LMS Patient Acquisition Manual for Philips Scanners

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Use and Limitation

This Manual is intended to be used as a reference guide for the acquisition of images using either a Philips 1.5T or 3T MRI system with CardiacQuant. Perspectum shall not be held liable for improper installation, operation, or maintenance of the system in circumstances where procedures and specifications set out in this Manual have not been followed correctly. It is essential therefore, that you follow the specifications, procedures, and recommendations outlined in this Manual.

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1. Glossary

Term	Description
A-P	Anterior-Posterior
ARRT	The American Registry of Radiologic Technologists
B0	Main magnetic field
CE	Continuing Education
DICOM	Digital Imaging and Communications in Medicine
DOB	Date Of Birth
ECG	ElectroCardioGram
F-H	Feet-Head
FFE	Fast Field Echo
GRE	Gradient Recalled Echo
IDEAL	Iterative Decomposition of water and fat with Echo Asymmetry and Least-squares estimation
ID	Identifier
LMS	LiverMultiScan
LSN	Liver Surface Nodularity
MOLLI	Modified Look Locker Inversion Recovery
MOST	Magnitude Only thin-Slice T2*
MRE	Magnetic Resonance Elastography
MRI	Magnetic Resonance Imaging
MR	Magnetic Resonance
NOLLI	Non-MOLLI T1 Mapping
PACS	Picture Archiving and Communication System
PG	Peripheral Gating
PII	Personally identifiable Information
PPU	Peripheral Pulse Unit
R-L	Right-Left
RF	Radio Frequency
RIS	Radiology Information System
S-I	Superior-Inferior
SAR	Specific Absorption Rate
SNR	Signal-to-Noise Ratio
SSFP	Steady State Free Precession
WIP	Work In Progress

Term	Description
dB/dt	Time varying gradient
tantanh	tangent hyperbolic tangent

2. Introduction

2.1. Scope

This manual is intended to describe the correct procedure to perform the Perspectum set up protocol to an *MR* operator on Philips scanners. Please use this document as a reference guide when performing the protocol acquisitions. The manual is divided in three main sections: Preparation, Acquisition and Data Export.

2.2. Continuing Education

In some territories, such as the USA, this training is eligible for continuing education (*CE*) credit. The *CE* is sponsored by Perspectum and will be presented by a member of the Imaging Applications team. The presenter's name, date, and attendees will be written on the Imaging Staff Training Checklist at the time of training; this form will be kept in Perspectum's records of site training activities and an electronic copy will also be sent to the site. In order to qualify for *CE*, the document, Multiparametric Liver MRI Applications Training – MRA1157, should also be provided along with the training. This document includes post-activity evaluations that must be completed to award credit.

2.3. Compatibility and Requirements

All sequences described in this manual require scanner hardware and software to be compliant with all manufacturer's specifications, especially gradient performance, eddy current compensation, and magnetic field (*B0*) homogeneity and stability. The protocols cannot be utilized on scanners outside of the manufacturer's service specifications and calibration schedules. Do not use phased-array coils with failed elements or without *SNR* checks passed.

2.3.1. T_2^* and Proton Density Fat Fraction Mapping Requirement

The system should also have the Multi-Echo Gradient-Echo package available. This package is offered as a product on most Philips scanners without the need of additional license.

2.3.2. T1 Mapping Requirement

T1 mapping protocols require the manufacturer's clinically approved software product CardiacQuant.

3. Preparation

3.1. Patient Registration

> **CAUTION**
> Ensure the subject is registered to a new *MR* study.

The minimum required information for registering the patient is as follows:

- Registration *ID*: <Use agreed on Subject ID Naming Scheme>
- Patient Name: <Use Agreed Subject Naming Scheme>
- Date of birth (*DOB*): <Use agreed DOB Scheme>
- Study Comments: Operator <operator initials> (example: Operator AB)
- The patient's height (when available), weight and sex

Subject Naming Scheme: If this scan is being performed for a research study or clinical trial, ensure no personally identifiable information (*PII*) has been entered. The study will have provided a Patient ID unique to each subject.

