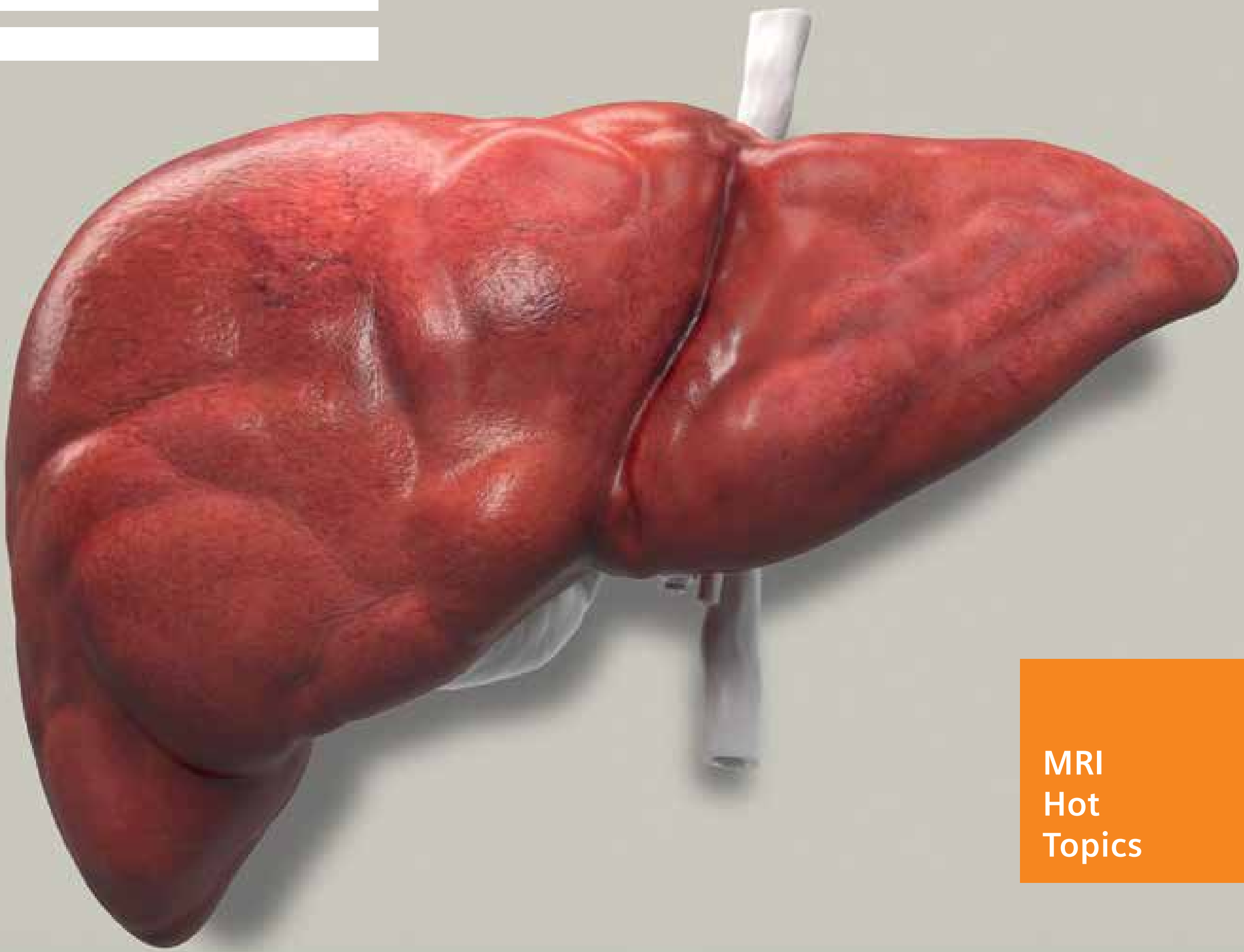
SIEMENS



MRI
Hot
Topics

FREEZEit

New Imaging Techniques to Improve Body MR Imaging

www.usa.siemens.com/bodymri

Answers for life.

Breathe Easy with FREEZEit—New Imaging Techniques to Improve Body MR Imaging

Ning Jin, PhD, Siemens Healthcare

Currently, Body MR imaging (Chest, Abdomen and Pelvis) represents about 10% of MR imaging procedure volume[1], yet some institutions have experienced huge growth in body referrals—with body referrals tripling within a few years[2]. The key to their growth was delivering fast, consistent exams that patients could complete.

Conventional MR imaging is very sensitive to motion, whether voluntary (e.g., respiratory motion or physical movement by the patient) or involuntary motion (e.g., cardiac motion, bowel movement, etc.). In Body MR imaging, breath-holding is often required to achieve diagnostic image quality; however, many patients, especially children, elderly or very sick patients, find it difficult to comply with the breath-hold commands. Robust fat suppression is also required to increase the conspicuity of the vessels and of the lesions. Furthermore, contrast timing is essential for characterization of lesions, but also presents challenges.

Therefore, in order to expand body MR referrals, we need techniques that are insensitive to motion, offer homogeneous fat suppression, provide precise contrast timing, and can be run reliably by all technologists.

