Published in final edited form as:

J Comput Assist Tomogr. 2011 ; 35(4): 459–461. doi:10.1097/RCT.0b013e31822227c3.

T1 pseudohyperintensity on fat-suppressed MRI: A potential diagnostic pitfall

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Abstract

MRI findings in two patients with misleading T1 hyperintensity seen only on fat-suppressed images are presented, one with a renal cell carcinoma that was misinterpreted as a hemorrhagic cyst and the other with an ovarian serous cystadenocarcinoma that was misinterpreted as a complicated endometrioma. The apparent T1 hyperintensity on fat suppressed images in these cases was likely due to varying perception of image signal dependent on local contrast, an optical effect known as the checker-shadow illusion. T1 pseudohyperintensity should be considered when apparently high T1 signal intensity is seen only on fat-suppressed images; review of non fat-suppressed images may help prevent an erroneous diagnoses of blood-containing lesions.

Keywords

MRI; Hemorrhage; Cyst, renal; Endometrioma; Artifact

Introduction

Fat suppression is a generic term used to describe any one of various methods employed to attenuate the usually hyperintense signal characteristic of fat on MRI. This is commonly achieved by exploiting the difference in resonance frequencies, precession frequencies or relaxation times between fat and water [1]. In body imaging, fat suppression is routinely used to better appreciate contrast enhancement, for distinction of macroscopic fat from blood (since both may be of high T1 signal intensity on non fat-suppressed images, but only blood remains of high signal intensity after fat suppression), and for reduction of ghosting artifact from moving fat (such as in the abdominal wall). Described interpretative artifacts and pitfalls related to fat suppression have been primarily related to local field inhomogeneity causing failure of fat suppression [1, 2], particularly around air-tissue interfaces such as the diaphragm [3]. We recently encountered two cases in which spurious high T1 signal intensity or “pseudohyperintensity”, likely due to the so called checker-shadow illusion (Figure 1) [4], on fat suppressed MRI resulted in erroneous diagnoses of blood containing pathology. To our knowledge, this particular source of misdiagnosis at abdominal MRI has not been previously reported. We report these cases here to expand the described ranges of pitfalls in the evaluation of fat-suppressed T1-weighted MRI.

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Materials and Methods

This was a retrospective study and was approved by our committee on human research, with waiver of the requirement for informed consent. During 2009, the senior author (---) encountered two patients in whom a lesion seen at MRI of the abdomen or pelvis was incorrectly diagnosed as blood-containing pathology based on apparent high T1 signal intensity on fat-suppressed T1-weighted images. Clinical and imaging findings were made by review of the medical and radiological records. Patients underwent MRI at our institution on a 1.5 Tesla whole body MR scanner (Signa; General Electric Medical Systems, Milwaukee, WI) using a surface coil (General Electric Medical Systems, Milwaukee, WI). Specific sequences acquired in both patients included dual echo axial gradient echo T1 and dynamic axial gradient echo fat suppressed T1 before and after administration of intravenous gadolinium.

Case Reports

Patient 1

A 56 year old woman with a past history of hysterectomy for uterine prolapse presents with abdominal pain. Transvaginal ultrasound demonstrated a right ovarian cyst with suspicious mural nodularity. Pelvic MRI confirmed a right ovarian cyst with solid mural nodules. The fluid content of the cyst appeared of moderately high T1 signal intensity on pre-gadolinium fat-suppressed T1-weighted images (Figure 2), and the possibility of endometrioma complicated by malignancy was raised [5]. The patient underwent bilateral salpingo-oophorectomy and omentectomy which demonstrated an ovarian serous cystadenocarcinoma without internal hemorrhage.

Patient 2

A 68 year old man presented with abdominal pain. Abdominal MRI demonstrated a right renal mass that was of high T1 signal intensity on pre-gadolinium fat-suppressed T1-weighted images (Figure 3). These findings were considered suggestive of a hemorrhagic cyst [6, 7]. CT and ultrasound performed 5 months later due to persistent abdominal pain suggested the mass was solid, and renal cell carcinoma without internal hemorrhage was confirmed at partial nephrectomy.

