

How to Learn MRI

An Illustrated Workbook

Exercise 5: Scanning the Abdomen

Teaching Points:

- How to eliminate wrap around artifact of the arms.
- How to reduce respiration motion artifact.
- What is axial in-phase & out-of-phase and how to get these images.
- What is axial LAVA and how to get axial LAVA images.

So far you have learned how to scan the phantom, knee, and the brain. They are all stationary, right? What if you add motion on the subject you're scanning like respiratory motion? This can lead to an artifact! There are different ways to avoid respiratory artifacts. One is reducing the scan time to less than 25 seconds, so that the scan can be acquired during a single breath-hold, others include respiratory gating and respiratory compensation (or phase re-ordering), which both utilizes the respiratory bellows. The success of both techniques depends on the patient maintaining regular breathing throughout the scans.

Step 1: Patient Prep

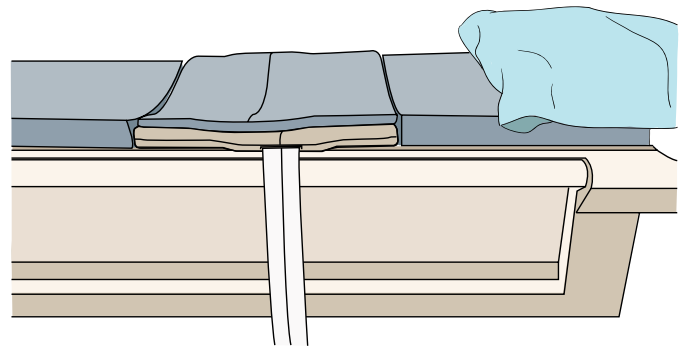
Refer to the previous exercises to ensure that your volunteer is MR safe and ready for scanning. Make sure that all the appropriate forms (consent, IRB, and safety screening) are filled up. Confirm if there's no metal in them and have them change to a lab gown. Explain the nature of the exams to your volunteer before going through the procedure.

Step 2: Prepare the room and coil

Place the posterior portion of the cardiac coil on the table, about where your volunteer's liver will be. Cover the coils with a clean sheet. Put a clean cover on the pillow for your volunteer's head.

Go to the PAC unit and retrieve the respiratory bellows and lay them on the table so that your friend will lay on top of them.

Fig 5.1 Preparing the room and positioning the posterior cardiac coil



Step 3: Place volunteer on the table

Have your volunteer lay on the table, feet first. Wrap the respiratory monitoring bellows around them. Use the nasal bellows if this is not available. Usually this is more sensitive in respiratory motion detection.

Place the anterior portion of the coil on your patient, centered over their abdomen—be sure that their abdomen will be covered (Fig5.3b).

Volunteer must have comfortable pillow for head and a cushion under the knees to relieve back pressure. Give your volunteer ear-plugs, and the squeeze ball. Ask them if they want a blanket, because the fan cooling the gradients makes it really chilly in the scanner.

Lifting the arms over head or crossing them on the chest can keep the arms away from the abdomen where they can cause aliasing. For patients who cannot lift arms over head, use the No Phase Wrap sleeves to eliminate aliasing or wrap-around artifact (Fig5.2).