If local rules prohibit scanning without a real name, or if registration is populated from a *RIS*, after scanning please remove the *PII* from the *DICOM* files to send to Perspectum. The Data Export section and the Patient De-Identification Manual will give instructions.

If this scan is being performed as part of a clinical scan to aid diagnosis, *PII* may be acceptable in the patient registration.

Date of Birth (*DOB*) Scheme: If *PII* is allowed, the patient's date of birth *DOB* may be used. Otherwise, **please use 01-Jan, and the correct YEAR of birth.**

Please note that the MRI technician/radiographer who performs patient acquisition must have undergone training by either:

- (a) Authorised Perspectum Imaging Applications specialists
- (b) Previously trained site personnel authorised to perform internal training

A record of such internal training must be provided to Perspectum with the appropriate Imaging Staff Training Checklist.

3.2. Breath-hold Instructions

Breath-holding should be explained and practised when required because variations in the depth of a subject's breathing can markedly alter the image quality and the consistency of the abdomen position between acquisitions. End-expiration breath-hold is chosen because breathing out is a more repeatable process. This should be explained to the patient: 'The scans are better if you hold your breath after

breathing out comfortably.' The following instructions should be given to the patient ahead of each scan:

- Breathe in.
- Breathe out.
- Stop and hold your breath there.
- Breathe away or Resume breathing (after data has been acquired).

3.3. Patient preparation

LMS requires cardiac gating, end-expiration breath-hold and phased-array receiver coils.

Please prepare the patient following these steps:

1. Explain and demonstrate the breath-hold instructions as above.
2. Position the patient in the supine position.
3. Set up cardiac trace input (gating or simulator) and check the signal has clear R-wave triggering.
4. Select the correct trigger source in the Gating Window.
5. Patient arms can be positioned at the sides, though above the head is acceptable if subject does not easily fit into bore.
6. Use the spine array and the torso/body phased-array coil.
7. Scanner laser should be landmarked on the xiphisternum of the patient.

3.4. Cardiac Trace Input

Some pulse sequences require cardiac triggering/gating. This input can be from either the patient or a cardiac trace simulator. Both methods are outlined below.

3.4.1. Cardiac Trace Simulator

This feature is only available when access to either gyrotest, MRService or MRResearch account is possible.

1. Right click the protocol window and select <control parameter editor>.
2. Under the <General Tab> select <Yes> for <Physiology Simulation>.
3. Set the number of RR intervals to **`1`**.
4. Set the first RR interval to **`1000`**.
5. Click <Apply>.
6. Under <patient information> tag please enter **`60`** for <entered heartrate>.

