ACRIN
AMERICAN COLLEGE OF RADIOLOGY IMAGING NETWORK

www.acrin.org

Site Imaging Manual

ACRIN PA 4008

Arterial Stiffness and Wave Reflections as Determinants of Regression of Left Ventricular Hypertrophy and Fibrosis Assessed with Cardiac MRI after Aortic Valve Replacement for Severe Aortic Stenosis

Version:	Final v.2
Date:	02 January 2014

Table of Contents

History of Revisions:

02-Jan-2014	Revisions to reflect Amendment 3 of the Protocol. Edits made to eligibility criteria and protocol specific parameters.

Letter of Introduction

Dear Imaging Staff,

This Site Imaging Manual contains the image acquisition instructions for the **ACRIN PA 4008 trial: "*Arterial Stiffness and Wave Reflections as Determinants of Regression of Left Ventricular Hypertrophy and Fibrosis Assessed with Cardiac MRI After Aortic Valve Replacement for Severe Aortic Stenosis.*"**

To successfully meet the study objectives, it is critical that the Cardiac MRI image datasets are acquired according to the imaging protocol detailed in this manual.

Quality Control (QC) review of the images will be performed by the ACR Imaging Core Laboratory. This review will be performed in a timely fashion, as part of ACRIN standard operating procedures. If any protocol deviations or technical issues are identified during the review, an ACR Core Lab Imaging Technologist will contact your site to provide feedback expeditiously. This will allow your site to make any necessary adjustments early in the conduct of the study.

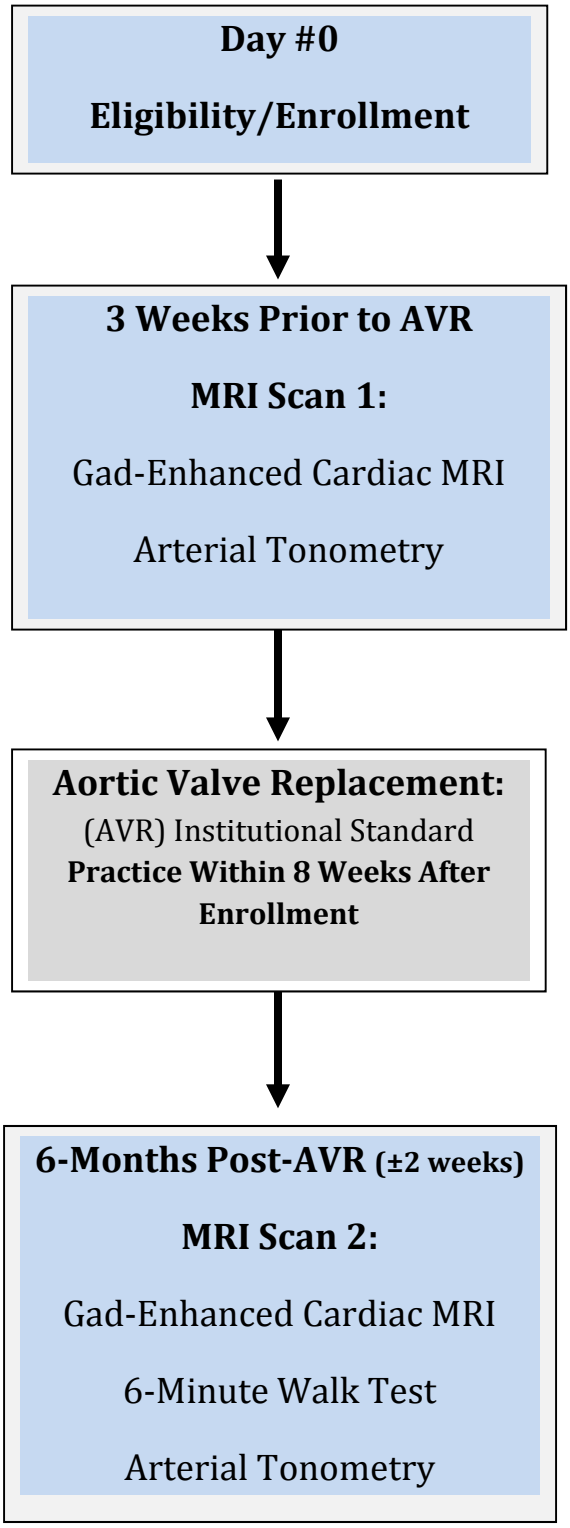
The ACRIN PA 4008 Imaging Team wishes to thank you in advance for your diligence in adhering to the procedures described in this manual to ensure the integrity of the image data collected for the study. Please do not hesitate to contact the ACRIN PA 4008 Imaging Technologist (see contact information below) if you have any questions.