Fig5.2 No Phase Wrap Sleeves

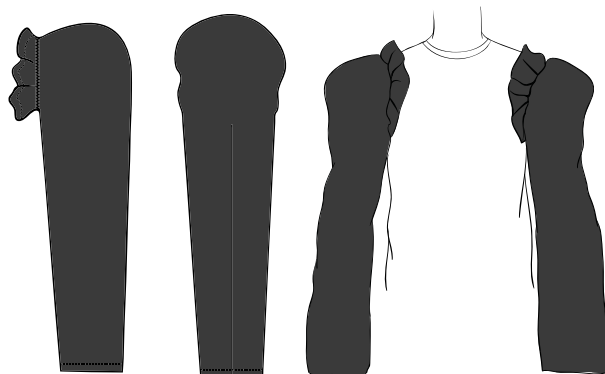
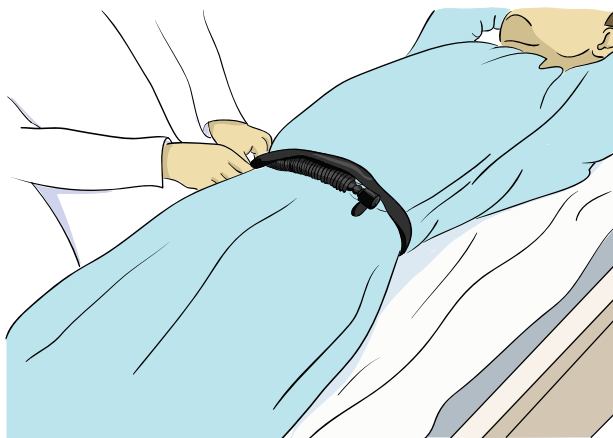
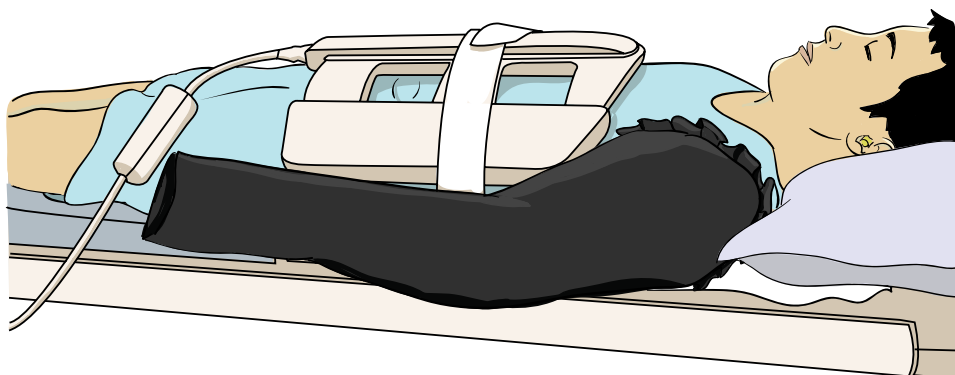


Fig 5.3 Positioning the volunteer

(a) Wrap the bellow around the waist, nice and tight to give a good signal.



(b) Placing the anterior cardiac coil on the volunteer



Step 4: Landmarking

Landmark the volunteer approximately two finger widths below the xiphoid process, a cartilage attached to the sternum at the lower end of the breast bone. Press Advance to scan then leave the scanner room. Close the door tightly, and proceed to the computer console.

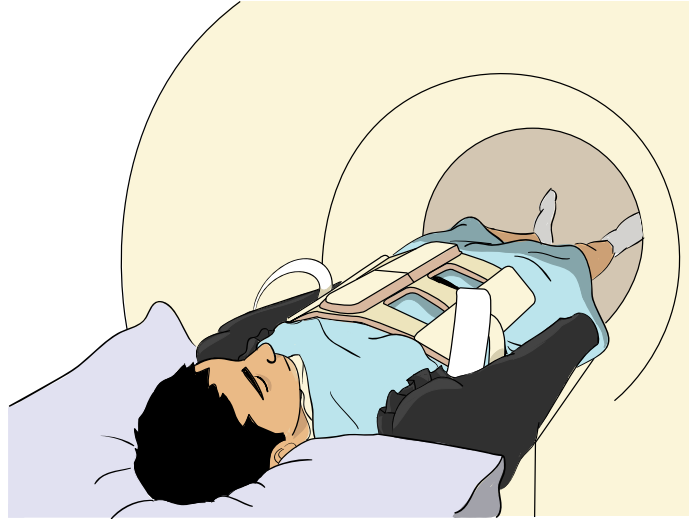


Fig 5.4 Landmarking

Step 5: Display the Respiratory Waveform on the Work Station

Click **Gating Control** on the Rx Manager (fig 5.5), select **Respiratory** in the Gating Control popup screen (fig 5.6), and then click Accept. The respiratory waveform of your patient must appear on the lower right portion of the screen (fig 5.7).

Is it clearly visible and does not saturate when your volunteer is breathing normally? If there's a problem, take them out of the scanner and adjust the respiratory bellows.