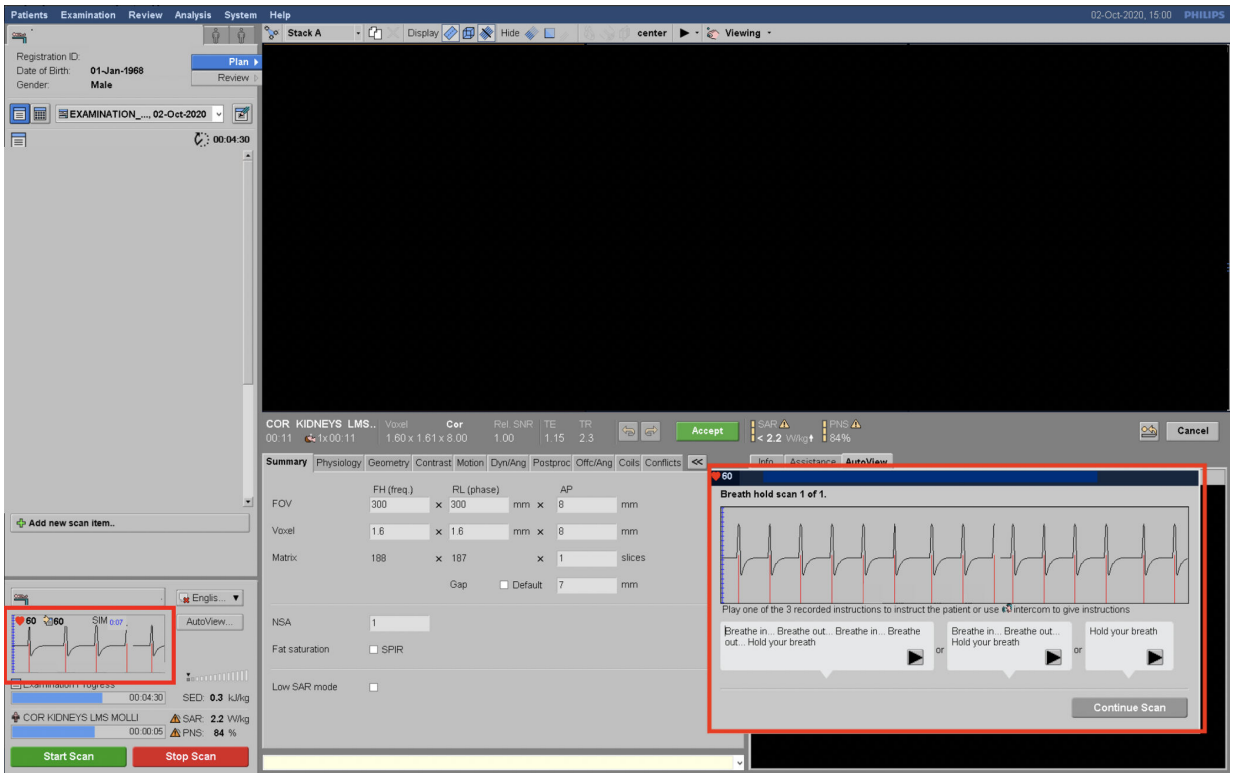

Figure 1. The simulated heartbeat is highlighted with a red box.

3.4.2. Cardiac Gating

1. Use *ECG* or pulse oximeter to set up the patient's cardiac gating.
2. select the correct trigger source in the gating window (physiology monitoring window) and confirm the signal has clear R-wave.

After a regular heartbeat is picked up by the *ECG* leads or pulse oximeter, double click on the second number on the right number and it will automatically update to the current heart rate. In the case of Figure 2 (page 6), the current heart rate is 60, and the expected heart rate is 65.

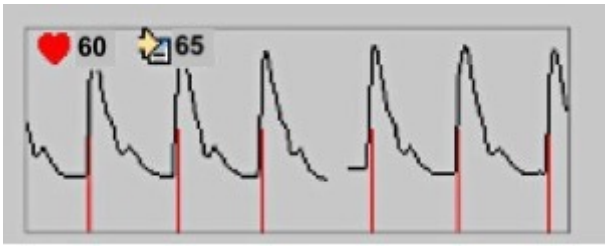

Figure 2. Update expected heart rate. 65 is the expected heart rate set by the radiographer and 60 is the actual heart rate of the patient detected by the scanner.

TIP

It is important to maintain the expected heart rate higher than the real heart rate to account for fluctuations.

3.4.3. Cardiac Trace Simulator

This feature is only available when access to either gyrotest, MRService or MRResearch account is possible.

1. Right click the protocol window and select <control parameter editor>.
2. Under the <General Tab> select <Yes> for <Physiology Simulation>.
3. Set the number of RR intervals to **1**.
4. Set the first RR interval to **1000**.
5. Click <Apply>.
6. Under <patient information> tag please enter **60** for <entered heartrate>.