StarVIBE

Free Breathing 3D T1 Imaging for Improved Compliance

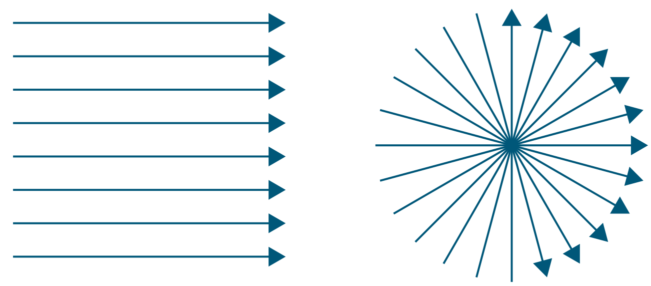
StarVIBE is an innovative 3D T1-weighted GRE sequence. Highly resistant to patient motion, StarVIBE enables the examination of the abdomen and upper chest during continuous shallow breathing. StarVIBE can also be used in other body regions where motion is difficult to avoid, such as head and neck or pelvic studies.

Method

In the conventional Cartesian sampling scheme, k-space is acquired along parallel lines (Fig. 1A), which differ by a fixed difference in signal phase. It is intrinsically very sensitive to motion. If the object moves during the scan, phase offsets are created, causing gaps in k-space coverage and resulting in ghosting or aliasing artifacts along the phase-encoding direction due to improper data sampling. The motion sensitivity can be reduced by changing the k-space sampling scheme to radial, which acquires data along rotated spokes passing through the center of the k-space (Fig. 1B).

Due to its nature of k-space oversampling in the center and varying readout orientations in every spoke, radial acquisition is motion resistant. Gaps in the k-space coverage cannot occur, therefore no ghosting artifacts would be observed. Data inconsistency from motion can sometimes lead to slight streak artifacts instead (if at all). However, in most cases, streaks appear mainly as “texture” added to the underlying object and are less likely to obscure pathology compared to ghosting artifacts from Cartesian acquisition.

StarVIBE has been implemented with a 3D radial “stack-of-star” approach[3-5]. It acquires the kx-ky plane along the radial spokes and the kz dimension with conventional sampling, resulting in cylindrical k-space coverage. (Fig. 2). The special k-space trajectory design enables the use of time-efficient fat-saturation to achieve homogeneous fat suppression. Due to the intrinsic motion insensitivity from radial sampling, it can be used clinically for 3D fat-saturated T1-weighted exams as a motion-robust technique.



(A) (B)

Figure 1: (A) Cartesian sampling along parallel lines. (B) Radial sampling with rotated spokes passing through the center of the k-space

Figure 2. Stack of Stars trajectory in StarVIBE

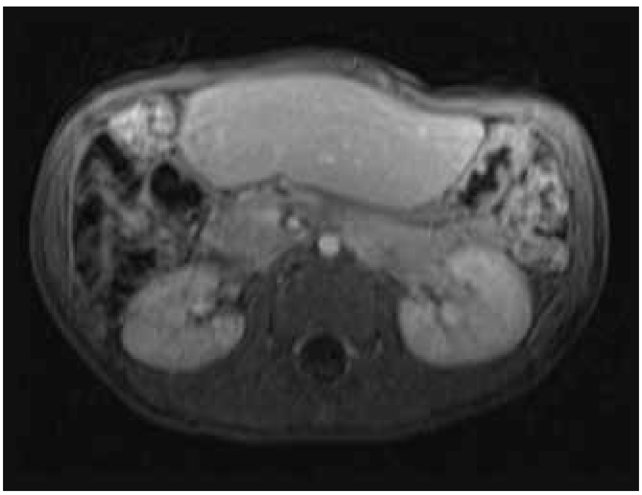
Contiguous Coverage, Fat Suppression, and High-Resolution with StarVIBE

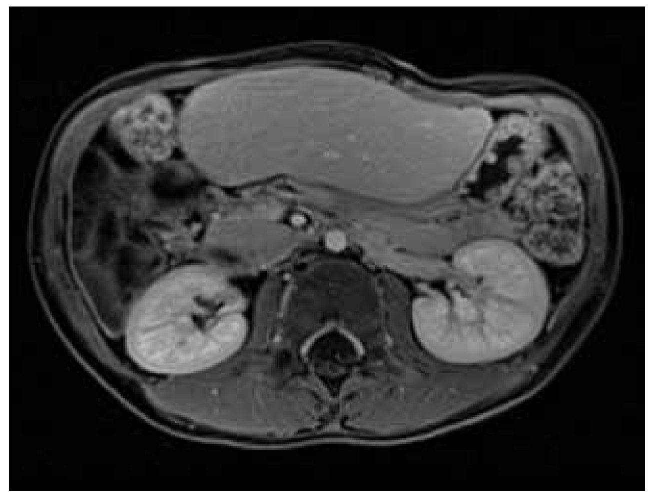
Free-breathing pediatric abdomen exams

5-year-old patient with history of Hepatoblastoma, post partial liver resection.

(A) Conventional VIBE with Cartesian sampling is affected by respiratory and bowel motion artifacts, with resulting blurring.