Fig 5.5 Click Gating Control on Rx Manager

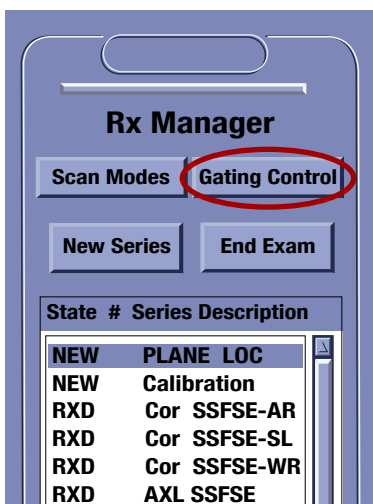
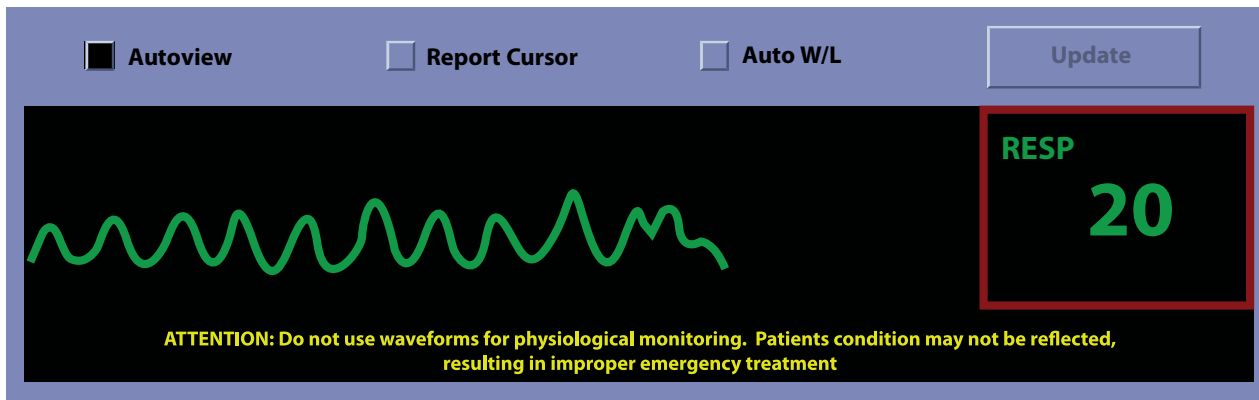


Fig 5.6 Select Respiratory on the Gating Control Screen



Fig 5.7 Displaying the respiratory waveform



Step 6: Protocol Selection

After completing the patient information, go to the Patient Protocol section and choose Abdomen/lumbar. Click on the **Abdomen (routine)** protocol from the protocol menu and then Accept (figure 5.8).

Go to the Patient Position section, select supine for the patient position and Feet First for the Patient Entry. Be sure to select the cardiac coil.

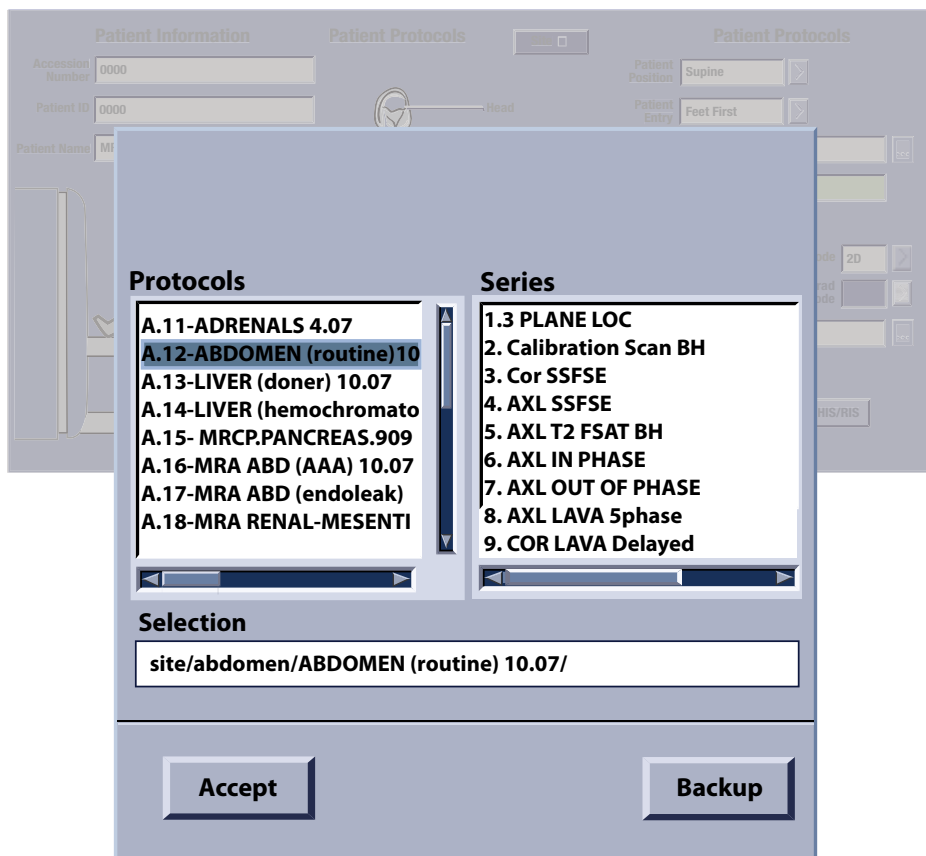


Fig 5.8 Protocol Selection

Step 7: Run the 3-Plane localizer

The 3-Plane localizer allows acquisition of symmetrical axial images. The wide field of view of the anatomy of interest can be seen using this plane. Select 3-Plane from the Rx Manager, click View Edit, Save series, and Download.