Sincerely,

Dena Flamini
ACRIN PA 4008 Imaging Analyst

American College of Radiology
1818 Market Street- Suite 1600
Philadelphia, PA 19103
Phone: (215) 940-8880
Fax: (215) 923-1737
www.acrin.org
Dflamini@acr.org

ACRIN PA 4008 Study Schema



1.0 Overview of Imaging Requirements

Qualification	Submit prior to site activation (for each scanner): • Protocol Specific Application (PSA); • Submission of one protocol specific qualification exam
TRIAD Installation	Should be installed prior to study participant enrollment for secure, electronic submission of imaging to ACRIN.
Time Points for Trial Examinations	• **MRI Scan 1**: (Within 3 weeks prior to AVR) o Gad-Enhanced Cardiac MRI and Arterial Tonometry • **MRI Scan 2**: (6 months post AVR surgery) o Gad-Enhanced Cardiac MRI, 6-Minute Walk Test, and Arterial Tonometry
Image Submission	ACRIN PA 4008 imaging should be submitted electronically to the ACR Imaging Core Lab via TRIAD. All imaging should be submitted **within 48 hours** after acquisition and should include an Image Transmittal Worksheet (ITW).
Data Queries	ACRIN will issue queries, as needed, based on QC review of imaging.

General Trial Requirements:

- 1.5T Siemens MRI scanner
- Institutional expertise in cardiac MRI (established cardiac MRI program)
- Site must be able to utilize a phased-array coil
- Site must be able to utilize a power injector
- The site must be able to submit (1) protocol specific qualifying examination
- Site must submit all trial exams to ACRIN within **48 hours** after acquisition

NOTE: It may be helpful to keep a copy of this Manual in the imaging department, so all technologists involved in the image acquisition of ACRIN PA 4008 are privy to the protocol-required imaging specifications.

2.0 Study Objectives and Specific Aims

2.1 Study Overview

ACRIN PA 4008 is a multi-institutional project to prospectively evaluate potential determinants of the regression (improvement) of LV hypertrophy and fibrosis assessed by cardiac MRI before and after AVR for severe aortic stenosis. A total of 80 eligible participants will join the study from ACRIN-qualified institutions with the required technology. Potential participants will be scheduled to undergo AVR for severe symptomatic aortic stenosis within 8 weeks after enrollment. A gadolinium-enhanced cardiac MRI scan, along with arterial pulse wave recordings and novel non-contrast myocardial tissue characterization sequences (T1rho mapping), will be performed within 3 weeks before the AVR and repeated approximately 6 months after AVR. These data will be used to assess LV mass, LV myocardial fibrosis, arterial stiffness, and wave reflections. Additional procedures in the study will include arterial tonometry measurements, medical history review, blood collection, a quality-of-life questionnaire and a 6-minute walk test.

2.2 Primary Hypothesis

Study hypotheses include that arterial stiffness and arterial wave reflections are associated with a less pronounced reduction of LV mass and fibrosis and with a greater degree of residual fibrosis and hypertrophy despite correction of aortic stenosis via AVR. Researchers expect to demonstrate that arterial stiffness and wave reflections are important determinants of residual left ventricular hypertrophy and fibrosis (adverse prognostic markers assessed with cardiac MRI) after aortic valve replacement. This would identify a novel, potentially treatable mechanism that could be targeted with therapy in future studies and can be assessed by cardiac imaging studies.

Importantly, the value of T1rho imaging will be assessed to evaluate its value in detecting the degree of myocardial fibrosis at baseline and degree of reduction after AVR, using post-gadolinium T1-mapping as a reference method. Researchers expect to validate T1rho, a novel MRI imaging method that does not require gadolinium contrast, as a technique for the assessment of myocardial fibrosis. This would allow for myocardial fibrosis (an important abnormality that needs to be assessed in several cardiac conditions) to be imaged without the use of gadolinium contrast, which is contraindicated in many patients who have advanced kidney impairment.

3.0 Scanner Qualification

Participation in the ACRIN PA 4008 trial requires that all sites adhere to the protocol specific cardiac MRI parameters detailed in this manual. The use of standard imaging guidelines is an essential component of clinical trials in which imaging plays a central role in the research endpoints. This is of particular importance in multicenter trials where equipment, personnel, and imaging acquisition protocols can vary significantly. Thus, the use of standardized imaging guidelines helps control the inter- and intra-variability inherent in multicenter imaging trials.

The purpose of any imaging qualification process is to help ensure the trial imaging is of high quality and performed per the trial-standardized acquisition protocol. To participate in the ACRIN PA 4008 trial, each site must qualify by first scanning **(1)** volunteer utilizing the ACRIN PA 4008 scanning protocol parameters (**without an injection of gadolinium contrast**). The submission of a qualifying exam provides an opportunity to evaluate compliance with sample imaging acquisition protocols prior to participant recruitment and actual trial-specific protocols.

The qualifying exam will be reviewed by the ACR Imaging Core Lab for both protocol compliance and image quality; approval of the qualification exam is required prior to ACRIN PA 4008 site activation. Suboptimal image quality and/or imaging not performed per the trial-standardized protocol can result in exclusion of the imaging exam(s) and/or the entire case from analysis. Therefore, routine QC and strict adherence to the ACRIN PA 4008 image acquisition protocol are of great importance, and sites will be asked to re-scan a volunteer should there be any substantive changes in hardware or software to the scanner during the conduct of the trial.

