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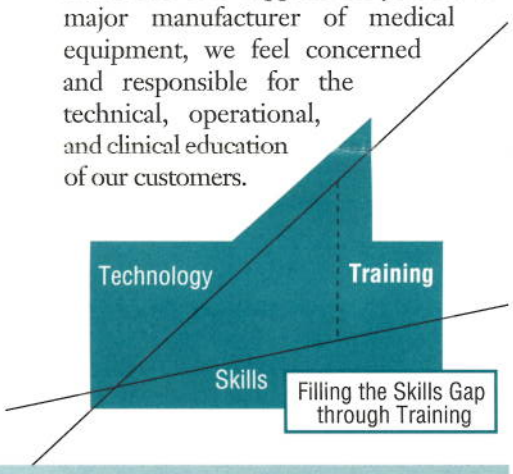
MAGNETOM Flash

An Applications Reference for Siemens MAGNETOM Users

Siemens' Commitment To Continuing Education

MICHELE KESSLER, ISG APPLICATIONS MANAGER, SIEMENS MEDICAL SYSETEM, ISELIN, NJ

No matter what their modality, technologists play an important role in the success of their hospitals and imaging centers. With insufficient or incomplete understanding of imaging systems and their clinical applications, patient examinations might require more time, be incomplete, be inadequate, or not even provide the needed information to make a diagnosis. Therefore, education contributes a large part in maximizing the output of the daily clinical routine. The key is to ensure that technologists have the appropriate knowledge and the training, and are provided a method to continue receiving that knowledge. We in the Siemens Applications Group want to make sure this happens for you. As a major manufacturer of medical equipment, we feel concerned and responsible for the technical, operational, and clinical education of our customers.

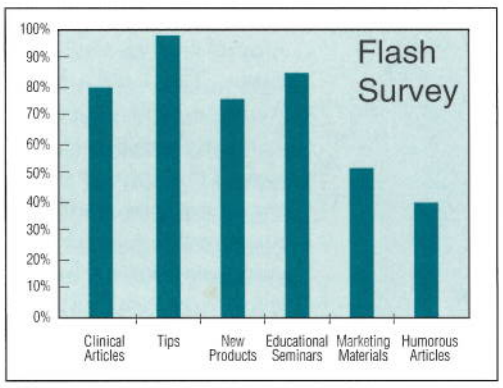


As the technical performance of imaging equipment continues to increase faster than the technical skills of technologists, training will continue to play an important role in filling the gap. The old adage "You get what you pay for" holds true not only for the equipment itself but also for the training of the personnel. Siemens has recognized how important training is — a significant amount of time is devoted to training and educating our applications specialists. We intend to spend no less time or effort in training and educating our customers.

As has been the custom for the past several years, the Siemens Applications Group continues to find new methods to support our customers. We recently conducted two different types of feedback sessions designed to listen to you — our customers — to help us continue enhancing our customer support.

Improving *The Flash*

The MAGNETOM Flash is distributed to over 6000 MRI customers worldwide. In the last issue we distributed a survey asking a number of questions to help us tailor the content and format to better meet your expectations. We were pleased to receive responses from all over the world and would like to thank those of you who took the time to return the reponses from as far away as India, China, and Norway — just to mention a few. The responses indicate that we are fairly close to providing the information you most desire. We have always tried to maintain the *MAGNETOM Flash* as primarily an applications reference for you, rather than another marketing opportunity for Siemens. We are glad to see that your expectations agree.



Improving Applications Videos

For the past several years, Siemens has provided you with educational videos to introduce new software releases, new examination techniques, and even new concepts. During our annual MR Technologists Seminar held in San Diego this May, we invited all attendees to participate in a feedback session to discuss improvements to our applications videos. The objectives of this feedback session were to determine how effective and useful these videos are and what can be done to improve them.

We started with these goals:

- Make new techniques, software, and hardware immediately available for your use
- Furnish materials for continued and standardized training of entire staff
- Provide a valuable ongoing resource (shelf item)
- Present complex or new concepts (Phased Array Technology, EPI, HASTE, Spectroscopy)

We asked you these questions:

- Are we giving enough information and did we explain the concept adequately?
- Are we making too many assumptions when presenting new concepts?
- Do you feel you could perform the exam or application after viewing the video?
- What could we have done to improve?
- Do the videos excite you in the possibilities of these new techniques and options?

The responses were entirely positive. Our customers like and use the videos. Mary Ellen Bentham from Shands Hospital in Gainesville, FL, particularly praised the childrens' patient education video, saying that they use it with every pediatric patient of appropriate age and that there have been countless times that they have avoided the use of sedation after the child has watched the video. Another customer complimented us on the creativity of the safety video. Based on the feedback we received, we will improve future applications videos by:

- List and explain the clinical use of all new sequences in the initial "highlights" segment
- List and explain the sequence name and its properties in each subsequent "new technique" segment
- Use comparative images to demonstrate benefits of a newer technique versus an older one
- List the Continuing Education Credits available with the video quizzes, and how to obtain them
- Provide a Siemens phone number to call for additional copies of the videos and quizzes
- Update the distribution list for the videos

Changes occurring in the health care industry have brought changes to most of our job-related duties and responsibilities. With these changes comes new opportunities and new challenges. We urge you to take advantage of these by viewing your position as a career rather than just a job. Increase your knowledge and participation — this will lead to professional and personal growth.

IN THIS ISSUE:

THE MAGNETOM FLASH

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Upcoming Meetings And Seminars 1997

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Jul 14-18, Aug 25-29, Oct 6-10, Nov 17-21: MR Imaging Concepts and Applications Course, Siemens Training Center, Cary, NC

Jul 17-20: 4th Annual Economics Summit, Chicago, IL

Jul 20-25: Magnetic Resonance Imaging 1997: National Symposium, Las Vegas, NV

Aug 2: MRI Technologists Seminar, St. Mary's MRI Center, Richmond, VA

Sep 7-11: Kanal's MR Physics: A Look at the Basics, Washington, DC

Sep 19-20: MRI Review, Toronto, Canada

Sep 20-25: 4th International Conference on Magnetic Resonance Microscopy, Old Town, Albuquerque, NM

Oct 16-19: 9th Annual Advances in Mid & Low Field MRI, Orlando, FL

Oct 20-24: MRI/CT Update, Harvard, Cambridge, MA

Oct 27-30: International MRI Course, Riyadh, Saudi Arabia

Oct 30-Nov 2: MRI/CT Update, Hilton Head, SC

Optimized Peripheral 2D MRA

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A new Peripheral MRA Package (option) for demonstrating the major arteries of the lower extremities is now available to users of the MAGNETOM Vision and Impact Expert systems with B31 software. This article discusses optimal use of one of the techniques contained in this new software package: ECG Triggered 2D Time-Of-Flight with Traveling Presats.

Achieving a quality study is very dependent upon a good ECG trigger, elimination of "dead time" throughout the exam, and the cooperation of the patient (which, is highly dependent upon how comfortable the patient is and how well the patient understands what is expected of him or her). The procedure is a simple one, once you get the hang of it, but it does require strict adherence to some very specific rules.

Peripheral Vascular Anatomy

First, the patient table must be prepared. Understanding the location of the vascular structures will help. The aorta bifurcates into the left and right common iliac arteries which, again, split to form the internal and the external iliacs. The internal iliac artery takes a slight dip posterior, while the external iliac stays more anterior and passes over the pubis bone to become the femoral artery (this is the most anterior region of your study). The profunda femoris (deep femoral) branches off at this point and moves posterior, while the femoral artery continues on to move along the medial side of the thigh and eventually moving posterior to become the popliteal artery behind the knee (this is the most posterior region of your study). Just below the tibial plateau, the popliteal artery branches laterally into the anterior tibial artery and, further down, bifurcates into the peroneal artery (laterally) and posterior tibial (medially). These last three vessels continue to the foot and are the primary end blood supply to the foot/ankle region. When you can visualize this path you can better plan your patient's positioning.