Hit the Prep Scan then tell the volunteer to “Breath in, breath out, and hold their breath.” Immediately after you give your volunteer those instructions, hit scan. Remember to tell your volunteer to breathe when the scan is over.

Note: Breath-holding in inspiration allows longer holding of breath but the diaphragm may not be held in the same position for the next batches of scans. Expiration is more reproducible, but patients can not suspend their breathing for longer periods. So if the scan time is long, it is advisable to do their breath hold during inspiration. On the other hand, if the scan time is short, breath hold is done during the expiration.

Step 8: Calibration Scan for ASSET or PURE

To setup the calibration scan, highlight it in the Rx manager and select View Edit. It should open in the graphic RX screen, but if it doesn't, click on the graphic Rx button. Pull down the slices, extending them, and then push them way up beyond the field of view to cover the whole anatomy of interest. Do the same for the bottom part of the slices. Click Save series, Download, Prep Scan, give instructions for breath holding, then hit Scan.

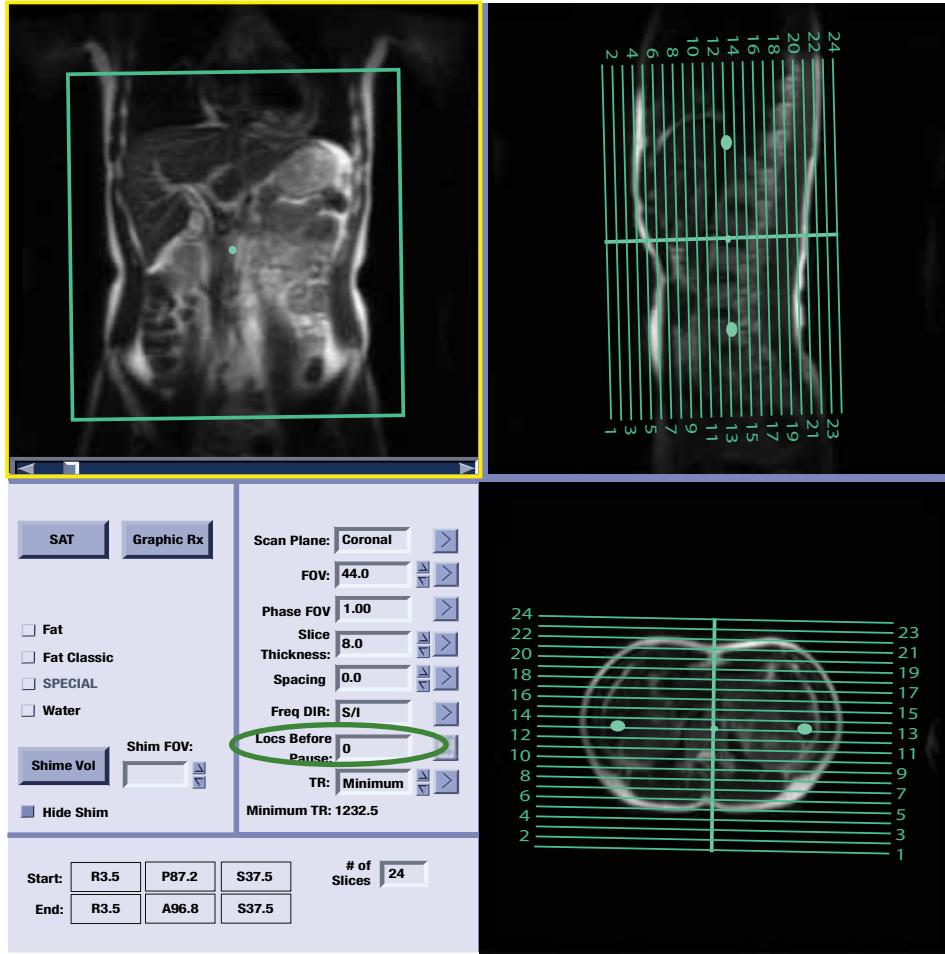
Step 9: Coronal Single Shot Fast Spin Echo (SSFSE)

Single Shot Fast Spin Echo is a sequence where there's only one initial RF excitation (90°) pulse followed by a very long echo train over which all the phase-encode steps are acquired. Over the course of acquisition, there's a lot of T2 signal decay so fluid structures can be seen clearly.

