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The MAGNETOM Flash

Newsletter for Siemens MAGNETOM Users

IN THIS ISSUE...

From the Editor

This is the second issue in a series focusing on routine clinical MR angiographic techniques. Whereas the previous issue focused on time-of-flight (TOF) angiography techniques, this issue will focus on phase contrast angiography (PCA) techniques. We continue the new column called "Ask The Experts" in which acknowledged experts in the field of MRA will answer questions that you, our users, commonly ask. You will also find announcements of upgrades available for the MAGNETOM system, including the Gradient Overdrive System with enhanced Echo Planar Imaging (EPI). One article summarizes the clinical experience with ultrafast HASTE imaging at a prominent pediatric center. As always, this issue contains announcements about upcoming conferences, useful applications tips, and an interesting case history.

All articles represent the techniques and opinions of the authors and may not represent specific recommendations or endorsements from Siemens Medical Systems, Inc. Authors sometimes describe results from their own "home-brewed" or modified sequences and post-processing programs developed by their own in-house scientists. Contact them directly for further information about their unique techniques.

We urge you to contribute articles, images, announcements, interesting cases, questions, comments, etc. Your special technique or unique insight into a particular issue may be big news to other Siemens' users. Contact us by phone, fax, or mail to submit your contributions, to request previous issues, or to add your name to the mailing list for the MAGNETOM Flash (no home addresses).

Gary R. McNeal, Editor

THE MAGNETOM Flash

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186 Wood Avenue South
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Editor and Correspondence:
Gary R. McNeal
1108 Bradley Drive
Franklin, TN 37069
(800)753-6336,ext2112.
Fax (615) 591-7094

Technical Editor:
Helmuth Schultze-Haakh, Ph.D.

Contributions by:
Anne Deery
Michele McDonald
Dean Kaufman

ANNOUNCEMENT: GRADIENT OVERDRIVE UPGRADE

Siemens Medical Systems is pleased to announce the new Gradient Overdrive Upgrade option for the MAGNETOM Vision system to perform high speed imaging applications such as Echo Planar Imaging (EPI). Orders can be accepted immediately and deliveries will begin in the first quarter of 1996. The hardware/software upgrade will require approximately two days to perform, and will include:

1. EPI gradient performance on all three axes, allowing imaging with orthogonal, oblique, and double oblique orientations.

2. A reduction in the minimum rise time from 600 microseconds to 300 microseconds for the 25mT/m gradient system, applicable to sinusoidal gradient waveforms that may include "hybrids" such as sinusoidal ramps and varying gradient plateau periods. The faster rise time can be used for routine sequences as well as EPI sequences.

3. EPI sequences with Spin Echo, Inversion Recovery, and Free Induction Decay contrast behaviors.

4. Non-linear ADC sampling for acquisition of data during ramp up/down of sinusoidal gradients.

Since elevated dB/dt levels may cause mild peripheral stimulation, the new system software (B25A) also includes a "stimulation monitor". This software monitor checks each sequence prior to its loading to determine whether the dB/dt levels will exceed allowable thresholds. If exceeded, an "alert window" will appear on the operating console to inform the user that peripheral stimulation may be possible. To proceed with the exam, the user must acknowledge this message.

The clinical benefits of the Gradient Overdrive option include higher acquisition speeds, smaller FOV's, and the reduction in motion artifacts due to cardiac or respiratory motion. In addition, Siemens is realizing the evolution of "true" single shot EPI. This allows the acquisition of the most information in the shortest amount of time so that image quality and clinical benefits are maximized. For more information on the Gradient Overdrive option, contact your local Siemens sales representative.

ANNOUNCEMENT: COMFORT KIT

Siemens is pleased to announce the Comfort Kit for the MAGNETOM Vision, Impact, and Open systems -- the comfortable answer for patient immobilization. Sometimes even the most cooperative patient cannot hold still throughout the entire imaging exam. They cough. They sneeze. They simply cannot hold their position any longer due to pain. But any motion, regardless of intent, will result in artifacts that degrade the image quality and can interfere with the diagnosis.

The Comfort Kit consists of a vacuum pump and three cushions constructed from a lightweight Gortex shell filled with small soft pellets. The cushions are feather light to the patient, but the Gortex material is durable and easily washed.

Drape the cushion around the desired anatomic area. Connect the cushion to the built-in vacuum pump via a convenient connector on the patient table. Turn on the vacuum and the cushion will mold itself around the anatomy. The light, firm support stabilizes the anatomy and provides comfort to a patient in pain. A comfortable patient cooperates a little longer, which translates into better image quality and fewer repeat exams. When the exam is over, unplug the connector from the patient table to allow the cushion to quickly inflate to its original shape, ready for the next exam.

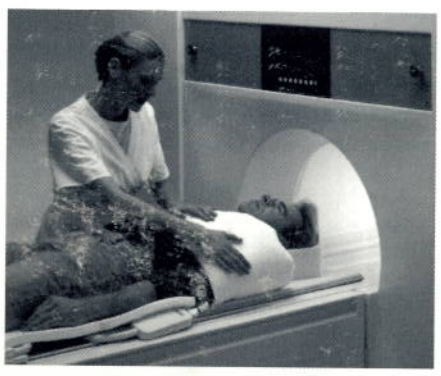


Figure 1. Positioning the medium sized vacuum cushion for a shoulder exam. (MAGNETOM Impact)

The 105 x 55 cm cushion recommended for abdomens and legs.

The 84 x 60 cm cushion recommended for large shoulders and elbows.

The 55 x 30 cm cushion recommended for small shoulders, wrists, and pediatrics.

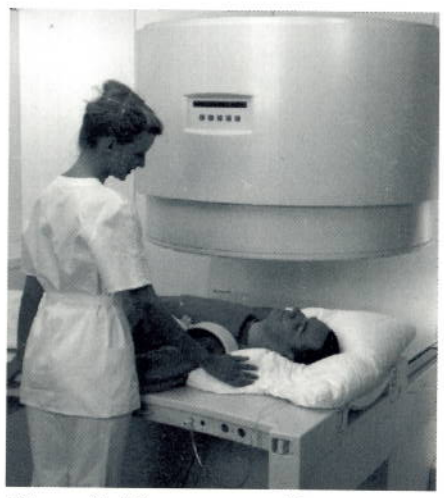


Figure 2. All vacuum cushions connect directly to the patient table top. (MAGNETOM Open)

Announcement: Seminars and Meetings

For additional information on any of these meetings, or to include a meeting announcement in our next issue of the FLASH, please contact Michele McDonald (MR Applications Group) at (908)321-3270 or fax (908)321-3219.

Nov 22-24, 1995	MRI 1995 5th Annual International Orthopedic & Sports Injuries Workshop, Chicago, IL
Nov 26, 1995	Radiological Society of North America, Chicago, IL
Feb 10-17, 1996	11th Annual Snowmass 1996: MR & CT of the Head and Spine, Snowmass, CO
Mar 9-16, 1996	Snowmass MRI in Clinical Practice, Snowmass, CO
Mar 21, 1996	ARRT Registry Exam for MRI (Application Deadline, January 1, 1996)
Apr 10-14, 1996	Siemens Spring MR Technologist Seminar, Omni Inner Harbor Hotel, Baltimore, MD
Apr 27-May 3, 1996	SMR, Magnetom Users Meeting, New York Hilton and Towers, New York City, NY
Jun 23-28, 1996	MRI Orthopedic Workshop, Vienna, Austria
Jul 21-26, 1996	11th Annual MRI 1996: National Symposium, Caesars Palace, Las Vegas, NV
Sep 4-8, 1996	8th Annual Advances in Mid & Low Field MRI. Buena Vista Palace, Lake Buena Vista, FL

CLINICAL ARTICLE: ULTRAFAST IMAGING

Alan DiGiovanne, B.S., R.T., MR Applications Specialist

Siemens Medical Systems, Philadelphia, PA

While fast imaging with MRI is becoming routine, it must be seen as a true benefit to the patient's diagnosis rather than to an institution's ability to increase profitability via increased throughput. Fast imaging should provide the spatial resolution and contrast resolution sufficient for good lesion conspicuity in a variety of clinical diagnoses. A new ultrafast imaging sequence available in the Siemens "Ultrafast Imaging Package" is Turbo Gradient Spin Echo (TGSE), essentially a hybrid between Turbo Spin Echo (TSE) and Gradient Recalled Echo (GRE). Another new ultrafast sequence in the package is Half Fourier Acquisition Single Shot Turbo Spin Echo (HASTE), essentially a Half Fourier TSE. While these two new sequences seem to be gradually gaining acceptance by some progressive MRI institutions, more education and experience are needed to promote wider acceptance throughout the entire MRI community.