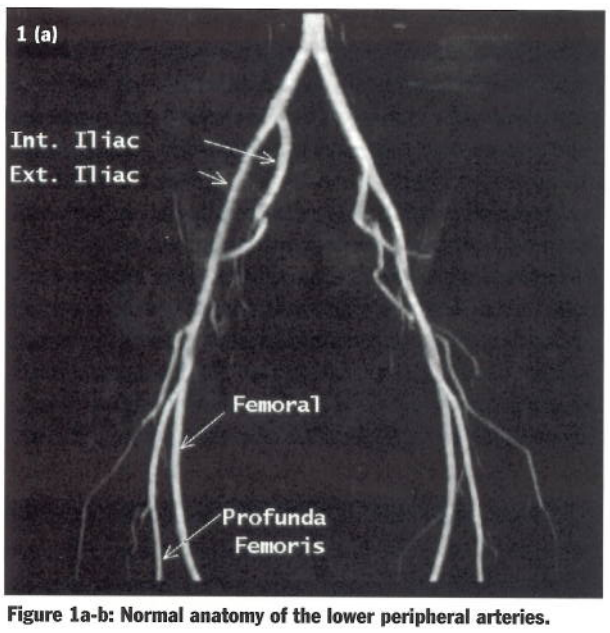
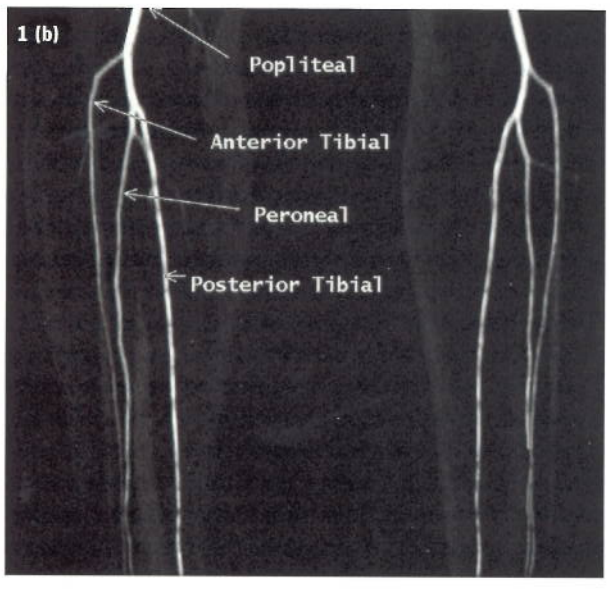


Figure 1a-b: Normal anatomy of the lower peripheral arteries.



Patient Preparation

Patient orientation is feet-first and supine. Build up the cushions in the area of the lower legs by approximately 1-3 cm using a blanket or a Siemens coil pad (not the knee pad). By doing this you are raising the popliteal arteries closer to isocenter and making the patient more comfortable. Most people will begin to cramp if their knees are in a "locked-back" position for very long. Do not, however, raise the knees more than the recommended range and be careful to keep the lower legs parallel to the table surface. This will help you maintain a smaller Volume-Of-Interest (VOI) during the Maximim Intensity Projection (MIP). In addition, some radiologists may prefer that the feet be rotated inward to simulate positioning in a typical radiographic angiogram. As with a conventional angiogram, some patients may not be able to hold this position well, even with restraints, so you may choose to simply move both legs into a relaxed position before immobilizing them. If possible, both legs should be rotated symmetrically.

To immobilize the patient, use a combination of sheets (or blankets) and the Siemens velcro straps. Place one rolled up sheet between the patient's ankles and lower legs to separate them comfortably. Next, place two more rolled up sheets lateral to the patient's lower legs. A fourth blanket may be placed over the top of both legs to act as a cushion before the velcro straps are secured. Remember that with Peripheral Vascular Disease (PVD) of the lower extremities, this area of the leg is usually the most painfully sensitive to pressure. By distributing the pressure with this type of cushioning technique, patient discomfort will be minimized. With most cooperative patients, this should be all the immobilization necessary. I rarely need to place a strap across the mid-thigh region.

After attaching the ECG leads to the patient, ensure a strong and reliable ECG signal (readjust the ECG leads if necessary). As the exam consists of multiple slice groups which must be correctly aligned with each other, instruct the patient to remain completely immobile during the entire exam, even during the "quiet times between scans" and during the "table shift times". Instruct the patient how to use the emergency squeeze ball and the headphones. In order to avoid possible wrap artifacts, the patient's upper extremities should remain above the waist during the first table position of the MRA procedure.

To correctly position the Aortic bifurcation and Iliac arteries, align the laser light about 120 mm inferior to the iliac crest, turn off the laser light, and drive the table into the starting position at isocenter. Register the patient. Now you are ready to begin using the Peripheral MRA Package.

Acquire The Localizers

First, Select and run the two-slice scout protocol 1_TRANSVERSE_SCOUT_19 without any changes. If your positioning is correct, you will get two axial slices, one demonstrating the distal aorta and one demonstrating the Iliac arteries as they pass anteriorly over the pubic bones. Evaluate these images to verify that the posterior structures in the image do not wrap into the arteries that are anterior in the pelvis. If you need to increase the FOV, re-run the same scout protocol to verify that the larger FOV is adequate (do not shift the FOV on this second localizer). Never decrease the FOV, even if the patient is small, because the FOV determines the minimum coverage which can be MIP'd along the z axis. For example, if you acquire 5 contiguous axial groups and each group is 70 mm thick, the FOV must be at least 350 mm (5 x 70 = 350) in order to load all these slices together into a single MIP. Do not increase the RecFOV factor because this will increase the exam time and, thus, increase the likelihood that the patient may not be able to complete the exam. Do not offcenter shift the

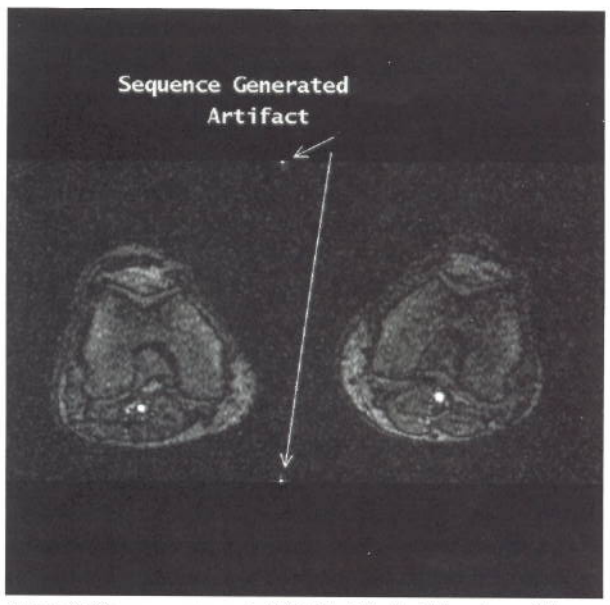


Figure 2: Sequence generated "dot" artifact at the edges of the FOV may shift into the area of interest if the RecFOV is offcenter shifted.

