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High Definition Abdominal MRI

Signa HD 1.5T and LAVA

Recent advances in MRI technology have greatly impacted abdominal MR applications. Improvements in hardware have boosted signal to noise by concentrating a large number of coils in the field of view (FOV). Improvements in software have taken advantage of this enhancement to increase resolution, reduce scan time, add tissue contrast and help ensure clinical consistency.

Recent progress in image quality arises, directly or indirectly, from the simultaneous acquisition of the MR signal by many small coils. The expression "high-density coil" describes this concept well. Only high-density coils yield the extra signal to noise, the solid foundation from which GE Healthcare offers a comprehensive solution for abdominal MRI applications.

While a high-density body coil lays the required firm foundation for abdominal MR, GE's Parallel Imaging technique – ASSET™ – constitutes the central pillar of the structure. ASSET adds a new degree of freedom to the scan protocols. With echo trains cut short, Single Shot Fast Spin Echo (SS-FSE) and Single Shot Echo Planar Imaging (SS-EPI) show less blurring artifacts and less susceptibility distortions. As a result, the clinical status of SS-FSE has evolved from a mere fast localizer to a robust technique insensitive to patient motion and further, to the accepted standard in the study of abdominal ducts. On the other hand, ASSET serves as an acceleration device, able to change signal-to-noise ratio (SNR) into speed or spatial resolution.

When scan time doesn't match a reasonable breath-hold, ASSET can reduce it with uncompromised resolution and salvage the examination of an uncooperative or elderly patient. More importantly, ASSET is an integral part of a new technique used for liver and pancreas with contrast uptake.

This technique, known as LAVA™, combines contrast-enhanced, multi-phase imaging of the abdomen with high resolution, large coverage and uniform fat suppression. In one breath-hold, LAVA acquires a stack of overlapping thin slices with high in-plane resolution. The usual protocol repeats this acquisition three or more times. In this way, LAVA produces images of the arterial, portal and venous phases that

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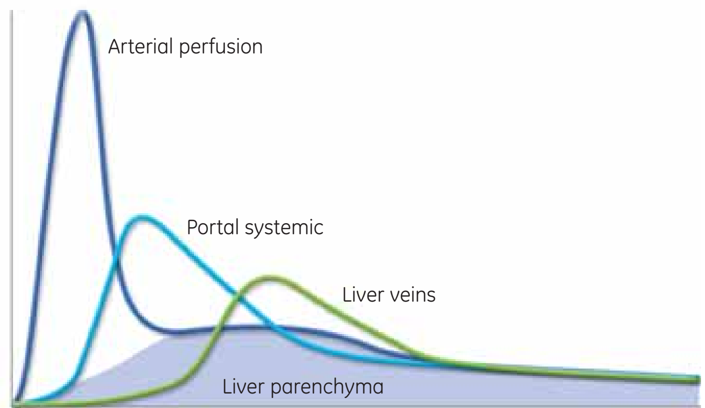
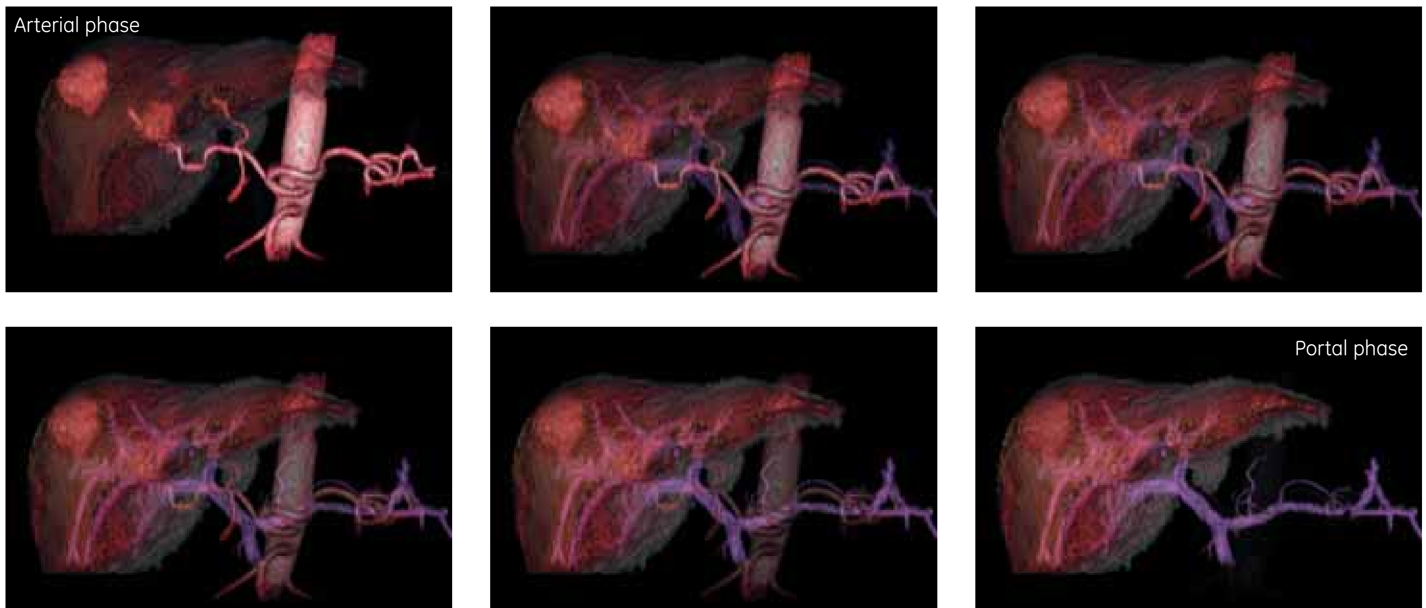
not only precisely depict anatomy and contrast uptake, but also contain vascular information, easily revealed by a MIP post-processing. A single multi-phase LAVA acquisition, with one injection, provides more information than two traditional scans. LAVA enables abdominal imaging with the information-rich contrast of MR and the simplicity of CT.