During the first six months of 1995, Childrens Hospital of Philadelphia (CHOP) was testing the use of TGSE and HASTE for pediatric MR imaging. TGSE was determined to be as good as TSE (if not better) in all the cases that were tested. Also, TGSE was decidedly better than TSE in the detection of methemoglobin and deoxihemoglobin. It is assumed that this is due to the higher susceptibility sensitivity of the GRE components, although there have been other reports to the contrary. The CHOP group found it encouraging that TGSE was, at worst, comparable to TSE and in no cases less accurate. On the MAGNETOM Vision system at CHOP, the Siemens protocol HEAD.TRAUMA.T2_TGSE_TRA_512 was run axially on all routine brain exams (sequence tgse21_132b150.wkc at 294x512 matrix).

HASTE also has its unique advantages and disadvantages. With children, it is desirable to reduce the use of sedation when possible. If a pediatric patient gets restless, or begins to arrest from excessive sedation, imaging may be quickly concluded with the HASTE technique if the patient motion is only slight occasional jerking. Since HASTE acquires T2-weighted snapshot images at a rate of about 1 or 2 seconds per slice, any images that are corrupted by patient motion can simply be re-imaged in a very short period. Some of the disadvantages of using HASTE for pediatric head imaging were that the grey/white matter contrast was poor, there was a general "fuzziness" in resolution, and it was difficult to get enough slices to cover the entire head in a single scan. The need for improved grey/white matter contrast is the most critical of these disadvantages. Although HASTE is used at CHOP for all children (regardless of age), it has really been an asset (due to its speed) for imaging the unsedated child and the child who is slowly arousing from sedation. HASTE was also seen as a potential major tool for the detection of shunt paths and shunt fluid levels in both children and adults. Also, HASTE seems to be "superb" in detecting spinal syrinx in both children and adults. On the MAGNETOM Vision system at CHOP, the Siemens protocol HEAD.PEDIATRIC.T2_SINGLE_SHOT is performed in all three planes (interleaved) on all routine brain exams (haste240_87b260.wkc sequence). The Siemens protocol SPINE.LUMBAR.T2_HASTE_SAG_GAP_1 is performed in the sagittal mid-line for all spine exams (sequence haste240_87b260.wkc).

Based upon the results at Childrens Hospital of Philadelphia, we have good reason to be optimistic that the ultrafast imaging sequences TGSE and HASTE which are currently available for the MAGNETOM Impact, Impact Expert, and Vision systems (Ultrafast Imaging Option) will become useful tools in the day-to-day business of MR Imaging.

The sequences and protocols tested, to date, were run under software version B21A on the MAGNETOM Vision using the CP Spine Array coil for spines and the CP Head coil for heads. Recently, CHOP has updated to software version B21C with the accompanying gradient hardware update for 600 microsecond risetimes. Improved TGSE and HASTE sequences are now available which utilize the faster gradients for quicker scan times and minimal image blurring. It will be interesting to see if these new sequences will be incorporated into routine use by the MR department at CHOP.

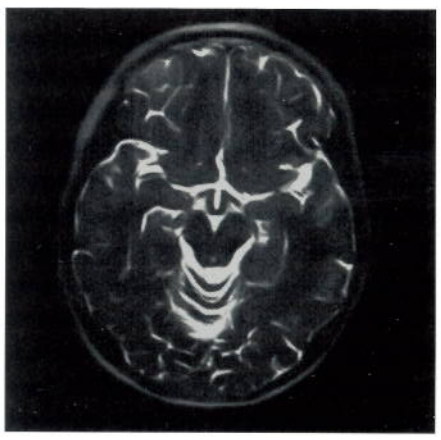


Figure 5: Ultrafast HASTE T2-weighted pediatric head, sequence used was haste240_87b260.wkc, TR 10.9 ms, TE 87 ms, Flip 180 deg, FOV 200 mm, no RecFOV, Swap, matrix 240h x 256o, slice 5 mm, 1 acquisition, scan time 26 sec, F:9 image filter. (Courtesy of Childrens Hospital of Philadelphia)

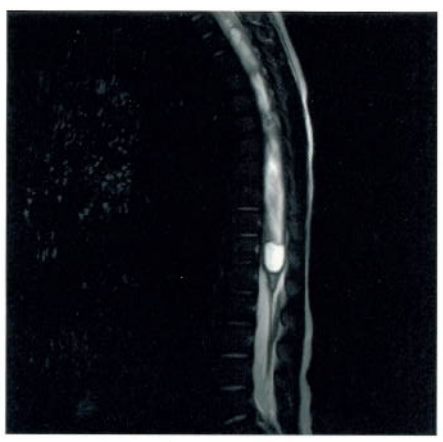


Figure 1: Turbo Spin Echo T2-weighted pediatric spine pathology, sequence used was TSE11_99b130.wkc, TR 5400 ms, TE 99 ms, Flip 180 deg, FOV 300 mm, 6/8 RecFOV, no Swap, matrix 308 x 512o, slice 3 mm, 2 acquisitions, scan time 5+ min, F:7 image filter. (Courtesy of Childrens Hospital of Philadelphia)

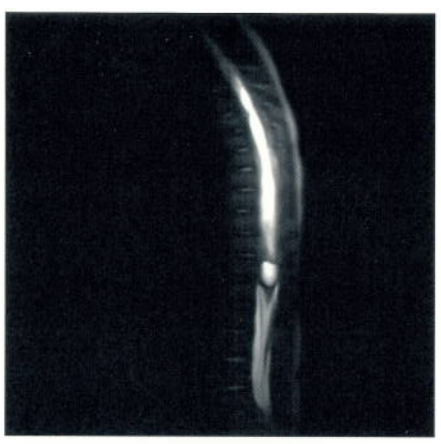


Figure 2: Ultrafast HASTE T2-weighted pediatric spine pathology, sequence used was haste240_87b260.wkc, TR 10.9 ms, TE 87 ms, Flip 150 deg, FOV 280 mm, no RecFOV, no Swap, matrix 240h x 256o, slice 5 mm, 1 acquisition, scan time 10 sec, F:7 image filter. (Courtesy of Childrens Hospital of Philadelphia)

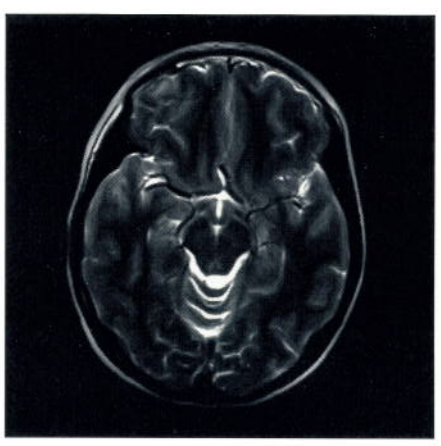


Figure 3: Turbo Spin Echo T2-weighted pediatric head, sequence used was TSE5_16b130_98b130.wkc, TR 3000 ms, TE 16/98 ms, Flip 180 deg, FOV 210 mm, 6/8 RecFOV, Swap, matrix 190 x256o, slice 5 mm, 2 acquisitions, scan time 4- min, F:9 image filter. (Courtesy of Childrens Hospital of Philadelphia)

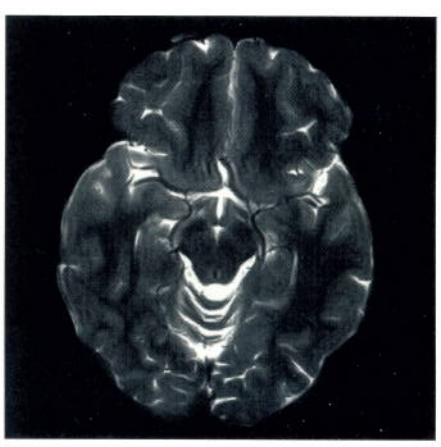


Figure 4: FatSat Turbo Gradient Spin Echo T2-weighted pediatric head, sequence used was tgse21_132b150.wkc, TR 5016 ms, TE 132 ms, Flip 180 deg, FOV 200 mm, RecFOV, Swap, matrix 378 x512o, slice 5 mm, 2 acquisitions, scan time 6+ min, F:9 image filter. (Courtesy of Childrens Hospital of Philadelphia)

TIPS: 63SP TECHNIQUES

Jim Mackey, R.T., MRI Technologist
The Methodist Hospital, Houston, TX

Figure 1. Standard bandwidth sequence se_17b130 has some metal artifact.