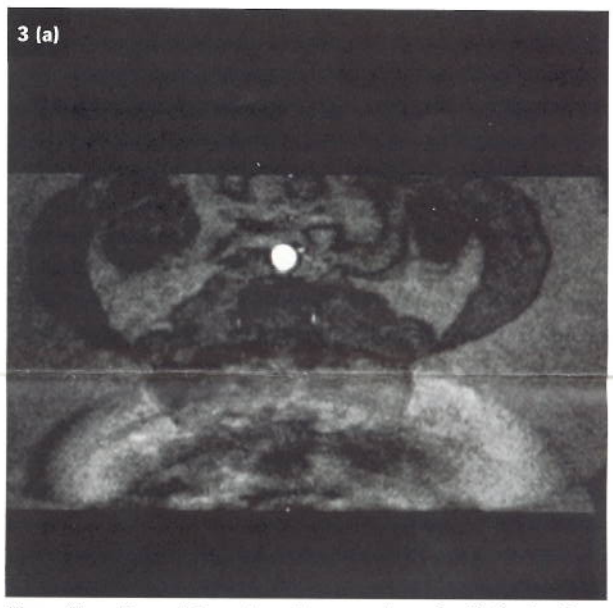
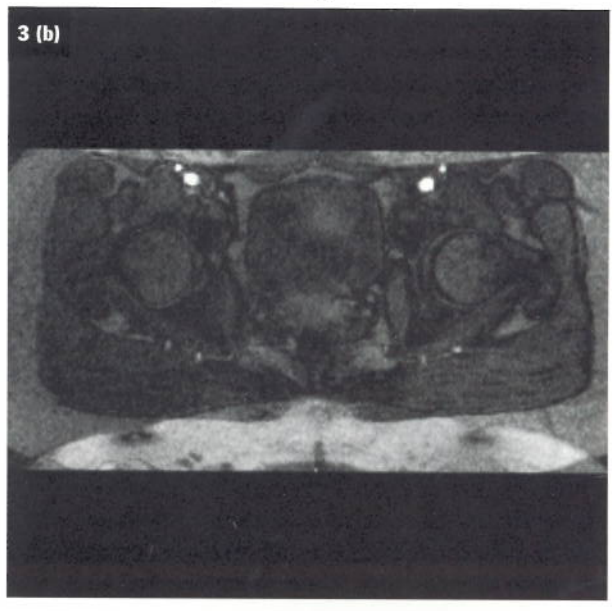
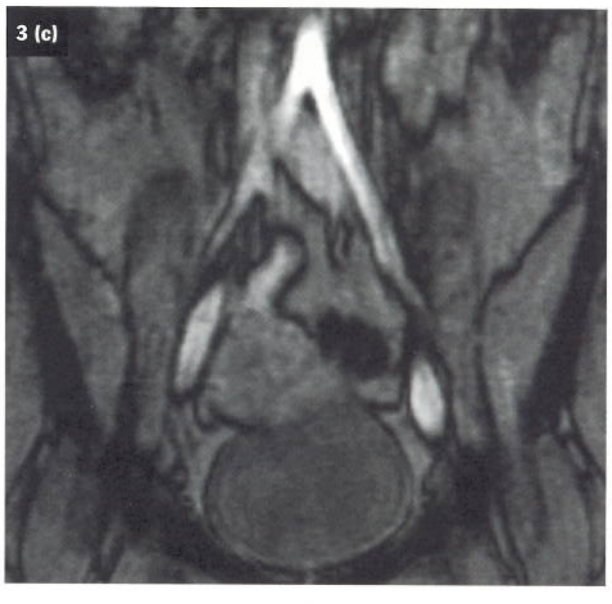


Figure 3a-c: Two axial scouts and a coronal scout with the Aortic bifurcation near the top of the image.





RecFOV because this may allow a sequence generated "dot" artifact to shift from the edges of the FOV into the area of interest. When you have determined the correct FOV then you may proceed with the next scout.

Next, select and run the one-slice scout protocol 2_CORONAL_TRIG_SCOUT_13 without any changes. Position the coronal slice through an image of the aorta that was obtained in the first localizer. The resulting coronal scout image should demonstrate the Aortic bifurcation near the top of the image. If the bifurcation is not present within the 400 FOV, then you must reposition the patient and repeat the same localizer, rather than simply increasing the FOV to include the bifurcation. You may choose to either start again from the beginning or simply move the table slightly into the bore to get the bifurcation within the 400 mm FOV. If you decide to move the table, do so in 10 mm increments (rounded numbers) and do not turn on the positioning laser light before or after the moves. You must use the touch panel Table Drive Button to move the table in order to re-tune the coils in the new position, although you may release the Table Lock Button and move the table by hand for fine adjustments (remember to reset the Table Lock Button).

Acquire 2D-MRA Data

Now that you have axial scouts and a coronal scout with the Aortic bifurcation near the top of the image, you may proceed with the first five groups of axial slices, all at the first table position. Choose either the protocol 3_STANDARD_19_FLOW_DOWN for heart rates up to 95 bpm or the protocol 3B_FAST_HEART_13_FLOW_DOWN for heart rates from 95 up to 125 bpm. Note that the trigger delays required for "below the knees" are greater than those for "above the knees" due to differences in the flow patterns in these two areas. Using the coronal scout, position the first group of axial slices exactly at "shift-mean = -140 mm", which should position the group right over the Aortic bifurcation. This same protocol will be run five times at "mean-shift" positions of -140, -70, 0, +70, +140 with the optimal FOV as determined earlier with the axial scout. When using the Positioning menu to see where the axial slices are located on the coronal scout, do not use the Second Localizer function to offcenter shift the slices in the phase or readout directions. In fact, just to be sure, go back to the Free Slice menu afterwards to verify that there are no offcenter shifts before running the scans.

To avoid confusion in image numbering do not perform any MIP post-processing and do not use the Copy Segment function until all the images of the entire exam are acquired and reconstructed (the entire exam is completed). To see the images immediately as they are reconstructed, use the Auto Display feature.

After acquiring the first five scans of the pelvic region at the first table location, you are ready to drive the table to its next location to acquire the next five scans of the upper to mid thigh region. Without repositioning the patient, use the touch panel Table Drive Button to drive the table out exactly 340 mm from its first location (do not turn on the localizer laser light again). For example, if the first table position was "0 mm" then move it to "+340 mm", or if it was "-30 mm" then move it to "+310 mm". Since the table drives too quickly to stop at any specific position, you may need to again release the Table Lock Button to exactly adjust the desired table position. Note, if you did not use the Table Drive Buttons to initially move the table, you will not be able to re-tune to your new table position.

Now, recall the same shift-mean positions that you used for your first five scans at the first table position and apply them again to this next position without any changes. Since the first five groups of slices had a total coverage of 350 mm along the z axis, yet you shifted the table by only 340 mm along the z axis, the second table position will overlap the first table position by 10 mm along the z axis (just for a slight margin of safety).

After you have acquired the five groups at the second table position, shift the table out again by 340 mm and acquire five groups of slices at the same mean-shifts. However, at this third table position you will probably begin scanning "below the knees", which will require a slightly greater trigger delay than "above the knees" (see the Peripheral MRA Users Guide). Repeat this procedure until you get near the patient's ankles, but probably not all the way to the feet. In fact, the last table shift should be made the same as all the others (340 mm), but you may not need to scan all five groups of slices. If you are using the Auto Display feature to review the images as they are reconstructed, you may decide not to perform the last few groups at the final table position.

Finally, go back and load all five groups of slices from the first table position into the MIP program, target down to a suitable VOI, and generate a series of coronal to sagittal projections. Repeat this procedure for each separate table position (only one table position at a time can be loaded into MIP).

Although the study has probably taken about an hour to complete, I think that you will agree that it was much easier than a routine radiographic angiogram in many ways. No recovery time is needed for the patient, no injections or needles are needed (the patients have always been grateful), no sterile fields or additional specialized equipment are needed, and no drugs are needed in most cases (although some medications may be helpful for patients who are in pain because of advanced disease).