(B) Free-breathing StarVIBE with fat sat provides sharper images with improved spatial resolution.
(176 slices, 2 mm, 256^2 matrix, 25-cm FOV)





Free-breathing adult abdomen exam

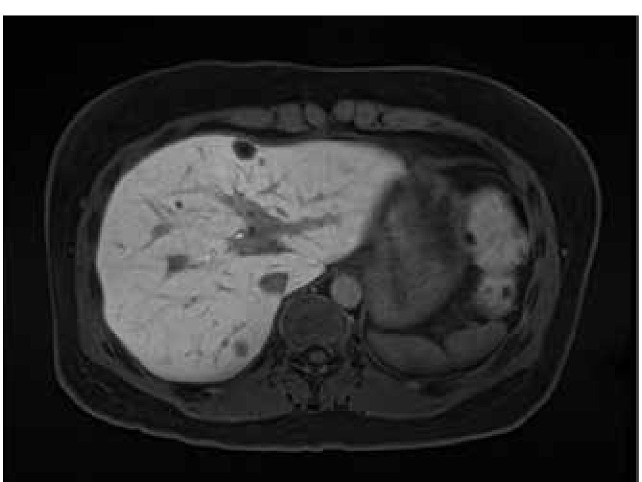
48-year-old patient with Multiple Hepatic Cysts.

Free-breathing StarVIBE provides crisp delineation of the multiple lesions in the right lobe of the liver without any visible artifacts, and excellent fat suppression.
(52 slices, 3.5 mm, 320^2 matrix, 345 cm-FOV, 3:25)

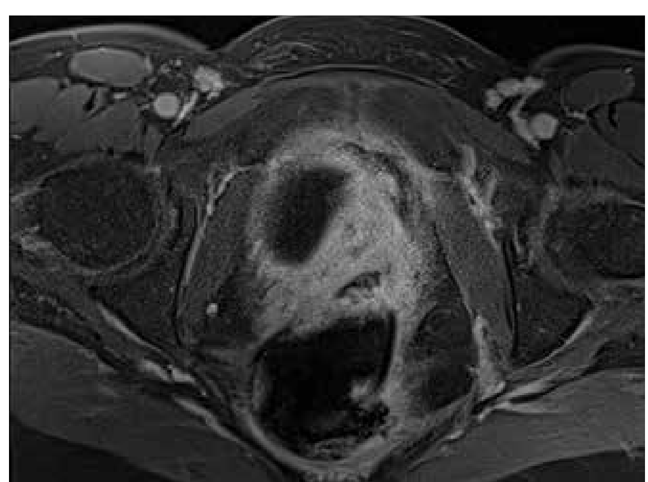
Free breathing pelvic exam

14-year-old patient with Vaginal Adenocarcinoma.

The pelvis has multiple sources of motion: bowels, arteries, abdominal wall respiration, etc. Free breathing StarVIBE exams eliminate the motion for high resolution, no gap coverage of the pelvis.
(72 slices, 2.5mm, 320^2 matrix, 20cm FOV, 1:45)



Courtesy of Dr. Taouli, Mount Sinai Hospital, New York, USA

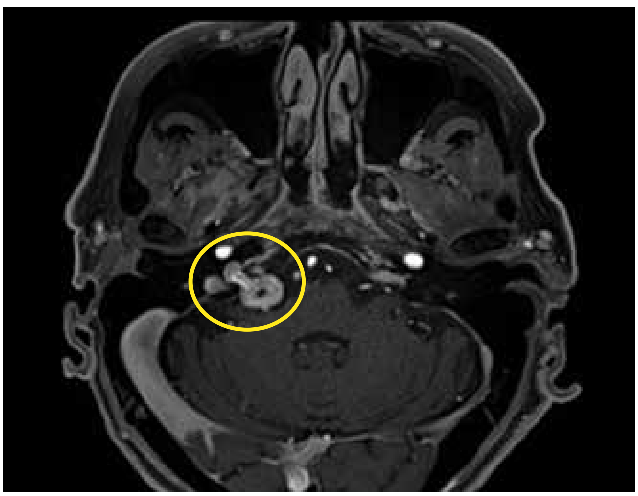


Courtesy of M. Kean, FSMRT, Royal Children's Hospital, Melbourne, Australia

Free breathing head & neck exams

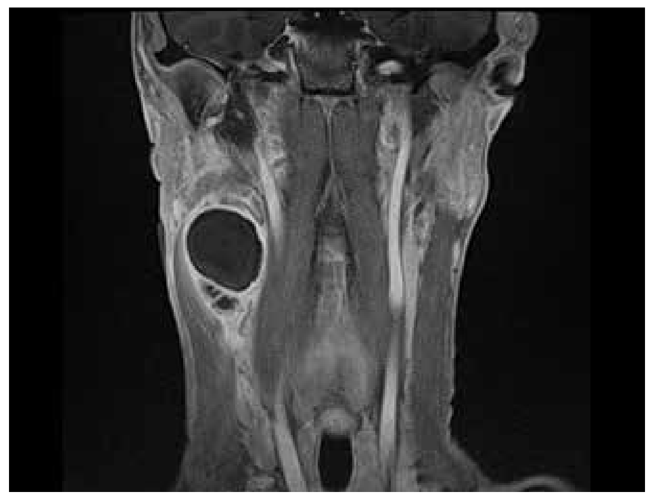
85-year-old patient with Internal Auditory Canal (IAC) Tumor.