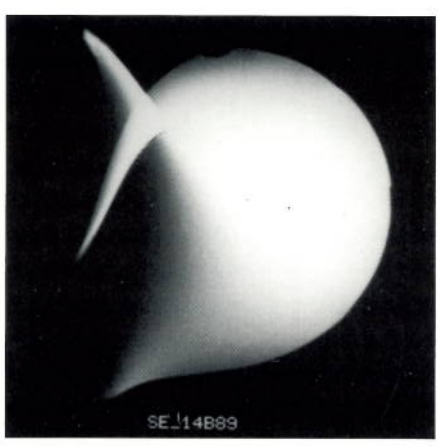


Figure 2. Low bandwidth sequence se_14b89 has more exaggerated metal artifact.

Metal artifact reduction

The low bandwidth sequence se_14b89 delivers excellent T1 contrast and SNR, but will exaggerate metal artifacts as compared to higher bandwidth sequences such as se_15b130, se_17b130, or se_22rb156. These alternative sequences offer adequate T1 contrast and SNR for most applications, while somewhat limiting the signal void and spatial warping from metal. Artifacts from oral orthodontics are greatly reduced by these higher bandwidth sequences, while artifacts from spinal fusion wires and spinal rods are only slightly reduced.

Breath-hold Fatsat

The standard FatSat sequence flash2d_10b130_fs63 in software version A2.7 can be used as a breath-hold scan for the abdomen and pelvis. Selecting a matrix 128 x 256 and TR 172 ms will allow 4 slices in 25 seconds, or selecting TR 129 ms will allow 3 slices in 19 seconds. While not a slice intensive technique, this is useful for looking at the pancreas and the adrenal glands as an additional post-contrast exam. With a TE 10 ms, pulsation and flow artifacts can be a problem due to the absence of presat bands. In this case, swap the phase/readout directions.

TECHNICAL ARTICLE: PHASE CONTRAST ANGIOGRAPHY

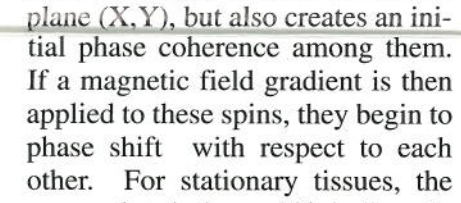
Jay Rocker, B.S., R.T., MR Applications Specialist
Siemens Medical Systems, Minneapolis, MN

Introduction

MR Phase Contrast Angiography (PCA) is based upon the principle that moving spins (protons) acquire a phase shift at a rate proportional to their velocity when they are subjected to a magnetic field gradient. By measuring the amount of phase shift, we can measure the magnitude and direction of the flow. Reasons for choosing this method of MR angiography are two-fold. First, PCA can improve the detection of slow-flowing vessels by superior background suppression. Second, PCA can provide information about the flow dynamics of the visualized vessels due to its inherent velocity-phase relationships. Whereas time-of-flight angiography (TOF) is based upon differences in the longitudinal magnetization, PCA is based upon differences in the transverse magnetization. Both methods have 2D and 3D sequences available and both methods can use Maximum Intensity Projections (MIP) for post-processing.

Flow Induced Phase Shifts

A 90 degree RF pulse not only tips fully relaxed spins from the longitudinal axis (Z) into the transverse plane (X,Y), but also creates an initial phase coherence among them. If a magnetic field gradient is then applied to these spins, they begin to phase shift with respect to each other. For stationary tissues, the accumulated phase shift is linearly proportional to the magnitude and the duration of the applied gradient pulse. Thus, in the graph below, you see a linear increase in the accumulated phase shift of stationary spins during a gradient pulse. Any gradient pulse causes phase shifting, even those gradients applied during an imaging sequence for spatial encoding in the phase, readout, and slice directions. When the gradient is turned off, the phase shift is maintained until another gradient pulse is applied. Thus, you see a plateau in the graph below. Any equal and opposite gradient pulse will exactly reverse the accumulated phase shift until the spins are completely rephased with respect to each other and the net phase shift is zero.



Although the phase shift is linear for stationary spins, the phase shift is non-linear for moving spins. Furthermore, for moving spins, the net phase shift is not zero after a bipolar pair of gradient pulses. When the first pulse is applied, the stationary and moving spins begin to accumulate phase shifts. When the second pulse is applied, the phase shift of the stationary spins is completely compensated. Moving spins, however, have travelled some distance since the first pulse and will experience a different gradient field than the stationary spins during the second pulse. Incomplete compensation of the moving spins causes a residual phase shift which is proportional to their velocity along the direction of the gradient, as expressed by :

$\Phi = \gamma$ VTA.

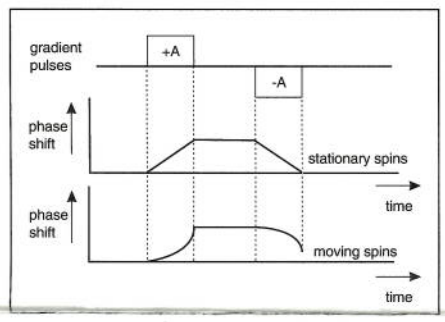
Φ is the flow induced phase shift

γ is the gyromagnetic ratio

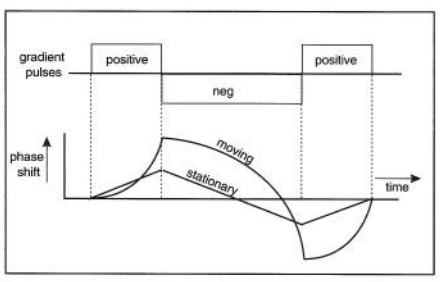
V is the velocity component in the direction of the gradient

T is the time interval between the centers of each pulse

A is the area of each pulse (amplitude times duration)

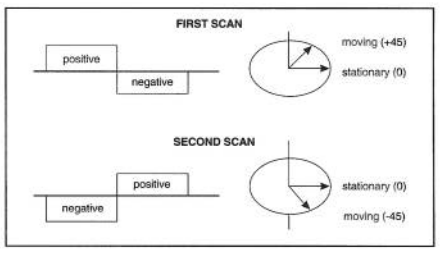


If one wishes to eliminate the residual phase shift Φ, one must replace the second gradient pulse itself with a negative/positive bipolar pair, thus using a total of three pulses to compensate not only the stationary spins but also the moving spins. This method of flow compensation for constant velocity motion is known as gradient motion rephasing (GMR).



Phase Contrast Sequences

PCA sequences use bipolar gradient pulses to encode the magnitude and direction of flowing spins. The superior background suppression of PCA results from the fact that, ideally, the stationary spins accumulate no net phase shift from a bipolar gradient pair but the flowing spins do. Often, however, some small phase shift can actually occur in stationary spins from small variations in the magnetic field (inhomogeneities or susceptibility). To overcome this non-ideal case, it is possible to eliminate any unwanted phase shift from stationary spins by acquiring two biplolar scans and subtracting the two data sets. For example, the first data scan is acquired with a +/- bipolar gradient pair and the second scan is acquired with a -/+ bipolar gradient pair. This ensures that the phase shifts in the stationary background tissues will cancel out and that the phase shifts in the flowing tissues will actually be accentuated after subtraction. In the figure below, for example, the stationary spins have no net phase shift from either the first or the second scan, so they cancel out after the subtraction. The moving spins have a +45 degree phase shift after the first scan and a -45 degree phase shift after the second scan, so subtraction of the moving spins yields a maximum signal with a phase shift of +90 degrees. The classical Six Point method requires that two such scans be acquired in each of the three directions (X,Y,Z).