Venous Exam

Additionally, a variation of this study to demonstrate viens can be accomplished by selecting from the Sequence File list the "_su_" versions of the sequences rather than the "_sd_" versions used in these protocols to demonstrate arteries. The venous exam may be run without ECG triggering because of the low pulsatile movement of the viens, and this will have the added advantage of shortening the scan time (the difference between the TR and the RR interval is eliminated).

Remember that you can call on your Siemens Applications Specialist to assist you through your first exam, but I believe that the procedure is so well designed by Siemens that you will catch on in no time at all (see Peripheral MRA Users Guide).

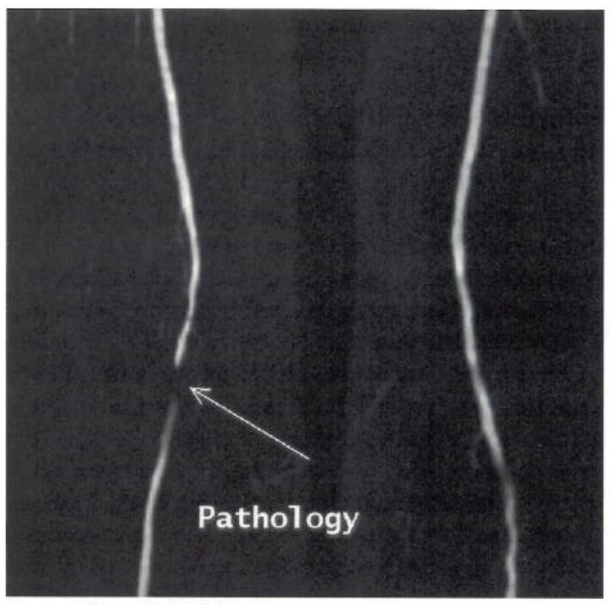


Figure 4: Vascular Pathology

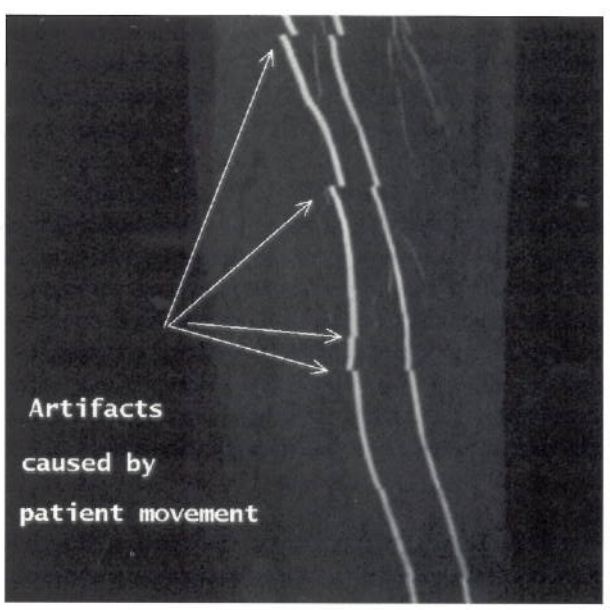


Figure 5: Artifacts cased by patient movement.

Applications Tips For New B31 Software

MAGNETOM Vision, Open, Impact Expert, Impact Basic

- Display Text should have Evaluation Text switched On for all consoles.
- Defaults should be reset to Anatomical for the commands Register Patient, Patient Renew, Patient Pre-Register.
- Display Screen should be set to your preference of First or Middle Image when selecting Studys.
- Display Window should be set to your preference of Fast or Slow Windowing.
- When using the CP Array Spine Coil, your choice of coil elements can now be saved to the Customer Protocol list. However, if you select a pulse sequence directly from the Sequence File list rather than your Customer Protocol list, it will default back to the first four coil elements.

MAGNETOM Impact Expert, Impact Basic

- Some pulse sequences may automatically switch to Offline Reconstruction, thereby taking a longer time for image reconstruction. To force these sequences to use Online Reconstruction, thereby taking a shorter time for image reconstruction, do not use Readout Oversampling during the scan.
- Multi-Slice Multi-Angle (MSMA) protocols must be saved with the slice groups created in correct ascending order down the spine (from superior to inferior).
- When upgrading from A2.2 software, if you experience errors when running a protocol which uses a DESS3D pulse sequence, go to the sequence file to pull up that same DESS3D sequence, then rebuild and resave the protocol under the Customer protocols list.

MAGNETOM Open

Under the Siemens protocol list, the ANGIO_CAROTIDS/TOF_FL2D_TRA_TRAV_SAT protocols saved under the HEAD COIL and the 16S and 21S MULTIPURPOSE COILS have Interpolate On, thereby allowing only about 20 slices to be MIP'd. Resave these protocols with Interpolate Off under the Customer protocol list in order to allow more slices to be MIP'd.

Digital Cameras

Some new film formats may be available for various cameras. The Kodak cameras need firmware version 2.3 or higher. If the message "WRONG FORMAT" occurs when trying to film with a Kodak camera, check the firmware version and have it upgraded by Kodak if necessary.

Optimized Breathhold 3D MRA

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The role of magnetic resonance angiography (MRA) in the evaluation of vascular anatomy is still evolving. Three-dimensional MRA (3D-MRA) has recently been shown to be a useful rapid imaging technique when used in conjunction with T1-shortening intravenous contrast agents. This technique has clear advantages over 2D Time-Of-Flight (2D-TOF) techniques due to its rapid acquisition time, high resolution, and lack of in-plane saturation. The entire acquisition can be easily performed during a single breathhold. Although the technique works fairly well in most cases, the signal contrast between blood vessels and background tissues can be optimized by applying a few basic principles.

The primary mechanism for increased vascular signal contrast is based upon the shortening of the T1 relaxation time of blood by adding a paramagnetic contrast agent. In addition, the Body Phased Array Coil is used to further improve the signal-to-noise ratio. Since most of the signal is contained in the central lines of k space, it is imperative to acquire the central k space of data during the arterial peak of the bolus injection of contrast agent. Thus, knowing the time required for the bolus peak to arrive at the intended target is an important prerequisite to optimize the protocol. The transit time of the bolus peak in patients with vascular disease differs significantly from that in normal patients due to variations in the circulation time and cardiac status. In this article we provide a relatively simple method to estimate the arrival time of the peak bolus of contrast agent to the target area, and provide optimal pulse sequence parameters for the imaging conditions.

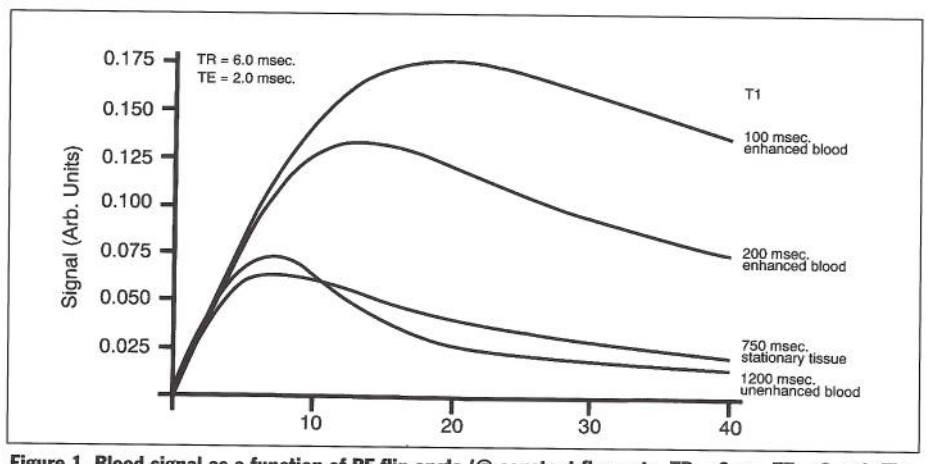

Figure 1. Blood signal as a function of RF flip angle (@ constant flow rate, TR = 6 ms, TE = 2 ms). The plot represents the signal at various T1 relaxations times due to presence of paramagnetic contrast. For comparison, a stationary tissue signal is also shown at T1 = 750 ms. Two observations are clear from this figure: the net signal increases and the corresponding optimal flip angle shifts to higher values when T1 is shortened.

