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Image-Guided Adrenal and Renal Biopsy

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Image-guided biopsy is a safe and well-established technique that is familiar to most interventional radiologists. Improvements in image guidance, biopsy tools, and biopsy techniques now routinely allow for safe biopsy of renal and adrenal lesions that traditionally were considered difficult to reach or technically challenging. Image-guided biopsy is used to establish the definitive tissue diagnosis in adrenal mass lesions that cannot be fully characterized with imaging or laboratory tests alone. It is also used to establish definitive diagnosis in some cases of renal parenchymal disease and has an expanding role in diagnosis and characterization of renal masses before treatment. Although basic principles and techniques for image-guided needle biopsy are similar regardless of organ, this paper highlights some technical considerations, indications, and complications that are unique to the adrenal gland and kidney because of their anatomic location and physiological features.

KEYWORDS adrenal biopsy, image-guided biopsy, percutaneous needle biopsy, renal biopsy

Adrenal Biopsy

Background

As use of ultrasound (US), computed tomography (CT) and magnetic resonance imaging (MRI) has increased with ever-improving resolution, the number of incidentally discovered adrenal masses has also increased. The vast majority of these adrenal masses are benign adenomas and myelolipomas, but differential considerations include pheochromocytoma, adrenocortical carcinoma, and metastases, especially in patients with known or suspected malignancies, such as lung carcinoma and lymphoma. Although the use of adrenal biopsy has declined in recent years due to improvements in and validation of noninvasive CT and MR techniques that can now diagnose benign adrenal lesions with a high degree of confidence,[1,2] it remains an accurate and safe means of obtaining definitive tissue diagnosis. Clinical scenarios in which needle biopsy may be indicated include an adrenal lesion in patients with multiple malignancies, the need for staging a known malignancy, defining an unknown primary source, or differentiating benign from malignant adrenal masses with equivocal imaging findings.

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Pre-Biopsy Adrenal Imaging

The ability to characterize and classify adrenal pathology based on imaging has advanced in step with improvements in CT, MRI, US, and nuclear medicine studies. Although the sensitivity of US for detecting adrenal tumors is very high (96% for masses <2 cm and 100% for masses > 2 cm), its ability to further characterize these lesions is limited.[3,4] Multidetector row CT is the primary modality for visualizing and characterizing suspected adrenal adenomas, based on the high lipid content of these benign lesions. An adrenal CT protocol uses 3- to 5-mm slice thickness and consists of an unenhanced CT followed by early and delayed contrast-enhanced studies, which are typically obtained 60 seconds and 15 minutes after administration of IV contrast and can be used to calculate percentage of absolute and relative contrast washout. The combination of CT density on noncontrast images [<10 Hounsfield units (HU) is a lipid-rich adenoma] and degree of contrast washout can diagnose adrenal adenomas with a high degree of accuracy. For example, adrenal masses with absolute contrast washout of >60% and relative contrast washout of >40% can be diagnosed as adrenal adenomas with a reported sensitivity of 98% and a specificity of 92%.[5,6] If further imaging characterization is needed, MRI can supplement CT findings. MRI evaluation of adrenal adenomas also takes advantage of their lipid content. T1- and

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T2-weighted images plus chemical shift imaging (CSI) that consists of in-phase and out-of-phase imaging are required. On MRI, adrenal adenomas appear homogeneous on all sequences with signal intensity equal to or slightly lower than that of normal liver. On CSI, adenomas lose at least 30% of their intensity on out-of-phase images when compared with in-phase images. This is quantified using the signal intensity index (SII), and, depending on the set threshold, adrenal adenoma can be diagnosed with a very high accuracy with MRI.[3]

Adrenal masses other than adenoma can also be characterized by noninvasive imaging. For example, pheochromocytoma is characteristically a hypervascular mass that is markedly intense on T2-weighted MRI. Nuclear medicine [^{123}I] MIBG scans are also used to diagnose this lesion with 83-100% sensitivity and 95-100% specificity.[7] Furthermore, urine and plasma metanepharines are routinely used to screen patients with suspected pheochromocytoma. The noninvasive characterization and diagnosis of pheochromocytoma is especially important because this lesion can be problematic to biopsy due to the potential of precipitating hypertensive crises secondary to catecholamine secretion during the procedure, a risk that can be mitigated by pharmacologic blockade (alpha, beta, and conversion blockade) whenever possible.[8]