StarVIBE provides sharp images to well visualize a cystic, enhancing dumb-bell shaped mass centered in the right cerebellopontine cistern with extension into the right jugular foramen.
(64 slices, 0.8 mm, 224^2 matrix, 18-cm FOV)



14-year-old with Brachial Cleft.

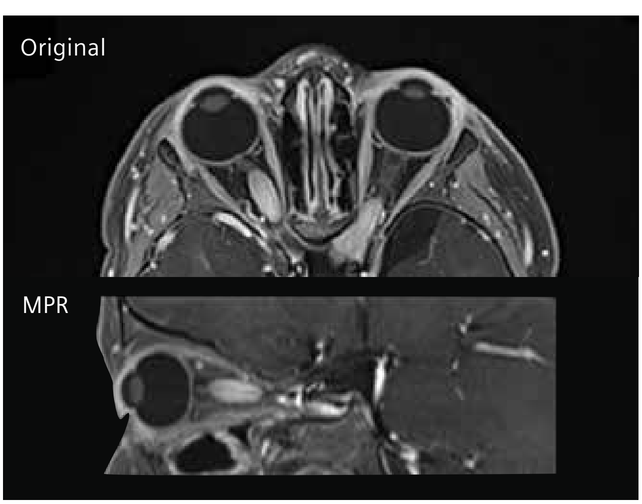
Free-breathing StarVIBE can be used for head and neck studies, where voluntary and involuntary motion can degrade image quality.
(56 slices, 1.5mm, 256^2 matrix, 21cm FOV, 5:08)



Courtesy of M. Kean, FSMRT, Royal Children's Hospital, Melbourne, Australia

4-year-old patient with Optic Glioma.

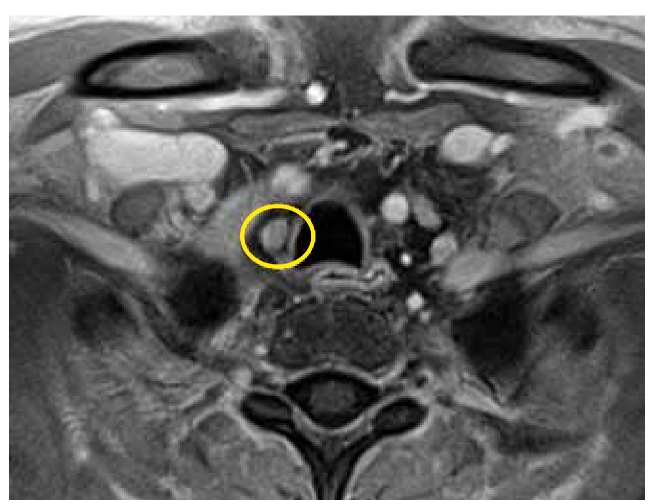
StarVIBE provides motion free imaging of the optic nerves. Sub-isotropic resolution in the axial data set allows for high quality Multi-Planar Reconstructions (MPR).
(72 slices, 0.75 mm, 256^2 matrix, 19-cm FOV, 6:37)



Courtesy of M. Kean, FSMRT, Royal Children's Hospital, Melbourne, Australia

52-year-old with Parathyroid Adenoma.

Free-breathing StarVIBE of neck provides motion-impervious imaging. Patient is spared CT radiation dose from 3 studies—whole neck baseline, arterial, and delayed studies.
(63 slices, 2.5 mm, 192^2 matrix, 15 cm, 3:59)



Courtesy of Dr. Khan and Dr. Nael, University of Arizona, Tuscon AZ, USA

TWIST-VIBE

Improve Contrast-Timing In Dynamic Contrast-Enhanced MRI with TWIST-VIBE

TWIST-VIBE is a novel, highly accelerated 3D, fat suppressed, T1-weighted sequence for time-resolved imaging of the abdomen during the first pass of contrast media transit, aiming to improve contrast timing. Contrast-enhanced volumetric 3D T1-weighted gradient-recalled-echo (GRE) imaging with fat suppression is an essential part of routine abdominal MR imaging. Precise contrast timing is very important. It is critical to capture the right moment of contrast agent, particularly the hepatic arterial phase in liver imaging when strong hepatic arterial enhancement and portal-venous enhancement with no visible enhancement of the hepatic veins coexist[6]. Particularly for these cases, hepatic arterial images are unique markers for characterizing and differentiating benign, malignant, primary, and metastatic tumors[7]. In the conventional approach, due to the limitations of breath-hold duration and acquisition speed, only one set of 3D images is acquired with a fixed delay of 25 to 30 seconds after the injection of contrast agent, attempting to capture the hepatic arterial phase. This approach can fail if the images are acquired either too early (only arterial signal is present) or too late (hepatic venous enhancement is present). The crucial diagnostic information would be lost (Fig. 3A).

