continuous certification requirements. ABR continuous certification requires 75 CME credits every 3 years, at least 25 of which must be self-assessment CME (SA-CME) credits. All SAM credits earned via Contemporary Diagnostic Radiology are now equivalent to SA-CME credits (www.theabr.org).

Online quiz instructions: To take the quiz online, log on to your account at www.cdrnewsletter.com, and click on the “CME” tab at the top of the page. Then click on “Access the CME activity for this newsletter,” which will take you to the log-in page for http://cme.lww.com. Enter your username and password. Follow the instructions on the site. You may print your official certificate immediately. Please note: Lippincott CME Institute will not mail certificates to online participants. Online quizzes expire on the due date.

1. The majority of lipid-rich adrenal adenomas can be characterized on the basis of
   A. noncontrast CT density
   B. appearance on radiography
   C. ultrasound echotexture
   D. PET FDG avidity
   E. T2 MR signal

2. Which one of the following adrenal lesions is most likely to demonstrate a low-signal rim about its periphery on MRI?
   A. Colonic metastasis
   B. Chronic hematoma
   C. Adrenocortical carcinoma
   D. Adenoma
   E. Pheochromocytoma

3. A young male adult presents to the emergency department with paroxysmal hypertension, tachycardia, flushing, and headache. A fat-saturated, contrast enhanced, T1-weighted, MR image of the abdomen demonstrates an adrenal mass with a “salt and pepper” appearance. The most likely diagnosis is
   A. myelolipoma
   B. adenoma
   C. pheochromocytoma
   D. adrenocortical carcinoma
   E. metastatic hepatocellular carcinoma

4. Figure 11 is an axial, unenhanced CT scan of the abdomen that demonstrates an incidental left adrenal lesion. The most likely diagnosis is
   A. adrenal metastasis
   B. acute adrenal hematoma without an underlying adrenal lesion
   C. pheochromocytoma
   D. adrenal myelolipoma
   E. adrenocortical carcinoma

5. Which one of the following primary carcinomas is most likely to cause hypervascular metastases to the adrenal glands?
   A. Pancreatic
   B. Colorectal
   C. Bronchogenic
   D. Gastric
   E. Renal cell

6. An axial, contrast enhanced CT scan reveals an 8.0-cm adrenal mass with heterogeneous enhancement and associated invasion of the inferior vena cava. The most likely diagnosis is
   A. adrenal adenoma
   B. adrenal myelolipoma
   C. adrenocortical carcinoma
   D. adrenal cyst
   E. adrenal hemorrhage

7. All of the following adrenal lesions can contain macroscopic fat, except
   A. adenoma
   B. acute adrenal hematoma without underlying adrenal lesion
   C. myelolipoma
   D. adrenocortical carcinoma
   E. pheochromocytoma

8. Which one of the following is required to differentiate a functional from a nonfunctional adrenal adenoma?
   A. Physical examination
   B. History of malignancy
   C. Biochemical analysis
   D. Imaging CT washout study

9. All of the following are causes of adrenal hemorrhage, except
   A. surgery
   B. overhydration
   C. shock
   D. sepsis
   E. anticoagulation

10. The APW on CT required to diagnose an adrenal lesion as a benign adenoma is more than
    A. 40%
    B. 45%
    C. 50%
    D. 55%
    E. 60%