Fast acquisition allows scanning from top of liver to bottom of liver producing T2 weighted breath holding imaging, thus higher patient cooperation. Higher SNR is produced in this sequence so better quality images are obtained due to the decreased noise and respiratory motion artifact.

Select COR SSFSE from the Rx Manager and click View/Edit. Go to graphic Rx and cover the whole abdomen by adjusting the localizer (Fig 5.9). View the **Rx Scan Time** and if it's not possible for a single breath hold, change the **Locs Before Pause** to specify when to pause, at predetermined points for scans with more than two prescribed slices.

Fig 5.9 Graphic Rx for COR SSFSE



Click Save series, Download, Prep Scan, give instructions for breath holding, then Scan. If there's more than one acquisition, give instructions again for breath holding then hit Scan on the Keyboard.

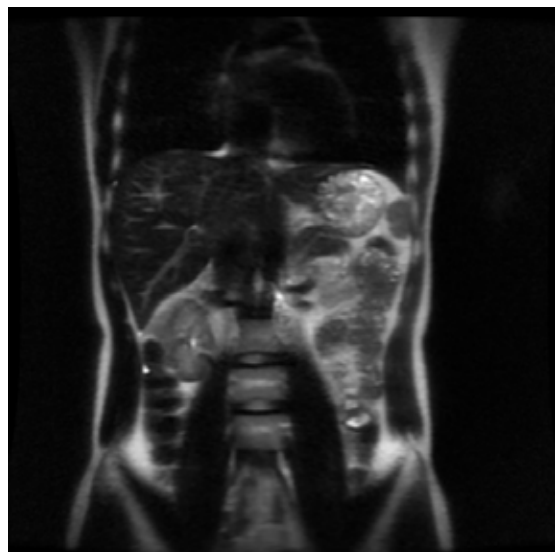


Fig 5.10 COR SSFSE

Step 10: Axial SSFSE

Select AXL SSFSE from the Rx Manager and click View/Edit. Adjust the localizer (Fig 5.11). View the Rx Scan Time and if it's not possible for a single breath hold, change the Locs Before Pause. Click Save series, Download, Prep Scan, give instructions for breath holding, then Scan.

Fig 5.11 Graphic Rx for AXL SSFSE

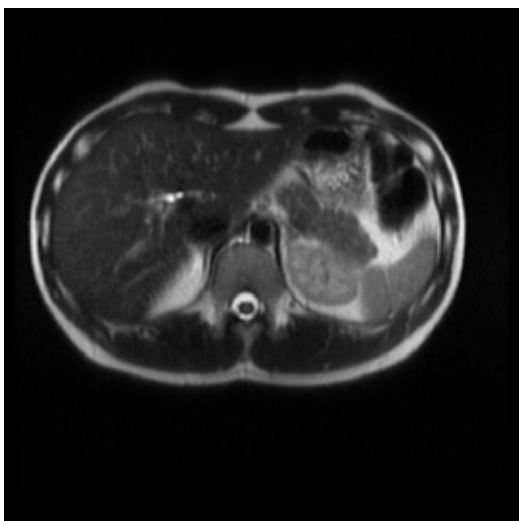
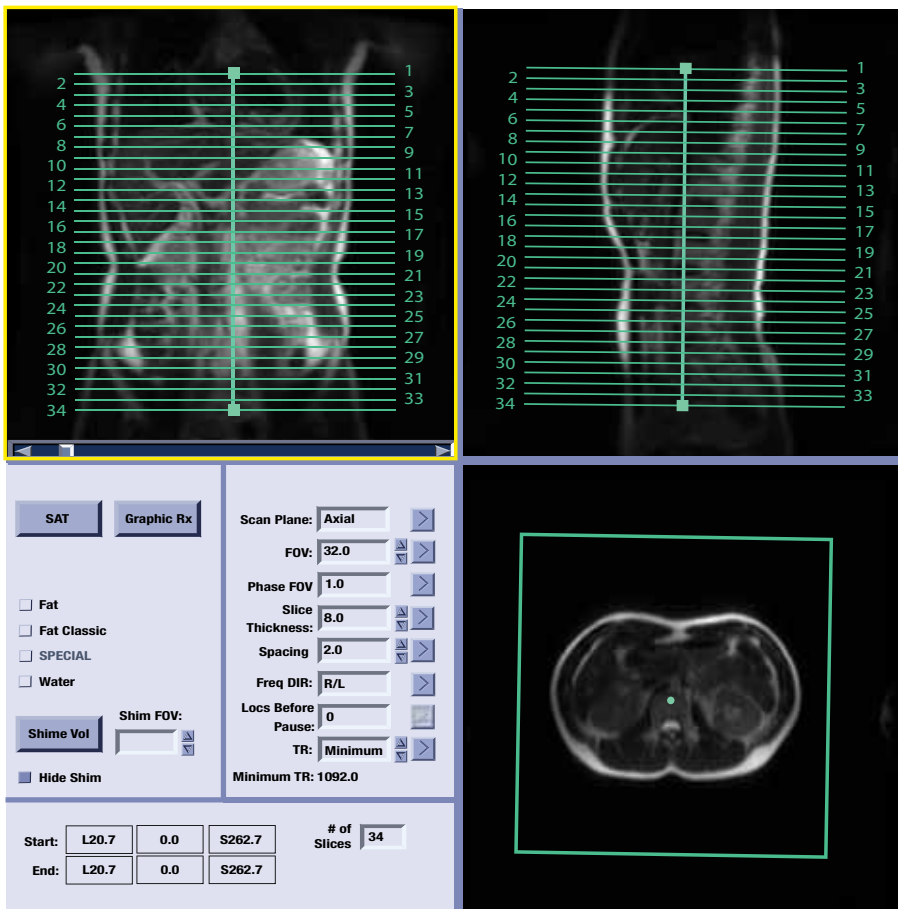