Method

The novel TWIST-VIBE sequence can be used to overcome the limitations of the conventional contrast-enhanced MR imaging in the abdomen. With the combination of a TWIST acquisition, controlled aliasing in parallel imaging results in higher acceleration (CAIPIRINHA) under sampling and Dixon fat/water separation, TWIST-VIBE enables high spatial and temporal resolution with full 4D coverage for multi-arterial imaging with precise contrast-timing (Fig. 3B).

TWIST is a view-sharing approach to significantly increase the temporal resolution for dynamic imaging[8]. k-space is divided into two regions A and B as shown in Fig. 4A. A low-frequency central region "A" determines the overall image contrast and a high-frequency outer region "B" provides image details. To achieve a higher temporal resolution, the outer region B is sampled less frequently compared to the central region A. At every time point, the central region A is scanned, while only part of the outer region B is updated. To fill in the missing data in k-space, the outer region B is shared across different time points (Fig. 4B).

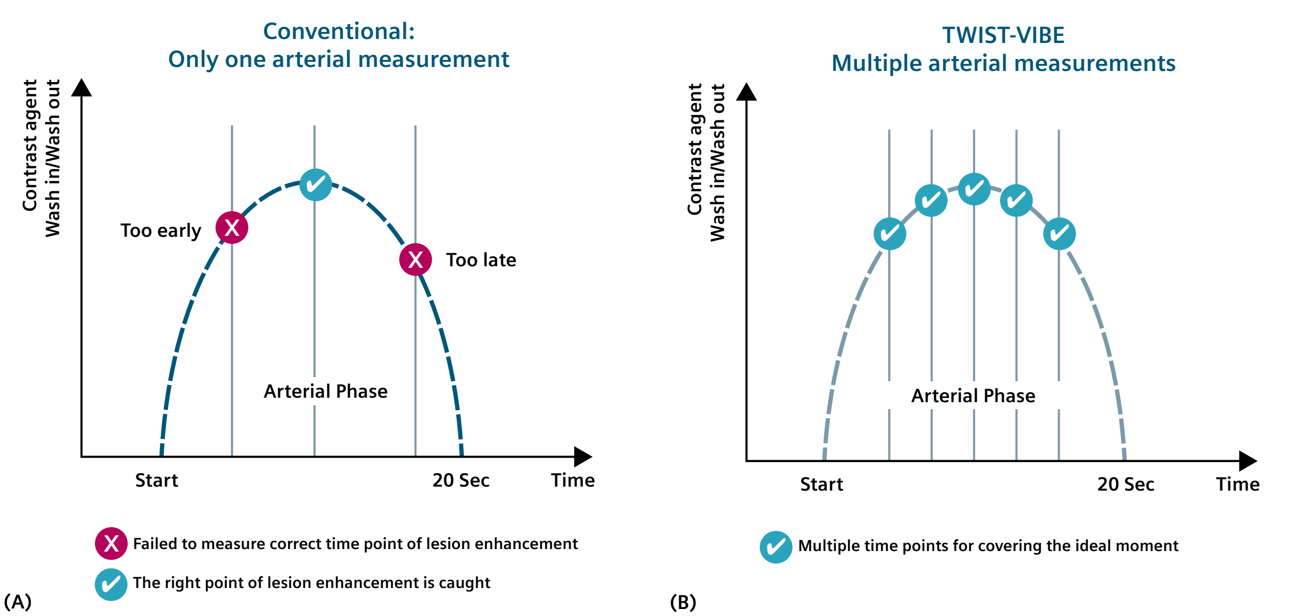
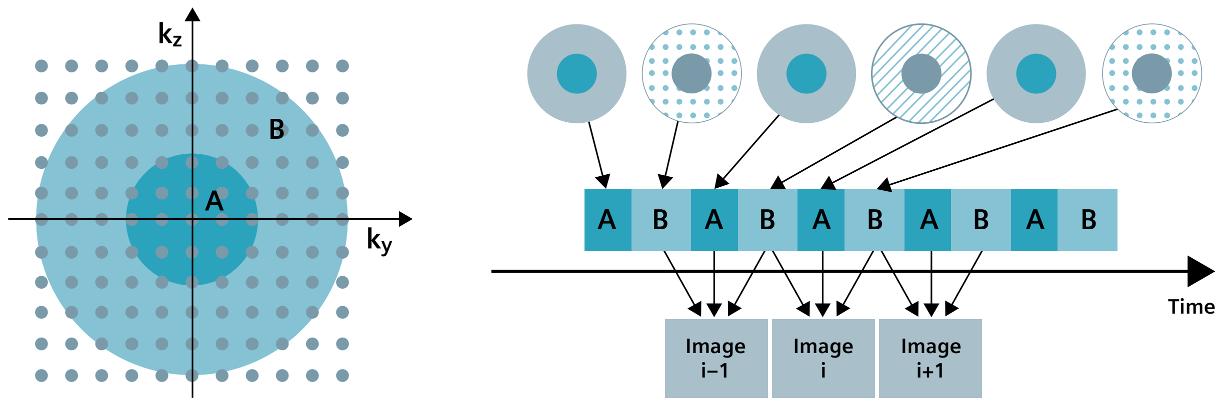


Figure 3: (A) The conventional approach can fail if the images are acquired either too early (only arterial signal is present) or too late (hepatic venous enhancement is present). (B) TWIST-VIBE enables high spatial and temporal resolution with full 4D coverage for multi-arterial imaging with precise contrast-timing.