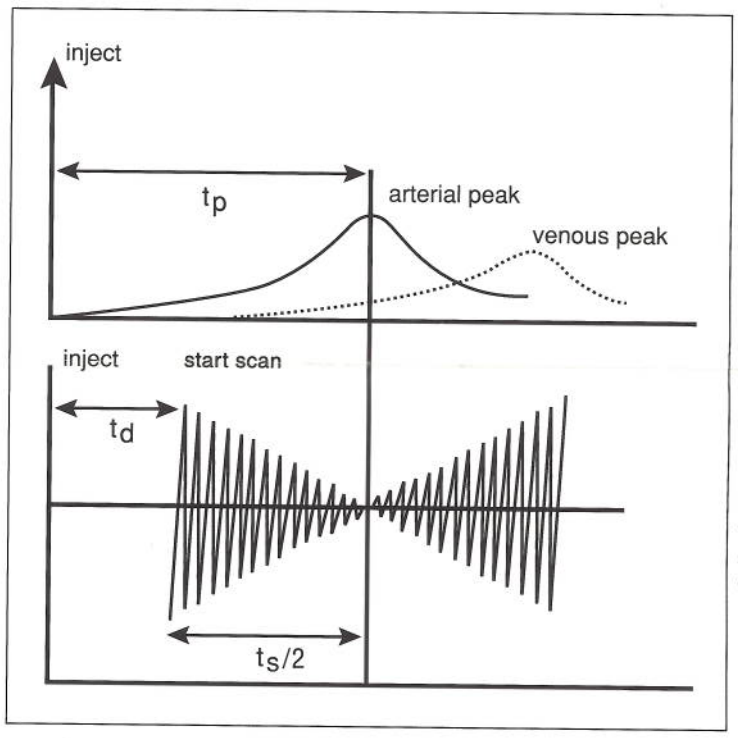

Figure 2. The arterial concentration of the contrast is maximal at the peak transit time tp after the bolus is injected. Since the central lines of k-space are primarily responsible for determining the image contrast, the middle of the scan acquisition must occur at t_p. Thus, the scan delay time t_d is the difference between t_p and one-half the scan acquisition time ($t_s/2$).

Breathhold 3D MRA Pulse Sequences

3D-MRA is performed using a FISP3D pulse sequence in which the echo time (TE), the pulse repetition time (TR), and the flip angle (Ø) are held very small so that the entire scan can be acquired in 20-50 seconds, a reasonable breathhold period which we call 3D-BH. Figure 1 shows the signal response of such a pulse sequence as a function of RF flip angle at various T1 values of the tissue. Note that the optimal flip angle tends to increase as the T1 of the blood decreases from 1200 ms (no contrast agent) toward 200 ms (single dose contrast agent) or 100 ms (double dose contrast agent). At a short TR and short TE, the optimal flip angle with contrast administration is about 14-18 degrees. Figure 2 shows the arterial concentration of the contrast from the time it is injected. Remember, obtaining optimal vascular image contrast requires that the arterial peak bolus should arrive at the target area (vessels to be imaged) just as the central lines of k-space are being acquired. This requires that the operator carefully estimates the relative timing between the start of the bolus administration and the start of the pulse sequence.

For performing contrast enhanced 3D-MRA, two pulse sequences are available on the MAGNETOM Vision system configured with B31 software, either in the Cardiac Package or in the Angio Package (fi3d_trig_2b488.ykc and fi3d_2b488.ykc). Also, for this type of exam, two pulse sequences are available on the MAGNETOM Impact Expert system configured with B31 software, either in the Cardiac Package or in the Advanced Angio Package (fi3d_trig_3b325.wfc and fi3d_3b325.wfc). Imaging with any of these four sequences may be performed within a single breathhold. The triggered versions are designed with a different loop structure than the non-triggered versions to take advantage of the triggering, so it is essential to use the appropriate version. Due to these differences, FatSat pulses are slightly less efficient in the triggered versions than in the non-triggered versions of these sequences.

1. fi3d_trig_2b488.ykc & fi3d_trig_3b325.wfc: Triggered; the linearly ordered lines loop is within the linearly ordered partitions loop.
2. fi3d_2b488.ykc & fi3d_3b325.wfc: Non-triggered; the centrically reordered partitions loop is within the linearly ordered lines loop; the FatSat pulse is used once for each line.

Coordinated Timing Required

In a breathhold contrast enhanced 3D-MRA exam there are three events that require extremely well coordinated timing: start of the bolus injection, start of the scan, and giving breathhold commands to the patient. A single technologist can perform the entire procedure with the help of a power injector to deliver the contrast bolus. However, in situations where a power injector is unavailable, two technologists are needed: one to stay in the magnet room to deliver the bolus, and another to give breathhold commands to the patient while starting the scan.

Estimate Arterial Peak Transit Time

The first step is to estimate the transit time for the arterial peak of the bolus to reach the region-of-interest (see Figure 2).

1. A TurboFLASH pulse sequence (eg, tfl_t1_4b279) is setup in a transverse plane with a single slice placed slightly caudal to the region-of-interest (eg, through the inferior poles of the kidneys for a renal artery MRA). Typical sequence parameters are: TR = 9 ms, TE = 4 ms, TI = 100 ms, Flip = 10 deg, FOV = 350 mm, Thickness = 5 mm, Matrix = 90 x 128, Acquisitions = 1, Measurements = 40 (interval = 1 sec). The total contrast required was based on patient weight. The contrast agent Gadoteridol (Prohance) is administered at a dose rate of 0.2 mmol/kg (before attempting this technique, check with the drug manufacturers to ensure that it has been FDA cleared for this dose rate: Prohance, Bracco Diagnostics, NJ.) Slowly advance about 2 ml test dose of contrast into the IV line until it reaches the injection site (do not inject yet). To keep the same bolus characteristics while estimating the arterial peak transit time, an amount of saline equal to the remaining final contrast dose for the actual MRA scan will be used as a flush. For example, if the total calculated dose for the patient's weight is 20 ml, and the test dose will be 2 ml, then the final contrast dose for the actual MRA scan will be 18 ml, and thus the saline flush to be used following the test dose should also be 18 ml. Perform a Sequence Load prior to beginning the breathhold for the test dose scan.
2. By instructing the patient to inhale and exhale in a rapid succession for several breaths, you can extend the patient's maximal breathhold duration (slightly hyperventilated). Then, simultaneously instruct the patient to hold his breath, begin to deliver the test dose and flush at a rate of 2 ml/sec, and perform a Sequence Start to launch the scan series (total 40 images @ 1/sec). Wait for the scan series to finish and instruct the patient to breathe normally. Patient need not hold his breath for the entire duration of the scan, and some images may be misregistered, however this will not effect the estimation of peak transit time.
3. Use the function Evaluate Mean Curve to plot the signal intensity of the region-of-interest (the enhancing vessel) for all 40 images, as shown in Figure 3. Based on the slice number corresponding to peak arterial signal, estimate the arterial peak transit time for that patient.

Estimate Scan Delay Time

Prior to estimating the scan delay time t_d, determine the exact scan acquisition time t_s of the 3D-MRA sequence, which can be read directly off the Protocol Change menu of the scanner. The scan acquisition time t_s is based on four sequence parameters: the TR, the number of in-plane phase-encoding lines, the number of partitions, and the number of acquisitions.

