

# Update on Contrast Agents for Body MRI

Martin R. Prince, MD, PhD  
Cornell and Columbia Universities

Although MRI provides a rich array of tissue contrast different and often better than CT and Ultrasound, the addition of exogenous contrast agents can enrich the MRI information to enhance diagnostic accuracy for many diseases, especially inflammation, necrosis and neoplasms. Sometimes, contrast agents do not enhance accuracy but are still very useful because they provide greater diagnostic confidence to facilitate efficient clinical decision making. Paramagnetic exogenous contrast agents also shorten T1 relaxation allowing faster T1-weighted acquisitions with higher spatial resolution and SNR. 3D Chest, Abdomen and Pelvis MRI data are readily acquired sufficiently rapidly for breatholding using only modest doses of gadolinium based contrast agents. Here we review the important features of contrast agents for body applications.

**Volume of Distribution:** The most important characteristic of an exogenous contrast agent is where it goes upon introduction into the body. Volume of distribution determines what enhances and what does not. Time resolved imaging during introduction of the exogenous contrast agent shows how it redistributes which may yield important insights into the physiology of the tissues through which the agent passes. Exogenous contrast agents can also highlight and assess the normal functioning of their excretion pathway. Examples include: Hyperpolarized He<sup>3</sup>: inhaled

Volumen (1% barium in Sorbital) ingested

Ultrasound Jelly: per rectum or intra-vaginally

Gd:DTPA: intravenous → distributes into extracellular compartment → excreted renally

Gadoxetate: intravenous → extracellular compartment → 50:50 biliary and renal excretion

Gadofosveset: intravenous → blood pool → slow renal excretion

Ferumoxytol → blood pool → incorporated into iron stores

**Relaxivity:** Paramagnetic Contrast Agents cause the magnetic field to increase locally in the region of the Agent. This disturbance of the magnetic field facilitate both T1 and T2 relaxation making the tissue with contrast agent appear brighter on T1 weighted image and darker on T2 weighted images. The magnitude of this effect is known as the relaxivity. R1 relaxivity refers to the magnitude of the effect on T1 weighted images and R2 relaxivity refers to the effect on T2. The higher the R1 relaxivity of a contrast agent, the less dose is needed to attain the same T1 enhancement effect. Gadolinium based paramagnetic agents are available with a broad range of relaxivities. As a general rule, the more contrast, the greater the effect except that at high concentrations (e.g. at high injection rates), the R2 relaxivity may dominate creating the paradoxical effect of less signal. Thus, dose optimization has become a balance between maximizing T1 and minimizing T2 effects all the while adjusting imaging parameters to attain the highest SNR and CNR.

**Safety:** All of the MRI contrast agents have favorable safety profiles and they are among the safest contrast agents utilized in imaging. Rarely, they may be an allergic reaction to any agent, and thus crash carts and personnel trained in cardiopulmonary resuscitation must be readily available whenever exogenous contrast agents are employed. Other rare safety issue to be discussed.

**Future Advances in Contrast Agents:** Some of the more exciting advances in contrast agents for body imaging include: manganese agents with extracellular distribution and high R1 relaxivity to replace gadolinium and thereby eliminate NSF risk; Imaging perfluorocarbons tuned to the fluorine peak for extremely high contrast; Hyperpolarized molecular imaging of tracers synthesized from carbon13; CEST and ParaCEST agents to image chemical exchange.