Discussion

Our observations in these two cases suggest visual assessment of T1 hyperintensity on fat suppressed images may be misleading and falsely suggest blood-containing pathology. Such pseudohyperintensity is a potential pitfall in MRI that the interpreting radiologist must be aware of when examining fat suppressed studies. We believe the mechanism of this pseudohyperintensity has two components. First, the fact that the hyperintense T1 signal was seen on fat-suppressed images but not on unsuppressed images suggests the apparent high signal partially reflects the altered dynamic range when fat signal is subtracted. Essentially, the next brightest signal is assigned to a whiter shade on the display grayscale. However, this is likely only a partial explanation, because the T1 hyperintensity was much less apparent on post-gadolinium images. Review of the cases suggests this reflects altered visual appreciation of signal intensity as the ambient contrast is changed, the same principle that underlies many popular optical illusions. This is perhaps most famously illustrated by the checker-shadow illusion (Figure 1). These optical illusions occur due to subconscious processing of retinal input [8, 9], demonstrating that our perception of the intensity of various shades of gray can be manipulated by their surroundings - a point with obvious parallels in MRI interpretation. Thus, it is especially important to be aware of this diagnostic

limitation as it is inherent to how our visual system was designed to perceive light intensity rather than any technical flaw of image acquisition which may be correctable.

Yousem et al described paradoxically low signal intensity in structures after intravenous contrast administration that appeared of high signal intensity on precontrast imaging [10], and suggested the effect was due to gadolinium-related changes in signal intensity of tissues due to altered relaxation times at varying TR and TE values [10]. While this mechanism might contribute to changed contrast in solid tissue, such effects would probably not explain changes in signal intensity of a purely cystic structure (Figure 2).

Some limitations of our study deserve mention. First, this was a single institution retrospective review. The individual cases were not identified systematically and with our small sample size we were unable to estimate the frequency of which pseudohyperintensity contributes to diagnostic errors. As no cases have been previously reported we can speculate that it is either very rare or under-recognized - further study with larger case series are needed to clarify. Also, each patient in our study obtained only one MR scan, not allowing us the opportunity to examine whether or not these findings were reproducible or had evolved significantly with disease progression.

In conclusion, we recommend that all suspicious hyperintense lesions on fat suppressed MRI studies be compared with the corresponding non fat-suppressed MR image or with supplemental CT or ultrasound studies. Otherwise pseudohyperintense signals, especially when resembling pathologic lesions, may lead to unnecessary patient workup, misdiagnosis or diagnostic delay of more serious pathology.

Acknowledgments

TJ supported by NIBIB T32 Training Grant T32 EB001631

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Figure 1. Checker-shadow illusion. On the image to the left, the 2 squares marked A and B are the same shade of gray, although square B appears whiter. On the right, only after connecting the 2 squares does this become obvious. Images were reproduced from http://web.mit.edu/persci/people/adelson/checkershadow_illusion.html. Images may be reproduced and distributed freely.

Figure 2.

A, Axial T1-weighted MR image in a 56-year-old woman with abdominal pain showing a cystic right ovarian mass (arrow) with mural nodularity. B, Axial T2-weighted MR image demonstrating a cystic mass (arrow) of fluid signal intensity with mural nodularity. C, Photomontage of axial fat-suppressed T1-weighted gradient echo images before (left side of montage) and after (right side of montage) the administration of gadolinium. The adnexal mass on pre-gadolinium imaging appears of high T1 signal intensity, although this is much less apparent on the post-gadolinium image. A mural nodule (arrow) is visible, and the possibility of malignancy arising in a preexisting endometrioma was raised because of the combination of an apparently bright T1 cystic lesion with a mural nodule. D, Same photomontage as B but with the addition of a rectangle that is the same shade of gray as the adnexal mass on pre-gadolinium images. This demonstrates that the lesion is essentially the same color on both images, and the apparent high T1 signal intensity on post-gadolinium imaging is artifactual.

Figure 3. A, Axial T1-weighted MR image in a 56-year-old man who presented with abdominal pain showing a lesion (arrow) in the lateral pole of the right kidney. B, Axial T2-weighted MR image showing that the lesion (arrow) is of low signal intensity (a small cyst is also visible

anterior to the lesion, and this was confirmed as an incidental simple cyst at surgery). C, Coronal fatsuppressed T1-weighted MR image before gadolinium administration. The mass (arrow) appears to be of high T1 signal intensity. This finding was considered suggestive of a hemorrhagic cyst. D, Coronal fat-suppressed T1-weighted MRI after gadolinium administration. The hyperintensity seen in C is less apparent now that the adjacent renal parenchyma is enhanced, and in retrospect, this may have been an indication that the apparent hyperintensity on fat-suppressed imaging was artifactual.