3.1 Qualification Review

The qualifying exam will be evaluated for image quality (e.g. artifacts, distortion, and signal-to-noise) and compliance with the protocol specific cardiac MRI parameters. An ACR Imaging Core Lab Imaging Technologist will notify the site of the results of the qualifying review via e-mail. E-mail documentation will include your site's Study Coordinator (SC), site PI, and lead technologist to inform the site team whether the qualifying exam has been approved. If the qualifying exam is not approved, required corrections for rescanning will be included in the e-mail.

NOTE: Approval of the qualifying exam is mandatory prior to your site registering a participant onto the ACRIN PA 4008 trial.

3.2 Volunteer Re-scanning

If the initial qualifying exam is not approved, a re-scan of a volunteer will be required until parameters for approval are met for site qualification. Upon approval of the qualifying exam, no additional requalification is required unless one of the following conditions occurs:

a. New scanner being introduced.

b. Major changes to the qualified scanner. A major change in scanner hardware or software occurs during the course of the study. This would include major software upgrades (i.e., a software upgrade that result in a new software primary version number) and changes to the coil system, gradient systems, or RF amplifier. Periodic minor updates to existing software versions are not considered major changes.

3.3 Qualifying Image Submission

All qualifying exams in DICOM format are to be sent to the ACR Imaging Core Lab on Compact Disc (CD) or DVD.

Please label the disk, in permanent marker, with the following information:

- Site Name
- Trial Name: ACRIN PA 4008
- Date of Imaging (DD-MMM-YYY)

For questions related to scanner qualification, please send an email to: imagearchive@acr.org. Enter **"ACRIN PA 4008 Scanner Qualification"** in the subject line.

Ship All Qualification Imaging to:

American College of Radiology
1818 Market St., Suite 1600
Philadelphia, PA 19103
Attn: ACRIN PA 4008 Scanner *Qualification*

4.0 Participant Eligibility

4.1 Inclusion Criteria

- 18 years of age or older
- Severe symptomatic aortic stenosis (estimated aortic valve area <1 cm2)
- Planned for AVR procedure within 8 weeks after enrollment
- Able to have a cardiac MRI within 3 weeks prior to AVR
- Able to tolerate cardiac MRI imaging with gadolinium contrast
- Willing and able to provide a written informed consent

4.2 Exclusion Criteria

- Known LV ejection fraction <50%
- Previous aortic valve replacement
- Planned additional valve repair/replacement
- Infective endocarditis
- Moderate or severe aortic valve regurgitation
- Rhythm other than sinus rhythm (i.e., atrial fibrillation)
- Unstable angina in the previous month
- Pre-operative estimated glomerular filtration rate (eGFR) <45 mL/min/1.73m² of body surface area
- Presence of a bicuspid aortic valve, which is associated with an intrinsic aortopathy that may affect arterial load in its own right
- Resting heart rate >120 beats per minute, systolic blood pressure >180 mm Hg, or diastolic blood pressure > 100 mm Hg
- Pregnancy or intent to become pregnant
- Unwillingness of the patient to sign the consent form

5.0 Participant Scheduling

Participants will undergo two 1.5T cardiac MRI studies for the trial. MRI SCAN 1 must be completed within (3) weeks prior to AVR and MRI Scan 2 must be completed (6) months post AVR.

6.0 Participant Preparation for MRI Imaging

- Prepare the participant according to local standard practice, including any pre-treatment for severe claustrophobia or anxiety.

- Confirm renal function sufficiency prior to imaging; eGFR must be **>**30 mL/min/1.73m² of body surface area.

- If the participant has smoked, or had food, alcohol or caffeinated beverages within four (4) hours prior to testing, the MRI scan for the study will need to be rescheduled.

- If the participant has taken a short-acting nitrate within four (4) hours prior to testing, the MRI scan for the study will need to be rescheduled

  NOTE: *an inclusion criterion for the trial is the presence of* ***eGFR>45 mL/min/1.73m²*** *of body surface area. This is to minimize the possibility of eGFR dropping to <30 mL/min/1.73m² by the time of the 2nd (final) MRI 6 months post-AVR. Should a subject demonstrate a eGFR<30 mL/min/1.73m² at the time of the final MRI (6-months post-AVR), the subject should undergo the MRI but contrast administration, perfusion imaging, and delayed enhancement inversion recovery sequences should not be performed. In this instance, various other MRI measurements will still be useful for some study end-points (for instance, LV mass).*

- Same size and placement of the intravenous catheter is recommended for both MRI scans. Optimally, each participant should receive an intravenous catheter with a gauge **no smaller than 20 gauge**.

- The participant will be placed supine in the magnet; arms at side are acceptable. The phased-array coil should be placed and the participant should be localized per institutional standard practice.