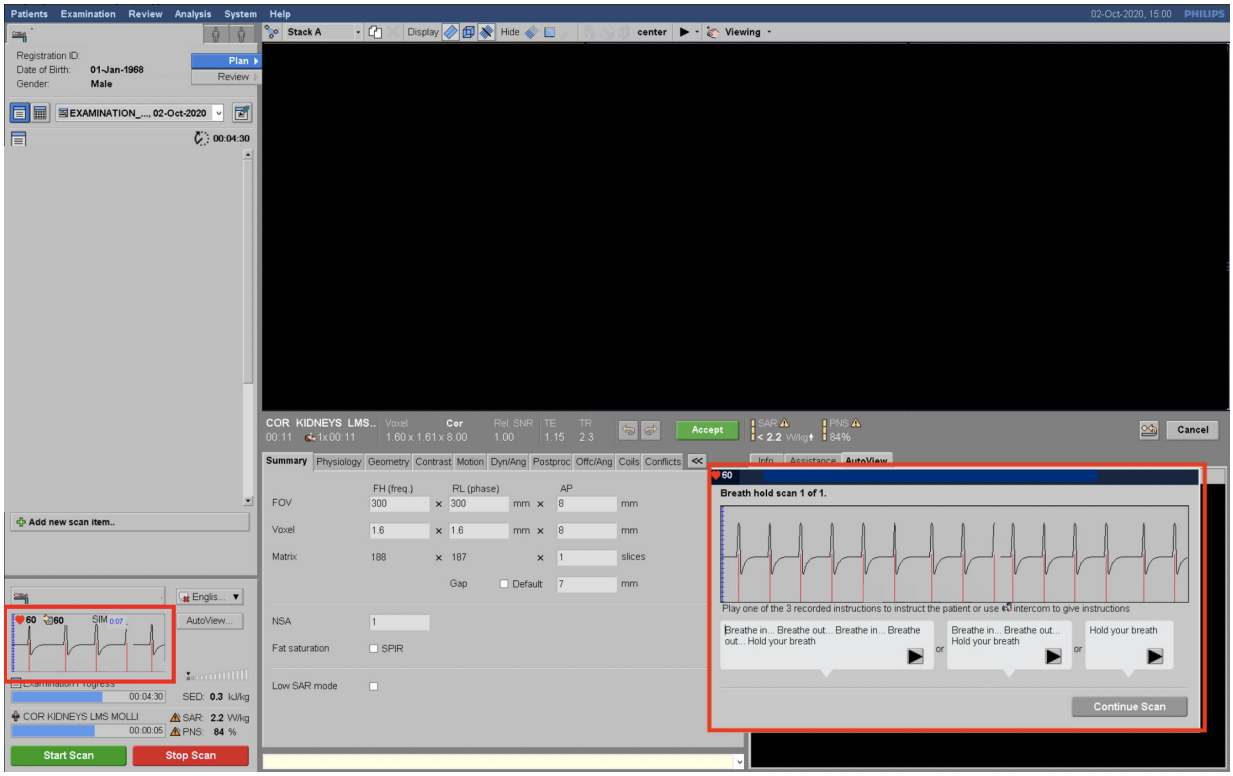

Figure 3. The simulated heartbeat is highlighted with a red box.

3.4.4. Cardiac Gating

1. Use *ECG* or pulse oximeter to set up the patient's cardiac gating.
2. select the correct trigger source in the gating window (physiology monitoring window) and confirm the signal has clear R-wave.

After a regular heartbeat is picked up by the *ECG* leads or pulse oximeter, double click on the second number on the right number and it will automatically update to the current heart rate. In the case of Figure 4 (page 8), the current heart rate is 60, and the expected heart rate is 65.

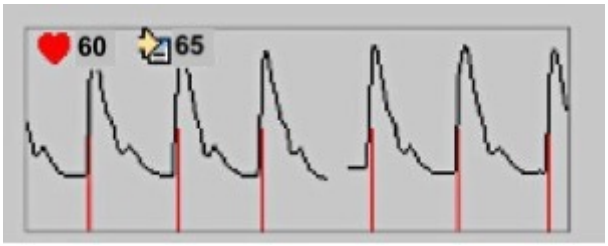

Figure 4. Update expected heart rate. 65 is the expected heart rate set by the radiographer and 60 is the actual heart rate of the patient detected by the scanner.

TIP

It is important to maintain the expected heart rate higher than the real heart rate to account for fluctuations.

4. Acquisition

Please note that:

1. All protocols must be acquired before any contrast agent injection. Note that contrast agents are not necessary for any of the acquisitions.
2. All scans are performed during end-expiration breath-hold, including the Survey scan.

> **CAUTION**
> Protocol parameters should not be changed. Any changes not specifically covered in these instructions risk corrupting the resultant parameters and cause data rejection by Perspectum Ltd.

> **CAUTION**
> Please do NOT inject any contrast agent prior to the acquisition of *LMS* protocol. This might result in erroneous parameter quantification.