(A) (B)

Figure 4. (A) TWIST divides k-space to regions A and B with different sampling properties to achieve faster update rates. (B) k-space points in Region B are sampled less frequently than region A and are shared across different time points.

CAIPIRINHA is a new parallel imaging technique for 3D volumetric imaging[9]. Compared with the GRAPPA technique, it modifies the image acquisition pattern to undersample k-space in both phase and partition directions to exploit the sensitivity variations in the receiver coil array more efficiently, allowing the use of higher acceleration factors and further reduction of acquisition time. Figure 5 shows a CAIPIRINHA sampling pattern with acceleration rate = 4.

Dixon fat/water separation technique is a robust method for fat suppression[10]. It is based on the chemical shift, i.e., the difference in resonance frequencies between fat and water protons. Two echoes are acquired: one in-phase echo and one opposed-phase echo to generate fat and water images. Compared to the conventional spectral fat-saturation technique, the Dixon technique is insensitive to B0 and B1 field inhomogeneities and suppresses fat more homogeneously in the abdomen. (Figure 6)

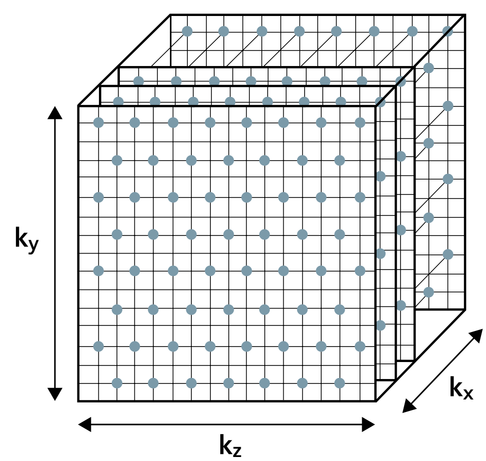


Figure 5. CAIPIRINHA sampling pattern (acceleration rate = 4)

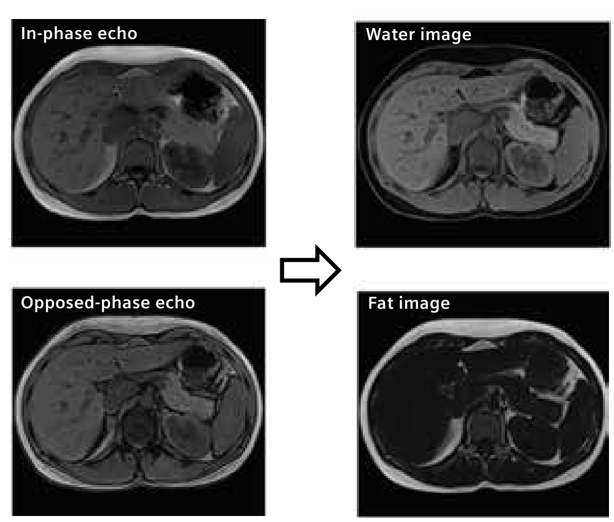


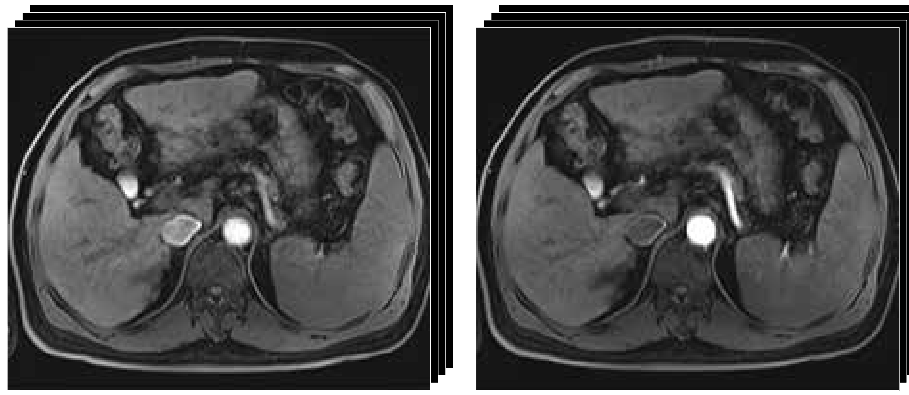
Figure 6

Capture the Right Contrast Timing with TWIST-VIBE

Liver

62-year-old patient with Hepato-Cholangiocellular Carcinoma (HCC).

