

Gd-EOB-DTPA combined with Gd-DTPA: Hepatobiliary contrast with familiar hepatic dynamic contrast enhancement

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PURPOSE:

Hepatobiliary contrast agents add an additional form of image contrast to hepatic magnetic resonance (MR) imaging, allowing differentiation of tumors which have functional hepatic and biliary components from those without. Gd-EOB-DTPA has sufficiently significant elimination via the hepatobiliary pathway to make it a feasible contrast agent in the time allotted to a typical clinical abdominal imaging examination.

Evaluation of lesion kinetics on dynamic contrast enhanced (DCE) imaging is critical for differentiating different types of hepatic masses; however, we observed in our initial use of Gd-EOB-DTPA that the liver takes on an unfamiliar, "washed out" appearance in the portal-venous and equilibrium phases of DCE imaging. Two factors may contribute to this appearance: (1) the lower recommended dose of Gd-EOB-DTPA (0.025 mmol/kg) compared to the recommended doses of extracellular agents such as Gd-DTPA (0.1 mmol/kg) results in decreased relative enhancement, and (2) the increased hepatic parenchymal enhancement from hepatobiliary uptake on portal-venous and equilibrium phases when using Gd-EOB-DTPA reduces the contrast-noise ratio (CNR) of hepatic vasculature and enhancing hepatic masses relative to the background liver.

We postulated that administering a combination of the hepatobiliary contrast agent Gd-EOB-DTPA in conjunction with an extracellular agent (Gd-DTPA) would produce hepatic imaging which provides hepatobiliary characterization on delayed phase images, without significantly altering the appearance of hepatic vasculature and lesions on the DCE phases of imaging.

METHODS:

Patients were referred for characterization or followup of hepatic lesions seen on prior imaging. Routine hepatic imaging protocol was utilized, with DCE images obtained using breathhold 3D spoiled gradient echo technique (TR ~ 4ms, TE ~ 1.5ms, BW +/- 63 kHz, ST ~ 3mm, FOV 32-40cm, matrix 192 x 160, chemically-selective fat suppression). The DCE component of the examination protocol was performed with mask images obtained prior to the administration of contrast, followed by acquisition during the arterial phase, portal-venous phase, and equilibrium phase, with the arterial phase timing determined using a test-bolus timing run.

The choice of contrast agent was determined by a clinical radiologist, based on the clinical indication.

Patients who were prescribed Gd-DTPA received 0.1 mmol/kg administered at an injection rate of 2 cc/second.

Patients receiving Gd-EOB-DTPA initially received 0.025 mmol/kg either administered over approximately 8 seconds (0.25 mol/L, diluted with an equal volume of normal saline, injected at 2 cc/second) or over approximately 4 seconds (0.25 mol/L, undiluted, injected at 2 cc/second).

After observing the "washed out" appearance of the liver on DCE imaging with Gd-EOB-DTPA, the clinical protocol was altered such that patients being prescribed hepatobiliary contrast received a solution consisting of the recommended dose of Gd-EOB-DTPA (0.025 mmol/kg) combined with half the recommended dose of Gd-DTPA (0.05 mmol/kg), and administered over approximately 6 seconds (injected at 2 cc/second).

RESULTS:

Using all contrast agents, aortic and hepatic arterial signal peaks in the arterial phase DCE images, with noticeably greater signal intensity when compared to liver parenchyma, and then declines on the two subsequent DCE acquisitions. Portal venous signal correspondingly peaks in the portal venous phase images and then declines. IVC and hepatic vein signal plateaus beginning at the portal-venous phase images.

With extracellular contrast (Gd-DTPA), enhancement within the aorta, portal veins, and hepatic veins remains noticeably greater than hepatic parenchymal enhancement on all phases of DCE imaging (chart A, below).

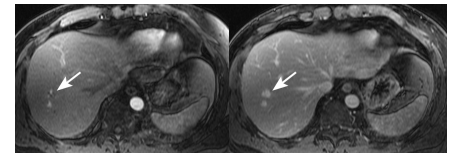
However, when using Gd-EOB-DTPA, **rapid and persistent hepatic parenchymal enhancement becomes very similar to intravascular enhancement in both the portal-venous and equilibrium phases**. As a result, CNR of intrahepatic vasculature compared to liver is markedly diminished when using Gd-EOB-DTPA alone (chart B).

By combining Gd-DTPA with the Gd-EOB-DTPA, intravascular enhancement remains significantly greater than hepatic parenchymal enhancement in all three of the DCE phases, and the unique features of the subsequent 20-minute delayed hepatobiliary phase acquisition are preserved (chart C).

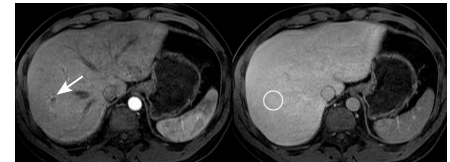
DISCUSSION:

Background hepatobiliary uptake obscures perceived enhancement in DCE imaging. The recommended dose of Gd-EOB-DTPA is also one quarter that of extracellular contrast agents such as Gd-DTPA. Despite its higher relaxivity, overall extracellular enhancement effects from Gd-EOB-DTPA alone is only half that of Gd-DTPA.

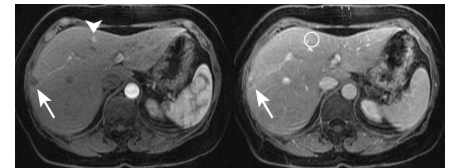
After adding a half of the recommended dose of Gd-DTPA to the recommended dose of Gd-EOB-DTPA, overall intravascular enhancement when compared to background liver in the DCE phases of imaging becomes perceptually similar to that of pure extracellular agents, raising the CNR of hepatic vasculature (and hepatic lesions by correlate) compared to the background parenchyma. This results in familiar appearing images and volumes of contrast administration, with persistent vascular landmarks during DCE imaging with hepatobiliary contrast.



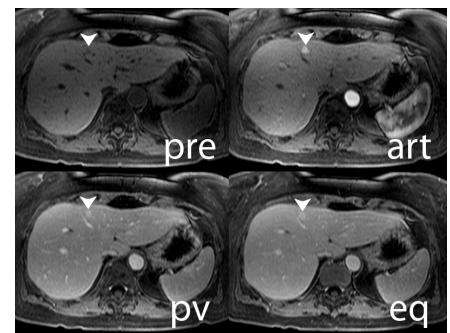
Gd-DTPA — Arterial (left) and equilibrium (right) phases: Hemangioma [arrow] shows peripheral nodular enhancement on arterial phase images, and fills in on equilibrium images. Like vascular structures, the hemangioma is hyperintense to liver on equilibrium images.



Gd-EOB-DTPA (same patient as above) — Arterial (left) and equilibrium (right) phases: Hemangioma [arrow] shows peripheral nodular enhancement on arterial phase images, but is not distinguishable [circle] from the bright background liver in equilibrium images. Vascular structures also blend into the liver parenchyma.



Gd-DTPA — Arterial (left) and equilibrium (right) phases: Hemangioma [arrow] and focal nodular hyperplasia [arrowhead] are clearly seen on arterial phase images, but FNH blends [circle] as expected into background liver on the equilibrium images.



Gd-EOB-DTPA & Gd-DTPA together (same patient as above) — Pre-contrast [pre], arterial [art], portal venous [pv], and equilibrium [eq] phase images: Vascular conspicuity is preserved on all phases of imaging. Interestingly, in contrast to the above images, focal nodular hyperplasia [arrowhead] remains hyperintense to liver on equilibrium images due to early hepatobiliary contrast uptake.