Using one of these two formulas, determine the scan delay time t_d between the start of the bolus injection and the start of the 3D-MRA sequence (see Figure 2).

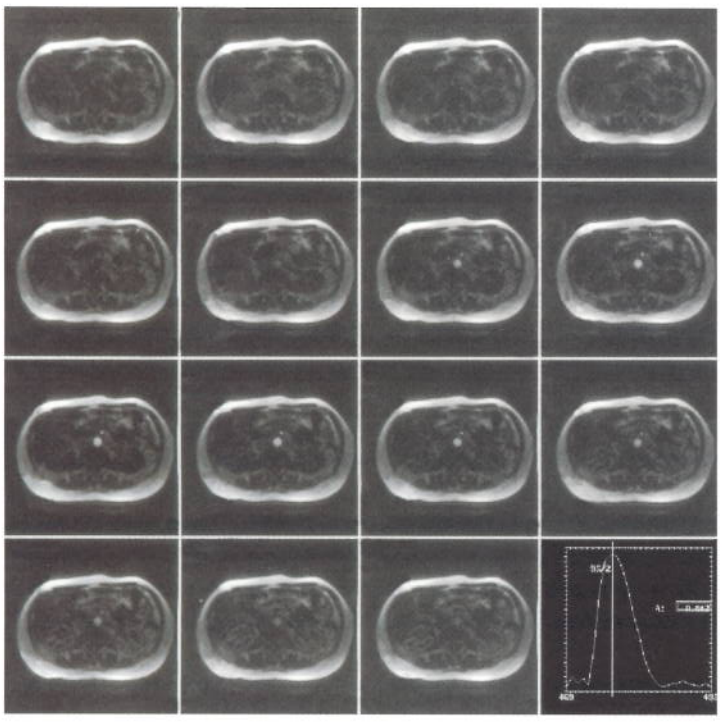

Figure 3. The test bolus injection to estimate the arterial peak transit time. Series of transverse images through the aorta slightly inferior to the region-of-interest. The arterial peak transit time can be estimated either by counting the number of images corresponding to the aortic signal peak or by plotting the signal intensity as a function of image number.

1. If one-half the scan acquisition time is shorter than the arterial peak transit time ($t_S/2 < t_P$), then the 3D-MRA sequence is started after the contrast bolus is started:

$$\text{Start scan after a delay} = \text{Transit Time} - \frac{\text{pulsesequence time}}{2}$$

2. If one-half the scan acquisition time is longer than the arterial peak transit time ($t_S/2 > t_P$), then the contrast bolus is started after the 3D-MRA sequence is started:

$$\text{Start bolus injection after a delay} = \frac{\text{pulsesequence time}}{2} - \text{Transit Time}$$

Acquire 3D-MRA Data

Draw up the final contrast dose for the actual MRA scan (typically 18-20 ml, depending on patient's weight) and advance 2 ml of it into the IV line until it reaches the injection site (do not inject yet). Prepare about 10 ml of saline flush ready to follow. Select one of the protocols described below, perform a Sequence Load, and instruct the patient to hyperventilate for a few breaths. Instruct the patient to hold his/her breath, then start either the bolus injection or the scan acquisition using the appropriate scan delay time as calculated above. Inject the contrast bolus followed by the saline flush at 2 ml/sec.

Discussion

As shown in Figure 1, theoretical simulation suggests an optimal flip angle (Ø) of 14-18 degrees to maximize the arterial signal peak under constant-flow conditions when the T1 relaxation time of blood has been shortened to 200 ms from the contrast agent. Since the contrast mechanism is primarily due to T1 shortening, inflow saturation effects are minimal.

Consequently, the imaging can be performed in any desired plane with the center of the 3D slab positioned at the region-of-interest. The coronal orientation is preferred in most cases in order to place the frequency axis along the length of the vessel to visualize the entire length of the vessel.

Some institutions practice the use of slow infusion of contrast agent throughout the entire data acquisition period, but the drawbacks of such an approach are:

1. It is difficult to achieve a steady rate of injection manually over the scan time (usually 4-6 minutes).
2. A presat band is used to saturate the venous flow because contrast agent accumulates in both arteries and veins with the slow-infusion technique. However, if there is retrograde flow, the arteries may inadvertently be saturated by the presat band, thus mimicking stenosis.

Clearly, with further reductions in echo time (TE) this technique can be made more robust, as the intravoxel dephasing even with a 2 ms TE is still a problem in some cases. Also, by reducing the pulse repetition time (TR) one could afford to increase the number of partitions within the same breathhold period, thereby increasing spatial resolution. The acquisition time at our institution varies from 20 sec to 65 sec, depending upon the type of study. Furthermore, in evaluating peripheral vasculature, breathholding is not required and the resolution can further be increased by using more partitions.

Protocol For Distal Aorta, Renals And Iliac Arteries

Coil	Body Phased Array Coil
Sequence	Fi3d_2b488.ykc
TR	5 ms
TE	2 ms
Flip	15 deg
FOV	350 mm (RecFOV 6/8 for iliac arteries)
Matrix	192 x 256, o
Thickness	96 mm
Partitions	32
Orientation	Coronal (10 deg oblique for SMA)
Acquisitions	1
Measures	1
Swap	No
Comments	The test bolus method is required to estimate the scan delay time.

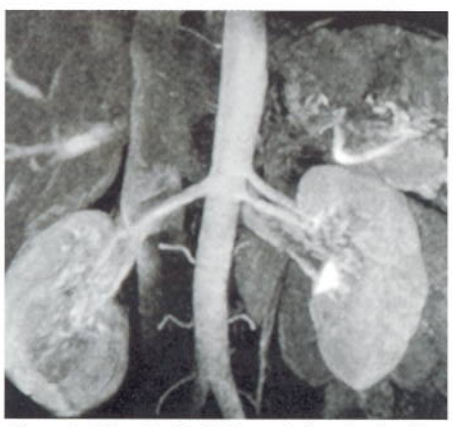

Figure 4. Using the Body Array Coil and a double dose of Prohance contrast, this patient's renal arteries were evaluated. A normal right renal artery, a unilateral left renal accessory artery, and several lower lumbar arteries are visualized. Due to the test bolus which was used to determine the scan delay time, a small amount of contrast is already present in the renal collecting systems. The patient held his breath for only 25 seconds of the 1 minute scan time. Due to centric reordering, most of the central lines of k-space were acquired while the patient was holding his breath.

Figure 5. Using the Body Array Coil and a double dose of Prohance contrast, this patient's superior mesenteric artery (SMA) was evaluated. The coronal 3D slab was obliqued 10 degrees toward transverse. A test bolus was used to determine the scan delay time.

Protocol For Carotid Arteries And Brachial Cephalic Arteries

Coil	Neck Coil, Head-Neck Coil, or Body Phased Array Coil (placed far superiorly)
Sequence	Fi3d_2b488.ykc
TR	5 ms
TE	2 ms
Flip	15 deg
FOV	300 mm
Matrix	256 x 512, o
Thickness	96 mm
Partitions	32
Orientation	Coronal
Acquisitions	1
Measures	1
Swap	No
Comments	The test bolus is not required. Start scan 4-7 sec after the bolus injection. Patient does not have to hold his breath because the targeted vessels are not influenced by chest motion. Use RecFOV 6/8 for carotids or full FOV for brachial cephalic arteries.

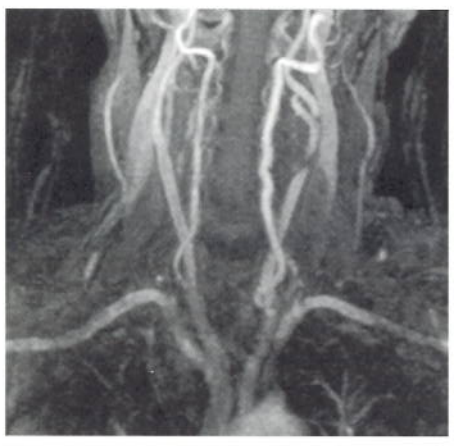

Figure 6. Using the Body Array Coil, this patient's carotid arteries were evaluated. Note the occlusion below the left bifurcation. No test bolus was used. The scan was started 4 seconds after the bolus injection was started.