Metastases are the most common malignancy involving the adrenal glands, and lung carcinoma is the most common adrenal metastasis. [^{18}F] FDG can differentiate metastatic lesions from adrenal adenomas with a sensitivity >95% and even higher specificity,[3] but biopsy is still needed for specific diagnosis, especially when adrenal involvement or histology alters staging of disease or therapy. Lymphoma may also be indistinguishable from other adrenal metastases with noninvasive imaging. Whereas primary adrenal lymphoma is rare with fewer than 100 cases reported in the literature, secondary adrenal involvement is common and may occur in up to 25% of patients with lymphoma. In these patients, an adrenal biopsy is often necessary to establish the tissue diagnosis.[3,5,7]

Thus, while the improvements in diagnostic imaging have made adrenal biopsies less common, there are still situations in which biopsy is necessary and prudent. In summary, if an adrenal lesion cannot be characterized as an adenoma by CT, further characterization with MRI using CSI is usually the next step. Most masses that are not typical for adenoma based on CT and MRI and not characteristic for pheochromocytoma based on imaging and laboratory tests may require biopsy, especially in the setting of known or suspected malignancy.[3]

Indications and Contraindications

As previously discussed, staging of known malignancy, identifying an unknown primary malignancy, and differentiating benign from malignant adrenal mass in equivocal cases are three accepted indications for adrenal biopsy. Making definitive tissue diagnosis when imaging is equivocal can drastically alter management, in almost a third of patients in one report.[9] Relative contraindications to image-guided adrenal biopsy include uncorrectable coagulopathy, inability to reach the tumor via a safe path, or an unsafe target,[10] but a skilled interventional radiologist should be able to place a needle in almost any image-able adrenal lesion. In practice, the question of whether to biopsy an adrenal mass is determined by the relative risk-to-benefit ratio of obtaining tissue diagnosis. With thorough preprocedural planning, including review of imaging and laboratory data, careful intraprocedural monitoring and availability of adrenergic blockade or anesthesia assistance, if necessary, these procedures can be performed safely. Because of the proximity of the adrenal gland to the diaphragm, a unique challenge for adrenal biopsy is the patient's inability to cooperate with breathing instruction or suspend respiration.[1,10] In these cases, respiratory gating tools may facilitate the procedure, as can performing the biopsy in one swift needle insertion during expiration. In cases where the lesion is visible with both US and CT, use of real-time ultrasound to watch the pleural reflection and lung edge during the procedure can also help to avoid diaphragmatic penetration.

Choice of Image-Guidance Modality

Multiple imaging modalities, including fluoroscopy, US, CT, CT fluoroscopy (CTF), MRI, PET-CT, rotational fluoroscopy, and multimodality or single-modality electromagnetic (EM) guidance (Medical GPS or Fusion Navigation) may all guide percutaneous adrenal biopsies.[11] In addition, adrenal biopsy using endoscopic ultrasound-guided (EUS) through a transgastric approach may also guide biopsy of some large left adrenal masses, but the right adrenal is poorly visualized.[9,12] Each modality has its advantages and disadvantages, but in routine clinical practice, the choice of imaging modality is based on equipment availability, cost, lesion conspicuity, and physician preference. US and MRI readily allow for complex oblique angles of approach, but US may be limited in large patients and MRI is expensive, often unavailable, and requires MR-compatible equipment and needles. By far, the most commonly used image guidance modalities for adrenal biopsy are CT, US, or CT and US.[1,11,13]

Benefits of US guidance include real-time multiplanar imaging, absence of radiation, low cost, portability, and the ability to rapidly confirm complications, such as bleeding. Drawbacks of US guidance include inadequate visualization of the target or needle due to operator experience, lesion depth, or intervening bowel gas or bony structures. Benefits of CT guidance include spatial resolution, ability to identify deep intervening structures along an ideal pathway, and the option for contrast enhancement if needed. However, CT uses radiation, takes more time, is more costly, and real-time oblique imaging either requires gantry tilting, or delayed multiplanar reconstructions.[1,10,11] Modality selection may also depend on patient-specific issues. US views from multiple windows may better localize mobile or hard to see lesions and is often faster than CT.[1,11] Both CT and US are used with high success to biopsy adrenal lesions, and many operators make use of both CT and US (with or without fusion imaging) to get the spatial resolution of CT and the temporal resolution of US ("CT is the eye, US is the hand").