Siemens PCA sequences, however, use a very efficient Four Point Null method. Three separate scans are acquired with bipolar gradient pulses to encode flow separately for each of the three axes and another scan is acquired with flow compensation in all axes. All four scans are interleaved within the same TR period to minimize patient motion misregistration artifacts. Then, the three flow-encoded echoes are each subtracted from the flow-compensated echo.

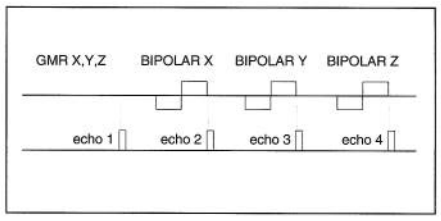
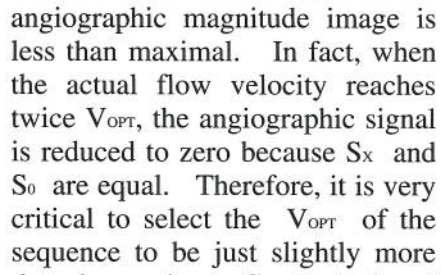


Image Reconstruction

During image reconstruction, two types of subtractions may be performed on the resulting four echoes. For 2D PCA sequences, a complex subtraction is performed to obtain a magnitude image for a typical angiographic depiction of the flow and a phase subtraction is performed to obtain a phase image for a directional depiction of the flow. For 3D PCA sequences, only a complex subtraction is performed. For flow quantification sequences, only a phase subtraction is performed. In the figure below, the vector S_x represents the signal from spins which are flow encoded along the X axis and the vector S_0 represents the signal from spins which are flow compensated along all axes simultaneously. S_0 and S_x correspond to echo 1 and echo 2, respectively, whereas S_Y and S_Z (not shown) correspond to echo 3 and echo 4, respectively. Complex subtraction measures the length of the difference vector D_x which is used to represent the pixel intensity in a magnitude image (figures 2-5). Phase subtraction measures the angle Φ_x which is used to represent the pixel intensity in a phase image (figures 6-8). In this example, the X axis could represent either the Phase, Readout, or Slice encoding direction.



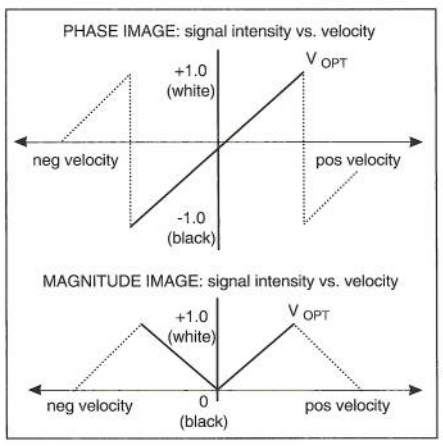
The maximum signal strength is obtained for a phase difference Φ_x of 180 degrees between the flow encoded and flow compensated spins. The flow velocity corresponding to this maximal phase shift represents the flow sensitivity of the sequence. Although some equipment manufacturers refer to this flow sensitivity factor as the Velocity Encoding factor (VENC), Siemens refers to it as the Optimal Velocity range (V_{OPT}). The amplitude and duration of the bipolar gradient pulses in the sequence determine the V_{OPT} for that sequence. When the actual flow velocity of the blood exceeds the selected V_{OPT} of the sequence, the phase angle Φ_x exceeds 180 degrees and, thus, the magnitude of the difference vector D_x is no longer maximal. In this case, the contrast of the blood vessel in the angiographic magnitude image is less than maximal. In fact, when the actual flow velocity reaches twice V_{OPT}, the angiographic signal is reduced to zero because S_x and S_0 are equal. Therefore, it is very critical to select the V_{OPT} of the sequence to be just slightly more than the maximum flow velocity of the blood vessel being imaged. This is the most important choice you must make when using PCA. In order to estimate the maximum blood flow of the vessel of interest, it is quite common to use several quick scans with 2D PCA at several different values of V_{OPT}, and then use the optimal V_{OPT} for a subsequent 3D PCA with higher resolution.

Magnitude images represent the "speed" of the flowing blood, irrespective of the direction of flow, so they are often referred to as "speed" images. In magnitude images, pixel intensities are displayed from black to white as "speeds" range from zero to maximum (regardless of direction). Phase images represent both the "speed" and direction of the flowing blood. In phase images, zero flow is displayed as a mid-grey pixel intensity, maximum flow in the positive direction is displayed as white, and maximum flow in the negative direction is displayed as black. In the figures below, V_{OPT} occurs at +/-180 degrees phase shifts: the bold lines represent signal from flow velocities within V_{OPT} and the dotted lines

(continued on page 4)

Phase Contrast Angiography (continued)

represent signal aliasing which occurs when the actual flow velocity exceeds V_{OPT} .



From a 2D PCA sequence, eight different images may be produced from various subtraction reconstructions among the four measured echoes. The first image demonstrates a magnitude reconstruction of flow compensated in all directions, and it looks like a typical Gradient Echo image with flow compensation. The next three images use complex subtraction between a flow-encoded echo and a flow-compensated echo. The second image demonstrates a magnitude reconstruction with flow encoding in the PHASE direction; flow along the Y axis is bright whether it is going anterior or posterior. The third image demonstrates a magnitude reconstruction with flow encoding in the READOUT direction; flow along the Z axis is bright whether it is going superior or inferior. The fourth image demonstrates a magnitude reconstruction with flow encoding in the SLICE direction; flow along the X axis is bright whether it is going left or right. The fifth image demonstrates a magnitude reconstruction with flow encoding in all three directions; flow along all axes is bright regardless of its direction. This image results from combining the images 2 through 4. For a 3D PCA sequence, only this fifth image reconstruction is produced for each partition. The sixth image demonstrates a phase reconstruction with flow encoding in the PHASE direction; flow along the Y axis is bright when going anterior or dark when going posterior. The seventh image demonstrates a phase reconstruction with flow encoding in the READOUT direction; flow along the Z axis is bright when going superior or dark when going inferior. The eighth image demonstrates a phase reconstruction with flow encoding in the SLICE direction; flow along the X axis is bright when going left or dark when going right.

Phase Contrast Applications

The main clinical benefits of PCA derive from its excellent background suppression, its sensitivity to slow flow, and its ability to demonstrate not only the "speed" but the direction of flow. PCA methods are insensitive to short T1 tissues (fat, or gadolinium enhanced structures) which can be confused with flow signal when using TOF methods. PCA depicts a wide range of inplane flow velocities in a large anatomic region without significant signal saturation problems experienced by time-of-flight (TOF) techniques. Quantitative analyses may be performed with PCA techniques to measure not only vascular flow rates but also CSF flow rates. The single slice 2D PCA technique is actually the fastest MR angio technique available. Slow flow applications include the imaging of the sagittal sinus, large aneurysms, arterial-venous malformations, spinal dural fistulas, venous angiomas, CSF flow, and any veins throughout the body. Fast flow applications include the imaging of the carotid arteries, intracranial arteries, the aorta, iliac arteries, and peripheral arteries in the arms and legs. 2D PCA sequences may be acquired with cardiac triggering to provide cine displays of blood or CSF flow. PCA should always be used as an adjunct to 3D TOF, 2D TOF, or both.

Although the PCA technique relies upon phase shifts of flowing spins to generate the signals, there is still some tendency toward signal saturation if the excitation pulse has too large a flip angle or if the repetition period is too short. Thus, it is recommended to use flip angles of about 10-15 degrees and be aware of possible saturation of very small vessels or very slow flow if using a TR shorter than about 30-60 ms.

