Two types of commercially available contrast media are useful during imaging of the liver.\(^1\)\(^-\)\(^4\) One type is composed of purely extracellular agents. The other is composed of hepatobiliary agents, which have properties of extracellular agents but are also taken up differentially by functioning hepatocytes.

**Extracellular agents** are suited to liver imaging applications that require the following:
- Information obtained during the dynamic contrast-enhanced phase, or
- Excellent vascular visualization

With their ability to visualize vascular perfusion, extracellular agents such as gadobutrol (Gadavist®, Bayer HealthCare [US]; Gadovist®, Bayer Schering Pharma [EU]) and gadoversetamide (Optimark™, Covidien [Mallinckrodt]) can be used to detect and characterize focal liver lesions as well as evaluate liver vasculature.

**Hepatobiliary agents** are suited to applications focusing primarily on these characteristics:
- Biliary visualization, and
- Ability to distinguish between lesions that contain hepatocytes and lesions that do not contain hepatocytes

**Liver-specific agents** such as gadoxetate disodium (Eovist®, Bayer HealthCare [US]; Primovist®, Bayer Schering Pharma [EU]) and, to a lesser extent, gadobenate dimeglumine (MultiHance®, Bracco) have extracellular properties but also have an affinity for hepatocytes.

The European Union has approved liver imaging indications for Gadovist, Optimark, Primovist, and MultiHance. The US Food and Drug Administration has approved Eovist and Optimark for liver imaging. MultiHance is widely used off label in the United States for liver imaging.

The pharmacokinetic differences among extracellular agents are largely insignificant. Gadolinium-based contrast agents are associated with an increased risk for nephrogenic systemic fibrosis. The risk appears highest among those with chronic, severe kidney disease and acute kidney injury, and use of these agents should generally be avoided in these patients. The choice of an extracellular contrast medium is based primarily on differences in local preference, safety profile, and cost considerations.
In regard to hepatobiliary agents, Stanford guidelines\(^1\) recommend the following:

- **Eovist** for bile duct imaging and lesion characterization using delayed imaging
  
  *Note: Eovist should not be used for nonhepatobiliary applications*
- **Gadavist** for characterization of lesions using dynamic imaging
- **MultiHance** for liver transplant evaluations

**GENERAL APPLICATIONS/INDICATIONS**

The following protocols and approaches are used at Stanford University. Similar approaches are used at most academic Body MR services.

**GADAVIST**

- Cirrhotic liver (hepatocellular carcinoma screening/evaluation; complications of portal hypertension)
- Metastatic disease with no previous liver imaging (known malignant disease; no known metastatic disease -- rule out liver metastases)
- Characterization of liver lesion (incompletely characterized focal liver lesion/unlikely to be focal nodular hyperplasia (FNH) or hepatic adenoma)
- Evaluation of nonhepatic abdominal pathologic condition or symptomatic patient with no previous imaging/relevant history

- Biliary and vascular complications suspected (biliary leak/stenosis, vascular complication)
- Living-related liver donor evaluation

**MULTIHANCE**

- Before liver transplantation (evaluate liver anatomy; unsuspected pathologic condition)
- Complications of liver transplantation:  
  - Vascular complications (hepatic, arterial, or portal venous stenosis/occlusion/thrombosis)

**EOVIST**

- Intravenous use in T1-weighted MRI of the liver to detect and characterize lesions in adults with known or suspected focal liver disease
- Metastatic disease with previous imaging with MRI, CT, and/or ultrasound (follow known metastatic disease; improve characterization of extent of disease seen on other imaging; liver segment volume measurements before resection)
- Complications of liver transplantation with biliary complications such as biliary leak; anastomotic stenosis
- Characterization of FNH vs adenoma (incompletely characterized focal liver lesion with high suspicion for FNH or hepatic adenoma (Note: Previous imaging with CT or ultrasound required)
EXTRACELLULAR CONTRAST MEDIA

Radiologists at Stanford University apply the following protocols when using extracellular gadolinium contrast agents and MultiHance to enhance the liver.

Field Strength: 1.5T or 3T

PRECONTRAST PULSE SEQUENCES

- Multiplanar localizer
- Diffusion-weighted imaging (axial), b values of 50 and 500
- T2-weighted imaging: 2D axial T2-weighted fast spin echo with fat suppression
- 3D axial fat-suppressed T1-weighted in- and out-of-phase gradient echo with 2-point fat-only and water-only Dixon reconstructions
- Optional: 3D coronal heavily T2-weighted fast spin echo respiratory-triggered MR cholangiopancreatography at high resolution

INJECTION

- **Dose**: 0.1 mmol/kg body weight
- **Injection rate**: 2.5 mL/sec followed by 20 mL of saline chaser injected at 2.5 mL/sec

CONTRAST PULSE SEQUENCES BY PHASE

3D axial T1-weighted SPGR triple-arterial phase with fat suppression or Dixon dual echo:

- acquire 3 consecutive phases (triple-arterial) or acquire single-phase (single-arterial) with bolus triggering
- Data acquisition start: delay in data acquisition depending on the patient’s age (15 seconds in patients <60 years and 20 seconds in patients >60 years)
- Portal venous: at 1 minute
- Delay: at 3-4 minutes
- Hepatobiliary phase (if Eovist is used): 20-minute delay with flip angle increased to 25 degrees. Note that markedly improved images can be obtained if your scanner has a navigation option; in that case, the matrix may be increased to more than 416 x 416 and the section thickness decreased to less than 2 mm.

References

1. Reeder SB. Contrast media for liver MRI: which one to choose? In: Proceedings of the International Society for Magnetic Resonance in Medicine (ISMRM); May 7-13, 2011; Montreal, Quebec, Canada.

