Seminars in
ROENTGENOLOGY

Pitfalls in Adrenal Imaging

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Introduction

With the widespread dissemination of cross-sectional imaging, incidental adrenal nodules are frequently encountered in clinical practice. Although most incidental adrenal nodules are benign adrenal adenomas, the incidence of malignancy increases in patients with a personal history of malignancy and in adrenal lesions larger than 4 cm in size.[1] The imaging diagnosis of adrenal nodules is therefore clinically important. The purpose of this review article is to highlight common and uncommon pitfalls that might be encountered when evaluating the adrenal glands in clinical practice to help guide radiologists to provide more accurate interpretations. Specific details regarding the imaging features of various adrenal gland pathologies are beyond the scope of this article; its intended purpose is to review pitfalls in adrenal imaging. The reader may refer to several earlier review articles on adrenal imaging for further details regarding a complete description of imaging features of adrenal lesions.[1-3] Similarly, management strategies for incidentally discovered adrenal nodules have also been discussed elsewhere and are not reviewed.[4] This article focuses on interpretation pitfalls encountered at computed tomography (CT) and magnetic resonance imaging (MRI) in adults.

Technical Pitfalls

Technical Pitfalls Related to MRI

As detailed in a review article by Schieda et al,[5] the accuracy of chemical shift MRI is dependent on the use of appropriate MR parameters. When performing chemical shift imaging of the adrenal glands, the opposed-phase (OP) images should be acquired before the in-phase (IP) images are acquired. If the OP images are acquired after the IP images, it becomes unclear whether a decrease in signal on OP imaging is due to lipid-water cancellation or T2* effects from the longer echo time (Fig. 1). This problem is effectively only encountered on 3-T scanners where lipid and water protons are out of phase with each other every 1.1 milliseconds compared with every 2.2 milliseconds on 1.5-T scanners. At 3 T, the first echo pair occurs at 1.1/2.2 milliseconds, which is more technically challenging to sample owing to the necessary higher receiver bandwidth requirements, compared with the typical 2.2/4.4 milliseconds echo pair, which can be routinely sampled at 1.5 T. On first-generation 3-T scanners, sampling the first echo pair at 1.1/2.2 milliseconds may not be possible without significant trade-off in signal-to-noise ratio by increasing receiver bandwidth and through the application of parallel imaging. In these instances, sampling of later echo pairs is a reasonable alternative, for example, using an OP-IP pair of 3.3/4.4 milliseconds is acceptable as long as the OP images are acquired before the IP images are acquired to eliminate ambiguity between T2* effects and signal intensity reduction from intracellular lipid. The OP-IP echo pair should also be sampled during the same breath-hold to avoid misregistration of images, which can result in limitations in visual and quantitative evaluation as well as errors in image subtraction. We refer the readers to the article by Schieda et al[5] for a more detailed discussion on how to surmount these technical challenges if one encounters them in practice.

Technical Pitfalls Related to CT

Hounsfield unit (HU) measurement is an integral component of adrenal nodule evaluation using CT. To accurately measure the HU values of an adrenal lesion, a region of interest (ROI) is placed within the lesion. Care must be taken to ensure that the ROI is placed over the central two-thirds of the lesion to arrive at an accurate HU value that is representative.[6,7] If the ROI is too large, it could include other structures outside the adrenal gland, such as retroperitoneal fat, which may falsely lower the measured value of the adrenal lesion. If the ROI is too small, it could result in spurious values owing to undersampling and image noise (Fig. 2). When evaluating heterogeneous lesions, the ROI should be placed on a more homogeneous solid component when present.[8] Variability between scanners is another potential source of error encountered in clinical practice when using absolute HU values to characterize adrenal lesions. Lamba et al[9] demonstrated a significant difference in