- Initiate imaging …

7.0 Contrast Agent Administration

- Each participant should receive an intravenous catheter no smaller than **20 gauge**
- MultiHance should be administered in a dynamic fashion with a power injector at both time points.
- For the dynamic sequence, MultiHance should be administered intravenously at a dose of **0.15 mmol/kg of body weight** and **rate of 2 ml/second**, followed by a **20 ml saline flush**.
  The type, amount, rate of injection, and site/gauge of IV should comply with the study guidelines and should be documented by the technologist on the **MRI Assessment form**.

NOTE: Keep in mind that the same dose and rate of MultiHance, same arm, and same rate of contrast administration should be maintained for both MRI Scan 1 and 2.

8.0 MRI Standardized Image Acquisition Protocol

Both MRI Scan 1 and 2 ACRIN PA 4008 imaging protocol will include a:

- **Localizer Series**
  - 3-plane localizers SSFP (BH expiration)
  - Axial thoracic single shot axial scout SSFT (Non-BH)
  - HASTE thoracic Fat sat (from lower neck to below costo-phrenic angles) (Non-BH)
  - Double-oblique long-axis LV plane, e.g pseudo VLA and HLA views SSFP (pseudoscout) (BH-expiration)
  - Short axis LV planes from base to apex (pseudoscout) (BH-expiration)

➢ **PRE-GAD Acquisitions**:

- **TI-Scout Look-Locker** inversion recovery acquisition of a mid-ventricular short-axis LV view. There will be both a long and a short breath-hold TI Scout image acquisition. **NOTE: All subsequent mid-ventricular short axis views should be done at this level.** Approximately ten images need to be acquired sequentially at increasing inversion times.
  Note: Ask the patient to do his best to hold his/her breath on the long breath hold, letting them know it will likely be difficult and if they have to, let the air out of their lungs slowly before they breath. If they are unable to hold their breath for the long breath hold sequence, it is very important they do their best to hold it on the short breath hold sequence.
  - **Recommended Parameters:**
    - **Increasing inversion times:** approximately 50 to 1,000 ms
    - **Slice thickness:** 6mm
    - **Base resolution:** 192
    - **Phase resolution:** 50%

- **SH-MOLLI** acquisition of T1 maps (mid-ventricular short-axis view, same slice as the TI-scout) using single-shot, modified Look-Locker inversion recovery sequence. (BH- expiration)
  - **Recommended Parameters:**
    - **Slice thickness:** 6mm
    - **Base resolution:** 192
    - **Phase resolution:** 81%
    - **Partial Fourier:** 6/8

- **T1Rho MAP** Acquisition T1rho myocardial maps (mid-ventricular short-axis view, same slice as TI map above) using various spin-lock times in order to reconstruct T1rho maps. **There will be both a long and a short breath-hold T1Rho MAP image acquisition. (BH-expiration)**.
    - **Recommended Parameters:**
        - **Various spin-lock times:** 10-50 ms
        - **Slice thickness:** 8 mm

- **MultiHance Injection:** 0.15 mmol/kg of body weight at a rate of 2 ml/second, followed by a 20 ml saline flush. Before injection, set up turbo flash dynamic perfusion sequence, short axis, at the same location as the TI scout. Just before injection, start the perfusion sequence and then inject contrast. Do not change any parameters.

➢ **POST-GAD Acquisitions**:

- **Sequential contiguous short-axis cines** covering the LV from base to the apex with the use of breath-hold cine steady state free precession sequence (SSFP). 1. Que Sax slice. 2. Hit "SCAN," **DO NOT** use **"APPEND"** 3. Press control-3 or 4 to shift by 1 slice toward the apex 4. Repeat until full LV coverage. Note 1: Control-4 or 3 shifts backwards towards the base. Note 2: If poor quality (breathing, artifacts etc.) repeat scan **AND discard the poor quality image *(from the local data base)*. (BH-expiration)**

    - **Recommended Parameters**:
        - **TR**: 28 ms
        - **TE**: 1.18 ms,
        - **Phases**: 30
        - **Slice thickness**: 8 mm
        - **Interslice distance**: 0 mm
        - **Matrix:** 192 x 192
        - **IPAT:** 3 or 2 **(the fastest the coils will allow with an acceptable image)**

- **SSFP Cine long-axis planes** (2-, 4-, 3- chamber views and LVOT)
    - **Recommended Parameters**:
        - **TR**: 30.6 ms
        - **TE**: 1.3 ms
        - **Phases**: 30
        - **Slice thickness**: 8 mm

- **Matrix:** 192 x 192
- **IPAT:** 3 or 2 (**the fastest the coil will allow with an acceptable image**)

- **TI-Scout Look-Locker** inversion recovery of a mid-ventricular short-axis LV view (**same parameters, plane, and field of view as in pre-contrast acquisition**). This sequence allows for measurement of average myocardial T1 time
  - **Recommended Parameters:**
    - Approximately 10 images acquired sequentially at increasing inversion times (approximately 50 to 1,000 ms).