Since the use of gadolinium as in intravascular contrast agent is still investigational, Siemens does not recommend it for diagnostic MR angiographic imaging. However, if gadolinium is being used for investigational purposes, please note that preliminary studies have suggested that gadolinium will shorten the T1 signal of the blood, which tends to reduce the slight spin saturation effects of the PCA sequence (see Reference). The resulting increase in signal-to-noise allows visualization of smaller and/or slower-flowing vessels as compared to a PCA sequence without gadolinium.

Recommendations for typical PCA techniques include:

CIRCLE WILLIS:
V_{OPT} 60-80 cm/s, Axial

VERT/BASILAR:
V_{OPT} 30-45 cm/s, Cor

SAGITTAL SINUS:
V_{OPT} 10-30 cm/s, Sag

CAROTID:
V_{OPT} 45-60 cm/s, Sag

RENAL:
V_{OPT} 30-45 cm/s, Axial

ARMS/LEGS:
V_{OPT} 10-30 cm/s, Cor/Sag

HANDS/FEET:
V_{OPT} 5-10 cm/s, Cor/Sag

Reference:

Clinical Magnetic Resonance Angiography, Anderson, Edelman, Turski, Raven Press, 1993.

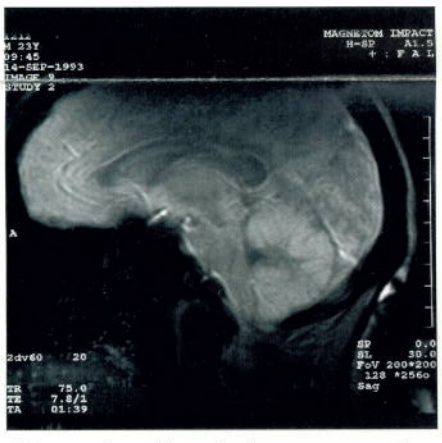


Figure 1. Magnitude reconstruction with flow compensated in all directions: length of S_0

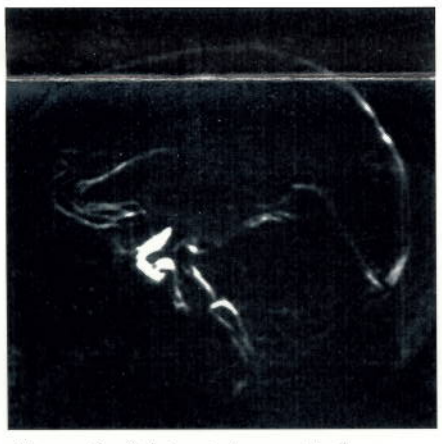


Figure 2. Subtracted magnitude reconstruction with flow encoding in the PHASE direction: length of $D_P=S_P - S_0$

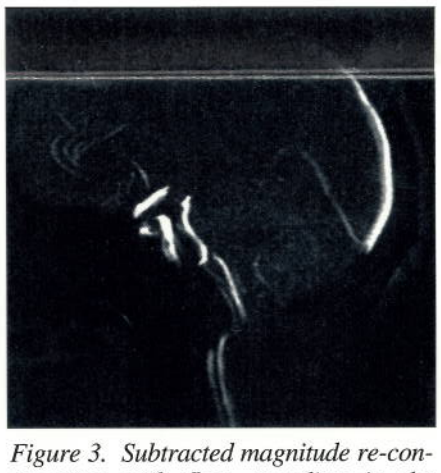


Figure 3. Subtracted magnitude re-construction with flow encoding in the READOUT direction: length of $D_R=S_R-S_0$

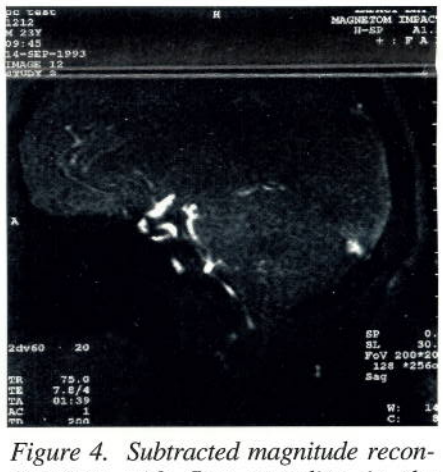


Figure 4. Subtracted magnitude reconstruction with flow encoding in the SLICE direction:length of $D_S = S_S - S_0$

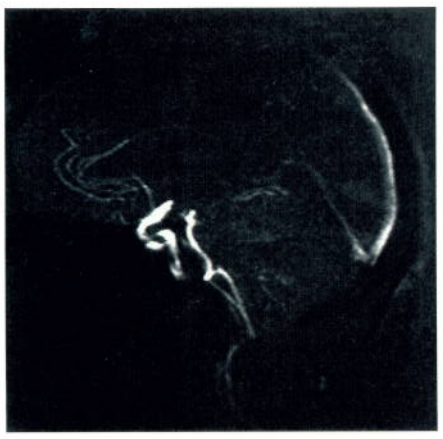


Figure 5. Combined magnitude reconstruction with flow encoding in all directions:length of $\sqrt{(D_P^2 + D_R^2 + D_S^2)}$

Figure 6. Subtracted phase reconstruction with flow encoding in the PHASE direction: angle of Φ_P

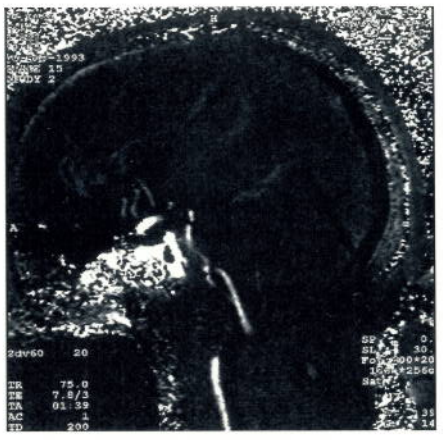


Figure 7. Subtracted phase reconstruction with flow encoding in the READ-OUT direction: angle of Φ_R

Figure 8. Subtracted phase reconstruction with flow encoding in the SLICE direction: angle of Φ_S

TIPS: CLAUSTROPHOBIA

Jose Lopez, R.T., MRI Technologist

Johns Hopkins Bayview Medical Center, Baltimore, MD

As an MR tech for the past 10 years, I have found that "communication" is the best way to deal with claustrophobic patients. Most patients feel like they are going into a coffin. I provide relief to their fears by explaining in detail the procedure, including the placement of the coil over the anatomy to be scanned, the loud knocking sound, and the need for him/her to be perfectly still during and between scans. Most importantly, I tell the patient that he is not alone, he is not tied down. I am monitoring him all the time, but he can remove himself from the scanner if he ever feels the need. For the seriously claustrophobic patient, we typically apply sedation.

I have also found another method for dealing with claustrophobia. Have the patient close his/her eyes and put your hand in front of his eyes, then have him open his eyes. Explain that if he cannot see how tight it is in the bore he will probably not feel claustrophobic. Then place an eyeshade mask over his eyes and have him close his eyes before entering the bore. Reassure him as often as possible during the exam and keep him updated on the scan time for each study. This procedure allows many patients who suspect that they are claustrophobic to successfully complete the exam without the need for sedation.

ASK THE EXPERTS:

PHASE CONTRAST OR TIME-OF-FLIGHT?

Ralph E. Lee, M.A., R.T. (R, MR), MRI Research Associate
UCSF-VA Campus

Since both phase contrast angiography (PCA) and time-of-flight (TOF) techniques seem to provide good MRA images of the intra-cranial arteries, which technique should you use? One way to answer this question is to look at what other MRI sites are doing. I often ask technologists attending multi-vendor seminars which techniques they are using. Five or six years ago, about 25% of the sites were using 3D PCA techniques for imaging the intracranial arteries of the Circle-of-Willis. This number has now dropped to below 10% of sites running 3D PCA as their first choice. Most high-field sites, irrespective of vendor, are choosing 3D TOF as their principle screening tool for pathologies of intracranial arteries and they are running 2D PCA or 3D PCA techniques only in those few cases where something questionable is identified on their TOF images.