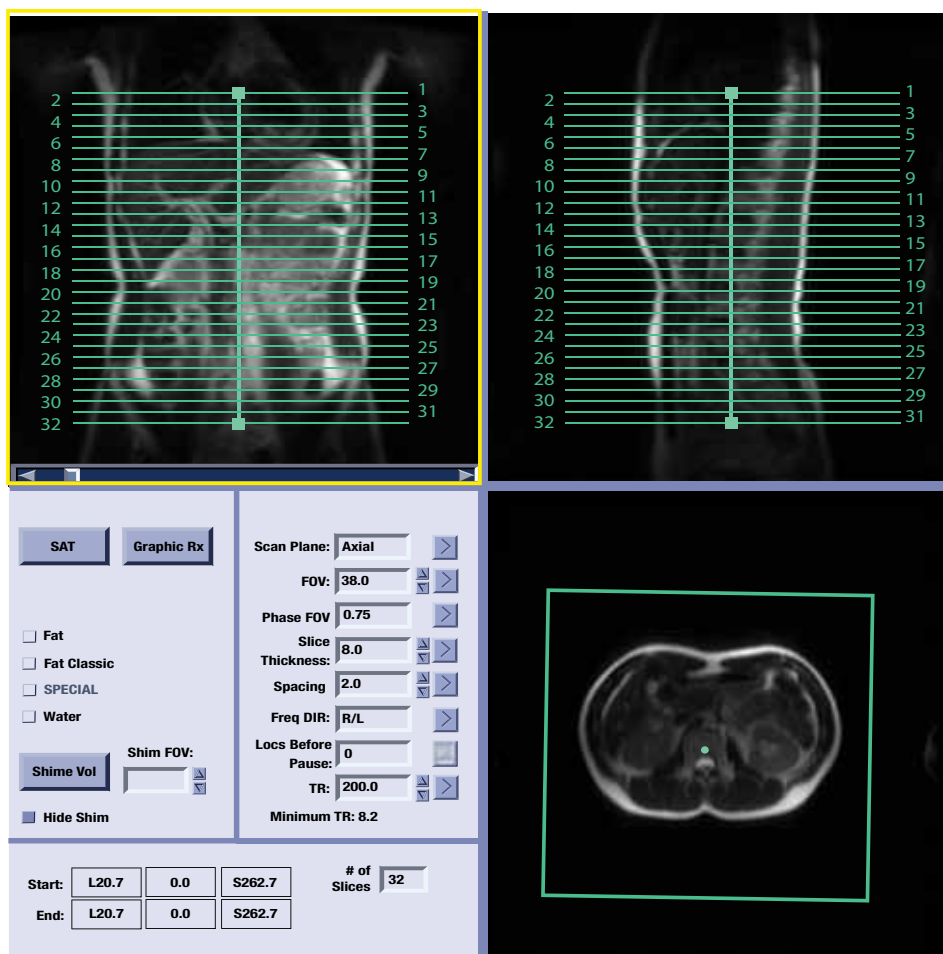
Fig 5.12 AXL SSFSE

Step 11: Axial In and Out of phase

Water and fat have different precession frequencies. Due to the difference in precession frequencies there will be points where fat and water will periodically appear in and out of phase. Immediately after the excitation pulse, water and fat signals are directly in phase with one another. This produces images where the interface between fat and water will either appear bright (in phase, fat and water signals add together) or dark (out of phase, fat and water signals subtract from each other). This effect occurs with gradient echo sequences since in spin echo sequences once the inverting pulse is applied water and fat signals are back in phase at the time of the echo. This out-of-phase artifact is commonly known as 'India ink' or the phase cancellation artifact, especially noticeable in the abdomen where water-based tissues are surrounded by peritoneal fat.

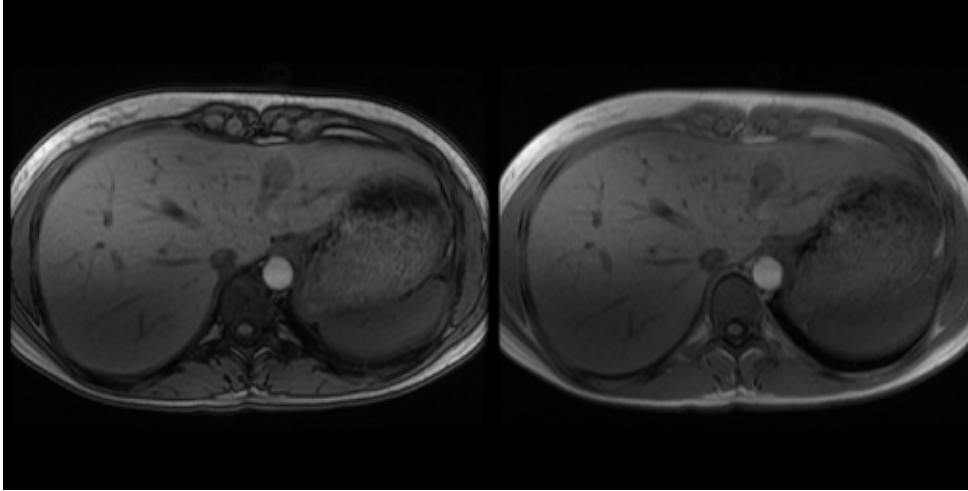