TWIST-VIBE images were acquired in a 16 second breath-hold post contrast injection. A temporal resolution of 2.08 s ensures the capture of hepatic arterial images and well visualization of HCC. (64 slices per 3D data set every 2.08 seconds, 3mm, 180 x 316 matrix, 30 x 38cm FOV)



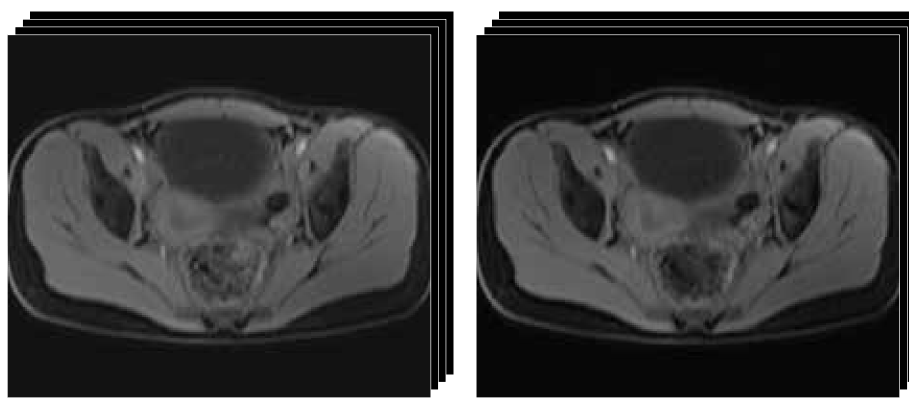
+8 s +10 s

Courtesy of PUMC Hospital, Beijing, P.R. China

Pelvis

14-year-old female with Massive Edema of the right ovary.

With super high temporal-resolution, TWIST-VIBE makes it feasible to do contrast-enhanced imaging in the pelvis. (64 slices per 3D data set every 3 seconds, 250 x 512 matrix, 32.5 X 40 cm^2 FOV)



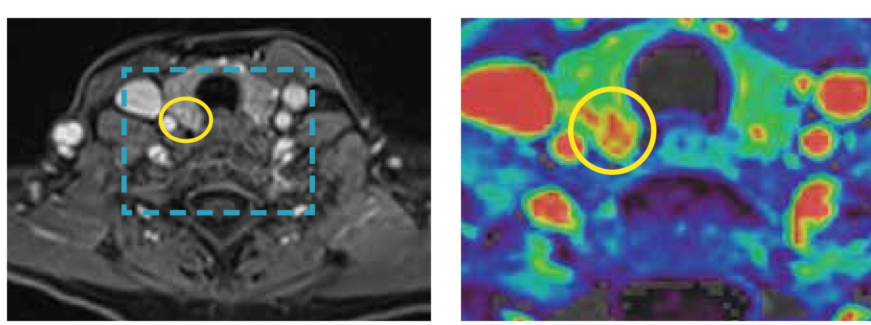
+0 s +3 s

Courtesy of Institut für Radiodiagnostik, Homburg, Germany

Head & Neck

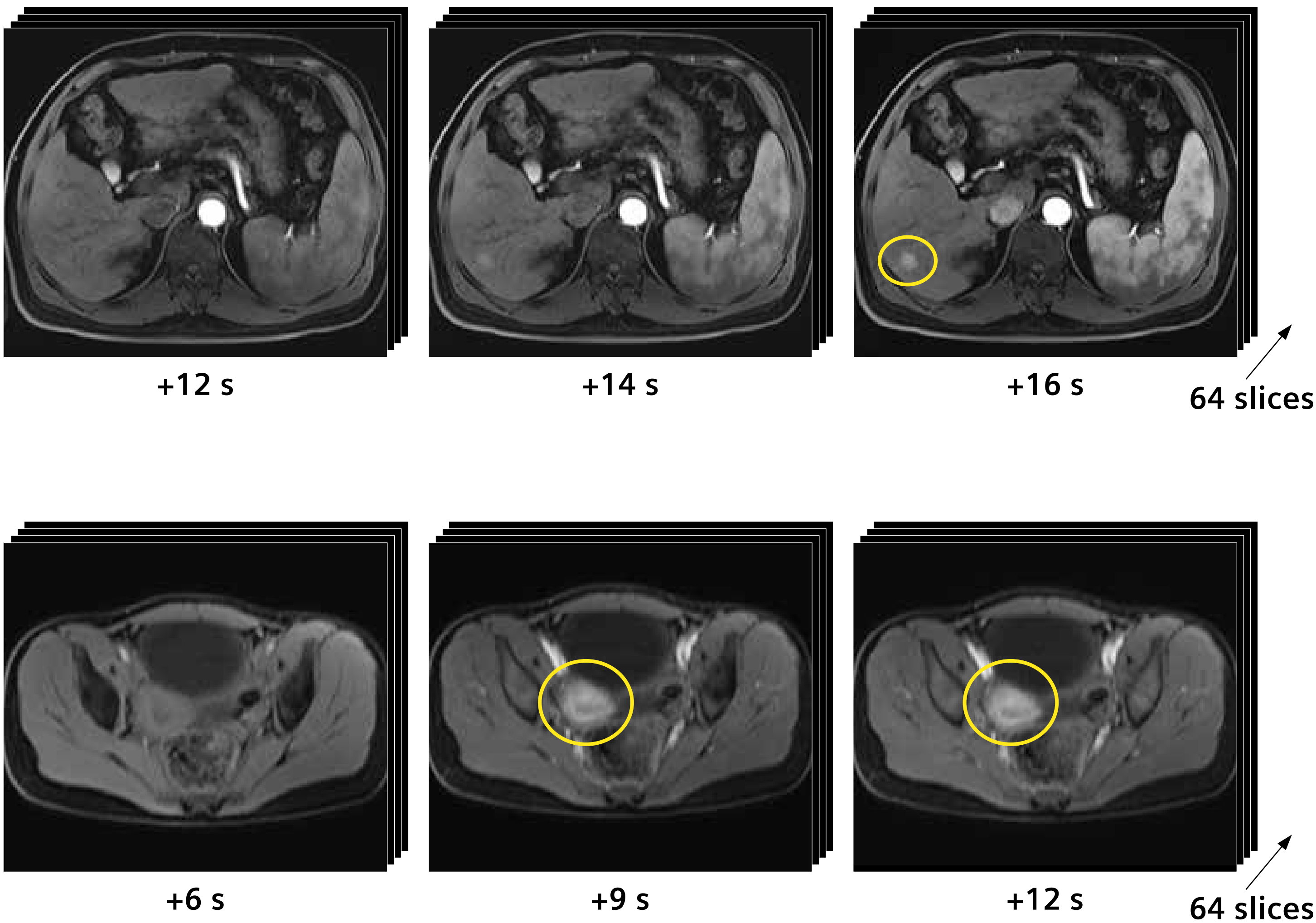
61-year-old patient with Adenoma of the right parathyroid gland.