4.1. Localization Protocols

4.1.1. Three-plane Survey

A three-plane Survey should be run at end-expiration breath-hold to produce at least one sagittal, one coronal and one transversal view of the abdomen.

> **CAUTION**
> Check that the phased-array coil is positioned to give good *SNR* over the entire liver. Reposition the coil on the patient if necessary. Low image *SNR* adversely impacts the quality of the resulting parameter estimates.

4.1.2. Additional Localizers (optional)

Additional localizers may be run to acquire axial/transversal slices to find the right view for subsequent *LMS* slice positioning.

4.2. Liver LMS Imaging Location

4.2.1. Base Slice Positioning

This slice location will be used as the centre for the majority of the sequences. Hence it is imperative to position correctly. The base slice should be positioned such that it intersects the porta hepatis, and it should display the liver, spleen, and may also contain the stomach.

If the lungs are visible in the transverse slice, please shift the image lower on the patient's abdomen as the lungs will cause susceptibility artefacts. Please refer to the localizer images in Figure 5 (page 10) for positioning of the transverse slice.

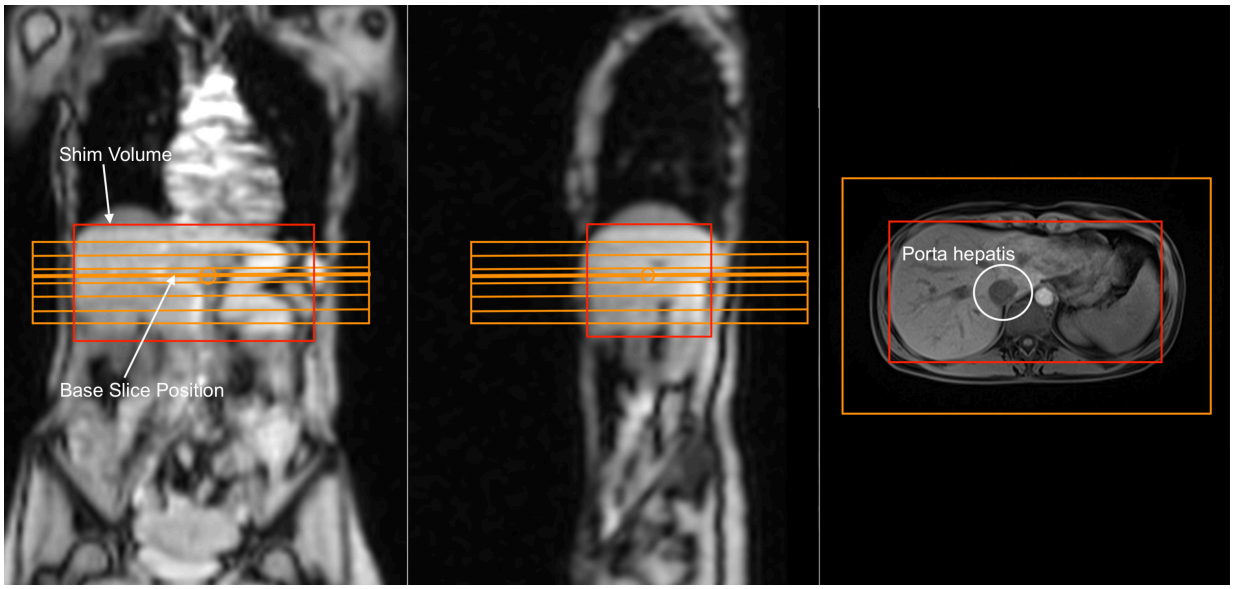

Figure 5. Three-plane Survey view of the abdomen in coronal, sagittal, and transversal (axial) plane. The base slice location for LMS protocol is indicated in orange and the shim volume in red.

4.2.2. Shimming

The shim volume should be centred as shown in Figure 5 (page 10) . The *F-H* direction should cover the entire stack of slices and should be remained as in the protocol. In the *R-L* and *A-P* directions, the shim volume can be adapted until the liver is fully covered, excluding as much air as possible. Please also exclude the subcutaneous fat in obese patients.

CAUTION

Shim adjustments other than those described in this manual may corrupt the parameter mapping.