- **SH-MOLLI** acquisition of T1 maps of a mid-ventricular short-axis LV view **(same parameters, plane, and field of view as in pre-contrast acquisition)** using an ECG-gated single-shot modified Look-Locker inversion recovery (sh-MOLLI) sequence

- **Flow 3 chamber phase contrast** R to L **AND** A to P (two separate acquisitions with the ONLY change the direction of the VENC)
  - **Recommended Parameters**:
    - **TR**: 35.15 ms
    - **TE**: 3.14 ms
    - **Slice thickness**: 5.5 mm
    - **Base Resolution:** 256
    - **Phase Resolution:** 50%
    - **IPAT:** 2
    - **Flip angle:** 10 degrees
    - **Venc:** 130
    - **Flow Mode:** Single Direction

- **DENSE** Acquisitions of displacement-encoded sequences in a mid-ventricular short axis (same slice position as all other single slice Sax images) and a 4-chamber view
  - **Recommended Parameters:**
    - **Slice thickness:** 8mm
    - **Matrix:** 112 x 112

- **TI-Scout Look-Locker** inversion recovery of a mid-ventricular short-axis LV view (**same parameters, plane, and field of view as in pre-contrast acquisition**). This sequence allows for measurement of average myocardial T1 time.
    - **Recommended Parameters:**
        - Approximately 10 images acquired sequentially at increasing inversion times (approximately 50 to 1,000 ms).

- **SH-MOLLI** acquisition of T1 maps of a mid-ventricular short-axis LV view **(same parameters, plane, and field of view as in pre-contrast acquisition)** using an ECG-gated single-shot modified Look-Locker inversion recovery (sh-MOLLI) sequence

- **TRUE FISP PSIR** *single-shot SSFP phase-sensitive inversion-recovery acquisition* with an inversion time prescribed to null the myocardial signal approximately **20 minutes after** the administration of gadolinium performed in contiguous short-axis views **(copy prescription from short axis cine)**. *This will be done in 2 breath holds although can be changed if needed*.
    - **Recommended Parameters:**
        - **Slice thickness:** 8 mm
        - **Base resolution:** 160
        - **Phase resolution:** 75%.

- **TURBO FLASH** *segmented phase-sensitive inversion-recovery acquisition* with an inversion time prescribed to null the myocardial signal immediately after the SSFP single-short inversion recovery acquisition. **1 short-axis slice (same slice position as all other single slice Sax images).** *If there is breathing artifact, please repeat the acquisition until a high-quality image is obtained.*
    - **Recommended Parameters:**
        - **Slice thickness:** 8 mm
        - **Base resolution:** 256
        - **Phase resolution:** 75%.

- **TI-Scout Look-Locker** inversion recovery of a mid-ventricular short-axis LV view (**same parameters, plane, and field of view as in pre-contrast acquisition**). This sequence allows for measurement of average myocardial T1 time
    - **Recommended Parameters:**
        - Approximately 10 images acquired sequentially at increasing inversion times (approximately 50 to 1,000 ms)

- **SH-MOLLI** acquisition of T1 maps of a mid-ventricular short-axis LV view **(same parameters, plane, and field of view as in pre-contrast acquisition)** using an ECG-gated single-shot modified Look-Locker inversion recovery (sh-MOLLI) sequence

CANDY-CANE/VENC IMAGING FOR TONOMETRY COMPARISON

In-plane phase-contrast acquisitions in the "candy-cane" aortic view, to visualize in-plane flow for determination of aortic pulse wave velocity followed by short-axis aortic SFP cine acquisitions and through-plane proximal aortic phase-contrast acquisitions (which will be used for measurement of volume flow).

NOTE: See Appendix I for detailed phase-contrast image acquisition instructions

Figure 1: Timeline for MR Imaging Protocol

9.0 Arterial Tonometry

Applanation tonometry should be **performed immediately after the MRI scan** (in which phase contrast acquisitions of aortic flow are acquired). The tonometry procedure should be performed with prohibitions on smoking, meals, and alcohol, and beverages containing caffeine for the four **(4) hours** before measurements, and beverages containing caffeine for **24 hours** before measurements. The high-fidelity Millar tonometer will be used to record brachial and radial artery waveforms from the wrist of the dominant arm.

For detailed procedures, see the Arterial Tonometry Standard Operating Procedures, available online at www.acrin.org/4008_imagingmaterials.aspx

10.0 Image Submission

10.1 TRIAD

All trial exams will be submitted to ACR Core Laboratory via TRIAD. TRIAD is a software application that ACRIN provides for installation on a site's PC. One or several computers of choice within the institutional "firewall" and on the institutional network may be equipped with TRIAD software; internet access is also required. The TRIAD application can then be configured as a DICOM destination on either scanner(s) and/or PACS system for direct network transfer of study related images into the TRIAD directory. When properly configured, the TRIAD software anonymizes, encrypts, and performs a lossless compression of the images before they are transferred to the ACRIN image archive in Philadelphia.