The 3D TOF technique is quick to acquire, offers high resolution source images (which should be filmed), and provides high quality MIP images. This technique consistently identifies arterial flow within the velocity ranges commonly encountered in all but the most extreme cases. The 3D TOF technique is faster to acquire and, because of its shorter minimum TE, suffers less than 3D PCA from artifactual loss of vascular signal at sites of turbulent blood flow (areas of severe and critical stenosis). The 2D PCA technique is fastest to acquire, but an axial 2D PCA scan provides only low resolution axial MRA images which cannot be viewed from various angles.

The 3D TOF technique has some known limitations which are overcome with PCA techniques. First, it can fail to show vessels that exhibit very slow flow, such as the venous sinuses of the brain, the venous components of an AVM, and redundant flow within a giant aneurysm. For example, blood in a giant cerebral aneurysm remains in the imaging volume for an extended time and looses its bright flow signal. When this is suspected (by reviewing a quick MIP done before the patient leaves the scanner), a fast 2D PCA scan should be performed through the same area to answer the question. Position a 2D PCA slab with the same thickness and location as your 3D TOF slab (3 cm to 5 cm, axial). A velocity encoding range (V_{OPT}) of 10 cm/sec or 20 cm/sec from the "ICV SLOW FLOW" protocols might be a good choice in this instance. If there is any flow at all within the aneurysm, this technique should show it better than a 3D TOF technique. Notice that fast flow may still be visible with PCA due to velocity aliasing.

The second limitation of the 3D TOF technique is that background tissues with unusually short T1 characteristics may not be well suppressed, and these may mimic the bright signal of flowing blood. Tissues of this kind include blood in the methemoglobin stage of breakdown or gadolinium enhanced tissues with artificially shortened T1 characteristics. Methemoglobin from a bleed remains bright (although not moving) and mimics flow. If this is suspected, a fast 2D PCA scan should be performed through the same area to answer the question. A velocity encoding range (V_{OPT}) of 45 cm/sec or 60 cm/sec from the "ICV FAST FLOW" protocols might be a good choice in this instance. If the bright spot is eliminated with the 2D PCA technique, it is a short T1 tissue rather than actual flow.

These additional 2D PCA scans should only take a couple of extra minutes to acquire. They require no MIP post-processing since they are single slice techniques. They provide quick, low resolution answers to the clinical questions "is there flow or not in that suspected aneurysm" or "is that bright spot actually flow or just a bleed". If high resolution evaluation of small structures is required in addition to answering these "yes/no" questions, the results of the 2D PCA scan may be used to choose the optimal velocity encoding range (V_{OPT}) for a more lengthy 3D PCA scan. This topic will be addressed in the next issue of the MAGNETOM Flash.

For those MAGNETOM SP users who have no PCA sequences, a quick axial 32 partition 3D Rephased-Dephased MRA scan will usually suffice for met-hemoglobin subtraction and a few quick axial 2D TOF slices will usually provide images of blood flow which is too slow for 3D TOF techniques.

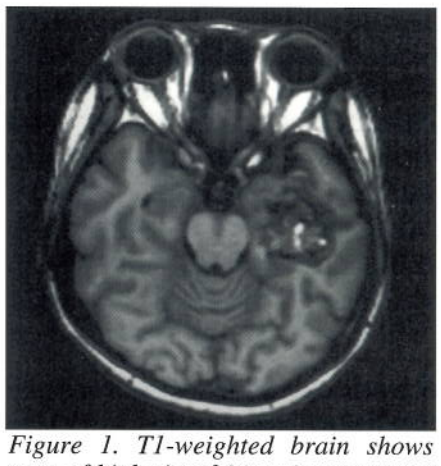


Figure 1. T1-weighted brain shows area of high signal intensity consistent with short T1 blood in the methemoglobin stage of breakdown. This would also show up on a time-of-flight MRA.

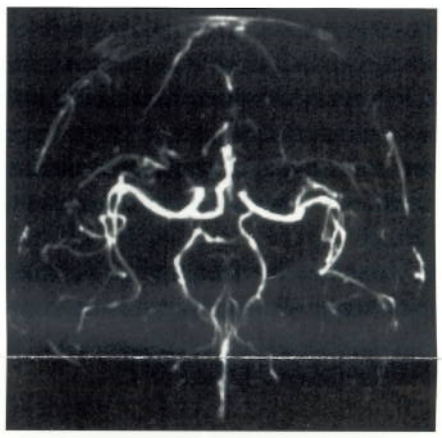


Figure 2. PCA of the same patient shows complete removal of this potential "flow mimicking" artifact.

TIPS: CHOLANGIOGRAPHY

Gary McNeal, M.S., MR Applications Specialist
Siemens Medical Systems, Iselin, NJ

MR cholangiography of patients with obstructive jaundice has been shown to demonstrate the site and extent of stricture of the biliary system, and to map the extent of biliary dilatation. This type of exam is preferably done with a coronal breath-hold scan using a strongly T2-weighted HASTE sequence. If HASTE is unavailable, try a coronal breath-hold scan using a strongly T2-weighted 3D PSIF sequence. Although it is common to MIP process the results, the individual slices must be filmed and interpreted as well. The patient should be fasting prior to the exam in order to dilate the gall bladder. Again scanning the patient following a fatty meal or snack will reveal if the gall bladder is properly emptying.

For MAGNETOM systems with the Ultrafast Imaging Option (available for the MAGNETOM Impact, Impact Expert, and Vision), use a coronal breath-hold HASTE sequence with a high matrix (240hx256,o), thin slices (4-5 mm), a moderate FOV (320-400 mm), the shortest possible echo spacing (TR 10-12 ms), the longest possible echo time (TE 80-100 ms), a moderate refocusing pulse (120-180 deg), no phase oversampling, no RecFOV, FatSat when available (remember to shim), no presats, no swap of phase/readout, and no gradient motion refocusing. To avoid wrap from the patient's arms, position them on his chest for a coronal acquisition.

For MAGNETOM systems without the Ultrafast Imaging Option, use a coronal breath-hold 3D PSIF sequence with a low matrix (96x256,o), thin slices (4-5 mm), a moderate FOV (320-400 mm), the shortest possible repetition time (TR 9-17 ms), the shortest possible echo time (TE 5-7 ms), a large excitation pulse (70-90 deg), no phase oversampling, RecFOV 6/8 when available, no FatSat, no swap of phase/readout, and GMR along the slice selection direction.

Reference: Beyond Rapid Spin Echo Lies Even Greater Utility, Litt, Kaufman, MR - The News Magazine of Magnetic Resonance, Miller Freeman Press, Vol.4, No. 2, Spring 1994.

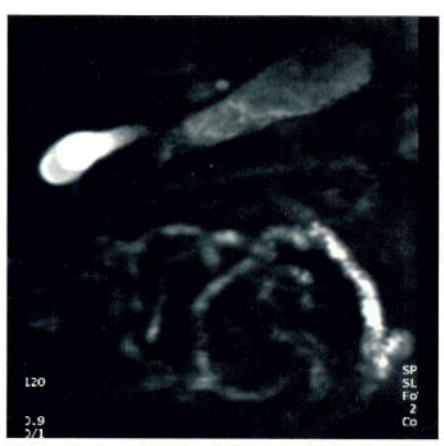


Figure 1. MIP of figure 2, including only those slices through the gall bladder.

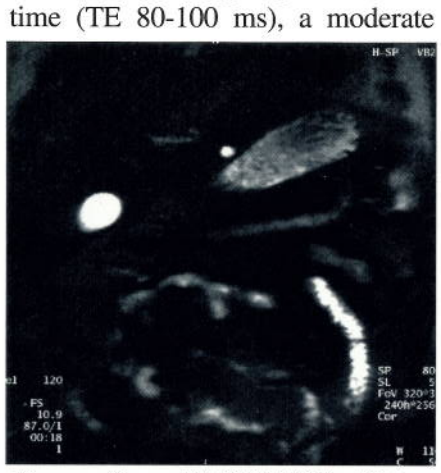


Figure 2. MAGNETOM Vision, haste240_87b260.wkc, matrix 240hx256o, slice 5 mm, FOV 320 mm, TR 10.9 ms, TE 87 ms, flip 120 deg, FatSat, acquisition time 18 sec.