Though the dynamic study is central to abdominal MR, there is also a need for a simple and fast abdominal survey of vasculature and soft tissue. Fat Sat FIESTA can efficiently accomplish this, even without contrast media. This steady-state 2D sequence, with a very short TR and a hybrid T2/T1 tissue contrast, presents several clear advantages compared with previous ultra-fast GRE sequences. It is of considerable value when a motion-insensitive method is needed. Often included in today's standard abdominal protocol, Fat Sat FIESTA is particularly helpful in assessing the portal and systemic venous system and the bowels.

High-density coils, parallel imaging and better pulse sequences have combined to offer a non-invasive, specific and reproducible diagnostic tool. Even as technology continues evolving, the clinical cases depicted in this article support the clear point that MR technology has already built a solid platform for the expansion of abdominal imaging.

Liver perfusion





Dynamic contrast enhanced T1 weighted acquisition is central to the abdominal examination.
LAVA acquisition: Post-processing using Volume Rendering and Movie Tool in Volume Viewer.

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"The LAVA images look like MDCT images, but with the soft tissue of MR!"

Pr. D. Weishaupt, M.D. – University Hospital of Zurich, Switzerland

Liver

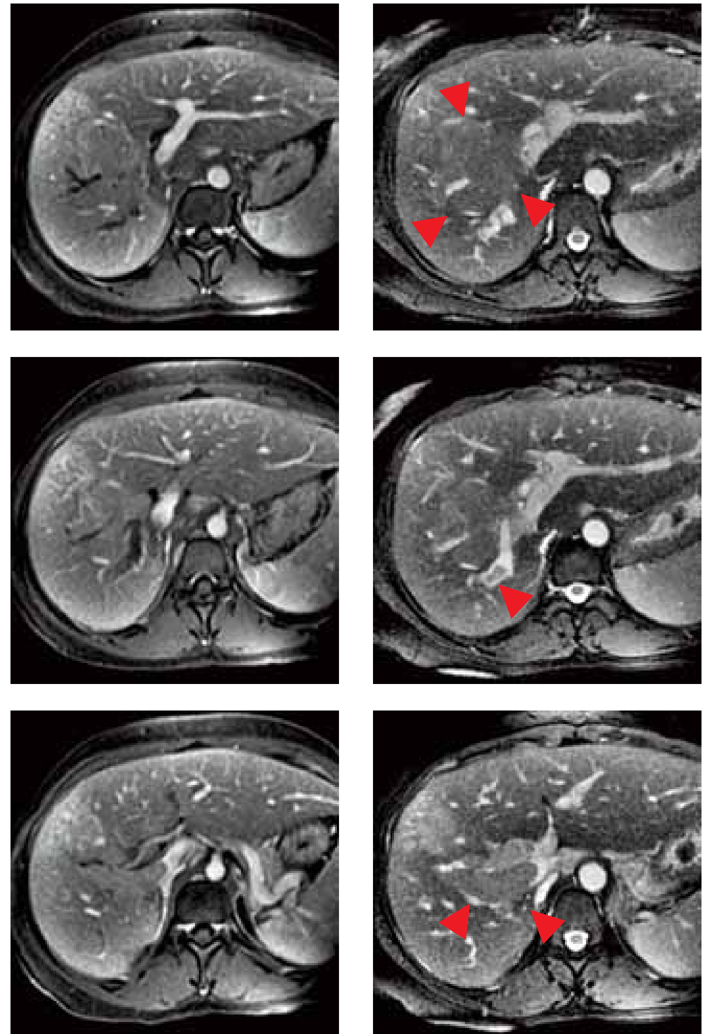
An MR liver examination must guide the therapeutic strategy and/or preoperative planning with a clear depiction of the segmental anatomy and its relationship with vascular and biliary structures.

Case

Hepatocellular carcinoma (arrow) with tumor invasion of the portal vein. Comparison between the FSPGR Fat Sat after contrast media injection and the Fat Sat FIESTA sequence without contrast.

Fat Sat FIESTA:
Sl. thickness: 5 mm
0.7 sec / slice

Fast-Spoiled GRE with Fat Sat:
Post-contrast media injection
Sl. thickness: 5 mm
24 slices
Acq. Time: 23 sec



Fast-SPGR with Fat Sat — Fat Sat FIESTA

"The Fat Sat FIESTA acquisition is a very useful sequence for assessing the venous system in the abdomen. The sequence is now part of our liver protocol, in particular of use in displaying the portal venous system. The sequence is very robust and the images are of high aesthetic quality. This sequence is also of considerable value when a motion-insensitive method is needed."

Pr. D. Weishaupt, M.D. – University Hospital of Zurich, Switzerland

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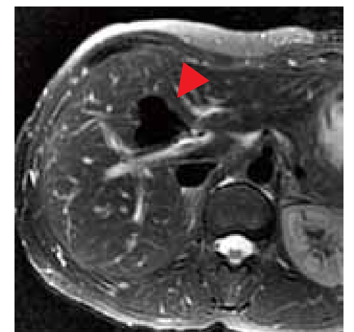
"The LAVA sequence is very useful for assessing small abnormalities within the biliary tract. High in-plane-resolution and the use of thin slices images allow a high accuracy in the evaluation of vascular structures. The ability to depict enhancement of the common bile duct wall provides an advantage for MRA using LAVA, as opposed to MDCT."

Dr. M. Zins – St Joseph Hospital, Paris, France

Biliary System

MR Cholangio-Pancreatography (MRCP) is a frequently used, non-invasive alternative to the classic endoscopic retrograde techniques. Either in breath-hold with SS-FSE, or triggered by respiration with FR-FSE, MRCP can depict the entire pancreatobiliary tract with high spatial resolution. As an emerging technique, LAVA in combination with liver-specific contrast agents, which are partially excreted through the biliary system, can produce a functional MRCP study with very interesting results such as in the case shown below.