CAUTION

Susceptibility Artefacts

Magnetic susceptibility artefacts appear due to: poor shim, proximity to the lungs, bowel gas or metallic implants. Susceptibility artefacts in the liver will preclude accurate parameter estimation in the areas affected as shown in Figure 6 (page 11).

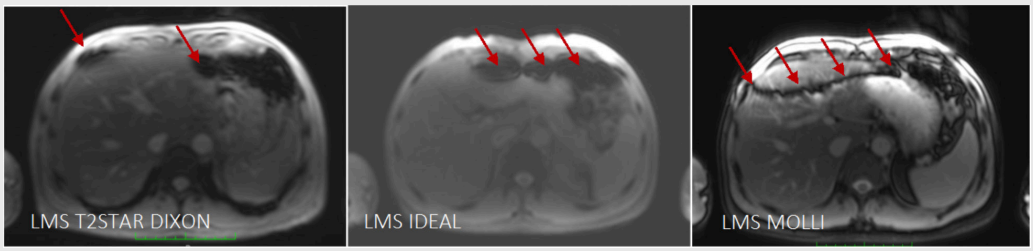

Figure 6. Susceptibility artefacts will appear as dark, distorted areas, in LMS MOLLI it also can appear as a banding artefact.

To mitigate susceptibility artefacts:

1. Ensure the centre of the multi-slice is at isocentre and make sure the shim volume is positioned as shown in Figure 5 (page 10).

2. Force a re-shim by :

Postproc tab > Set the Preparation Phases method to “Full” > Run the sequence again.

3. Re-acquire the data.

4.3. Liver LMS IDEAL

This is a 5-slice multi-echo sequence performed at end-expiration breath-hold. The breath-hold lasts approximately 9 seconds. This sequence will be used to generate a PDFF map of the liver.

1. Prescribe the slice stack so that the 3rd slice (middle slice) intersects the porta hepatis.

2. The shim volume should be centered as the slice stack and the R-L and A-P directions can be adapted to ensure the entire abdomen is included in the transverse view and the liver and the spleen are completely covered as shown in Figure 5 (page 10) .

3. The (F>>H) shim volume thickness should be manually adjusted to '90mm'.

4.4. Liver LMS MOST

This is a single-slice multi-echo gradient-echo sequence performed at end-expiration breath-hold. The breath-hold lasts approximately 11 seconds. This sequence will be used to generate a T2* map of the liver.

1. Set the centre of the slice and shim volume identical to LMS *IDEAL* (same GEO name).
2. Make sure the shim volume thickness is 20mm. Repositioning of the adjust volume may be required.
3. Give the breathing instruction, "**Breath in**", "**Breath out**", "**Hold your breath**" and then run the sequence.
4. Once the acquisition is complete, tell the patient to "**Resume breathing**"

4.5. Liver LMS T2STAR DIXON

This is a single-slice multi-echo gradient-echo sequence performed at end-expiration breath-hold. The breath-hold lasts approximately 10 seconds. This sequence will be used to generate a T2* map of the liver.

1. Set the centre of the slice and the shim volume identical to LMS *MOST* (same GEO name).

4.6. Liver LMS MOLLI

This is a multi-slice, multi-breath-hold, cardiac-gated acquisition performed at end-expiration breath-hold. This scan acquires 5 transverse slices, one slice per breath-hold. Each breath-hold lasts approximately 9-12 seconds. This sequence will be used to generate a T1 map of the liver.

After each slice has been acquired the operator will be prompted to give breathing instruction for the next slice. During the scan, it is imperative to monitor the physiological recording trace to check **no heartbeats are missed** by the system's triggering algorithm.

1. Set the LMS *MOLLI* slice centre as same as LMS *IDEAL* by ensuring they have the same GEO name.

2. The slice stack and shim volume should be positioned as shown in Figure 5 (page 10).

5. Data export

If the patient registration contains personally identifiable information (*PII*), please refer to the Patient de-Identification Manual for help removing the PII but preserving the private DICOM tags necessary for describing the image acquisition.