(A) TWIST-VIBE visualizes the dynamic contrast uptake in the parathyroid. Area under the curve map (B) created from TWIST-VIBE dynamic series helps differentiate the adenoma from the normal tissue.
(2.3 mm,160 matrix, 20 cm, 25 slices per 3D data set, every 8 seconds)



(A) **(B)** (Color image processed by Olea software)

Courtesy R. Khahn, MD, K. Nael, MD University of Arizona, Tuscon AZ, USA


+12 s
+14 s
+16 s
64 slices
+6 s
+9 s
+12 s
64 slices

Conclusion

FREEZEit enables a more confident diagnosis by adding imaging speed and motion compensation to body MR imaging. StarVIBE provides free-breathing abdominal MR scans with strong motion robustness, which makes it possible to scan many patients who could not be scanned before. TWIST-VIBE allows imaging the entire arterial phase with multiple 3D data sets within seconds while maintaining a high spatial image resolution.

References

1. IMV 2013 MR Market Outlook Report December 2013.
2. Internal surveys conducted September 2013, February 2014.
3. Chandarana H, Block KT, Winfeld JM, Lala SV, Mazori D, Giuffrida E, Babb JS, Milla S. Free-breathing contrast-enhanced T1-weighted gradient-echo imaging with radial k-space sampling for paediatric abdominopelvic MRI. European Radiology, September 2013.
4. Chandarana H, Block KT, Rosenkrantz AB, Lim RP, Kim D, Mossa DJ, Babb JS, Kiefer B,Lee VS. Free-breathing radial 3D fat-suppressed T1-weighted gradient echo sequence: a viable alternative for contrast-enhanced liver imaging in patients unable to suspend respiration. Invest Radiology 46(10):648-53, 2011.
5. Block KT, Chandarana H, Fatterpekar G, Hagiwara M, Milla S, Mulholland T, Bruno M, Geppert C, Sodickson DK, Improving the Robustness of Clinical T1-Weighted MRI Using Radial VIBE, MAGNETOM Flash, 2013; 5:6-11.
6. Semelka RC, Martin DR, Balci NC. Magnetic resonance imaging of the liver: how I do it. J Gastroenterol Hepatol. 2006;21:632Y637.
7. Martin DR, Sharma P, Kitajima H. Challenges and Clinical Value of Automated and Patient-Specific Dynamically Timed Contrast-Enhanced Liver MRI Examination. MAGNETOM Flash 2009; 3:40-5.
8. Laub G, Kroeker R. *syngo*TWIST for Dynamic Time-Resolved MR Angiography. MAGNETOM Flash 2006; 3:92-5.
9. Breuer FA, Blaimer M, Mueller MF, Seiberlich N, Heidemann RM, Griswold MA, Jakob PM. Controlled aliasing in volumetric parallel imaging (2D CAIPIRINHA). Magn Reson Med. 2006 Mar;55(3):549-56.
10. Horger W, Kiefer B, Fat Suppression Techniques—a Short Overview, MAGNETOM Flash 2011; 1:56-9.

Notes

Order No. A911IM-MR-141079-P1-4A00
Printed in USA 05-2014 | All rights reserved

Local Contact Information
Siemens Medical Solutions USA, Inc.
51 Valley Stream Parkway
Malvern, PA 19355-1406
USA
Telephone: +1-888-826-9702
www.usa.siemens.com/healthcare

Global Business Unit
Siemens AG
Medical Solutions
Magnetic Resonance
Henkestr. 127
DE-91052 Erlangen
Germany
Telephone: +49 9131 84-0
www.siemens.com/healthcare

Global Siemens Headquarters
Siemens AG
Wittelsbacherplatz 2
80333 Muenchen
Germany

Global Siemens Healthcare Headquarters
Siemens AG
Healthcare Sector
Henkestrasse 127
91052 Erlangen
Germany
Telephone: +49 9131 84-0
www.siemens.com/healthcare

Legal Manufacturer
Siemens AG
Wittelsbacherplatz 2
DE-80333 Muenchen
Germany

www.siemens.com/healthcare