Once equipment-readiness has been determined, imaging personnel from ACRIN will coordinate installation and training for the software.

- ***To contact TRIAD Support call:*** *215-940-8820 or email TRIAD-Support@acr.org*

10.2 Image Transmittal Worksheet (ITW)

All imaging should be submitted **within 48 hours after acquisition** and should include an Image Transmittal Worksheet (ITW). An Image Transmittal Worksheet (ITW) is used during the exam QC review to verify a complete transfer of image data has been submitted to the ACR Imaging Core Lab.

11.0 Image Quality Control (QC)

11.1 *ACRIN Core Laboratory Quality Control Technical Review*

Upon receipt of the images at the ACR Imaging Core Lab, an initial QC review will be conducted by a qualified ACRIN Imaging Technologist. The ACRIN Imaging Technologist will check for missing images/sequences, appropriate image anonymization, complete anatomical coverage of the heart, adherence of all sequences to imaging protocol, and absence of image artifact.

In cases where image sets are judged to be suboptimal ("technically inadequate"), the trial PI will be informed, and a replacement participant will be accrued from participating institution.

11.2 *Image Data Queries*

If it is found during the QC review that the submitted exam has missing data or does not follow the protocol guidelines, detailed in this manual, an Imaging Technologist will issue a query to the site SC. Sites are expected to resolve data queries expeditiously. Queries not resolved within **7** business days will be sent to the ACRIN PA 4008 trial team for additional follow-up.

12.0 Imaging Forms

There are (2) imaging forms that must be completed and submitted for each imaging timepoint:

- *Image Transmittal Worksheet (ITW)*
- *MRI Assessment Form*

It is recommended that each of the above forms be made available, in hard copy format, for the Imaging Technologists to complete *during* the image acquisition when the requested information on these forms is most readily available.

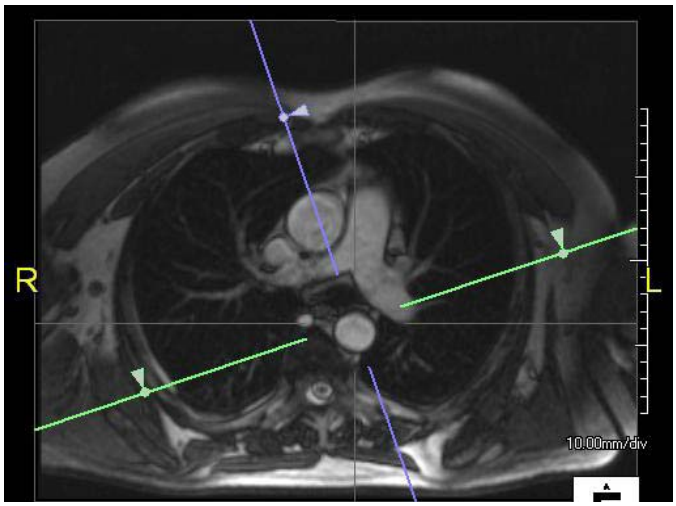
Appendix I

Phase-Contrast Image Acquisition Instructions

➢ Identifying and Prescribing the Candy Cane View

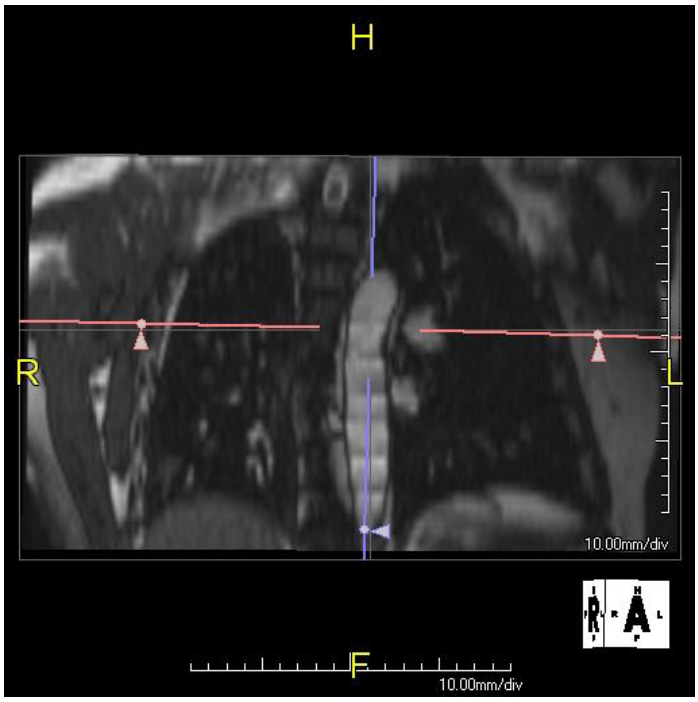
- Using the axial stack as a 3D scout volume, prescribe a plane that shows the thoracic aorta in its long axis *("candy cane" view, as shown below).*
- This plane should be prescribed so that it visualizes as large a segment of the thoracic aorta as possible.
- In order to prescribe this plane properly, find the axial localizer view that shows the ascending and descending aorta at the level of the pulmonary artery bifurcation and prescribe a plane that passes through the center of both the ascending and descending aorta *(purple plane in Figure 1 below):*