Protocol For Peripheral Arteries

Coil	Body Phased Array Coil
Sequence	Fi3d_2b488.ykc
TR	5 ms
TE	2 ms
Flip	15 deg
FOV	350 mm (RecFOV 6/8 for peripheral arteries)
Matrix	192 x 256, o
Thickness	64 mm
Partitions	40
Orientation	Coronal
Acquisitions	1
Measures	1
Swap	No
Comments	The test bolus method is required to estimate the scan delay time.

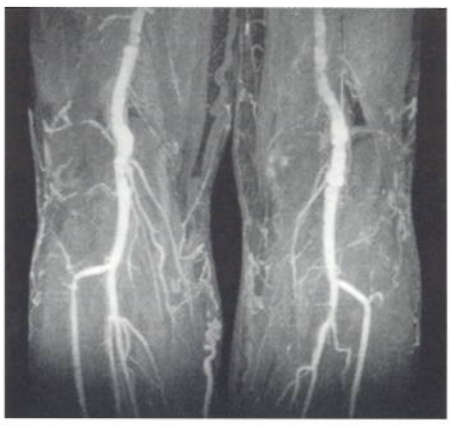

Figure 7. Using the Body Array Coil and a double dose of Prohance contrast, this patient's peripheral leg arteries were evaluated. A test bolus was used to determine the scan delay time. The number of partitions was increased to provide higher resolution, and the patient did not have to hold his breath.

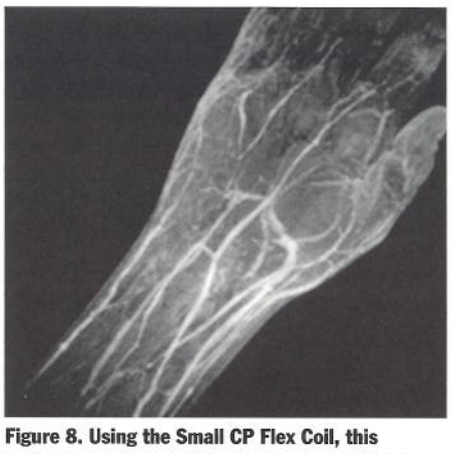

Figure 8. Using the Small CP Flex Coil, this patient's peripheral hand arteries were evaluated. A test bolus was used to determine the scan delay time. The FOV was decreased and the number of partitions was increased to provide higher resolution, and the patient did not have to hold his breath.

Protocol For Pulmonary Arteries

Coil	Body Phased Array Coil
Sequence	Fi3d_2b488.ykc
TR	5 ms
TE	2 ms
Flip	15 deg
FOV	350 mm
Matrix	96 x 256, o
Thickness	96 mm to 128 mm
Partitions	32
Orientation	Coronal
Acquisitions	1
Measures	1
Swap	No
Comments	The test bolus is not required. Simultaneously begin the breathhold and begin the injection, then 4 seconds later start the sequence. Have the patient hold his/her breath for as long as possible, and then breathe shallowly through the last moments of the scan if he can't hold his breath throughout. If you use the triggered version of this sequence, use 24-26 partitions and ensure the number of phase-encoding lines times the TR is about 150 ms less than the patient's R-R interval.

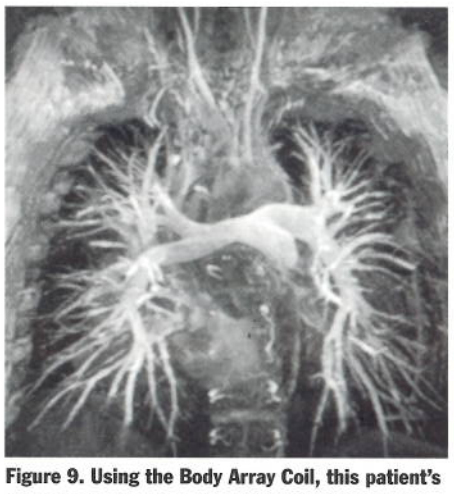

Figure 9. Using the Body Array Coil, this patient's pulmonary arteries were evaluated. The patient held his breath for almost the entire scan period. No test bolus was used. The scan was started 4 seconds after the bolus injection was started.

Highlights of B31 Software

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With the release of B31 software upgrade earlier this year, all current MAGNETOM products now share the same high performance software platform that was first introduced with the MAGNETOM Vision several years ago. This article describes new features specifically for the MAGNETOM Vision and Impact Expert systems, whereas a previous article (Vol. 4, No. 4, October 1996) described new features specifically for the MAGNETOM Open and Impact Basic systems. Some features listed below are optional, so contact your local Siemens sales representative for details.

MAGNETOM Impact Expert

In addition to the full complement of 15 mT/m pulse sequences, a set of additional sequences are included which utilize the 20 mT/m gradient system available for the MAGNETOM Impact Expert. These 20 mT/m sequences push the performance envelope with features such as 1024 matrix, 20 mm FOV, and sub-millimeter 2D slice thickness. A new CP Neck Coil, a new 4 cm Loop Coil, and over a dozen new techniques are available for the Impact Expert.

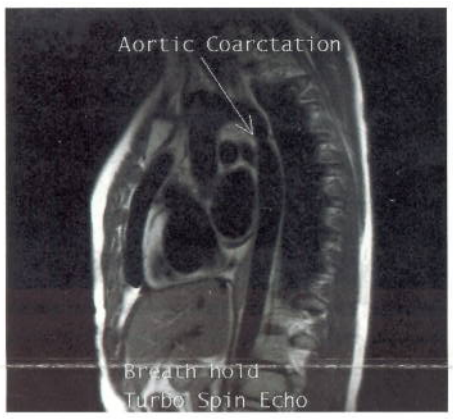

Figure 1. Dark blood and retrogated cine techniques for hearts.

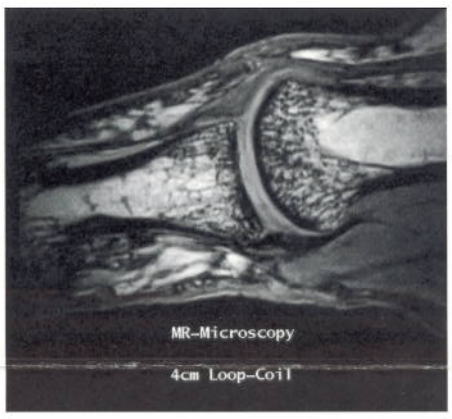

Figure 2. 4 cm loop coil and small FOV technique for high resolution fingers and toes.

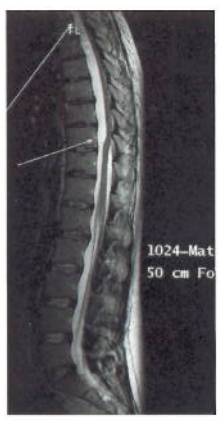

Figure 3. CP spine array coil and 1024 matrix technique for high resolution spines.

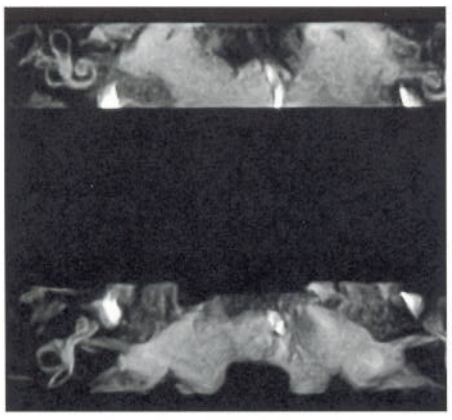

Figure 4. CISS technique for high resolution internal acoustic canals.

