

PVDOMICS CMR ACQUISITION REFERENCE GUIDE

Cardiac Structure and Function

1. Acquire images using consistent imaging parameters. Subject positioning and plane orientations must remain consistent throughout the study. *All subjects will be examined in the supine position.
2. EKG monitoring will be performed; lead placement is critical. Poorly placed leads result in blurred images and inaccuracies in data. *Breath holding must be consistent. Placement of slices can be off as much as 2 cm when inconsistency with breath holds occurs.
3. Three-plane scout, (True Fisp) or vendor related scout from axial, coronal, sagittal
4. Localizer: Axial single-shot blood (HASTE) images through the chest. Plan from sagittal and axial scout.
5. 8 mm thick, spaced to cover the aortic arch through the diaphragm. *Acquisition during breath-hold is optimal for accuracy.
6. Localizer: Axial bright blood images through the chest
7. Single-shot SSFP (True Fisp), or vendor related cine Plan from coronal scout, *8 mm thick slices, spaced to cover the aortic arch through diaphragm
8. SSFP (True Fisp) or vendor related cine imaging (3 orientations)
9. Vertical long-axis orientation (2 chamber)
10. Horizontal long-axis orientation (4 chamber)
11. Left ventricular outflow tract (LVOT) orientation (3 chamber view)
12. Common sequence parameters for cine imaging
 - a) 8-mm slice thickness
 - b) 2.3 mm minimum spatial resolution (for both phase and frequency encoding directions)
 - c) 25-35 ms temporal resolution preferred; can be obtained by dropping views per segment captured between R to R intervals.

→ ***If performing Optional Imaging do Pre-contrast MOLLI and pulmonary artery compliance remodeling next.

Rest Perfusion Imaging

1. Saturation-recovery imaging will be used to assess resting myocardial perfusion.
2. Short-axis images will be acquired (at least 3 slices per heart beat), using a slice thickness of 8 mm and parallel imaging, 2-fold acceleration, if available with in-plane resolution, $\sim < 3$ mm. Readout temporal resolution $\sim 100 - 125$ ms or shorter as available.
3. Contrast will be given (0.1 - 0.2 mmol/kg, 3–7 ml/s) followed by at least 30 ml saline flush (3–7 ml/sec). (See GFR dosing table on page 3.)
4. Breath hold will start during early phases of contrast infusion before contrast reaches the LV cavity.
5. Images will be acquired for 40-50 heart beats to ensure that the contrast has passed through the LV myocardium.

→ ***If performing Optional Imaging do 4D Flow Imaging next

Valvular Flow

1. Use Phase velocity encoded images to assess valvular flow.
2. Two separate images will be acquired, through the aortic valve and the pulmonic valve.
3. Images will be acquired “en-face” valve orientation at the level of the valve leaflet tips.
4. Temporal resolution < 35ms, will ensure accuracy in flow data.
5. VENC limits will be tailored to avoid aliasing (typically 1.5 m/sec). **Recommend careful assessment for aliasing, and increasing the VENC level as needed (i.e. 2 m/sec or greater as needed). VENC is important to not travel too high away from the normal values on each patient.**
6. Flow quantification will be assessed of the right and left pulmonary arteries.

DHE-Myocardial Scar

1. **CMR with Late Gadolinium Enhancement (LGE)**
Delayed short axis and long axis views should match slice locations of SSFP cine images. Copying the slice location is an industry standard. Cine images can be ordered to select the end diastolic trigger time by simply scrolling through a short axis image slice location. The selected time for end diastole can be entered into the actual trigger delay time prior to acquiring the delayed image set. This will enable a more accurate representation of the tracing to copy.
2. **Segmented Inversion-Recovery Sequence (tfi_psr_single-shot_PSIR) or vendor related delayed imaging**
3. **Should be acquired during breath hold approximately 10 minutes post IV administration of 0.15 mmol/kg of gadolinium chelate to optimize blood pool contrast myocardium nulling. If possible, capture a second set of late SAX stack of delays in single breath, acquiring 2 and long axis in between.**
4. **Inversion Time (TI) optimized by Look-Locker sequence (TI scout) to null normal myocardium. Proper selection of TI time for optimal nulling cannot be over emphasized.**
5. **Contiguous LV short axis stack to cover complete LV myocardium from valve plane to apex. (0 mm inter-slice gap)**
6. **Vertical long-axis orientation (2 chamber)**
7. **Horizontal long-axis orientation (4 chamber)**
8. **Left Ventricular outflow tract (LVOT) orientation (3 chamber view) \ Common sequence parameters for cine imaging**
9. **Recommended LGE Imaging Parameters**
 - a. **TR 4.3 ms**
 - b. **TE 2.1 ms**
 - c. **Flip Angle 45 degrees to optimize effectiveness of contrast agent**
 - d. **FOV 300-350 mm**
 - e. **Matrix 128 x 256**
 - f. **8 mm slice thickness**

g. 0 mm inter-slice gap (for contiguous stack)

***If performing Optional Imaging do Post Contrast MOLLI now.

Optional Protocol

1. **Extracellular Volume Fractionation:** Pre-contrast T1 mapping will be performed to quantify myocardial extracellular volume (ECV).
 - a. Use a modified look inversion recovery (MOLLI) pulse sequence, acquired in 3 short axis locations: basal, mid, and distal LV
 - b. Imaging acquired 5, 10, and at least 15 minutes post-contrast in spatially matched locations for calculation of ECV, which will be quantified in accordance with established convention $[ECV = (1 - \text{hematocrit}) * [(1/T1_{\text{myo post}} - 1/T1_{\text{myo pre}}) / (1/T1_{\text{blood post}} - 1/T1_{\text{blood pre}})]]$. **Recommend also acquiring high resolution MOLLI with in plane resolution of 1-2mm for T1 mapping/ECV quantification of the right ventricle.**
2. **Pulmonary Artery Compliance:** High temporal resolution cine-CMR (< 50 msec) performed to assess vascular compliance.
 - a. Cine-CMR will be acquired in three pre-specified locations – (1) main pulmonary artery (1.0cm proximal to bifurcation), (2, 3) left and right pulmonary arteries (1.0 cm distal to bifurcation). Images will be acquired in double oblique orientation (i.e. orthogonal to the PA vessel wall, as oriented based off cine images).
3. **Pulmonary Artery Vessel Wall Remodeling:** High anatomic resolution black blood imaging (typical in-plane resolution 1-2mm) performed to assess pulmonary arterial vessel wall thickness at spatially matched locations corresponding to high temporal resolution cine-CMR (main, left, right pulmonary artery).
4. **4D Flow:** Anisotropic 4D segmented k-space phase contrast gradient echo sequence with retrospective ECG gating with navigator-gating of respiratory motion to assess three-directional blood flow velocity information to visualize blood flow patterns and qualitatively assess flow.
5. 3D volume will cover apex to the aortic arch, the sternal border and spine, and the main stem of the right and left pulmonary artery until further branching in the right-to-left will be acquired (typical in-plan resolution 2-3mm). **If this sequence is available, it should be performed immediately after the resting perfusion sequence.**

CMR Dosing

GFR (mL/min/1.73m ²)	Gadolinium Dosage (mmol/kg)
<30	Non contrast exam
30-60	0.10
>60	0.20
Option	If necessary, follow site's institutional guidelines.