Figure 1:



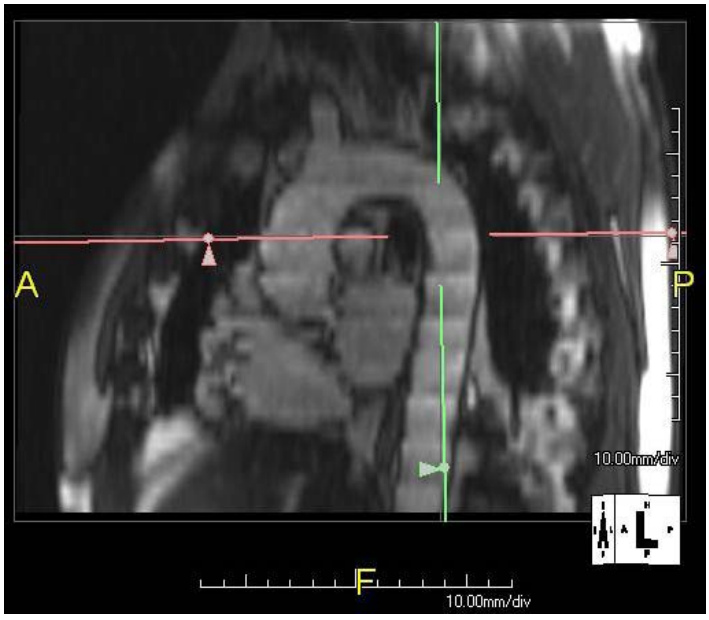
- Then, using the axial localizer stack viewed in 3D mode, use the coronal plane reconstruction to identify the descending thoracic aorta and make sure the plane goes through the middle of the lumen for as long a segment as possible ***(purple plane in Figure 2 below)***. Usually, this requires slight counter-clock rotation of the plane

Figure 2:



- Finally, "fine tune" the plane to visualize as large a segment of the aorta as possible. *As seen in* ***Figure 3 below****.*

Figure 3:



➢ Candy Cane View: Execution Details and Parameter Recommendations

- Once this plane is identified, a phase-contrast sequence with in-plane phase encoding from head to foot will be acquired. The velocity-encoding direction is represented by the blue arrow ***below in Figure 4***.

Figure 4:

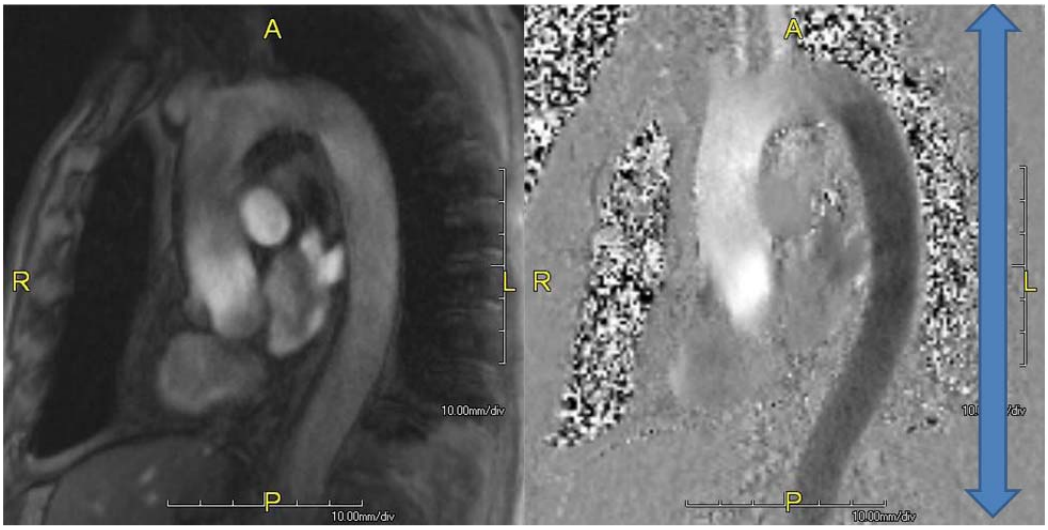


Table 1: Candy Cane View Parameter Recommendations	
Parameter	**Value**
Sequence type	FLASH
TR	minimized (~10 ms)
TE	3.2 ms
Segments	1
Flip angle	30
Field of view	~340 x 340
Image matrix	256 x 256
Slice thickness	8 mm
Number of slices	1

Gating	Retrospective
Number of averages	2
VENC	130 cm/sec **prescribed ad-hoc to avoid aliasing**
Number of phases	maximized (according to heart rate)
Breathing Type	Free-breathing
Bandwidth	31 KHz