The protocol lists both in-phase and out-of-phase scan, but you can actually run both scans at the same time by selecting 2 echoes. Choose the in-phase scan from the protocol then click View Edit. Change the # of TE(s) per scan to 2. This makes one slice be in-phase and the next out-of-phase. Prescribe the slices in the Graphic Rx (Fig 5.13).

Fig 5.13 Graphic Rx for AXL IN AND OUT OF PHASE



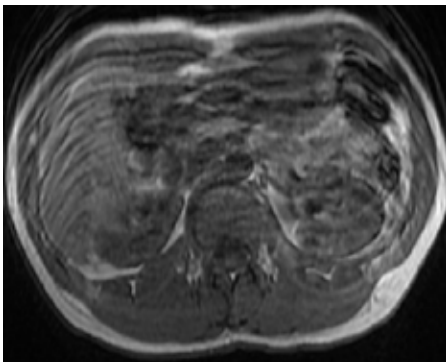
Adjust the Acqs Before Pause if necessary then click Save Series, Download, Prep Scan, give instructions for breath holding, then Scan.

Fig 5.14 Axial Out-of-phase (left) and In-phase (right)



Voxels with a mixture of tissues will have a reduced signal since the fat signal subtracts from the water, if the echo is acquired when fat and water are exactly out of phase. Due to the mixed voxels around the edge, a characteristic dark outline at fat/water interfaces appears. Increasing the TE will add the signals together instead of subtracting making the fat and water to be back in phase with each other, removing the black line.

This dual-phase chemical- shift imaging is used to detect lipid either in hepatic parenchyma or within hepatocellular neoplasm.