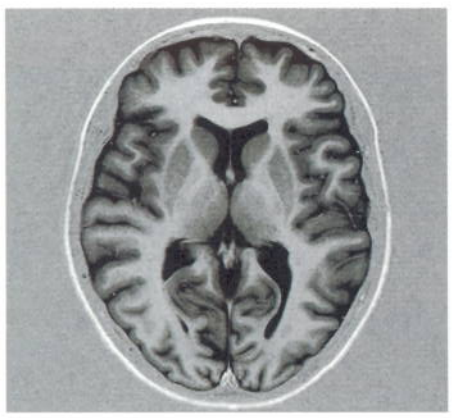

Figure 5. True inversion recovery technique for improved T1-weighting in brains.

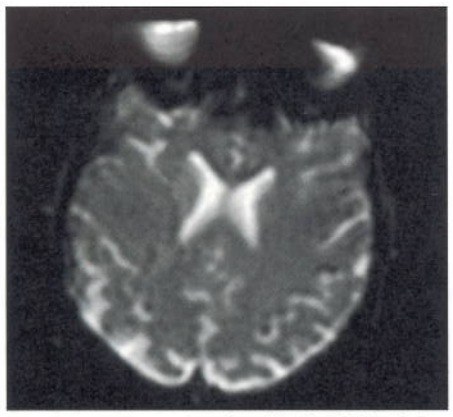

Figure 6. EPI technique for ultra fast T2*-weighted brains.

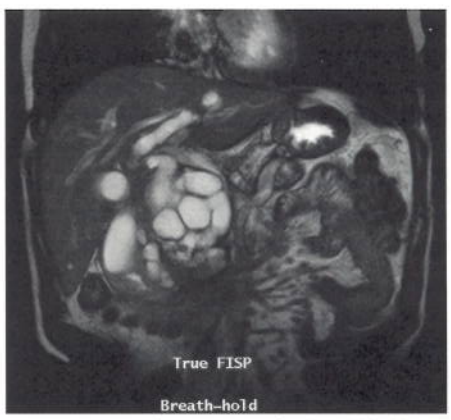

Figure 7. True FISP technique for breathhold T2-weighted abdomens and spines.

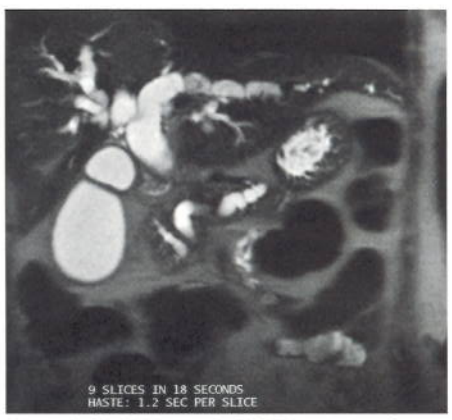

Figure 8. Variable matrix HASTE technique for breathhold T2-weighted abdomens and spines.

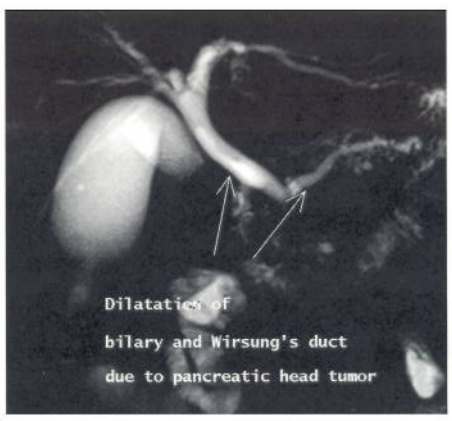

Figure 9. TSE 240 echo train technique for breathhold cholangiography, urography, myelography.

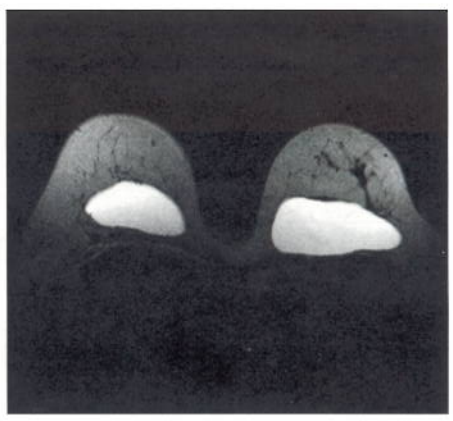

Figure 10. Fat and water nulling for visualization of silicone.

MAGNETOM Vision

In addition to those new coils and techniques described above for the Impact Expert, even more new techniques are available exclusively for the Vision.

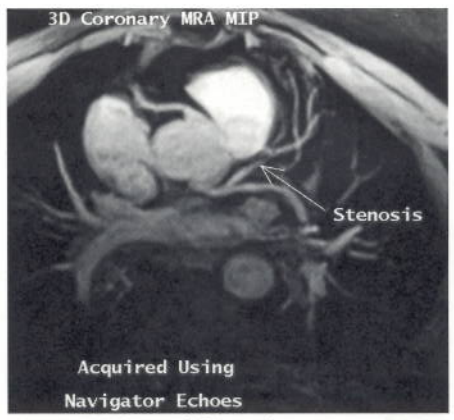

Figure 11. Triggered 3D respiratory compensation navigator technique for high resolution coronary artery MRA.

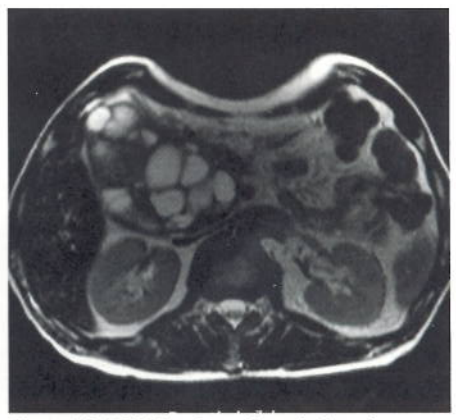

Figure 12. TSE 65 echo train technique for breathhold T2-weighted abdomens.

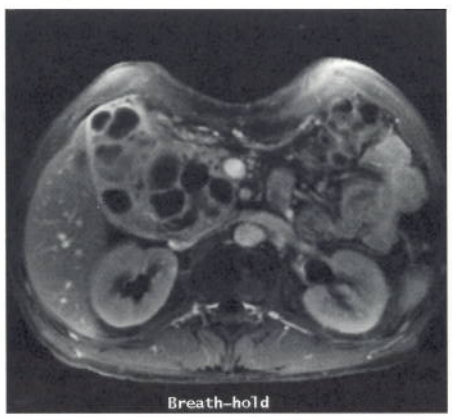

Figure 13. Water excitation FLASH technique for breathhold FatSat T1-weighted abdomens.

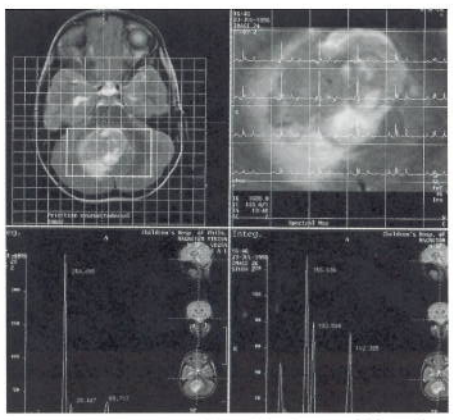

Figure 14. Phosphor 31 and hydrogen CSI techniques for metabolite imaging of the brain.

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