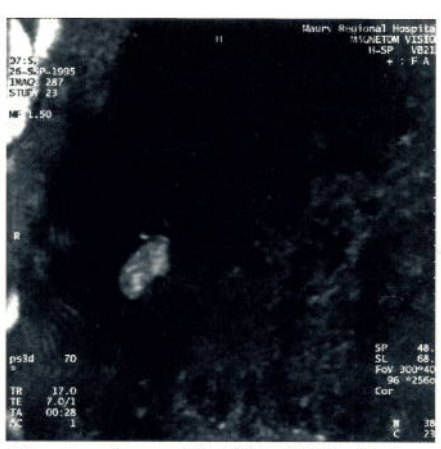


Figure 3. MAGNETOM Vision, ps3d_7rsb195.wkc, matrix 96x256o, slab 64 mm, partitions 16, FOV 400 mm, TR 17 ms, TE 7 ms, flip 70 deg, RecFOV 6/8, acquisition time 28 sec. (Courtesy of Maury Regional Medical Center).

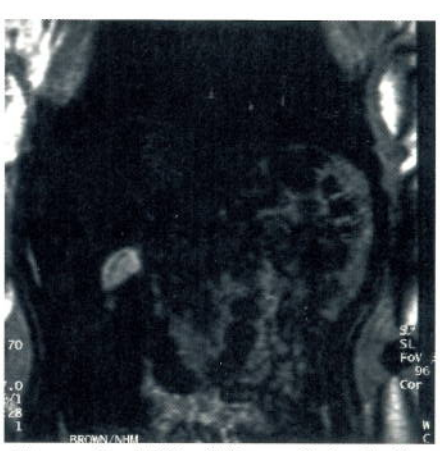


Figure 4. MIP of figure 3, including only those slices through the gall bladder. (Courtesy of Maury Regional Medical Center).

TIPS: TYPICAL PCA EXAMPLES

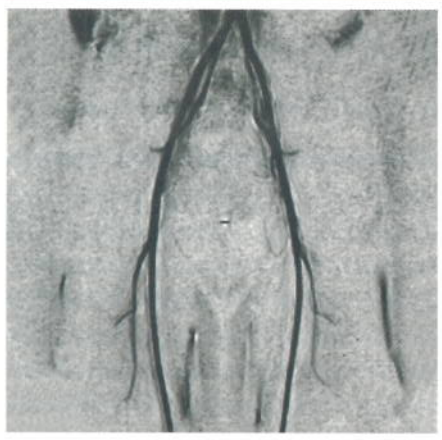


Figure 1: 2D PCA of iliac arteries, V_{OPT} 60 cm/s, sequence used was fl2d_pc_60_60_60_8fb108.wkc, TR 80 ms, TE 8 ms, Flip 11 deg, FOV 375 mm, no RecFOV, no swap, matrix 192x256, slice thickness 100 mm, 2 acquisitions, coronal, cardiac triggered with 100 ms trigger delay and 5 phases, scan time 5+ min, MAGNETOM Vision, Body coil. The best three acquired cine images were combined (added) and filtered (F:7) and the final image was negated (black on white) for optimal presentation, but no MIP was involved. (Courtesy of N.E. Indiana MRI)

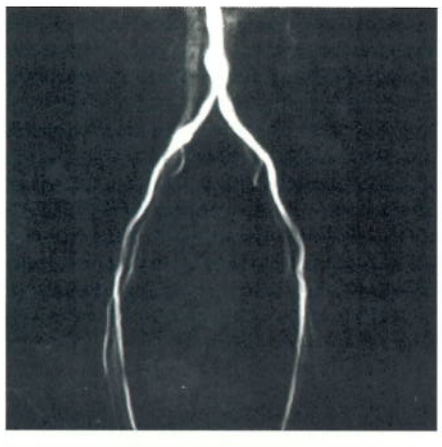


Figure 2: 2D PCA of iliac arteries, two sequences separately acquired with V_{OPT} values of 30 cm/s and 90 cm/s, TR 86 ms, TE 10 ms, Flip 10 deg, FOV 400 mm, 6/8 RecFOV, no swap, matrix 160x256, slice thickness 95 mm, 2 acquisitions, coronal, scan time 5⁻ min, MAGNETOM Vision, Body coil. The two acquired images at different V_{OPT} values were combined (added) for optimal presentation, but no MIP was involved. (Courtesy of University Uniklinicum)

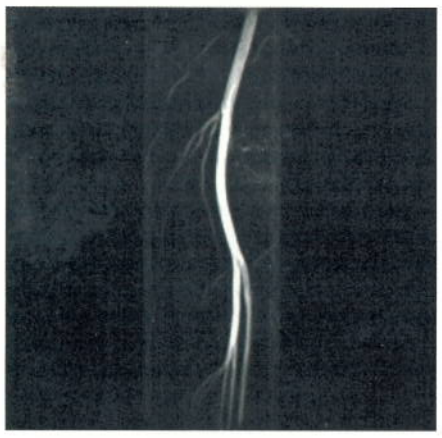


Figure 3: 3D Rephased-Dephased angiography of popliteal trifurcation (similar to, but not exactly PCA), flow sensitive only in the readout direction (superior-inferior in this case), sequence used was fisp3d_14rdb108. wfa, TR 25 ms, TE 14 ms, Flip 15 deg, FOV 240 mm, no RecFOV, no swap, matrix 192x256, slab thickness 64 mm, partitions 32, 2 acquisitions, coronal, scan time 10^+ min, MAGNETOM Impact, CP Extremity coil. The 32 images were MIP processed into a sagittal view with extreme targeting down to the vessels of interest for optimal presentation.

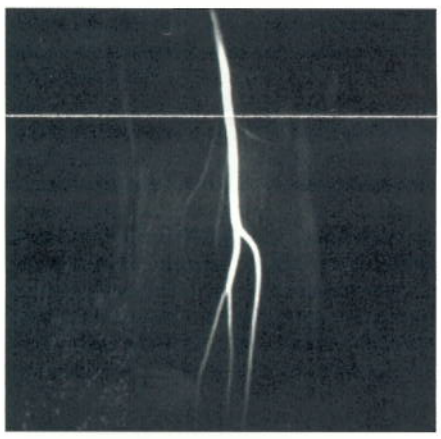


Figure 4: 2D PCA of popliteal trifurcation, V_{OPT} 45 cm/s, sequence used was fl2d_pc_45_45_45_9fb108.wkc, TR 81 ms, TE 9 ms, Flip 11 deg, FOV 275 mm, 6/8 RecFOV, no swap, matrix 144x256, slice thickness 70 mm, 2 acquisitions, coronal, cardiac triggered with 100 ms trigger delay and 5 phases, scan time 4^+ min, MAGNETOM Vision, CP Extremity coil. The best three acquired cine images were combined (averaged) and filtered (F:7) for optimal presentation, but no MIP was involved. (Courtesy of N.E. Indiana MRI)

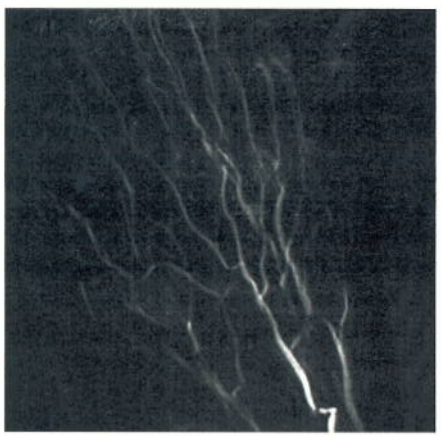


Figure 5: 2D PCA of hand arteries and veins, V_{OPT} 10 cm/s, sequence used was flash2d_pc_10_10_10_11fb108. wfa, TR 88 ms, TE 11 ms, Flip 20 deg, FOV 220 mm, no RecFOV, no swap, matrix 192x256, slice thickness 40 mm, 16 acquisitions, coronal, scan time 2^+ min, MAGNETOM Impact, CP Extremity coil. There was no image post-processing.