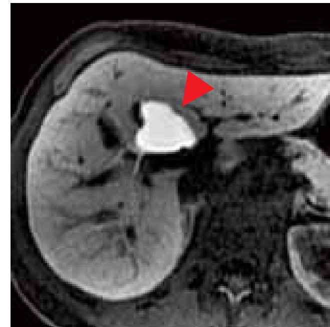
FR-FSE Fat Sat after contrast agent administration

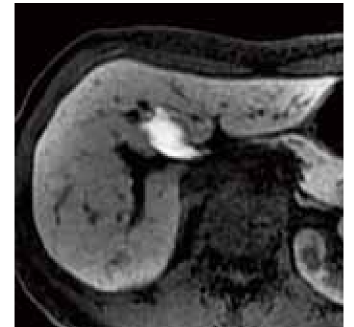
Case

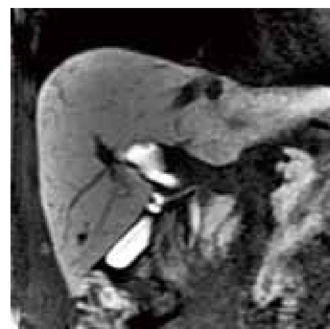
Investigation of a communication between a hepatic cystic lesion and the main bile duct after contrast agent (MnDPDP) administration: type I Choledochal cyst (Todani classification) of the common hepatic duct.

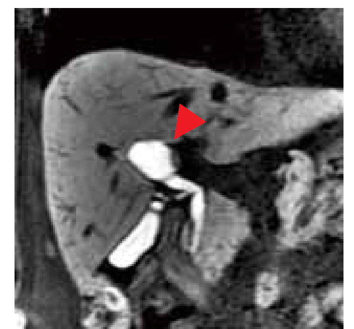
Respiratory-triggered FR-FSE with Fat Sat:
Sl. thickness: 6 mm
24 slices
Acq. time proportional to respiratory cycle

LAVA:
2 hours after contrast agent administration
Sl. thickness: 3.2 mm (ov-1.6)
Acq. time: 18 sec









LAVA after contrast agent administration

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Pancreas

An MR cholangiographic examination must depict the pancreatic and biliary ductal anatomy and delineate the extension of masses and inflammatory processes to the adjacent soft tissues. A pancreas MR examination is a comprehensive study.

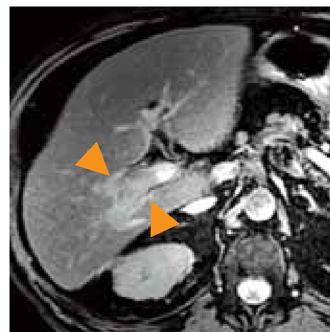
Case

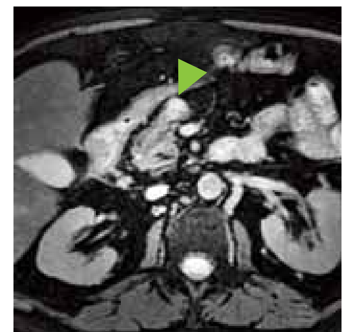
Chronic pancreatitis of the tail of the pancreas (▲) and pseudo-cystic lesion in the isthmus of the pancreas (▲). Notice the intra-hepatic portal thrombosis (▲).

LAVA:
Axial acquisition
Sl. thickness: 3.2 mm (ov-1.6)
Acq. time: 24 sec

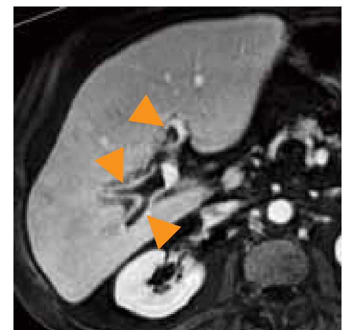
FIESTA Fat Sat:
Sl. thickness: 6 mm
Matrix: 224x256
0.7 sec / slice