Private DICOM tags are special tags added by the manufacturer to describe the MRI sequence. They do NOT refer to private information, nor PII. Many DICOM anonymization tools have an option to remove all Private Tags. Do not remove Private Tags when exporting data.

> **CAUTION**
> Private DICOM tags must be preserved in any data export. Private DICOM tags are not PII tags. PII must be removed if this scan is for research purposes.

These instructions cover exporting data from the scanner for transfer. If your site is unable to export from the scanner directly and transfers data via a *PACS* system please use the PACS export to save the DICOM images.

5.1. Saving *DICOM* Images for Transfer

To export data from the Philips MRI Scanner directly, from the <Patient> menu pick <Administration> to open the Patient Administrator.

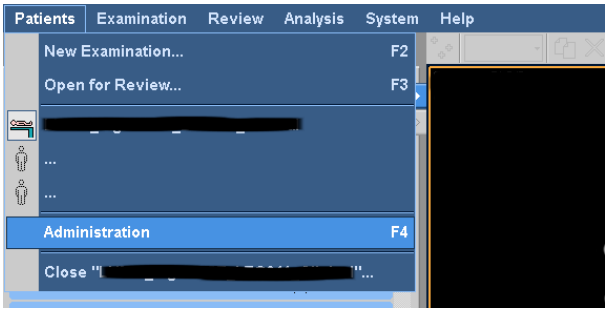

Figure 7. Click on Administration from the Patients tab to export data.

The source database or device can be chosen from the top-left corner. The default is the <Local Patient Database>. Select the data you want to export.

Exporting data to a CD or DVD:

Please select DVD as a destination on the Patient Administration window.

Exporting data to a specific location to the file system with a USB stick or external hard drive:

Please export the data in the following steps:

1. In <Patient Administration> select the appropriate subject folder.
2. click on <Disk Files> icon to open the <Export to Files> pop-up window.
3. Browse to your destination. This can be an external USB stick or hard drive.
4. Select format as <Classic *DICOM*>.
5. Confirm with Proceed.

> ⚠ **CAUTION**
>
> **DO NOT** select <suppress patient data> or <Anonymize>.

To check the status of data transfer, select <Queue Manager> from the <System> main menu or from the <Patient Administration> window.