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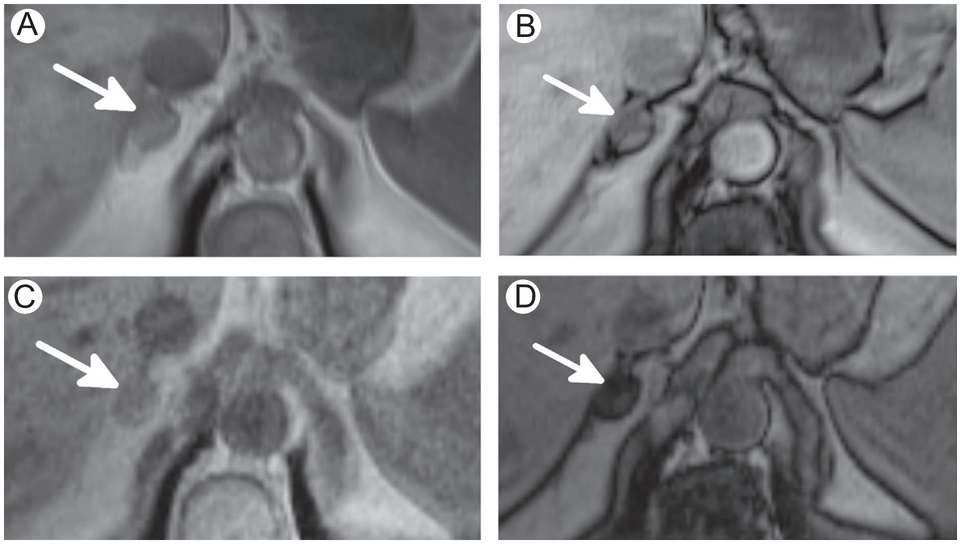

Figure 1 Ambiguity of chemical shift signal loss when the opposed-phase image is acquired before acquiring the in-phase image. A scan of a 64-year-old man with remote history of lung cancer treated at an outside institution presenting with right adrenal nodule on MRI performed for biliary colic. No previous imaging was available for review. (A and B) Initial MRI performed at 3 T, (A) in phase, TE = 2.5, and (B) opposed phase, TE = 3.7. There is a slight reduction in signal intensity (SI) on B when compared with A in the center of the nodule (arrow); however, because of the TE selection (OP after IP), the SI reduction could be due to either T2* effects or intracellular lipid. (C and D) The study was repeated at 1.5 T, (C) in phase, TE = 4.4, and (D) opposed phase, TE = 2.2. There is a profound reduction of SI on the OP when compared with that on the IP (arrow), which is diagnostic of adenoma. The difference in amount of SI drop within the nodule comparing 1.5 to 3 T may be related to the drift of echo times from the exact IP/OP echo pair and due to the sampling of later echoes. The diagnosis of adenoma was confirmed by interval stability over 5 years (not shown). TE, echo time.

the HU values when measuring abdominal soft tissues on 2 different vendor systems, a finding that has also been reported in other prior studies.[10,11] These differences arise from a multitude of factors that are beyond the scope of this article; however, it is sufficient to emphasize that an awareness of interscanner variability and attention to scanner calibration and quality assessment practices are required.

Adrenal washout CT requires attention to timing of image acquisition after contrast agent administration. At our institutions, we currently perform an unenhanced acquisition followed by contrast-enhanced imaging at 75 seconds (peak CT enhancement) and 15 minutes (delayed washout phase). It is important to emphasize that identical acquisition parameters be used for all 3 phases of the acquisition to allow meaningful comparison of HU among the 3 phases. The threshold values used to determine adenomas vs nonadenomas can also affect the accuracy of the test. We use an absolute percentage washout of more

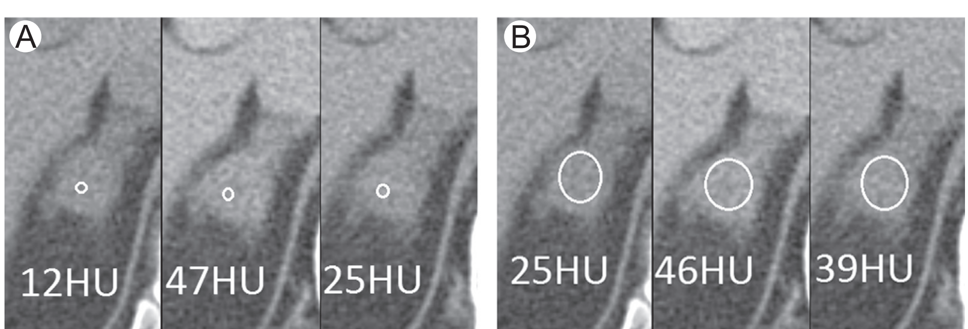

Figure 2 Small ROI resulting in erroneous CT washout characterization. A scan of a 57-year-old man with lung cancer undergoing adrenal washout CT for evaluation of adrenal nodule. (A) ROI on initial measurements did not occupy the central two-thirds of the lesion, resulting in washout values that incorrectly characterized the lesion as an adenoma (APW = 63% and RPW = 47%). (B) Repeat measurements encompassing the central two-thirds of the mass characterized the lesion as a suspicious mass (APW = 33% and RPW = 15%), later shown to be an adrenal metastasis. The initial measurements were not representative because of sampling error and excessive noise within the small ROI. APW, absolute percentage washout; RPW, relative percentage washout.