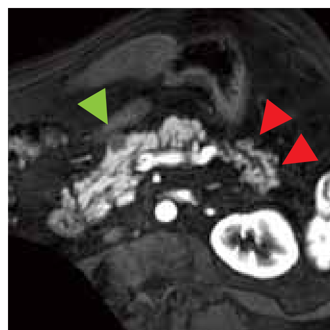
2D MRCP:
Sl. thickness: 20 mm
Matrix: 512x320

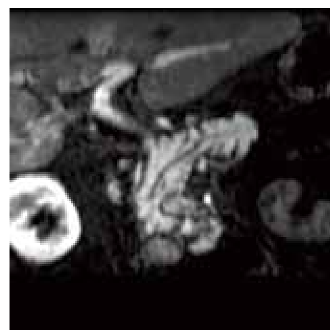

FS FIESTA

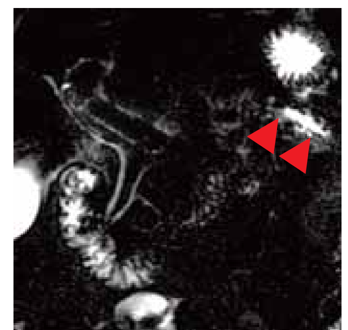

FS FIESTA

LAVA VR


LAVA Min IP


LAVA curved reformation


LAVA oblique reformation


2D MRCP

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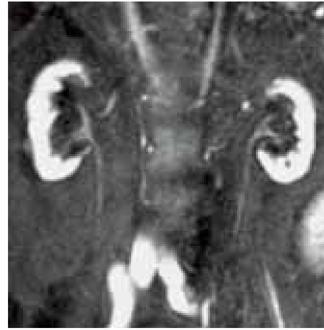
Kidneys

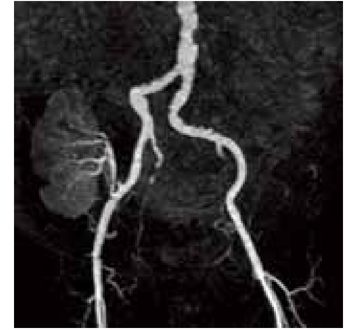
MRI plays a significant role in the imaging of the kidneys because of its high spatial and contrast resolution and its ability to assess the vascular supply. In particular, MRI helps reduce complications in the case of renal donation when laparoscopic nephrectomy is considered.

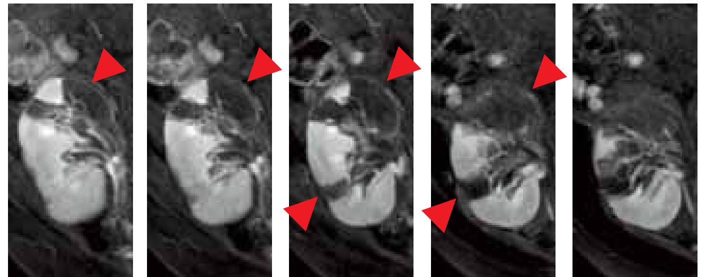
Case

63 year-old male with kidney transplant. Parenchymal perfusion defects at the upper and lower poles.

LAVA:
Sl. thickness: 3 mm (ov-1.5)
Acq. time: 25 sec


LAVA: Native atrophic kidneys


LAVA: MIP from Subtracted images


LAVA: tubular nephrographic phase – Transplant kidney

> "In a single breath-hold, the LAVA sequence may be used for assessment of the kidneys and arteries."
>
> *Pr. D. Weishaupt, M.D. – University Hospital of Zurich, Switzerland*

Bowel

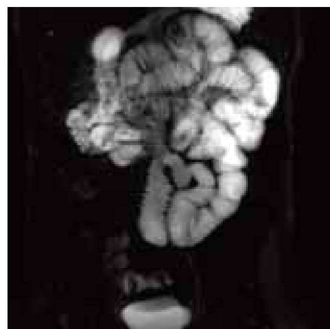
The excellent contrast resolution of MRI, combined with negative intraluminal contrast agents (such as water or iron oxides) and intravenous gadolinium, seems very promising for the evaluation of the gastrointestinal tract. MR enteroclysis, which combines functional and morphologic information, offers cross-sectional imaging multiplanar capabilities. Breathing-independent T2 or T2/T1 weighted images, acquired respectively with SSFSE or FIESTA pulse sequences, provide an excellent depiction of the anatomy with the possibility to monitor filling during enteroclysis. LAVA sequence is used after contrast to assess enhancing inflammatory or malignant processes involving the bowel.