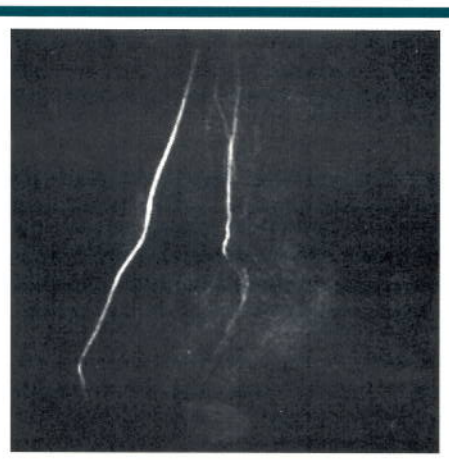


Figure 6: 2D PCA of foot, V_{OPT} 45 cm/s, the pulse sequence which was used was fl2d_pc_45_45_45_9fb108.wkc, TR 81 ms, TE 9 ms, Flip 11 deg, FOV 250 mm, 7/8 RecFOV, no swap, matrix 168x256, slice thickness 80 mm, 2 acquisitions, sagittal, cardiac triggered with 50 ms trigger delay and 5 phases, scan time 5⁻ min, MAGNETOM Vision, CP Extremity coil. There was no image post-processing. (Courtesy of N.E. Indiana MRI)

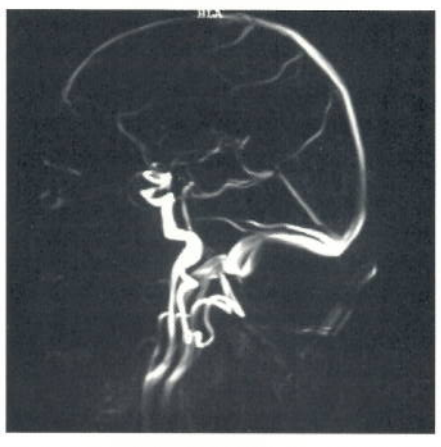


Figure 7: 3D PCA of intracranial vessels, the pulse sequence used was flash3d_pc_10_10_10_11fb108.wfa, TR 89 ms, TE 11 ms, Flip 15 deg, FOV 230 mm, no RecFOV, no swap, matrix 128x256, slab thickness 80 mm, partitions 64, 1 acquisition, sagittal, scan time 12^+ min, MAGNETOM Impact, CP Head coil. The 64 images were MIP processed into a sagittal view for optimal presentation. (Courtesy of Hoag Health Center)

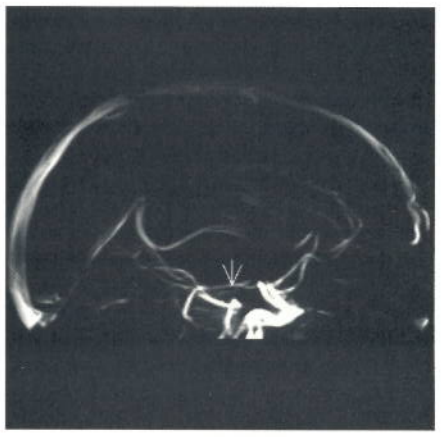


Figure 8: 3D PCA of intracranial vessels, the pulse sequence used was fl3d_pc_10_10_10_11fb108.wkc, TR 88 ms, TE 11 ms, Flip 10 deg, FOV 220 mm, no RecFOV, no swap, matrix 192x256, slab thickness 64 mm, partitions 58, 1 acquisition, sagittal, scan time 16^+ min, MAGNETOM Vision, CP Head coil. The 58 images were MIP processed into a sagittal view for optimal presentation. Arrow indicates posterior communicating artery.

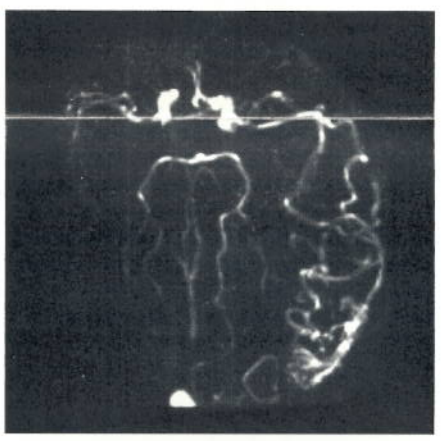


Figure 9: 3D PCA of intracranial AVM, the pulse sequence used was flash3d_pc_10_10_10_11fb108.wfa, TR 89 ms, TE 11 ms, Flip 15 deg, FOV 210 mm, no RecFOV, swap, matrix 192x256, slab thickness 40 mm, partitions 32, 1 acquisition, transverse, scan time 9^+ min, MAGNETOM Impact, CP Head coil. The 32 images were MIP processed into a transverse view for optimal presentation. (Courtesy of Universitaet Tuebingen)

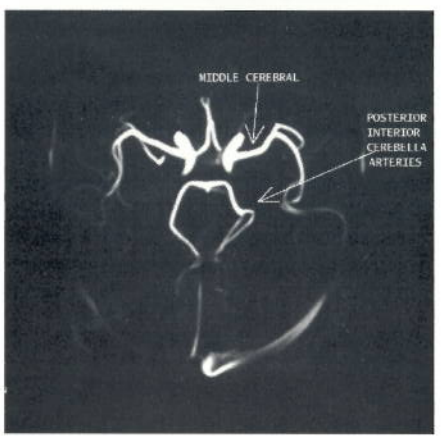


Figure 10: 3D PCA of intracranial vessels, the pulse sequence used was fl3d_pc_30_30_30_9fb108.wkc, TR 79 ms, TE 9 ms, Flip 11 deg, FOV 220 mm, no RecFOV, swap, matrix 192x256, slab thickness 64 mm, partitions 58, 1 acquisition, transverse, scan time 15⁻ min, MAGNETOM Vision, CP Head coil. The 58 images were MIP processed into a transverse view for optimal presentation.

CLINICAL CASE HISTORY: PHEOCHROMOCYTOMA

Jonathan Weiner, M.D., Director of MRI
Boca Raton Community Hospital, Boca Raton, FL

A 16 year old patient with suspected renal artery stenosis was imaged on a MAGNETOM Impact with the 15 mT/m Power Package option and the Advanced MRA option. A pheochromocytoma of the right adrenal gland was demonstrated with routine T1- and T2-weighted studies. A 3D Phase Contrast Angiography (PCA) study of the renal arteries was performed with the sequence flash3d_25_25_70_9fb108.wfa using the Siemens recommended protocol for renal arteries. Normal flow was demonstrated in both renal arteries.

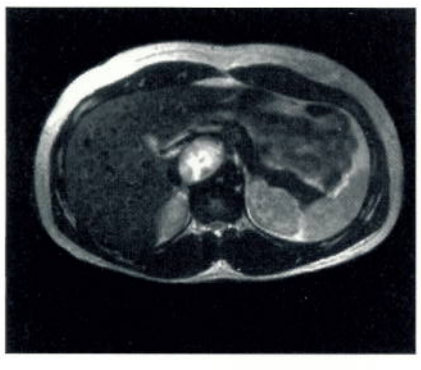


Figure 1. T2-weighted image demonstrates a large pheochromocytoma involving the right adrenal gland. (Courtesy of Boca Raton Community Hospital)

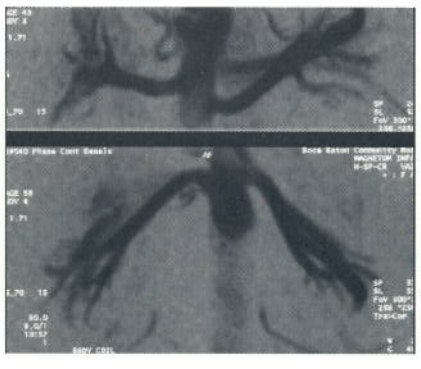


Figure 2. Transverse 3D PCA with mixed VOPT of 25 cm/s along the X and Y axes and 70 cm/s along the Z axis demonstrates normal flow in both renal arteries. (Courtesy of Boca Raton Community Hospital)

Figure 3. Appearance of a normal volunteer with the same technique as in figure 2, except with slightly larger FOV and slightly lower matrix.