➢ Short Axis Cine Execution Details and Parameter Recommendations

- One-slice SSFP (true FISP) cine
- The imaging plane should be prescribed immediately above the top level of the right pulmonary artery, or slightly above, to avoid the high-velocity flow close to the aortic valve.
- The sagittal scout view and the candy-cane view should be used to prescribe this plane.
- The plane should be perpendicular to the long axis of the aorta.
- The goal is to acquire the ascending and descending thoracic aorta as 2 "circles" *(See Figure 6 below).*
- In some subjects, the arch lies immediately cranial to the right pulmonary artery and therefore it is necessary to prescribe the plane at the level of (rather than above) the pulmonary artery.
- An approximate range of acceptable prescription planes is shown *below in Figure 5* (space between yellow lines), although particularly in subjects pre-aortic valve replacement, the "higher is better" since high velocity flow from the valve jet is best avoided.

Figure 5:

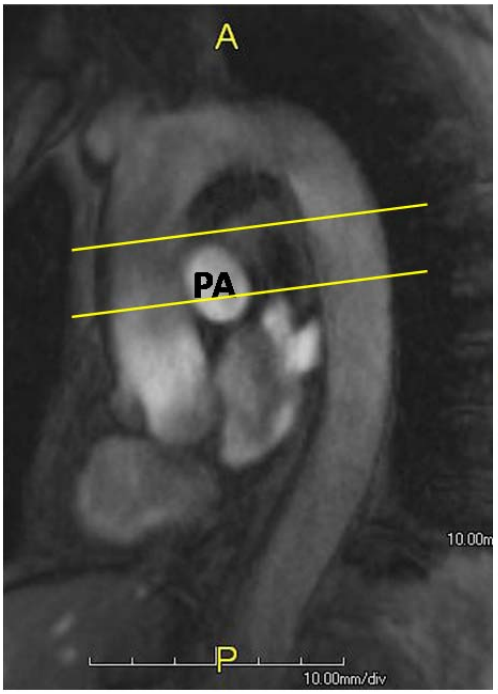


Figure 6:

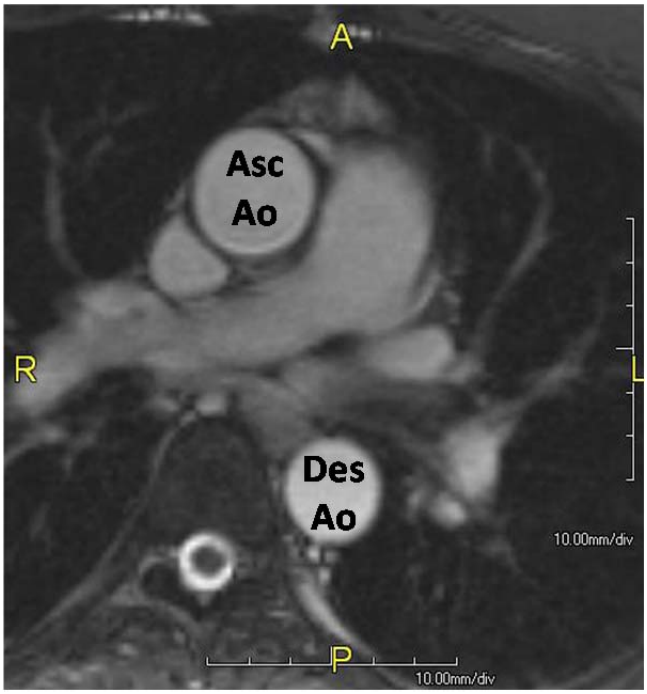


Table 2: Short Axis Cine Parameter Recommendations	
Parameter	**Value**
Sequence Type	SSFP (True FISP)
TR	<3.8 ms
TE	Minimized
Flip Angle	70
Field of View	360 x 360
Image Matrix	256 x 256
Slice Thickness	8 mm
Number of Slices	1
Partial Fourier	Off
Number of Phases	30
Parallel Imaging (optional)	GRAPPA Acceleration Factor:2
Gating	ECG Retrospective
Breathing Type	Breath-hold ≤15 seconds

➢ Aortic Axial Cine Execution Details and Parameter Recommendations

- Aortic axial one slice phase-contrast cine bright blood, **non-breath-hold** sequence.
- The slice should be positioned at exactly the same level as the SSFP sequence in the previous section

Table 3: Aortic Axial Cine Parameter Recommendations	
Parameter	**Value**
Sequence type	FLASH
TR	~10 msec (minimized)
TE	3.2 ms

Segments	1
Flip angle	30
Field of view	~340 x 340
Image matrix	256 x 256
Slice thickness	8 mm
Number of slices	1
Gating	Retrospective
Number of averages	2
VENC	130 cm/sec **prescribed ad-hoc to avoid aliasing**
Number of phases	maximized (according to heart rate)
Breathing Type	Free-breathing

NOTE: Please carefully review details in Section 6: Participant Preparation and Section 8: Standardized Image Acquisition in of the Site Imaging Manual as this imaging protocol may or may not align with your institution's standard protocol.