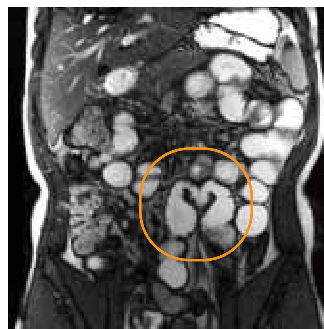
Case

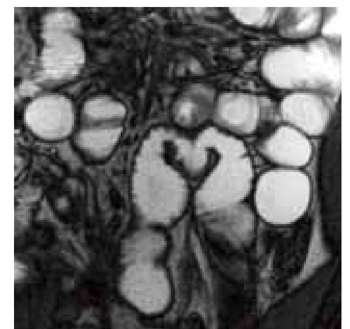
27 year-old patient with two adjacent previous surgical anastomoses (O) that look like possible stenoses. The slab SSFSE pulse sequence is used to monitor filling during enteroclysis. The FIESTA technique demonstrates there is no wall thickening.

2D SSFSE:
Coronal acquisition
Matrix: 256x256
Sl. thickness: 10 mm

2D FIESTA:
Coronal acquisition
Sl. thickness: 6 mm
Matrix: 192x288
(512 interpolated)
Acq. time: 1 sec / slice


Dynamic thick slab 2D SSFSE


2D FIESTA


2D FIESTA

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Conclusion

(by) Pr. C. A. Cuénod
European Hospital Georges Pompidou, Paris, France

Undoubtedly, abdominal and cardiac MRI are the topics where MRI experienced the most striking progress during the last few years. This is mostly due to advancements in phased array coil technology and parallel imaging strategies.

For years, radiologists have been conscious of the tremendous potential of MR contrast studies to characterize tissue. However, poor spatial resolution, motion artifacts and long acquisition times have constrained the spread of abdominal and thoracic applications in clinical routine. We have been eagerly waiting for the technological progress that is at our disposal today.

New pulse sequences have expanded the scope of applications for abdominal MRI and have radically changed our diagnostic strategies.

- The Fast Recovery FSE (driven equilibrium) sequence gives a very high T2 weighing with reduced TR, allowing shorter acquisition time.
- The 3D T1 weighted gradient echo sequence with optimized fat suppression (LAVA) fulfills at last the need to acquire dynamic images during the arterial and the portal phases after injection with high in-plane and through-plane spatial resolution. This sequence takes full advantages of the parallel imaging technique. The benefits in abdominal MRI are multiple and we probably do not yet perceive all its potentials.

In addition to liver imaging, the LAVA sequence makes it possible to consider imaging the pancreas as well as the digestive tract. When using gut relaxant drugs, the fast acquisition almost freezes the bowel loops. It may help in the evaluation of the lesion's activity and becomes the routine way to follow Crohn's patients, avoiding the irradiation risks induced by repetitive X-rays and CT examinations, especially in young patients.

The balanced gradient echo sequence FIESTA, initially developed for neuro and cardiac imaging, finds new applications in abdominal imaging.

Excellent in displaying water-filled areas such as cysts or bile and pancreatic ducts and digestive tract, FIESTA is also very sensitive for visualizing vessels. The exquisite dynamic imaging of the bowels, or MR enteroclysis, and other, less explored indications clearly indicate that the future place of FIESTA in the diagnostic arsenal is still evolving.

Finally these various improvements yield images with a spatial resolution near those of Volumetric CT, but with a much higher contrast and with a very large variety of contrasts. We can forecast that MRI in abdominal imaging will be used more for its high sensitivity and for its absence of irradiation. ■

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