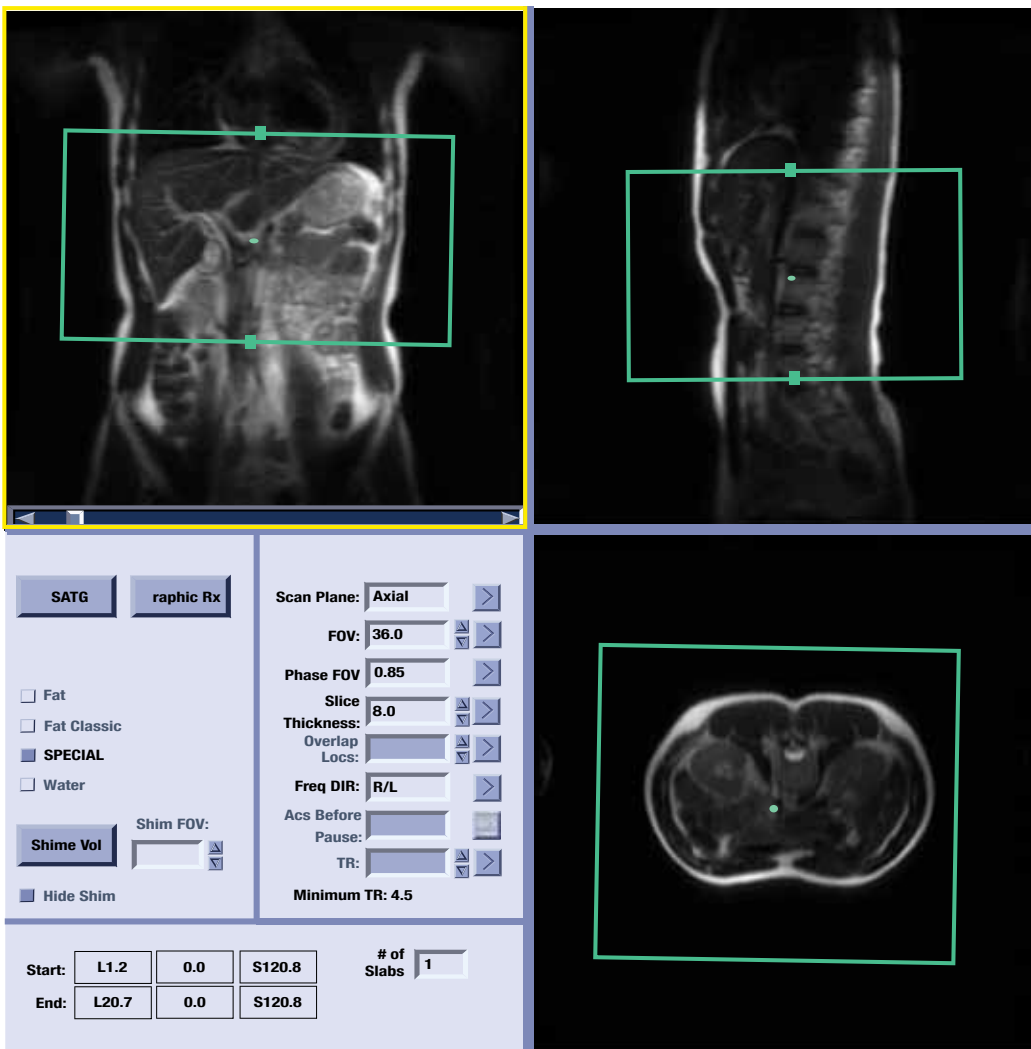
Motion artifact is the most common artifact in MRI. Any motion in the scan can cause image blurring (Fig5.15). It is a problem particularly for the heart and abdomen imaging. Breath holding is one way of reducing this artifact.

Step 12: Axial LAVA (Liver Acquisition with Volume Acquisition)

A 3D-LAVA scan is 3D spoiled gradient echo pulse sequence which provides high resolution images that optimizes inversion pulse and fat suppression technique. It enables the use of short breath holds for dynamic liver imaging with multiple phases.

Select the 3D LAVA 5 phases from the Rx Manager. Click View Edit and Prescribe the Graphic Rx (Fig 5.16). Click Save Series, Download, and Prep Scan.

Fig 5.16 Graphic Rx for Axial LAVA



This sequence has 5 phases, however we will use just one phase so that it's easy for us to do the reconstruction later on. Normally, the timer is already set for both the scans and pauses. The delay time and total time is displayed on the screen (Fig 5.17). We don't have to worry about this for now because we'll just scan once to get the first phase.

Fig 5.17 Count down timer



After the first phase, end the scan and do reconstruction of the image. Proceed to the browser window, select the 3D series and choose the IVI option on the right panel. A 3D image will appear on the screen and you can rotate it to see different angles.

Fig 5.18 3D LAVA



Step 13: Clean up

After scanning, go into the magnet room and move the table to home. Unplug the coils, lower the table and free your friend from the respiratory bellows.

Return the MRI, magnet room and console to its original tidy state.