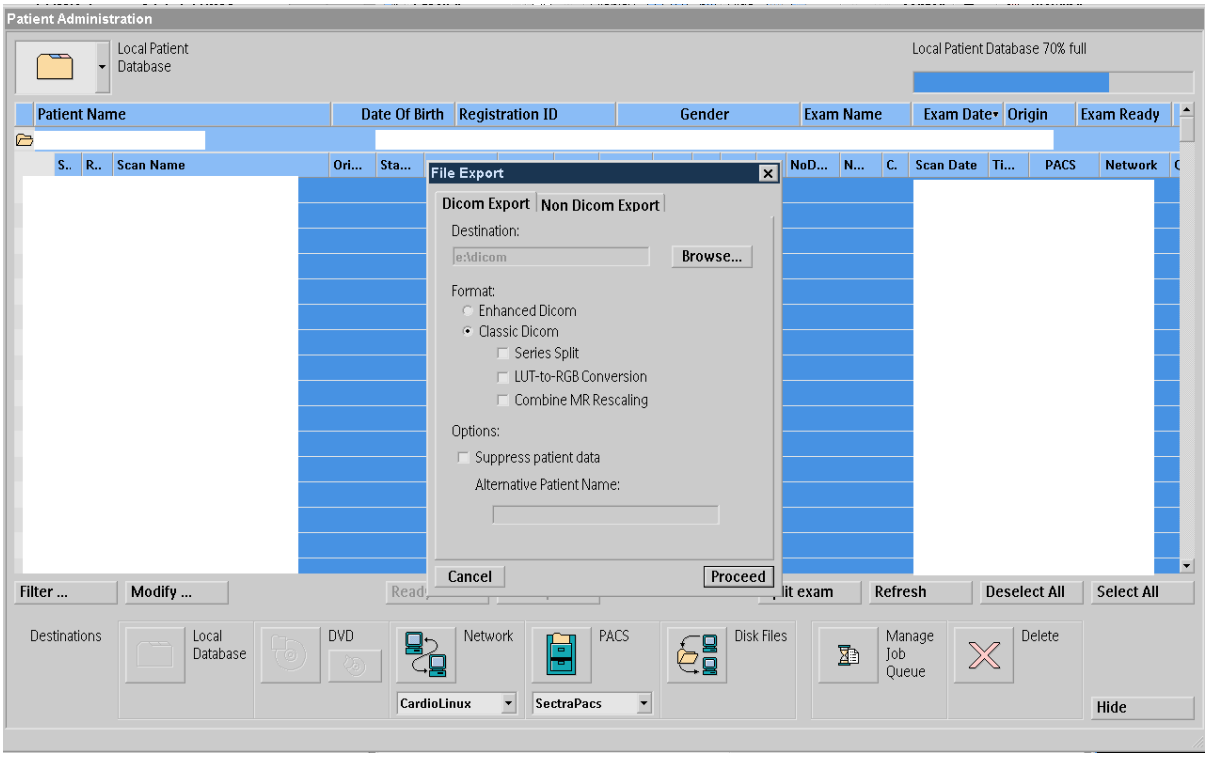

Figure 8. Data Export options.

It is preferable to compress the folder of exported DICOMs and submit the single compressed file to the Portal.

- **On a Windows**: right click on the folder in Windows Explorer and select <Send To> and <Compress (zipped) folder>. If the folder resides on a CD or DVD, you will need to copy the folder to a location that can be saved to.
- **On a Mac**: hold Ctrl and click on the folder, then select <Compress>.

Upload the compressed file to the Portal.

For additional instruction on using the Portal, please see the QAS Portal Customer Instruction - PDM077 on the Portal website.

6. Acquisition Checklist

Step	Task
Patient information	☐ Patient name: Use agreed patient naming scheme ☐ Registration ID: Use agreed patient ID naming scheme ☐ Date of birth: Use agreed scheme ☐ Correct sex, height, weight and exam date ☐ Study Comments: Input the initial of the operator. ☐ Patient Position: Select the appropriate position. ☐ Leave the rest of the fields empty.
Localiser (one breath-hold)	☐ Run localiser on expiration
LMS IDEAL (one breath-hold)	☐ Place the slice stack (5 slices) so that the middle slice (third slice) will intersect the porta hepatis. ☐ Position the shim volume centred on the slice stack. ☐ Adjust the shim volume only in R-L and A-P directions to the patient's dimensions so all of the abdomen is included in the transverse view. ☐ Scan the sequence at end of expiration. ☐ Check image quality, if there is motion artefacts please re-acquire the sequence.
LMS MOST (one breath-hold)	☐ Position the single with the same centre of LMS IDEAL, intersecting the porta hepatis. ☐ Position the shim volume centred on the slice; shim volume is thicker than the slice. ☐ Adjust the shim volume only in R-L and A-P direction to the patient's dimensions so all of the abdomen is included in the transverse view. ☐ Scan the sequence at end of expiration. ☐ Check image quality, if there is motion artefacts please re-acquire the sequence.
LMS T2STAR DIXON (one breath-hold)	☐ Position the slice with with the same centre of LMS MOST, intersecting the porta hepatis. ☐ Position the shim volume centred on the slice. shim volume is thicker than the slice thickness. ☐ Adjust the shim volume only in R-L and A-P direction on the patient's dimensions so all of the abdomen is included in the transverse view. ☐ Scan the sequence at end of expiration. ☐ Check image quality, if there is motion artefacts please re-acquire the sequence.

Step	Task
LMS MOLLI (5 breath-holds)	☐ Position the slice stack with the same centre of LMS IDEAL. ☐ Make sure the shim volume is centred on the slice stack and adjust the shim volume only in R-L and A-P direction so all of the abdomen is included in the transverse view. Exclude subcutaneous fat as much as possible. ☐ Check image quality for each slice; are there artefacts? If so, please re-acquire the sequence.

7. Issue Control

Issue	Details	Date	Initial
4.0	Conversion to Paligo; Sign-off	April 2019	FSN
5.0	Updated the acquisition sequences and added cardiac trace simulator	July 2020	FSN

8. Approvals

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